Volker Nissen, Dirk Stelzer, Steffen Straßburger und Daniel Fischer (Hrsg.)

Multikonferenz Wirtschaftsinformatik (MKWI) 2016

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Volker Nissen, Dirk Stelzer,
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Vorwort der Konferenzleitung

Liebe Leserinnen, liebe Leser,

die Multikonferenz Wirtschaftsinformatik 2016 (MKWI 2016) ist eine der wichtigsten Wirtschaftsinformatik-Konferenzen im deutschsprachigen Raum und wir freuen uns, dass diese Veranstaltung im Jahr 2016 an der TU Ilmenau stattfindet. Die MKWI 2016 umfasst 30 Teilkonferenzen mit insgesamt 163 wissenschaftlichen Fachvorträgen und anschließenden Diskussionen, drei Keynote-Vorträge und drei weitere eingeladene Vorträge, 16 Posterpräsentationen, elf Workshops und Tutorials, drei Panels sowie ein Praxisforum. Dabei lag die Annahmequote für schriftliche Beiträge zur MKWI 2016 bei 48 %.

Die Themenschwerpunkte der MKWI werden traditionell durch die Teilkonferenzen geprägt. Sie bieten wichtige Plattformen für den fachlichen Austausch und die Vernetzung von Wissenschaftlern und Unternehmensvertretern. Breite und Aktualität der im vorliegenden Konferenzband vertretenen Themen verdeutlichen die zunehmende Differenzierung unserer Wissenschaft sowie die Bedeutung der Wirtschaftsinformatik für Unternehmen, öffentliche Einrichtungen und unsere gesamte Gesellschaft.

Wir danken allen Kolleginnen und Kollegen, die mit vielen Ratschlägen und praktischen Hilfen zur Vorbereitung dieser Konferenz beigetragen haben und während der Durchführung mitwirken. Insbesondere danken wir den Leiterinnen und Leitern der Teilkonferenzen, den Hauptrednern, den Mitgliedern der Programmkomitees sowie den vielen weiteren Gutachtern.

Allen Sponsoren und Förderern der MKWI 2016 danken wir ebenfalls sehr herzlich. Ohne ihre Unterstützung wäre die MKWI 2016 in dieser Form nicht durchführbar gewesen.

Außerdem bedanken wir uns sehr herzlich bei allen Mitarbeitern und den vielen freiwilligen studentischen Helfern.

Wir wünschen Ihnen eine spannende Lektüre und viele Anregungen für die eigene Tätigkeit bei der Durchsicht der in diesem Konferenzband gesammelten Beiträge zur MKWI 2016!

Volker Nissen, Dirk Stelzer, Steffen Straßburger und Daniel Fischer

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- Business Intelligence, Analytics und Big Data
- Computational Mobility, Transportation and Logistics
- CSCW & Social Computing
- Cyber-Physische Systeme und digitale Wertschöpfungsnetzwerke
- Digitalisierung und Privacy
- e-Commerce und e-Business
- E-Government – Informations- und Kommunikationstechnologien im öffentlichen Sektor
- eHealth as a Service – Innovationen für Prävention, Versorgung und Forschung
- Einsatz von Unternehmenssoftware in der Lehre
- E-Learning und Lern-Service-Engineering – Entwicklung, Einsatz und Evaluation technikgestützter Lehr-/Lernprozesse
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- Hedonische Informationssysteme
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Keynotes

Process Mining: Spreadsheet-Like Technology for Processes

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Abstract

Spreadsheets can be viewed as a success story. Since the late seventies spreadsheet programs have been installed on the majority of computers and play a role comparable to text editors and databases management systems. Spreadsheets can be used to do anything with *numbers*, but are unable to handle *process models* and *event data*. Event logs and operational processes can be found everywhere. Recent breakthroughs in process mining resulted in novel techniques to discover the real processes, to detect deviations from normative process models, and to analyze bottlenecks and waste. Comparable to spreadsheet programs like *Excel* which are widely used in finance, production, sales, education, sports, process mining software can be used in a broad range of organizations. Whereas spreadsheets work with numbers, process mining starts from event data with the aim to analyze processes. This *keynote paper* uses spreadsheets as an analogy to make the case for process mining as an essential tool for data scientists and business analysts.

1 Spreadsheets: Handling Numbers

A spreadsheet is composed of cells organized in rows and columns. Some cells serve as input, other cells have values computed over a collection of other cells (e.g., taking the sum over an array of cells).

Richard Mattessich pioneered computerized spreadsheets in the early 1960-ties. Mattessich realized that doing repeated "what-if" analyses by hand is not productive. He described the basic principles (computations on cells in a matrix) of today's spreadsheets in (Mattessich, 1964) and provided some initial Fortran IV code written by his assistants Tom Schneider and Paul Zitlau. The ideas were not widely adopted because few organizations owned computers.

The first widely used spreadsheet program was *VisiCalc* ("Visible Calculator") developed by Dan Bricklin and Bob Frankston, founders of Software Arts (later named VisiCorp). VisiCalc was released in 1979 for the Apple II computer. It is generally considered as Apple II's "killer application", because numerous organizations purchased the Apple II computer just to be able to use *VisiCalc*. In the years that followed the software was ported to other platforms including the

Apple III, IBM PC, Commodore PET, and Atari. In the same period *SuperCalc* (1980) and *Multiplan* (1982) were released following the success of *VisiCalc*.

Lotus Development Corporation was founded in 1982 by Mitch Kapor and Jonathan Sachs. They developed *Lotus 1-2-3*, named after the three ways the product could be used: as a spreadsheet, as a graphics package, and as a database manager. When *Lotus 1-2-3* was launched in 1983, *VisiCalc* sales dropped dramatically. *Lotus 1-2-3* took full advantage of IBM PC's capabilities and better supported data handling and charting. What *VisiCalc* was for Apple II, *Lotus 1-2-3* was for IBM PC. For the second time, a spreadsheet program generated a tremendous growth in computer sales (Rakovic et al., 2014). *Lotus 1-2-3* dominated the spreadsheet market until 1992. The dominance ended with the uptake of Microsoft Windows.

Microsoft's *Excel* was released in 1985. Microsoft originally sold the spreadsheet program *Multiplan*, but replaced it by *Excel* in an attempt to compete with *Lotus 1-2-3*. The software was first released for the Macintosh computer in 1985. Microsoft released *Excel 2.0* in 1987 which included a run-time version of MS Windows. Five years later, *Excel* was market leader and became immensely popular as an integral part of the Microsoft's *Office* suite. Borland's *Quattro* which was released in 1988 competed together with *Lotus 1-2-3* against *Excel*, but could not sustain a reasonable market share. *Excel* has dominated the spreadsheet market over the last 25 years. In 2015, the 16th release of *Excel* became available.

Online cloud-based spreadsheets such as *Google Sheets* (part of *Google Docs* since 2006) provide spreadsheet functionality in a web browser. *Numbers* is a spreadsheet application developed by Apple available on iPhones, iPads (iOS), and Macs (OS X). Dozens of other spreadsheet apps are available via Google Play or Apple's App Store.

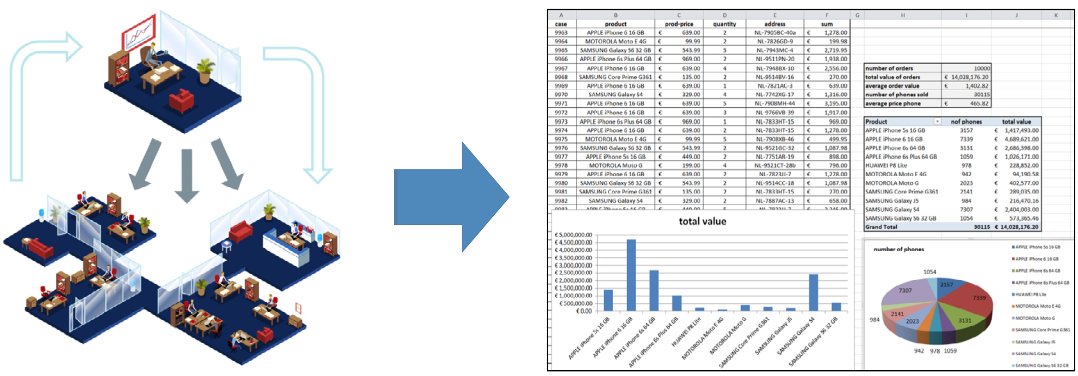

Figure 1: Reality is reduced to numbers in a spreadsheet: Concepts such as cases, events, activities, resources, etc. are missing and process models are not supported.

Spreadsheets can be used to do anything with numbers. Of course one needs to write dedicated programs if computations get complex or use database technology if data sets get large. However, for the purpose of this keynote paper we assume that spreadsheets adequately deal with numerical data. We would like to argue that *process mining software enables users to do anything with events*. In this paper, we introduce process mining against the backdrop of spreadsheets.

2 Process Mining: Handling Events

Instead of numbers process mining starts from *events*, i.e., things that have happened and could be recorded. Events may take place inside a machine (e.g., an ATM or baggage handling system), inside an enterprise information system (e.g., a purchase decision or salary payment), inside a hospital (e.g., making an X-ray), inside a social network (e.g., sending a twitter message), inside a transportation system (e.g., checking in at an airport), etc. Events may be "life events", "machine events", or "organization events". The term *Internet of Events* (IoE), coined in (Van der Aalst, 2014), refers to all event data available. The IoE is roughly composed of the Internet of Content (IoC), the Internet of People (IoP), Internet of Things (IoT), and Internet of Locations (IoL). These are overlapping, e.g., a tweet sent by a mobile phone from a particular location is in the intersection of IoP and IoL. *Process mining aims to exploit event data in a meaningful way*, for example, to provide insights, identify bottlenecks, anticipate problems, record policy violations, recommend countermeasures, and streamline processes (Van der Aalst, 2011).

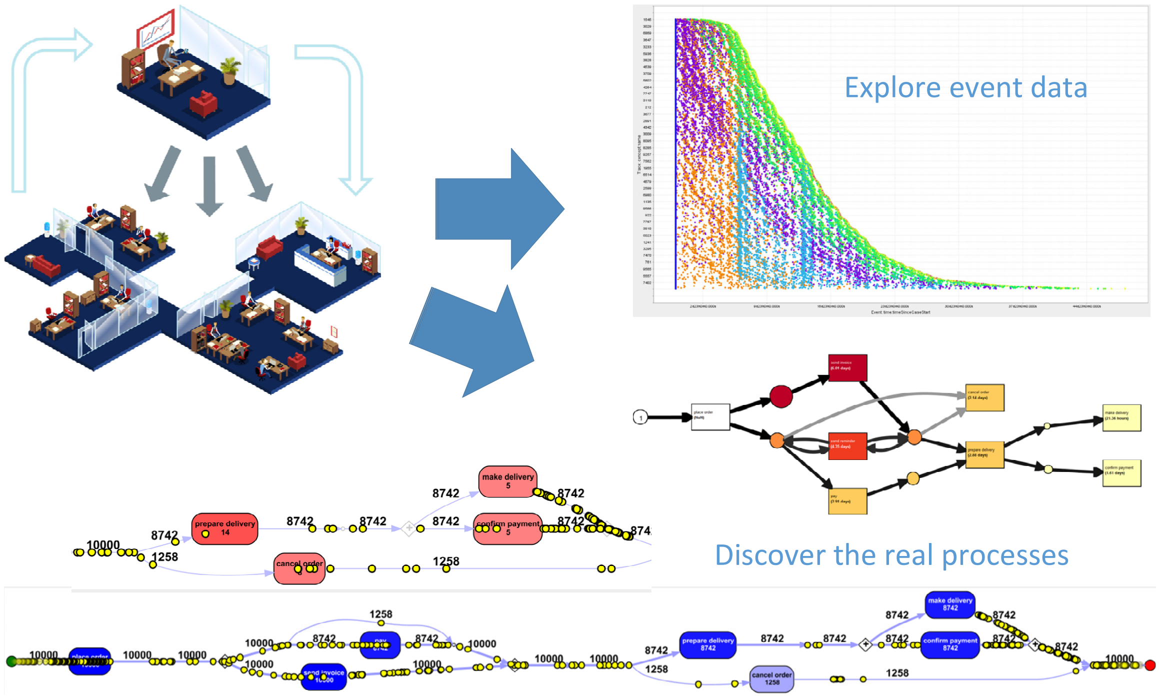

Figure 2: Process mining can be used to discover the real processes, detect deviations, predict delays and risks, and diagnose bottlenecks and waste. Concepts such as cases, events, activities, resources, etc. are natively supported and process models showing bottlenecks, risks, costs, etc. can be shown.

Process mining should be in the toolbox of data scientists, business analysts, and others that need to analyze event data. Unfortunately, process mining is not yet a widely adopted technology. Surprisingly, the process perspective is absent in the majority of Big Data initiatives and data science curricula. We argue that event data should be used to improve *end-to-end* processes: It is not sufficient to consider "numbers" and isolated activities. Data science approaches tend to be process agonistic whereas process management approaches tend to be model-driven without considering the "evidence" hidden in the data. Process mining can be seen as a means to bridge the gap between data science and process management. *By positioning process mining as a spreadsheet-like technology for event data, we hope to increase awareness in the WirtschaftsInformatik (WI) / Business & Information Systems Engineering (BISE) community.*

3 Outlook

Just like spreadsheet software, process mining aims to provide a generic approach not restricted to a particular application domain. Whereas spreadsheets focus on *numbers*, process mining focuses on *events*. There have been some attempts to extend spreadsheets with process mining capabilities. For example, QPR's *ProcessAnalyzer* can be deployed as an *Excel* add-in. However, processes and events are very different from bar/pie charts and numbers. Process models and concepts such as cases, events, activities, timestamps, and resources need to be treated as first-class citizens during analysis. Data mining tools and spreadsheet programs take as input any tabular data without distinguishing between these key concepts. As a result, such tools tend to be *process-agnostic*.

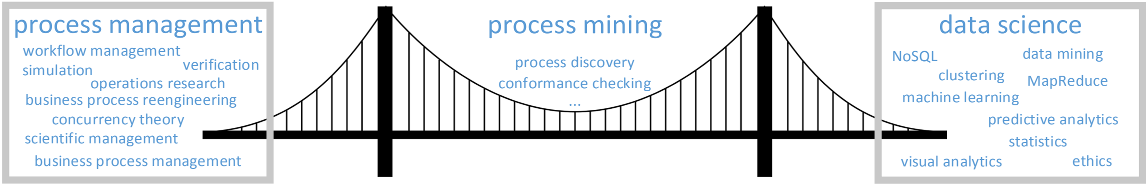

Figure 3: Process mining as the missing link between process management (BPM, WFM, BPR, etc.) and data science (data mining, statistics, etc.).

In this paper, we promoted process mining as a generic technology on the interface between data science and process management. We hope that process mining will become the "tail wagging the dog" (with the dog being Big Data initiatives) and play a role comparable to spreadsheets. This may seem unrealistic, but there is a clear need to bridge the gap between data science and process management. Process mining provides the techniques connecting both worlds.

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Digitale Souveränität – Die Überlebensstrategie für den IT-Standort Europa

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Abstract

Digitalisierung ohne Schutz und Vertrauen kann nicht funktionieren. Die digitale Souveränität ist der Schlüssel zu einem starken IT-Standort in Europa und der erfolgreichen digitalen Transformation der Wirtschaft.

Europa ringt mit seiner Rolle in der Digitalisierung. Die Stimmen werden lauter, die die digitale Entwicklung als Gefahr für unsere Freiheit und Demokratie wahrnehmen. Wenn wir uns in der digitalen Welt bewegen, hinterlassen wir Spuren mit persönlichen Informationen – über unsere Freunde, unsere Vorlieben und unser Verhalten. Dem Nutzer ist nur in Ansätzen bewusst, wofür diese Daten heute oder in Zukunft benutzt werden. Vielleicht wird unser Facebook-Freundeskreis künftig unsere Kreditwürdigkeit beeinflussen und die Höhe unserer Krankenkassenbeiträge. Und was passiert mit Leuten, die gar nicht bei Facebook sind?

Anhand unserer Profile, die wir freiwillig oder unfreiwillig in der digitalen Welt erzeugen, werden uns personalisierte Informationen in Form von Werbung oder Nachrichten zur Verfügung gestellt – in den meisten Fällen sogar kostenlos! Der Algorithmus gibt uns das was wir, laut unseres Profils, zu wollen scheinen. Damit verlieren wir jedoch die Informations- und Deutungshoheit.

Die Digitalisierung der Welt macht also bisher Privates öffentlich und beeinflusst damit unser Wohlergehen. Gleichzeitig wird unser Blick gelenkt und wir haben nur noch auf zensierte Informationen Zugriff. Die Gefahr der Freiheitsbeschränkung des Einzelnen für sich und als mündiger Staatsbürger ist also real.

Welche Konsequenzen müssen wir daraus ziehen? Das liegt auf der Hand: Um künftig unsere Freiheit zu erhalten und das Vertrauen in die Digitalisierung wieder herzustellen, müssen wir unsere digitale Souveränität wiedergewinnen.

Digitale Souveränität bedeutet, die Fähigkeit zur ausschließlichen Selbstbestimmung. Selbstbestimmte Bürger, Staaten und Unternehmen sind handlungs- und entscheidungsfähig. Sie lassen nicht unkritisch andere über ihre Angelegenheiten entscheiden, aber sie müssen auch nicht alles selbst tun. Diese Souveränität ist die Voraussetzung für Vertrauen in die Digitalisierung und damit die Grundlage für die erfolgreiche Transformation der Wirtschaft.

Benutzer-zentriertes Design in Unternehmen: Vom Exoten zum echten Wettbewerbsvorteil

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Abstract

2015 haben mehr und mehr Unternehmen externe Design-Agenturen gekauft, um sich von ihrer Konkurrenz abzuheben. Warum ist Design plötzlich so wichtig? - Kann Design nicht nur einen visuellen, sondern auch einen monetären Mehrwert für Unternehmen schaffen? In diesem Vortrag erfahren Sie, wie Unternehmen aller Größen SAPs benutzer-zentrierten Design-Ansatz nutzen, um die digitale Transformation bei sich voranzutreiben, neue Geschäftsfelder zu erschließen, sowie die gesamte Unternehmenskultur verbessern und sich so einen Wettbewerbsvorteil verschaffen.

Teilkonferenz
11. Konferenz Mobilität und Digitalisierung (MMS 2016)

Immer mehr Bereiche des täglichen Lebens werden digital erfasst: Menschen, Maschinen aber auch Produkte und Dienstleistungen werden miteinander vernetzt, wobei Arbeits-, Geschäfts-, Lern und Freizeitprozesse umfassend automatisiert werden. Als Konsequenz ändern sich diese Prozesse, Produkte und Dienstleistungen sowie die damit verbundenen (traditionellen) Geschäftsmodelle. Zentraler Treiber der Digitalisierung ist die Verbreitung und vor allem Nutzung mobiler Technologien. Die Nutzung mobiler Geräte für den Zugang zu Informationen, Unterhaltung und sozialen Netzen zu jeder Zeit und an jedem Ort ist selbstverständlich geworden. Die damit zur Verfügung stehenden Datenströme bilden die Grundlage zum besseren Verständnis von Nutzungssituationen und Nutzerbedürfnissen.

Damit verbunden ist eine Vielzahl an offenen Fragen, die es nach wie vor zu beantworten gilt. So stellt die umfassende Digitalisierung neue Herausforderungen an den Entwurf und Betrieb korrespondierender integrierter (mobiler) Informationssysteme, wobei die Entwicklung geeigneter Maßnahmen zur Sicherung der Privatsphäre gewährleistet werden muss. Thema der 11. MMS ist die Diskussion von Herausforderungen und Lösungsansätzen für die Realisierung von digitalen Systemen und Anwendungen, die auf eine Umsetzung dieser Vision einer digitalen Alltags-unterstützung abzielen. Dem interdisziplinären Ansatz der GI-Fachgruppe MMS folgend, stehen dabei gleichermaßen technische wie wirtschaftliche Entwicklungen und die Analyse und Gestaltung von Informationssystemen als Mensch-Aufgabe-Technik-Systeme im Mittelpunkt.

Wir möchten uns bei allen Einreichern, bei den Mitgliedern des Programmkomitees sowie den Organisatoren der MKWI bedanken, ohne die diese Teilkonferenz nicht möglich gewesen wäre.

Markus Bick, Key Pousttchi, Frédéric Thiesse

(Teilkonferenzleitung)

Opportunities and Challenges for Local Retailing in an Environment Dominated by Mobile Internet Devices – Literature Review and Gap Analysis

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Abstract

The massive spreading of Mobile internet devices (MIDs) and anytime, anywhere internet access has changed the retail environment. Consumers can access information, entertainment, and social networks through different channels like in-store, mobile, or social and touchpoints during the shopping process. These flexible and seamless experiences for customers can be defined as omni-channel retailing. To enable such an experience, local retailers should integrate all of these channels to enable a consistent brand image across all touchpoints, allowing for a broader view of the customer and an improved shopping experience. With the MID-empowered digitalization of retailing, physical stores have new relevance by bringing together online and traditional channels. While some basic findings about requirements, challenges and opportunities of MIDs in local retailing exist, their systematic analysis has been inadequate. With our contribution we provide a systematic overview of existing research and give a summary of opportunities and challenges for local retailers in an environment dominated by MIDs while identifying gaps for future research.

1 Mobile internet devices as a key enabler for local retailers in an omni-channel world

Mobile internet devices (MIDs), like smartphones, wearables or tablets, are one of the fastest spreading technologies in human history (DeGusta, 2012). By 2016, it is expected that 2.2 billion users, representing over a quarter of the world population, will be using smartphones.

The massive spreading of MIDs and anytime, anywhere internet access has increased access to information, entertainment and social networks (e.g. Blázquez, 2014). Customers have the opportunity to search for prices and reviews, compare products, scan for coupons and promotions or stay in contact with friends via the preferred social network and all these during the shopping activity (e.g. in-store), upfront, or after the shopping process (e.g. Spaid and Flint, 2014 or Verhoef et al., 2015). This may be why more than 50% of smartphone owners are using their device to shop (Cruz and McKenna, 2011).

Because of MIDs, customers have come to expect a flexible and seamless experience across different channels, whether at their local store or on the social web, whether mobile or at a computer, and whether online or offline (Fulgoni, 2014). These characteristics are also defined as omni-channel retailing (e.g. Rigby, 2011 or Levy et al., 2013).

For local retailers, this change means that it is no longer sufficient to manage separate channels. Their goal is to integrate all of these channels to enable a consistent brand image across all touch points, to get a broader view of the customer, and to improve the shopping experience in order to reducing the risk of losing the customer during customer journey (Peltola et al., 2015). Blázquez (2014) also stated that the massive spread of MIDs and possibilities for channel integration gives new relevance to physical stores. Local stores can serve as a hub that bring together online and traditional channels (Cao, 2014). The growth in adoption of MIDs and related changes in shopping behaviour have created a fertile environment to optimize the shopping experience (Spaid and Flint, 2014).

The requirements to enable an optimized shopping experience for both the customer and the shop owner must be precisely known. Given this knowledge, business processes can be realigned and challenges transformed into opportunities. While some basic findings about requirements, challenges and opportunities of MIDs for local retailing exist, their systematic analysis has been inadequate.

The main contribution of this article is to provide a systematic overview of existing research and give a summary of opportunities and challenges for local retailers in an environment dominated by MIDs. In addition, some research gaps are presented in these areas. To address these topics, we proceed with a systematic literature review and using the approach of Kitchenham et al. (2007).

The remainder of this paper is organized as follows. Our research method is explained in section two. In section three, we present the results of this systematic mapping study. We discuss the findings in section four. Finally, in section five, we critically reflect on our conclusions, examine limitations of the work, and highlight future research directions.

2 Research Method

Many attributes and properties characterize a comprehensive, structured literature review. According to vom Brocke et al. (2009), a lack of strictly defined rules in documenting the literature search process often causes problems regarding the reliability of a literature. To avoid this fundamental mistake and provide a well-structured and repeatable procedure in our review, we follow the often-cited approach for software engineering researchers by Kitchenham et al. (2007).

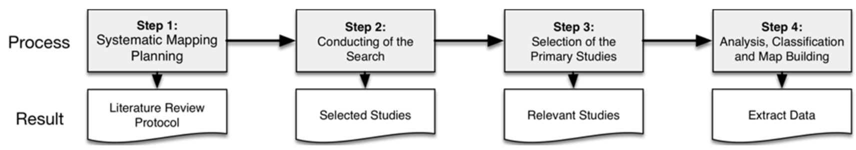

Figure 1. Systematic literature review process (Based on Kitchenham et al. (2007))

The systematic literature review involves four discrete process steps, which include all created results that are carefully documented in a review protocol. Figure 1 illustrates the process steps (i) plan systematic literature review (Protocol), (ii) conduct search of articles, (iii) screen papers, (iv) extract data and show the results of this extraction.

2.1 Step 1: Planning the Review

First we state the research interests of the paper in the form of two research questions. These questions define the main areas and guide the review. The literature extraction strategy, including the list of resource libraries, the search string, and inclusion/exclusion criteria, are defined afterwards. Inclusion and exclusion criteria are used to reject papers that are not relevant to answer the research questions.

2.1.1 Research Questions (RQ)

Despite all of the impressive research results named in Chapter 1, little research exists on the influence of MIDs in a local retailer environment. Groß (2015) and Lazaris et al. (2014) summarize that up to now, research in this area has been heavily fragmented and multidisciplinary. In order to give a systematic overview of existing research, we define the first research question:

RQ 1: What are the main topics and their contributions of the identified literature body?

Additionally, it is important to know more about opportunities and challenges for retailers in order to improve or reengineer retailer's business processes in a MID-dominated local retail world. Therefor we define our second research question:

RQ 2: What are the key opportunities and challenges in a MID-dominated retailer environment?

2.1.2 Literature extraction strategy

For the execution of the literature review, we used the following databases to include papers which are published in the proceedings of the most relevant IS conferences (e.g. ICIS, ECIS, WI, AMCIS, etc.) as well as a large part of the claimed VHB-Jourqual 'A' and 'B' rated journals (inclusive business economics journals): AIS Electronic Library, EBSCOhost/Business Source Premier, ScienceDirect, and Springerlink. Additionally, we performed a forward and backward search in relevant articles to identify further sources which could not be found by keyword search.

When searching for relevant articles the following keywords were used: 'local retail', 'local store', 'brick-and-mortar', 'brick and mortar', 'retail store', 'physical store', 'in-store' and 'in store' in combination with 'mobile internet device', 'smartphone' and 'mobile device'. The search terms are based on synonyms, characteristics (e.g. Mobile Internet Device and Smartphone) and differences in spelling and terminology of the main keywords local retail and mobile internet device. Synonyms and related terms were derived by brainstorming and collecting keywords from initially identified articles.

The literature review includes peer-reviewed journal articles and conference contributions that deliver in their title or abstract aspects of MIDs in local retailing to supply information for our research questions. We exclude duplicated papers from different search resources, inaccessible papers and papers written in other languages than English or German.

2.2 Step 2: Conducting the Search

In this section, the search for primary studies is conducted according to the previously established plan. It is done by looking for all primary studies that match the search terms in our sources. The search terms and filter criteria used in systematic literature are presented in Table 1.

The search was performed on 25th June 2015. The total amount of publications reached 557 entries. After checking the relevance of several abstracts to address the RQs, the selection was inspected.

	AISeL	EBSCOhost	ScienceDirect	Springer Link
Search terms	(“local retail” OR “local store” OR “brick-and-mortar” OR “brick and mortar” OR “retail store” OR “physical store” OR “in-store” OR “in store”) AND (“mobile internet device” OR “smartphone” OR “mobile device”)			
Filter	/	peer reviewed	journal articles only	Articles within business & management, computer science

Table 1: Search terms and filter criteria of databases

To extend our relevant literature, neighbouring research was included in the sample. For inclusion, the method of forward and backward article search was used.

2.3 Step 3: Selection of the Primary Studies

The selection of relevant studies was processed in two steps. At first, the abstract, introduction and conclusion of all papers were reviewed. An article was accepted if it fulfilled the inclusion and exclusion criteria. As result, we rejected 542 papers out of 557. Figure 2 provides an overview of the individual databases and how many accepted papers were from each source. Forward and backward search brought 10 additional articles. After the identification of all relevant studies, 25 in total, the articles were carefully analysed in order to identify relevant information for our research questions.

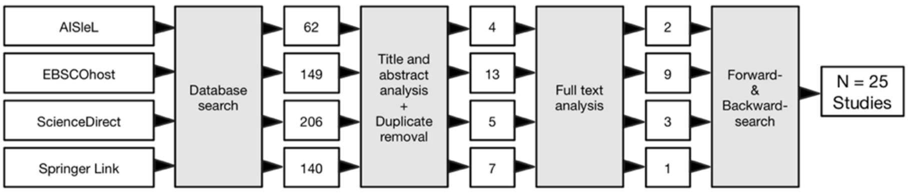

Figure 2: Literature selection process

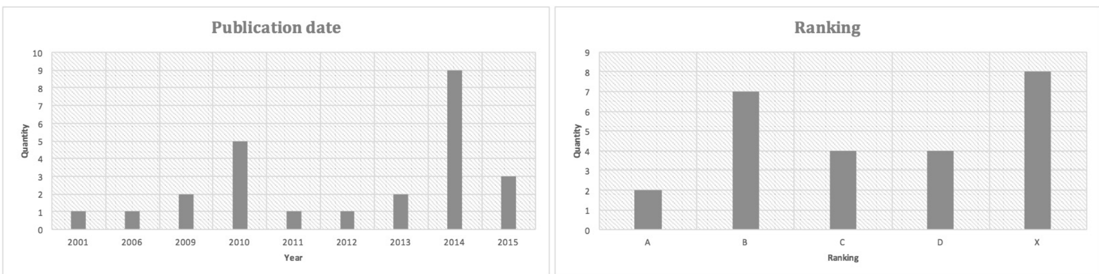

Figure 3: Publications by publication date and ranking

3 Analysis and Results

In the following we start with meta analysis about publication dates and the quality of studies and follow with the content analysis of publications.

3.1 Meta analysis

First, an analysis of the literature body with respect to the publication date and the quality of publications, in accordance with the by VHB JOURQUAL 2.1 assigned rankings. Figure 3 gives an overview about the findings. The low article count for 2015 is due to the fact that the selection process took place in June 2015. More literature in the remainder of the year is possible.

3.2 Content analysis of relevant publications

After our meta analysis we determine the literature body to extract all relevant information to answer our research questions. We now present how each research question can be addressed:

3.2.1 RQ 1: What are the main topics and their contributions of the identified literature body?

In the following the main topics of the identified literature are briefly summarized. Given similar topics were bundled into three major groups: (1) mobile services and the influence of customers shopping experience, (2) mobile recommendation agents and mobile decision support systems, and (3) literature about multi- and omni-channel topics.

The use of mobile services in different stages of the customer journey in order to increase the shopping experience are analysed with a survey by Karaatli et al. (2010) and with qualitative interviews by Spaid and Flint (2014). Spaid and Flint (2014) additionally develop a framework to describe extrinsic (product information, trust, and economics) and intrinsic (security and empowerment) motivators in order to support a view of the in-store MID use. The specific opportunities of local base services for mobile commerce are analysed by Mennecke and Strader (2001) and extended with the opportunities of barcode-scanning by Dauerer et al (2013). How to compete as retailer against global players like e.g. Apple, Google or Facebook is discussed by Pousttchi and Hufenbach (2014). Building blocks of mobile services to collect data for data-driven marketing are identified with a case study research approach. Additionally, a role-based reference model for the value network of future retail customer interface and marketing is created and evaluated with expert interviews. Finally, mobile services with MIDs during the shopping process and its adoption in Poland is researched by Kiba Janiak (2014).

Another large topic in our identified literature body is research on mobile recommendation agents and decision support systems. Li et al (2014) analysed based on three criteria factors (user preference, geographic convenience and friends´ influence) a group-coupon recommendation mechanism for local-sensitive products in order to bring customers back to a physical store. With these criteria it is possible to offer accurately-recommend products with a significantly increasing willingness to purchase by taking the advantage of the power of social influence. Kowatsch and Maass (2010) study, based on theory of planned behaviour, innovation diffusion theory, and technology acceptance model, the impact of MRAs on usage intentions, product purchases, and store preferences for consumers. The adaptation of recommendation systems from the e-commerce world and the issues to implement such systems for retails stores is analysed from a retailers' business and technical perspective by Walter et al. (2012). The specifics to access and share product recommendations with MIDs is analysed by Reischach et al. (2009). Lee and Benbasat (2010) explore "whether and how mobile MRAs enhance users´ decisions in retail stores by reducing effort to make purchase decisions while augmenting the accuracy of the decisions". With a laboratory experiment, they indicate that mobile MRAs reduce users´ perceived effort and increase accuracy in the decision making process. New concepts to enable a decision support system on small screens such as those of MIDs is analysed in an experiment by Heijden (2006), finding some new opportunities of effective in-store decision support with personal MIDs. The question whether product reviews on MIDs are helpful for customers and store owners and the question if customers are willing to pay for this information in order to help with purchase decisions are explored by Kowatsch et al. (2011 and 2009). They find out that product reviews help consumers in purchase decisions and they are willing to pay almost 5% of the product's price for a review.

How technology is changing the retail landscape towards an omni-channel environment is analysed with practical insights and examples by Brynjolfsson et al. (2013). Key findings are that distinctions between physical and online retailing are vanishing, advanced technologies on MIDs are merging touch-and-feel information in the physical world with digital content, and with mobile technologies it is possible to reach new customers and expand the market. In addition, Piotrowicz (2014) present key issues after a focus group discussion: channel integration, the changing role of physical stores, need to respond to diverse customer requirements, the balance between personalisation and privacy, and finally supply chain redesign. The article from Verhoef et al. (2015) goes in the same direction, initiating and summarizing a special issue in order to extend the literature about omni-channel retailing. They compare multi-channel and omni-channel retailing with (1) impact of channels on performance, (2) shopper behaviour across channels, and (3) retail mix across channel. Additionally, Lazaris and Vrechopoulos (2014) explore the existing literature about the movement from multi-channel to omni-channel retailing with a structured literature review. Key issues concerning integration, organizational structures, and synergies across channels in multi-channel retailing are synthesized from existing literature and industry practice by Zhang et al. (2010). Blázquez (2014) analysed with a quantitative survey the role of technology in multi- / omni-channel retailing to enhance customer experience for fashion shopping. Main findings are that "retailers must think in all channels holistically, boosting interactive and new technologies for the internet and taking advantage of all touchpoints with the consumer, including mobile devices and social networks". Fulgoni (2014) argues in the same direction but from a marketing point of view. He defines three key priorities to fit in an omni-channel world: 1. The elimination of organizational channel and platform silos to enable a seamless experience across the physical and digital worlds, powered by mobile technologies. 2. "Leverage the ability to electronically communicate with omni-channel shoppers by understanding how to best deliver digital advertisements and incentives to mobile devices that can be redeemed either online or in-store" and 3. the importance of analytical systems to be able to measure consumer behaviour across all touchpoints and provide management with a deep and unified understanding of the drivers of consumer choice. Therefor it is important to link online and offline exposure across all channels and touchpoints. Peltola (2015) draws a broader scope of influences in a changed digitalized omni-channel consumer behaviour. Beside the affects on mobile services, it also influences retailer organizational structure and supply chain. Instead of offering a full range of digital and physical services, it is more important to enable a seamless integration and intuitive linking of consumer-touchpoints in order to optimize the customer experience. The transformation of business models in moving to an omni-channel retail strategy is analysed with a case study on the largest Chinese retailer in consumer electronic appliances by Cao (2014). He finds out three major changes for retailers' business model: (1) redefinition of target clients, (2) a new proposition for shopping value, and (3) redesign of the value chain.

In addition to these three topic categories, Groß (2014) provides a classification framework and literature review of mobile shopping. He finds out that interests in m-shopping has increased continuously over the last decade, but most of the studies explore only the consumers´ acceptance and reactions to m-shopping. Technology aspects are still being researched. Shankar et al. (2010) take care of the specifics in mobile marketing like two- or multi-way communication and promotion of offers between firms and customers using MIDs. They also propose a conceptual framework in order to comprises three key entities: (1) the customer, (2) the mobile, and (3), the retailer.

After the overview of existing topics and relevant outcomes, we now analyse the key opportunities and challenges in a MID-dominated retailer environment.

3.2.2 RQ 2: What are the key opportunities and challenges in a MID-dominated retailer environment?

In order to convert the heterogeneous formulations for opportunities and challenges into a uniform manner of expressions, the model of iterative research process by Flick (1995) was applied. This model has the advantage that new findings can be documented and consolidated easily during our iterative determination process without neglecting the objective of a unified representation. Based on these approach, Figure 4 presents the dimensions and characteristics for opportunities and challenges in an MID-dominated retailer world. First, we describe in the following six identified sections of opportunities.

Novel concepts of customer interaction with unique key features of MIDs like internet access anytime and on any location (Karaatli, 2010), retailers have never had more opportunities to offer a seamless experience between different channels like mobile-, online-, social-, and in-store (Blázquez, 2014) and to stay in contact with customers in two- or multi-way community (Shankar et al., 2010). The ability to check product prices and availabilities in local stores can draw in people who might otherwise have only looked for products online (Brynjolfsson et al., 2013). With this information, customers can shop via MID and pick up in local stores (Brynjolfsson et al., 2013).

Local retailers get the opportunity to ***reach and acquire new customers*** and expand their markets with the adaption of the mobile channel (Brynjolfsson et al., 2013). Location-based services (Mennecke and Strader, 2001) and the possibility to interact with social networks via MIDs help to drive customers to the store (Blázquez, 2014).

Also, there are new possibilities to adapt the well-known concept of recommendation agents from the e-commerce world to ***mobile recommendation agents*** (MRA) with the power of MIDs (Walter et al., 2012). MRA improve the decision making process by providing relevant product information in purchase situations (Kowatsch and Maass, 2010 or Lee and Benbasat, 2010, or von der Heijden, 2006). With MRAs the sales volume could increase through an improved consumer frequency – triggered by consumers´ intention to prefer MRA-enabled retail stores (Kowatsch et al., 2009, Kowatsch and Maass, 2010). MRAs reduce users´ perceived effort in shopping situations and increase accuracy of purchase decisions (Lee and Benbasat, 2010). Additionally, the availably of location-information, social-influence, interactive product information (Kowatsch et al., 2011) and individual preference combined with mobile devices can support recommender systems (Li et al. 2014, or Spaid and Flint, 2014). With MIDs, users also can share recommendations directly after the buying process (von Reischach et al., 2009) in order to provide important content for other users.

New ways to track and analyse data are possible. MIDs enable new ways to track user-data from social, online and mobile channels (Brynjolfsson et al., 2013) that was previously only possible in e-commerce with fixed internet connections. Furthermore, with MIDs local data can also be tracked, like the interactions of customers in-store (Brynjolfsson et al., 2013). With free wireless internet access or bluetooth based technologies, such as beacons, there are new ways to track and understand what shoppers are doing (Spaid and Flint, 2014, or Kiba-Janiak, 2014).

Effective marketing based on consumer-data from social, mobile and local channels is entering a new stage (Brynjolfsson et al., 2013). Retailers can use consumer-data from one channel to improve the marketing in another channel (Zhang et al., 2010). Data from MID like current location empower local stores to send out promotional messages to customers who are close to the store or in a competitor´s store (Brynjolfsson et al., 2013). Integration of user data from multiple sources like mobile payment, mobile loyalty, or couponing (Pousttchi and Hufenbach, 2014) gives the ability to do predictive analytics in order to make offers and recommendations to each retailer's potential and existing customers (Brynjolfsson et al., 2013). Marketing activities like promotions can be monitored more effectively with MIDs (Karaatli et al., 2010). If personalized and contextual-related marketing is based on secure and trustful transaction mechanisms, ensuring privacy and avoid spamming, consumers' acceptance will increase and there are opportunities to achieve loyalty (Groß, 2014).

Finally, MIDs enable the combination of in-store and online benefits to ***increasing the shopping experience*** at all stages in the consumer's decision-making process (Karaatli et al., 2010, or Blázquez, 2014). Based on our concept matrix, mobile recommendation agents are one of the most studied mobile services which increase the shopping experience. They are followed by improved tracking, the analyse of user-data, and possibilities for new concepts for interacting with consumers.

	Opportunities						Challenges						
	Novel concepts of customer interaction	Reach and acquire new customers	Mobile recommendation agents	New ways to track and analyse data	Effective marketing	Incresed shopping experience	Blurring self determined processes between channels	Organi-zational	Strengthened position of customer	Impact of social media	Marketing and services must fit customers´ expectations	Permanent in-store internet access	Business model and privacy
Li et al. (2014)			x										
Brynjolfsson et al. (2013)	x	x		x	x		x		x		x		
Blazquez (2014)	x	x				x	x						
Kowatsch and Maass (2010)			x	x									
Lee and Benbasat (2010)			x										
Piotrowicz and Cuthbertson (2014)							x	x		x			
Fulgoni (2014)							x	x			x		
Spaid and Flint (2014)			x	x	x			x	x	x			
Kiba-Janiak (2014)				x					x				
Karaatli et al. (2010)	x			x		x					x		x
Walter et al. (2012)			x										
Kowatsch et al. (2009)			x										x
von Reischach et al. (2009)			x										
Kowatsch et al. (2011)			x										
Zhang et al. (2010)					x			x			x		x
Peltola et al. (2015)							x						
van der Heijden (2006)			x										
Mennecke and Strader (2001)					x								
Groß (2014)					x						x	x	
Verhoef et al. (2015)							x						
Cao (2014)							x						
Shankar et al. (2010)	x							x					x
Pousttchi and Hufenbach (2014)					x						x		
Total	4	2	9	5	6	2	7	5	3	2	6		4

Figure 4: Concept matrix: Opportunities and Challenges in a MID-dominated retailer world

Beside these opportunities there are challenges as well. One of these challenges is the ***blurring self determined buying process of users between channels*** by an increased digitalization by MIDs (Piotrowicz and Cuthbertson, 2014). Consumers can access product information in one channel like in-store and then purchase from another channel (Brynjolfsson et al., 2013). Retailers comes into a tricky position with the phenomenon of "showrooming", where user visit retailers´ store to "touch and feel" but than purchase the product online with their mobile phone (Fulgoni, 2014 or Cao, 2014 or Verhoef et al., 2015) and vice versa. Research results demonstrate that consumers do not separate channels (Blázquez, 2014) and the number of different touched channels in a customer journey is increasing (Peltola et al., 2015).

There are several ***organizational*** challenges in order to maintain multiple channels. Even if a retailer is offering different channels, they are often managed by different people and departments in a "silo-like" nature (Piotrowicz and Cuthbertson, 2014). This is especially the lack of integration in pricing, product information, promotion, markting, supply chain management, and experience provided across channels (Piotrowicz and Cuthbertson, 2014 or Fulgoni, 2014). Retailers must optimize her organizational structure in order to enable an integrated consistent philosophy across channels (Fulgoni, 2014 or Spaid and Flint, 2014) and achieving demand and efficiency synergies across channels (Zhang et al., 2010). Organizational culture with a missing understatement about the importance of MIDs are showstopper of the reorganization process (Shankar et al., 2010).

Information on MIDs at any time and place ***strengthens the position of the customer.*** Digital information, product price comparison (Kiba-Janiak, 2014) and the aggregation of offline information and online content increase the transparency in retail situations and makes the retail landscape more competitive (Brynjolfsson et al., 2013 or Spaid and Flint, 2014). Mobile technology is making omni-channel retailing inevitable but it breaking down geography barriers and ignorance to shield retailers from competition (Brynjolfsson et al., 2013).

Additionally, there are specific **impacts of social media in strengthen customer.** Growth of social media combined with MIDs has created the possibility to bring the whole social network into the store (Piotrowicz and Cuthbertson, 2014). Customer can check product ratings, share their experience about a product, service or store, share thoughts, opinions, videos or pictures as well their satisfaction or dissatisfaction or contact someone to ask a question (Piotrowicz and Cuthbertson, 2014 or Spaid and Flint, 2014). The challenge is that retailer does not have a direct influence on any individual social network (Piotrowicz and Cuthbertson, 2014).

In order to increase the number of consumers who adapt various mobile services and join mobile marketing campaigns, **marketing and services must fit customers' expectations** (Kraatli et al., 2010 or Groß, 2014). Marketing will need to become more data-driven, integrated across channels and analytics-oriented in order to deliver advertising messages to customers with surgical accuracy (Brynjolfsson et al., 2013 or Zhang et al., 2010 or Fulgoni, 2014) and in order to beat strong competitors in these field like Amazon or Ebay (Pousttchi and Hufenbach, 2014) and avoiding spamming at the same time (Groß, 2014).

Due the spread of MIDs there are some challenges in changed **business models and privacy**. The cost of service, e.g. for useful reviews of mobile recommendation agents (Kowatsch et al., 2009) and consumers´ concerns over privacy and security (Zhang et al., 2010 or Shankar et al., 2010) as well as government regulations are important challenges (Karaatli et al., 2010).

4 Discussion

The paper provides a valuable contribution to understanding the role of MIDs in local retailing environment by giving an overview of existing studies and summarizing opportunities and challenges with a concept matrix. Our literature analysis confirms the findings of Groß (2015) and Lazaris et al. (2014) that relevant studies on this topic are very multidisciplinary and fragmented. Most of the research activities are from the research areas of marketing, e-commerce and information systems. Lots of studies concern themselves with mobile recommendation agents and their influence on customers' decision-making process, followed by marketing-specific opportunities and challenges. Also discovered in several studies is the integration, management, or customer journey path across different channels. Several works report that it is important to deeply understand MID use so that retailers can offer experienced services as well as create effective marketing campaigns in order to improve customers' shopping experience.

Due to the high fragmentation there are several white spots for further research. Just a few studies (e.g. Cao, (2014) or Zhang et al., (2010)) concern themselves with changing requirements for the business model and business processes in order to achieve the required organizational changes for local retailers. Most of the studies between 2001 and 2013 are based on older MIDs like so-called “PDAs” or mobile phones with internet access. There should be more qualitative research with state-of-the-art MIDs like smartphones, tablets, or wearables, in order to review existing findings and improve research findings in general. Further research is necessary in order complete the understanding of requirements, challenges and opportunities of users and retailers in an environment dominated by MIDs. Therefore, we define the following research gaps:

1. Further research about the impact of MIDs in local retailing to expand the knowledge about purchase behaviour, store performance, and seamless shopping experience in order to reduce the probability of losing a customer during blurring self determined buying process to competitor.
2. Studies on how local retailers can improve existing business models, internal organization structures, and business processes in these areas in order to fulfill customer requirements in an efficient way.
3. Additional research about the impact of social media and the strengthened position of customers through MIDs to avoid the phenomena of “showrooming” for local retailers.

5 Summary and conclusion

The purpose of this literature review was to provide an overview of existing research topics and its contributions as well as challenges and opportunities in the context of local retailing and the existing domination of MIDs. This work has been conducted on basis of the review protocol explained in section 2. We identified that there are a high amount of studies between 2010 and an increased number of publications in 2014. We also gave an outline about main topics and contributions have already been investigated which are represented in section 3.2.1 as well as a dimensions and characteristics for opportunities and challenges which are structured with a concept matrix in section 3.2.2. We identified twelve sections of opportunities and challenges for local merchants.

When critically reflecting on this work, limitations of our literature review can be seen. Due to the selected term-based search method, the number of identified works from the literature is limited. Moreover, there are related studies e.g. about mobile shopping or mobile marketing which do not directly analyse impacts of local stores or the adaption of MIDs, but they can partly deliver important aspects which are also helpful.

Beside these limitations, we expect a broad impact for further research on the dominating role of MIDs in a local retail environment. As far as we know, this paper provides a first systematic overview about opportunities and challenges for retailers in an MID-dominated local retailing environment. Furthermore, we propose research gaps that should be addressed by researchers in future studies.

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Deconstructing the Sharing Economy: On the Relevance for IS Research

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Abstract

In the past few years, Sharing Economy (SE) has become increasingly popular mainly for consumer research. Past research focused on describing the phenomenon itself and its disrupting influences on current economic mechanisms. However, information systems (IS) research and scientific literature in general still lack a common understanding of SE and its underlying mechanisms. We therefore elaborate on this gap by conducting a literature review among contributions within IS scholarship that address SE in order to identify to what extent past IS research has covered the topic yet. We aimed to highlight interrelations to adjacent topics and illustrate potential research gaps. As a result, we identified the four perspectives on how the topic is addressed, namely business model, sharing service, sharing asset and exogenous influences. Furthermore, we identified the four principles of SE, which are multi-sided markets, crowdsourcing, trust and recommendation and consumption-based pricing. With this contribution, we aim to guide further investigation of the topic. Additionally, we aim to highlight potential research gaps, as we claim SE to become much more relevant for IS in near future.

1 Introduction

Founded in 2009 in San Francisco, the US car sharing company Uber is expected to generate revenue of 10 billion US dollars in 2015 as the world leading Person-to-Person (P2P) taxi service broker (Business Insider 2014). Uber benefits from car seats as spare resources, providing customers the opportunity to utilize them without the costs and effort of car ownership. The company receives a fee on every transaction via the Uber App, where customers can find de jure self-employed, private drivers nearby. Although Uber is successfully exploiting a position within a steadily growing two-sided market, recent lawsuits, strikes and demonstrations of ‘traditional’ taxi drivers against the company’s services indicate the disruptive character of sharing-based business models regarding traditional economy mechanisms. However, not only the car industry is eroded by innovative business models based on P2P sharing. More and more sectors are affected by disruptive sharing solutions, such as finance (Crowdfunding and P2P lending), tourism (private accommodation offerings) or engineering (e.g. lending or sharing of unused tools). While the count of sharing-focused companies is steadily growing, also more criticism comes up, mostly about exploitation of the sharing participants' workforce (e.g. Uber) or the contamination of these actually P2P based networks by commercial parties (e.g. Airbnb); In Berlin, already 0.4 % of flats are offered via Airbnb. About 10% of Airbnb property owners offer more than one apartment with the maximum of one property owner offering 44 apartments in Berlin Mitte (airbnbvsberlin 2015). These examples show that sharing economy platforms easily enable users to commercialize resources by bypassing legal regulations, taxes and other norms. Contrasted to professional service providers that have to comply with these normative aspects, this can be seen as 'unfair' advantage of SE business over 'traditional' ways of service provision.

However, these two controversial facets of SE, namely new opportunities to unleash hidden potential but also new ways to bypass established regulations and norms, indicate that sharing changes consumer behavior and thus may reflect a new paradigm with which companies have to provide their products and services. Since Sharing Economy is an interdisciplinary topic, it is inevitable to tackle its underlying mechanisms to structure this concept for future IS research. In the past, SE has mainly been focused by Consumer Research, attempting to explore the phenomenon of sharing as an alternative or complement to traditional ownership-based consumption (e.g. Bardhi and Eckhardt 2012; Belk 1988, 2014b; Botsman and Rogers 2011.; Gansky 2010; Weber 2015). Although these contributions help to build an understanding of the characteristics and mechanisms of SE, they mostly tackle the topic from a pure economic level and do not further elaborate on technical aspects nor do they show detailed interconnections to topics in IS research. However, since today's understanding of SE contains the notion of IT as an enabler (Belk 2014a), IS research may be path-leading for both empirically investigating existing SE cases of application and providing guidance on how to conceptualize, build and implement useful SE approaches. Surprisingly, the amount of IS contributions that cover SE is relatively scarce yet.

Within this research paper, we aim to position IS research as a key discipline to foster the investigation of SE and encourage IS researchers to dedicate their work to this topic. To do so, we conduct a literature review on prior IS research that address SE. By first describing possible perspectives and second elaborating on respective business mechanisms highlighting adjacent IS research topics, we provide a first overview of the fundamental principles of the topic. This paper proceeds as follows: In chapter 2, we establish a common understanding of SE by outlining basic principles and definitions of the concept. In chapter 3, we introduce how we conducted the literature review and display our findings based on good practice described by vom Brocke et al. (2009) and Webster and Watson (2002). Chapter 4 is dedicated to the findings of the review, categorized in research perspectives and basic principles of SE business. In chapter 5, we discuss our findings based on the initial situation described in the introduction and mention limitations as well as contributions to theory and practice of this review. Finally, we conclude our research in chapter 6 where we also provide an outlook to future research.

2 Theoretical Background

The term Sharing Economy (also: Share Economy or Shareconomy) describes the socio-economic phenomenon of temporary, not ownership but access-based utilization of consumer goods or services (Belk 2014b). These products or services are usually provided over Internet platforms by intermediaries, which serve as brokers who connect and link seekers and suppliers of information and knowledge (Howells 2006). They thereby reduce uncertainty in a multi-entity relationship, facilitate negotiations and manage respective networks (Zogaj et al. 2014). This approach aims at the use of spare resources by a community to obtain a specific value and thus contrasts with the 'traditional' notion of obtaining a good's value by possession. Belk (2014) distinguishes two kinds of sharing in the digital age: internet-facilitated sharing and Collaborative Consumption. Internet-facilitated sharing describes the free transfer or use of goods, which applies for e.g. Open Source Software, free bicycle sharing and also legal and illegal file sharing. Collaborative Consumption however refers to compensated acquisition of resources and coordinated distribution within a group. The Sharing Economy has originally been described by Weitzman (1984), who introduced sharing as an alternative to purchasing. Since then, the meaning of the term has been subject to change, not least due to the rise of the Internet. Today, the bidirectional communication and collaboration opportunities of Web 2.0 enable sharing to be facilitated mostly via virtual contact (Belk 2014b). This turn started with the 1999 founded music sharing platform Napster, which unleashed many discussions and lawsuits about Intellectual Property Rights, causing some authors to call this time the 'war on sharing' (Aigrain 2012). Both the examples of Napster and Uber show that IT-enabled sharing obtains characteristics of disruptive innovation. However, in the existing literature Sharing Economy has mostly been described as a new form of consumer behavior in marketing and consumer research (e.g. Bardhi and Eckhardt 2012; Belk 1988, 2010; Belk 2013; Giesler 2006; Lamberton and Rose 2012; Ozanne and Ballantine 2010). As opposed to numerous considerations in consumer research and marketing, existing IS research has not sufficiently tackled the topic yet. In the following, we will provide a closer look on the extent of prior IS research covering the concept Sharing Economy.

3 Methodology

To explore Sharing Economy for IS research, we conducted a Literature Review based on the recommendations of vom Brocke et al. (2009) and Webster and Watson (2002). Following the taxonomy of Cooper (1988) for describing the purpose of a literature review, our focus lies on extracting research outcomes in order to identify in which areas and to which extent IS research has covered the topic yet. Our goal is to summarize the main findings to identify 'blank spots' of SE coverage in IS research. However, we espouse the position that SE will become a relevant topic for the IS discipline in the near future and past research has not covered the topic sufficiently yet. Aiming at presenting our findings to both specialized (i.e. researchers dealing with SE) and general scholars in IS, we do so by conducting an exhaustive literature review of SE contributions which, however, is selective in a manner that only contributions in the IS discipline are regarded. The literature search was conducted in August 2015, using the search string ("sharing economy" OR "share economy" OR "shareconomy" OR "collaborative consumption"). Although we focused on searching in titles, abstracts and keywords of peer-reviewed, scientific papers only, no limitations were set regarding publication dates. The databases used for investigation are *AISeL, IEEE Xplore, ACM DL, EBSCO Business Source Premier, ScienceDirect* and *SpringerLink.* Although the open database search revealed numerous hits, most of the contributions treat the subject from a consumer research or marketing perspective. As the main goal of our review is to identify contributions made for IS research in order to show potential research gaps or shortcomings, we excluded consumer research contributions from deeper investigation. Although we are sure, that consumer and marketing research on SE is relevant for understanding the concept as a whole, we narrowed our search down to IS scholarship in order to display the status-quo of SE coverage in IS. By reading titles, abstracts and keywords first, we could find 22 contributions most probably relevant to our purpose. After an in-depth analysis, we identified 14 papers relevant for our review. Contributions that cover the phenomenon of SE on an abstract level and in which the authors either do not obtain an IS-relevant research perspective or do not elaborate on working mechanisms of SE were sorted out. In addition, we conducted a backward and a forward search but did not reveal any further results. Table 1 lists the contributions taken into account for our review.

Database	Contribution/s
AISeL	(Abramova et al. 2015; Andersson et al. 2013; Chasin and Scholta 2015; Chasin et al. 2015; Gutt and Herrmann 2015; Kim et al. 2015; Matzner et al. 2015; Rickenberg et al. 2014; Sach 2015; Trang et al. 2015)
IEEE Xplore	-
ACM DL	(Cusumano 2015; Malhotra and van Alstyne 2014)
EBSCO Business Source Premier	(Weber 2014)
Science Direct	-
SpringerLink	(Teubner and Flath 2015)

Table 1: Selected Sharing Economy literature in IS

Surprisingly, all of the identified papers have been published within the last 3 years. In contrast to literature in consumer research about Sharing Economy, which arose around the 1980s, this indicates that IS scholars just discovered the topic to be relevant for this field, too. In the following we will further elaborate on our findings, highlighting research perspectives as well as work principles of Sharing Economy and thus display touchpoints to adjacent scholarship in IS research.

4 Findings

4.1 Research perspectives

The literature revealed different perspectives on SE business:

Coming from a *business model perspective,* firms must react fast to emerging technologies and changing consumer needs. Therefore, Sach (2015) describes IT-user aligned business model innovation to be one of the most important dynamic capabilities of a sharing-based company. This approach should help to constantly integrate new technologies while not deviating too heavily from existing mechanisms. Apart from this view, no literature could have been identified that obtains a comprehensive view on sharing-based business models, e.g. including cost and revenue structures, customers, partners and value proposed through sharing activities.

From a *service perspective*, sharing services can be differed based on how sharing proceeds, depending on what is subject to share. This includes peer-to-peer file sharing, peer-to-peer trading. peer-to-peer goods sharing and peer-to-peer service sharing (Andersson et al. 2013). However, usually not a product or a service only, but bundles of complementary product and service elements (product-service systems) are shared. Although some papers clearly posit contributions to adjacent Service (Design) Research (e.g. Trang et al. 2015), few publications apply established service research concepts, such as service systems, to sharing activities.

Cusumano (2015) describes current Internet Start-ups in the Sharing Economy from a *sharing asset perspective* and sections them into four categories: spare time (e.g. TaskRabbit, Fiverr), spare time and cars to drive customers around (e.g. Uber, Lyft), extra rooms (e.g. Airbnb, Flipkey) and occasionally used tools and household items (e.g. Streetbank, Snap-Goods). Although many authors speculate which assets may be shared in the future, no research could be found that aims at holistically describing specifications of a product or service that is 'shareable'.

Furthermore, several contributions exist that investigate exogenous influences on Sharing Economy business. Chasin et al. (2015) displays the interplay between regulatory procedures and sharing mechanisms, highlighting the relationship to be bidirectional as new offerings have to comply with existing regulations but also discover holes in regulation, thereby forcing the law to act. On the other hand, Chasin and Scholta (2015) investigate how to exploit Collaborative Consumption for E-Government. Additionally, Sharing Economy may contribute to build a better world with the help of IS by working towards the 'Millennium Development Goals' (Rickenberg et al. 2014).

4.2 Principles of Sharing Economy

From an IS research perspective, we identified four main principles of how Sharing Economy business works:

1. Multi-sided markets: P2P offerings are enabled by intermediary platforms that provide sufficient matchmaking services between resource providers and demanders, often in exchange for a service or brokerage fee (Seamans and Zhu 2013). Multi-sided market business models bring many new challenges but also opportunities for actors within a sharing network. Dynamics of peer-to-peer, peer-to-platform and peer-to-platform-to-peer interaction must be regarded when investigating the provisioning of sharing services. As usually offerings have the notion of IT-enabled peer-to-peer exchanges, the distinction between customers being consumers or providers diminish (Gutt and Herrmann 2015; Kim et al. 2015). Therefore, the mechanisms of value co-creation may have a severe impact on service provision. However, peer-to-peer offerings also contain a major weakness compared to traditional business-to-consumer service provision: there is usually neither a service agreement between the peers nor external control over service provision nor legal foundations to govern it. For example, a lag in confirming reservations via Airbnb makes it difficult for consumers to make definite travel plans and drivers for Uber are able to decline service provision when they do not like the requested destination or the rating of their potential passengers (Cusumano 2015). Taking these risks, some contributions try to shed light on the motivation of people to participate at sharing networks, both as providers and consumers (Gutt and Herrmann 2015; Kim et al. 2015). Furthermore, non-intended peer-to-peer sharing (e.g. if someone who buys a Netflix account and rents films for a monthly fee makes profit by renting these films out to others in return of daily fees) may harm producing companies, although it is still in a legal gray zone (Malhotra and van Alstyne 2014). More principles of multi-sided market scenarios can be discovered by obtaining the intermediary's perspective. The intermediary's main tasks are to synchronize demands, balance conflicting needs and provide sufficient matchmaking between providers and consumers. Under the spotlight of value creation mechanisms, the intermediary is in duty to steadily enhance the value for all parties of the ecosystem. Therefore, Malhotra and van Alstyne (2014) mention the empowerment of customers as one important way to do so. This may include to train skills, deliver knowledge or to design tools for value creation, because better-trained freelancers will deliver higher quality and charge more for their work. However, sharing-based companies have often been criticized to enjoy the profits while offloading the risks of their services to the peers. For example, in 2013 an Uber

driver killed a pedestrian in the US, but Uber would not compensate the victim's family because the driver is not an employee, but only a contractor (Malhotra and van Alstyne 2014).

2. *Crowdsourcing*: shareable resources are offered by members for members of a mostly undefined group (the crowd) over the internet (Howe 2006). This means, that Crowdsourcing mechanisms may be examined for their appliance to the Sharing Economy. In fact, peer-to-peer sharing activities such as Uber's driving services, can be seen as microtasks (Malhotra and van Alstyne 2014). From this point of view, not only the work mechanisms but also ethical and legal aspects become very important subjects for future research, as for example a sharing service provider's income only covers marginal costs. Furthermore, Malhotra and van Alstyne (2014) describe sharing platforms as self-regulating ecosystems, which also applies to crowdsourcing platforms in certain ways. Teubner and Flath (2015) display the opportunities to make use of mass data from the crowd to improve the actual sharing service, using the case of multi hop ride optimization problems for car sharing services. Hence prior crowdsourcing research may be appropriate to guide future research regarding Sharing Economy.

3. *Trust and recommendation*: Business models in the Sharing Economy also often provide rating and recommendation systems to foster trust based on reputations and build social networks among users (Belk 2014a; Abramova et al. 2015). One major challenge for IS research is to investigate how IT can help to build trust among peers and in the intermediary to foster acceptance of the sharing services (Malhotra and van Alstyne 2014; Trang et al. 2015). Rating and review systems are one of the most important features to foster trust building between the peers and the intermediary in sharing networks. Malhotra and van Alstyne (2014) even argue that the viability of sharing offers hinges on the quality of the respective review system. This is especially due to network effects, which lead to positive feedback loops (Cusumano 2015). However, many rating mechanisms provide reply functionalities especially relevant to protect reputation in case of negative criticism (Abramova et al. 2015; Malhotra and van Alstyne 2014). Therefore, IS research recently started to investigate the influence of rating systems' characteristics to sharing behavior and to suppliers' intent to change service parameters such as pricing (Gutt and Herrmann 2015). Malhotra and van Alstyne (2014) mention the effects of rating mechanisms to parties outside the sharing network, alleging the example of health inspectors using Yelp ratings to identify restaurants that may be sources for food poisoning. Besides rating and review systems, there are other mechanisms for intermediaries to foster trust building. Malhotra and van Alstyne (2014) argue that it is a platform provider's duty to spot stalkers, run background checks on sharing providers and respond quickly to conflicts among members. One way to do so is to adapt and implement insurance mechanisms to e.g. help the lender against the concern of damage at the item he shares (Weber 2014). Furthermore, fair reporting, fraud protection mechanisms and trust networks may be regarded when investigating trust in the Sharing Economy (Malhotra and van Alstyne 2014). Adjacencies for investigating trust building may be found in other multi-sided market constellations and e-business, whereas research on social networks may contribute to the understanding of peer-to-peer and peer-to-intermediary behavior in sharing ecosystems (Cusumano 2015). Another topic of interest is the degree of human interaction for trust building and service acceptance, as Trang et al. (2015) found reduced human interaction to negatively influence these measures.

4. *Consumption-based pricing*: As in related concepts such as cloud computing or software-as-a-service, the customer only pays for the actual use of the resource but not directly for its ownership or maintenance. Thus, the sharing economy may create access-based real options for

individuals (Saya et al. 2010). In case of Internet technology facilitated sharing services, peer-to-peer synchronization can be offered for low transaction costs. Sufficiently managing the service pricing is crucial for sharing intermediaries to develop a profitable provision model. Therefore, some companies such as the German car sharing provider BlaBlaCar make use of price suggestion as a pricing strategy (Teubner and Flath 2015). Underlying calculation methods are especially interesting to investigate in case service offerings become more complex, as it is the case in (crowd) data driven calculation of multi hop ride sharing offers.

5 Discussion

Due to the fact that in today's world the mechanisms of SE are based on Internet (i.e. Web 2.0) technologies, the phenomenon has to be considered under the spotlight of digitalization and, thus, IS research should take a leading role in investigating it. Therefore, current IS literature tackles the topic on several levels, including the business model, the service and the sharing asset perspective as well as legal, ethical and governmental issues. Within these perspectives, many opportunities for IS research exist. On the business model level, future research should investigate sharing business models using existing concepts in this field, such as the business model or value proposition canvas (Osterwalder et al. 2010; Osterwalder et al. 2014). This includes but is not limited to a sharing business' (potential) cost structure and revenue streams, partners and resources necessary to perform sharing activities and value creation within these business models. Sharing activities and value propositions are also promising topics for investigation in service research in IS, focusing on the roles of the participants and the role of IT within P2P sharing exchanges. Regarding the sharing asset, IS research may first condense 'shareable' products and services described in prior (not only IS) research and derive specifications that characterize a 'shareable' asset with regard to technological possibilities and limitations. Future research approaches on all these levels should further address the four main principles of Sharing Economy identified within this review. Considering multi-sided market mechanisms, research may focus on peer-to-peer interactions and value co-creation, peer-to-intermediary relation and user empowerment to create greater value as well as matchmaking mechanisms. Using the relation to Crowdsourcing, future IS scholarship may address the nature of sharing activities compared to other microtask activities, ecosystem mechanisms and data elicitation, analysis and exploitation for service configuration. As trust building is crucial for sharing activities, IS research may investigate the design of trust fostering IT, such as rating and review systems, the influence of (negative/positive) ratings on user behavior and service configuration, the dynamics of social networking and community building as well as the influence of trust in the acceptance of sharing platforms and offers. Finally yet importantly, consumption-based pricing may also be a promising research area. This includes but is not limited to investigating price suggestion strategies and mechanisms for respective application contexts (e.g. accommodation sharing), effects of pricing variations to user behavior and the conception of compliant and legal pricing mechanisms with regard to future regulatory changes (e.g. tax regulation). However, prior research within all these fields in reverse may contribute to the understanding of the respective principles in the context of Sharing Economy.

6 Conclusion

Sharing Economy has the potential of manifesting a paradigm shift in economy and social life. As this implies a shift in both economic principles for value creation and appropriation and user behavior on the Internet, IS research may lay the foundation for research in many related fields. With this central role in mind, we accomplished to identify research perspectives on the topic in IS scholarship as well as the principles of how SE business works. With our results, we hope to provide the state-of-the-art of how the concept Sharing Economy has been addressed in IS research yet. By structuring the field and providing an overview of adjacent research topics in IS, we hope our contribution to guide future research in bridging the gaps between anticipated knowledge of the respective IS research fields and the peculiarities of SE. Besides the proposed theoretical contributions of condensing existing knowledge, providing a research structure and pointing out future research opportunities, our paper also contributes to practice by introducing sharing as an alternative to ownership-based consumption and highlighting challenges and opportunities for both startups and incumbent firms when participating in the SE. However, our research is not free of limitations. Since we focused on reviewing prior IS scholarship only, we accomplished to condense existing knowledge to structure the field but neglected the creation of new knowledge. However, we believe that this condensation will be an important fundament for future empirical or design knowledge creating research in IS. Next steps would be to find SE peculiarities and investigating them with reference to adjacent research topics. This approach may be path leading to establish a common and deeper understanding of the structure and effects of the concept, which in turn allows to elaborate on how to conceptualize, build and implement SE structures within diverse contexts. However, with this contribution we could only lay the foundation of research covering this topic. We could show that this research stream is just at the beginning and contains many facets that interrelate with existing concepts with high relevance to IS. As the economic importance of IT-enabled sharing as an alternative or complement to traditional forms of consumption rises, the research topic is going to emerge and gain relevance within the IS community, too. We therefore appreciate all prior research within this field and encourage scholars to tackle the issues we condensed for the Sharing Economy in information systems research.

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The Future of Personal Urban Mobility – Towards Digital Transformation

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Abstract

The integration of digital technologies into vehicles, traffic systems and infrastructures has been increasingly shaping our everyday experiences of mobility. In this study, we aim to understand the extent to which digitalization impacts personal urban mobility as we know it. By conducting a systematic literature review in the fields of information systems, transport, and automobile technologies, we identified four main themes that help shed light on this phenomenon: (1) mobility solutions, (2) intelligent mobility infrastructure, (3) partial virtualization of mobility and (4) enhanced mobility experience. In these themes, we observed that the effects of digitalization are double sided: While digitalization is transforming personal urban mobility by providing users with a seamless, safer and more flexible mobility experience, it also brings concerns of data security and privacy that can negatively influence users' acceptance of new mobility concepts. With the growing relevance of digital technologies in both society and organizations, our study provides implications and promising directions for further research in this interdisciplinary research field.

1 Introduction

Advancements in digital technologies, such as social media, mobile technologies and analytics, have been enabling transformational change in practically every aspect of society (Lucas et al. 2013; Yoo et al. 2010). Because of their pervasiveness and our intensive use of them, digital technologies are even affecting physical aspects of our everyday experiences, such as personal urban mobility (Henfridsson and Lindgren 2005). Urban mobility enables people to access city resources, shaping the daily understanding of the city and society (Miciukiewicz and Vigar 2012). In the last two decades, more and more personal urban mobility concepts have been created by integrating digital technologies into vehicles, traffic systems and infrastructure, bringing them closer to their users (Mitchel et al. 2010). This integration of digital technology into our lives is briefly conceptualized as digitalization. Following Tilson et al. (2010), we define digitalization as a sociotechnical process of using digitizing techniques to extend social and institutional contexts.

In the context of personal urban mobility, digitalization has been used to address overwhelming problems that involve the contemporary megatrends of urbanization, globalization, the aging of society, and environmental sustainability (Pavone et al. 2012). For example, the mobility concept of car rental that is contributing to dealing with urbanization and environmental concerns, i.e., car sharing, has been used ever increasingly since it was integrated with mobile technologies (Lee et al. 2011). In this case, these technologies enable providers to offer car-sharing users services that are more convenient and flexible, such as rapid vehicle access and location, mobile billing and real-time identification of parking spaces (e.g., Hildebrandt et al. 2015). Another example of digitalization in this context is the integration of automobile information systems and analytics within electric vehicles, which can improve prediction accuracy for driving patterns and battery conditions, facilitating the adoption of a more sustainable vehicle technology (e.g., Hanelt et al. 2015a). Furthermore, through sensor and connectivity technologies, vehicles can be transformed into interconnected nodes in transportation, energy, information and social networks, thus providing mobility access for the young and elderly (e.g., through autonomous vehicles) as well as reducing environmental, safety and congestion problems (Mitchel et al. 2010).

Although prior research has investigated some novel personal urban mobility concepts that are enabled through digitalization, to the best of our knowledge, there is no study providing an overview that identifies and structures the impact of digitalization on personal urban mobility. A better understanding of this topic could provide important implications for future research and practice, particularly serving as a foundation to help understand the integration of digital technologies as a solution approach for dealing with the megatrends affecting our society as well as the challenges that might follow. Therefore, in this study we aim to answer the following research questions: (1) To what extent has the body of literature explored changes in personal urban mobility resulting from digitalization? (2) Which areas provide potential directions for further research?

To address these questions, we conducted an in-depth systematic literature review in the fields of information systems (IS), transport and automobile technologies. The remainder of this paper is structured as follows. First, we briefly introduce the development of personal urban mobility and its main drivers of change. Next, we describe our methodological approach, explaining the research procedure used to guide our literature review. Drawing from the literature review findings, we propose and discuss four themes that attempt to explain the changes in personal mobility resulting from digitalization. Lastly, we provide implications for this interdisciplinary research field.

2 Development of Personal Urban Mobility

Before the invention of the automobile, transport systems were essentially limited to horse tramways, regional roads, water channels and railways (Leuenberger et al. 2014). The invention of the automobile in the twentieth century led to the most significant change in personal mobility, transforming transport and traffic systems while also making journeys more accessible and flexible (Leuenberger et al. 2014). Established as a means of personal mobility in the 1930s, the automobile became a symbol of individuality, freedom and social status (Dienel and Trischler 1997). In the United States alone, personal urban mobility yielded more than 5.5 trillion kilometers traveled by private automobiles in 2001, representing 75% of total automobile travel in the country (Pavone et al. 2012). This value, combined with the estimated growth of urbanization worldwide from the current 54% to more than 64% by 2050, indicates that personal urban mobility demands will increase significantly (Pavone et al. 2012; United Nations 2014).

Such drastic rises in mobility demands aggravate concerns over the impact of the mobility sector on the environment and society at large (Michel et al. 2010). The societal challenges posed by the widespread use of combustion engine vehicles in an urban environment include “energy consumption, air and noise pollution, crashes, traffic congestion, limited availability for parking and limited accessibility for all city dwellers to personal transportation” (Borroni-Bird 2012, 315).

To cope with these challenges, the old policy of infrastructure (i.e., repairing roads and bridges and providing more traffic lanes) must be augmented by integrating digital technologies to develop new personal urban mobility concepts and solutions (Michel et al. 2010). Digital technologies are a combination of information, computing, communication and connectivity technologies (e.g., social media, mobile technologies, cloud computing and analytics) (Bharadwaj et al. 2013). Such technologies have recently been investigated in the field of Green IS in order to foster environmentally friendly behavior (e.g., Ferreira et al. 2011; Pitt et al. 2011). For example, Ferreira et al. (2011) analyze a mobile application that offer users feedback on the environmental impact of their mobility choices and suggests alternative means of personal mobility that are more environmentally sustainable. Moreover, mobile technologies have also been investigated as a means of improving the diffusion of electric vehicles by offering the users information and recommendations about range, route planning, charging infrastructures, car-sharing services, and rescue requests for emergency situations (Hanelt et al. 2015a; Lee et al. 2011).

Further IS research has started to shed light on the digitalization of the automobile to cater to changes in consumer needs resulting from their increasingly ubiquitous digital lifestyles (e.g., Brandt 2013; Henfridsson and Lindgren 2005). As automobiles are expected to provide advanced computing as well as connectivity technologies, the driving experience will be enhanced in terms of safety, driver assistance, and infotainment services (Brandt 2013). For example, through connectivity technologies, vehicles should be able to respond to sudden traffic situations in real time, find alternative routes, and anticipate collisions (Henfridsson and Lindgren 2005). Moreover, autonomous vehicles could also enable drivers to disengage from driving, allowing them to manage their social activities and interactions, whether related to work or private life (Henfridsson and Lindgren 2005; Michel et al. 2010), as personal mobility is not only a concern of people traveling but also a means of interaction (Kakihara and Sorensen 2002).

In summary, previous research has indicated that digitalization is increasingly transforming the concept of personal urban mobility in various ways. Nevertheless, a holistic view of the extent to which digitalization impacts mobility is still underresearched. In our work, we aim to address this research gap, providing a foundation for further research in this area.

3 Research Methodology

3.1 Literature Identification Process

To identify the extent to which existing scientific literature has already explored changes in personal urban mobility resulting from digitalization, we conducted an in-depth systematic literature review based on the principles of Webster and Watson (2002) and vom Brocke et al. (2009). Due to the interdisciplinary nature of IS, we also investigated other fields of study that could be relevant for our research topic and decided to examine literature on transportation and automobile technology fields. We first aimed to focus on high-quality, peer-reviewed articles based on recognized ranking systems (i.e., the German VHB ranking for IS literature and SCImago Journal Rank for transportation and automobile technology literature) (Webster and Watson 2002). Because of the emerging nature of our research topic, we also explored conference proceedings (vom Brocke et al.

2009). To ensure a wide coverage of literature, we considered the following scholarly databases: Elsevier, JSTOR, ScienceDirect, EBSCOhost, IEEE and AIS electronic library. Our search string was defined using a brainstorming process to elaborate a keyword matrix (see Table 1). This matrix indicates our search string and how we proceeded with search process. For example, we combined the word "mobility" with the other keywords that are check marked as follows: "mobility" AND "digitalization", "mobility" AND "car*", "mobility" and "automotive*", etc. Combinations that could deviate us from the focus of our study are not check marked in the matrix and were not applied (e.g., "digitalization" AND "information system*"). The search string was applied in the title, abstract, keywords and main text of the articles.

Search string	Mobility	Digitalization	Car*	Automotive*	Information system*	Connectivity	Smart	Digital technolog*
Mobility		✓	✓	✓	✓	✓	✓	✓
Digitalization	✓		✓	✓				
Car*	✓	✓			✓	✓	✓	✓
Automotive*	✓	✓			✓	✓	✓	✓
Information system*	✓		✓	✓				
Connectivity	✓		✓	✓				
Smart	✓		✓	✓				
Digital technolog*	✓		✓	✓				

Table 1: Search string matrix

3.2 Literature Selection Process

We aimed to select articles that indicate changes in a personal urban mobility concept (e.g., car sharing) resulting from digitalization. As most of our search string was combined with the word "mobility", which is also frequently used in the field of telecommunication in reference to the application and use of mobile technologies, the initial search yielded more than a thousand articles. In a process of data selection, we first focused on the articles' titles and abstracts to exclude those unrelated to our selection criteria. As we used diverse databases, many articles found were duplicates; we therefore removed the identical results.

Furthermore, we read the titles, abstracts and sometimes introductions and conclusions of the remaining articles to identify relevant results that could help answer our research questions. We excluded articles that do not indicate or refer to any changes in personal urban mobility as a result of digitalization. For example, articles referring to organizational issues of automotive firms in coping with the digitalization of their products or services were excluded from our search. In total, we identified 30 relevant articles. We then conducted a backward and forward search, screening the references of the selected articles as well as articles citing them (Webster and Watson 2002). We used the database Web of Science for the forward search. In this process, 12 additional articles were identified. Our final sample consisted of 42 articles, which we categorized in our literature analysis into concept-centric themes that emerged from the articles (Webster and Watson 2002).

4 Findings

Essentially, we identified four themes that help us understand the changes in personal mobility resulting from digitalization: (1) mobility solutions, (2) intelligent mobility infrastructure, (3) partial virtualization of mobility and (4) enhanced mobility experience. These four themes are presented in Table 2 and will be discussed separately in the following section.

Literature	Mobility Solutions			Intelligent Mobility Infrastructure			Partial Virtualization of Mobility		Enhanced Mobility Experience		
	Car sharing	Bicycle sharing	Intermodal services	Vehicle-to-infrastructure communication	Intelligent traffic systems	Vehicle-to-grid	Virtual communities	Virtual work	Intra-vehicle communication	Vehicle-to-vehicle communication	Autonomous vehicles
Al-Sultan et al. 2013				X					X	X	
Anderson et al. 2013	X		X								
Belanovic et al. 2010				X						X	
Brandt 2013						X				X	X
Brandt et al. 2013						X					
Brown and O'Hara 2003								X			
Carrol and Rosson 2003							X				
Clay and Mokhtarian 2004								X			
Cichy et al. 2014										X	
Devi and Bajaj 2008									X		
D'Orazio et al. 2004									X		
Ericsson et al. 2006										X	
Faezipour et al. 2012				X	X					X	
Ferreira et al. 2011			X								
Ferreira et al. 2014						X					
Festag 2014				X	X					X	
Flath et al. 2012						X					
Fridgen et al. 2014						X					
Guler et al. 2014					X					X	
Hansen et al. 2010		X									
He et al. 2014				X	X						
Hildebrandt et al. 2015	X										
Jamson et al. 2013											X
Kakihara and Sorensen 2002							X	X			
Kietzmann et al. 2013							X	X			
Lee et al. 2011	X					X					
Le Vine et al. 2015					X						X
Levinson 2003										X	
Lim et al. 2012				X		X					
Liu et al. 2009					X						
Manzie et al. 2007										X	X
Perry et al. 2001								X			
Pitt et al. 2011	X										
Seeger and Bick 2013	X	X	X								
Shirazi et al. 2014									X		
Sorensen et al. 2008								X			
Spickermann et al. 2014			X								
Torrent-Moreno et al. 2009				X						X	
Wagner et al. 2013						X					
De Winter et al. 2014											X
Wu and Liu 2014					X						
Zulkefli et al. 2014				X		X			X	X	
N = 42	5	2	4	8	7	9	3	6	5	12	5

Table 2: Findings of the literature review

5 Discussion of Findings

5.1 Mobility solutions

In our literature analysis we observed that contemporary consumer megatrends, such as ownerless, simplicity and digital as well as eco-lifestyles, are fostering major changes in the mobility sector. This encourages a new range of (more sustainable) mobility solutions to fulfill individual mobility demands. We identified three forms of mobility solutions that are being promoted by the integration of digital technologies: car sharing, bicycle sharing and intermodal transportation. Advances in digital technologies allow for greater processing power in smaller mobile devices, combining the use of GPS and Internet technologies (Ferreira et al. 2011). The integration of these technologies in car or bicycle sharing and intermodal transportation solutions has the potential to meet consumers' demands concerning flexibility, reliable vehicle access, real-time information on vehicle availability, advance reservations and automated payments (Hansen et al. 2010).

Hildebrandt et al. (2015) demonstrate that digital technologies play a fundamental role in (re)designing mobility solutions to be more convenient for consumers, fostering their increased use. Moreover, Firnkorn and Müller (2012) conclude that the large-scale use of mobility solutions in combination with digital technologies could stimulate a fundamental rethinking of the entire personal mobility system. This has important implications for the automotive industry, particularly for incumbent automotive manufacturers. For instance, mobile technologies and applications providing real-time information on the availability of shared vehicles could enable business model innovations with the potential to transform automotive manufacturers' core business logics from producing and selling cars to being "suppliers of mobility" (Firnkorn and Müller 2012, 277). This calls for more research in the areas of servitization, business model innovations and digital transformation in the context of the automotive industry, which is being increasingly affected by the above-mentioned consumer megatrends and advances in digital technologies.

5.2 Intelligent mobility infrastructure

An intelligent mobility infrastructure consists primarily of collecting and analyzing relevant traffic information (i.e., big data and analytics) as well as applying such information to enable a more fluid traffic flow (Wu and Liu 2014). In our literature analysis, we identified three forms of intelligent mobility infrastructure: vehicle-to-infrastructure communication, intelligent traffic systems and vehicle-to-grid. In general, the concepts of intelligent mobility infrastructure consist of applying wireless access technology in vehicular environments to facilitate information sharing between moving vehicles and the road or traffic systems (Al-Sultan et al. 2013). This should enable safety-related, real-time, local and situation-based services aiming to improve road safety through the provision of timely information to drivers (Belanovic et al. 2010; Torrent-Moreno et al. 2009). There are still many challenges concerning the optimization of such vehicle-to-infrastructure communication, including the design and implementation of vehicle radar solutions as well as prioritization of data (Faezipour et al. 2012). Here, multidisciplinary analytics play a major role in processing the data from hundreds of nodes to maintain a strong and effective data communication link (Lim et al. 2012). Such data processing is still maturing and calls for collaboration among interdisciplinary areas in electrical, computer, telecommunication and mechanical engineering to address a variety of interrelated issues (Faezipour et al. 2012).

Recent advances in intelligent mobility infrastructures have also been paving the way to the development of vehicle energy management strategies (Zulkefli et al. 2014). With the continuous rise of electric mobility as an alternative to traditional combustion engines, the fields of energy and mobility are becoming more intertwined (Brandt et al. 2013). Vehicle-to-grid describes a system in which electric vehicles communicate with the power grid, being able to draw or supply power instantaneously (Wagner et al. 2013). On a large scale, electric vehicles might be used to supply demand response services by delivering electricity into the grid or by controlling their charging rates (Fridgen et al. 2014). In this case, digital technologies play an important role by providing electric-vehicle drivers with information regarding trips, driving patterns, battery conditions, the electricity market and public charging stations (Brandt et al. 2013). Taking into account the necessary information, it is possible to reduce both the charging costs of the electric vehicle batteries as well as general energy costs, to a certain extent (Ferreira et al. 2014). Hence, we might witness behavioral changes not only in terms of mobility but also in terms of energy consumption.

More research is needed to better investigate the potential of digital technology–based information exchange in the context of vehicle energy management strategies, particularly in relation to the barriers to consumer adoption, such as privacy concerns (e.g., lack of willingness to allow large corporations to have access to their driving behavior and use their data). Hence, behavioral research approaches could be very promising for further investigating this topic (Fridgen et al. 2014).

5.3 Partial virtualization of mobility

In this theme, two concepts illustrate the partial virtualization of mobility: virtual communities and virtual workspace. As computing and the Internet dematerialized means of communication and connected millions of people, a virtual spatiality was brought forth, enabling computer-mediated communication (Kakihara and Sorensen 2002). As the boundary between "here" and "there" disappears, geographical distance is no longer essential for interaction (Carroll and Rosson 2003). People participate in virtual communities to interact with one another in the pursuit of mutual interests or goals (Carroll and Rosson 2003). For example, social networking sites such as Facebook and Twitter can be seen as ways in which people can reunite or initiate relationships and participate in interactions for learning or sharing experiences and opinions anytime, anywhere (Jamson et al. 2013). The need for mobility in this context is met through virtualization.

Furthermore, mobile technology has enabled and strengthened the concepts of virtual workspaces and enterprise mobility, where virtual teams can work across time, space and organizational boundaries (Sorensen et al. 2008). This is often seen in global software development projects, for example, when the software is produced in multiple locations and the teams communicate via information technologies (e.g., Espinosa et al. 2007). Such technologies also allow people to work from home (i.e., telecommute), which is a flexible and travel-minimizing strategy, particularly in large metropolitan areas where congestion remains an aggravating problem (Clay and Mokhtarian 2004; Kakihara and Sorensen 2002). Moreover, mobile technologies have increasingly provided people the ability to work on the move (i.e., while traveling), encouraging a greater level of mobile work and distributed collaboration (Perry et al. 2001).

Although substantial research has been conducted on enterprise mobility since 2001 (Sorensen et al. 2008), further research is still necessary as the increased use and adoption of consumer devices for working purposes raises concerns of data and IT security for organizations. Further studies on this topic could contribute to the increasing IS scholarship discussions as well as the body of knowledge on the topic of IT consumerization and its implications for the role of IT within organizations (Ruch and Gregory 2014).

5.4 Enhanced mobility experience

In our literature analysis we identified three concepts that represent how digital technologies enhance the mobility experience: intra-vehicle communication, vehicle-to-vehicle communication, and autonomous vehicles. Intra-vehicle and vehicle-to-vehicle communication consist of intelligent systems for detecting both the driver's behavior (i.e., fatigue and drowsiness) as well as the vehicle's performance, which are critical for driver and public safety (Ericsson et al. 2006). Such systems are being developed at an ever-faster rate, and with the help of big data analytics, driver behavior detection systems are improving steadily (Devi and Bajaj 2008). Moreover, intelligent systems aim to alert the driver through in-vehicle alarms, also communicating with other vehicles via wireless technologies to assist drivers by, for example, providing cooperative information on traffic warnings and reports (Brandt 2013; Devi and Bajaj 2008). Although there are already some offerings on the market (e.g., iDrive systems by Toyota and BMW), this field is still in its infancy (Faezipour et al 2012). Issues regarding the development of wireless connections that meet the power and bandwidth prerequisites as well as data security and privacy requirements are still a great concern for the further advancement of vehicle-to-vehicle communication (Guler et al. 2014).

Automobiles built with vehicle-to-vehicle communication technologies (also known as "connected cars") are considered to be the first generation of autonomous vehicles (Manzie et al. 2007). The fundamental difference is that autonomous vehicles are able to plan directions and execute them without human intervention (Brandt 2013). These vehicles hold the potential to expand road network capacity, increase safety, and reduce driver workload (Jamson et al. 2013). The driver can then engage in leisure activities (e.g., entertainment) or economically productive (non-driving) tasks while on the road (Le Vine et al. 2015). Similarly to the theme of mobility solutions (see Section 5.1), this development will also contribute for giving a completely new meaning to the concept of mobility, because owning or driving a car might not be as important as getting from point A to point B. Therefore, more research is needed to understand the impact of such mobility changes, particularly for an industry that might be facing disruption through the digitalization of its products, i.e., the automotive industry. Because digitalization demands new capabilities, complementary partnerships and a combination of digital and physical ecosystems from incumbent automotive organizations (Hanelt et al. 2015b), exploratory research in this field should contribute to a new scholarly conversation on the phenomenon of digital transformation.

6 Implications and Conclusion

In this paper we reviewed existing literature in the fields of IS, transportation and automobile technology on the changes in personal urban mobility resulting from digitalization. The aim of our study was to provide a systematic overview of this topic that could serve as a foundation for better understanding different ways of integrating digital technologies to deal with the megatrends that are affecting our society (e.g., urbanization, environmental sustainability). Our results point to four different themes in which digitalization can be identified as fundamentally affecting personal urban mobility: (1) mobility solutions, (2) intelligent mobility infrastructure, (3) partial virtualization of mobility and (4) enhanced mobility experience. In these themes, we observed that the effects of digitalization are double sided: While digitalization is transforming personal urban mobility by providing users with a seamless, safer and more flexible mobility experience, it also brings concerns of data security and privacy that can negatively influence users' acceptance of new mobility concepts. Based on these findings, we also identified promising areas for future research, particularly for the IS community. For instance, the integration of digital technologies into the vehicle or transportation infrastructure systems brings about new issues concerning user interface design as well as the development of new services and business models for everyday personal urban mobility. Moreover, reflecting Yoo et al.'s (2010) call for further research on the phenomenon of digital transformation and its particular impact on industrial-age products such as the car, there is clearly a need to investigate this phenomenon in the organizational context of automotive manufacturers. Because digitalization is changing the concept of personal urban mobility, automotive manufacturers are being challenged with a shift from the physical to the digital consumer experience, going beyond the traditional core business logic of producing and selling a car. Thus, our study contributes with a foundation and first step for developing a more comprehensive understanding of the phenomenon of digital transformation and its implications for the mobility sector.

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Teilkonferenz
Automated Process und Service Management

Im heutigen dynamischen Wettbewerbsumfeld sind Unternehmen bei großem Innovations- und Kostendruck zugleich hohen Flexibilitätsanforderungen ausgesetzt. So müssen Unternehmen in der Lage sein, ihre Prozess- und IT-Servicelandschaften effizient und qualitätsgerecht anzupassen und umzusetzen. In der Praxis stellt das Management von Prozessen und IT-Services jedoch noch eine äußerst zeit- und kostenintensive Herausforderung dar. Vor diesem Hintergrund wird im Bereich Automated Process and Service Management der Einsatz von Ansätzen zur automatischen oder semiautomatischen Unterstützung derartiger Aufgaben immer stärker diskutiert. Strukturieren lässt sich diese Unterstützung anhand des Prozess- und Servicelebenszyklus, d. h. orientiert bspw. an den Phasen Process Planning & Strategy, Analysis, Design & Modeling, Implementation, Monitoring & Controlling sowie Refinement. So können Verfahren des Process Mining während der Analyse und Ansätze des Automated Process Planning im Rahmen der Phase Design & Modeling einen wertvollen Beitrag leisten. In der Phase Implementation können Algorithmen zur automatisierten Serviceselektion und -komposition genutzt werden.

Im Rahmen dieser Teilkonferenz werden Ansätze im Bereich Automated Process and Service Management diskutiert, wobei die automatische oder semiautomatische Unterstützung entlang des gesamten Prozess- und Servicelebenszyklus im Fokus steht. Die drei angenommenen Beiträge widmen sich hierbei unterschiedlichen Facetten dieses Bereichs, beginnend mit dem Matching und dem Clustering von Prozessmodellen bis hin zur Analyse und Verarbeitung komplexer Event Patterns in Ereignisgesteuerten Prozessketten.

Bernd Heinrich, Mathias Klier

(Teilkonferenzleitung)

Towards multi-dimensional Clustering of Business Process Models using Latent Dirichlet Allocation

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Abstract

Large process model collections are hard to handle and deciders face the challenge of diverse and unstructured process landscapes. Clusters of business process models allow structuring the process landscape and therefore ease the decision making of managers. Current modeling tools support mainly hierarchical clusters although methods like tagging, evolving from Web 2.0, provide a more flexible systematization. Furthermore, they lack an automated clustering of large process collections. In the paper at hand we present a methodology for an automated, tagging like, multi-dimensional-clustering of business process models. The processes are allocated to thematic clusters based on Latent Dirichlet Allocation which has formerly been used for text classification. We analyze strengths and weaknesses of the proposed method and present possible application scenarios. A prototypical implementation has been used to evaluate the method on the SAP reference models.

1 Introduction

Nowadays, business process management represents an important toolset for organizations. In order to improve corporate performance, business process modelling has been established in many large companies – and the size of the process repositories increases. Today's process repositories contain hundreds or even thousands of process models. Thus, organizing and structuring process repositories gains major importance. The processes are modeled either hierarchical or they are not structured at all. With regard to mechanisms like tagging, emerging from Web technologies, there are new possibilities to structure business process models. In nearly all cases a single process covers multiple topics. For example a process which describes the quality management in production, the process is linked to quality management but also to production. Such a linkage is not representable using hierarchies. Using tagging for business processes, we obtain a much more flexible structure, which is able to allocate business processes to multiple topics. Few process modelling tools already support tagging for structuring (e.g. Oryx[1]), but the adjustment of previous modeled business processes is very expensive with regard to large business process collections. Every tag has to be assigned individually to the processes and in large collections it will be hard to keep the

[1] http://bpt.hpi.uni-potsdam.de/Oryx/

terminology, especially with regard to synonymy. In this paper we present a method based on Latent Dirchlet Allocation which is capable of assigning processes to multiple topics. This opens new possibilities for multiple application scenarios. In unstructured business process model collections, process variants are hard to identify as such that most of current technologies to identify process variants by using matching or clustering techniques, focus on business process instances, instead of business process models. Using multi-dimensional clustering we can be able to identify semantic similar processes, which are potential process variants. Furthermore, the method could provide insights which are useful for semantic process analysis. In many approaches for semantic analysis of business processes ontologies are used, though in most cases they use WordNet or there is no ontology specified. Certainly, WordNet seems very likely in the sense that it covers most of the English language terms. Though, it lacks of domain knowledge and organization specific knowledge which is often used in business process models. By automatically identifying semantic topics, the method could support the development of ontologies, or at least the selection of appropriate ontologies for existing approaches. The research was conducted within the Softwarecampus-project ProLIN and the RefMod-Mine-Project. In the following we present the method itself, a prototypical implementation and an evaluation. Section 2 covers the basics of business process clustering and Latent Dirichlet Allocation as well as related work. Section 3 describes the method itself. Section 4 describes in short the prototypical implementation used in the evaluation. The evaluation itself is described in section 5. Section 6 covers the interpretation of the evaluation results. Concluding section 7 summarizes the results and answers the research questions.

2 Related Work

2.1 Latent Dirichlet Allocation and Text Classification

With regard to the research topic natural language processing LDA is allocated to methods of text classification. In our understanding, classification would be an allocation of objects to a predefined category whereas clustering is a grouping of similar objects. In the following we use the term classification according to the NLP context, though the meaning is similar to clustering. Multiple techniques exist to classify texts and documents, whereas most publications originate from the research areas information retrieval, machine learning and natural language processing, especially text mining. One approach which had a significant impact on this problem was Salton and McGill who introduced the popular tf-idf scheme in 1983 (Salton and McGill 1986). In this scheme a basic vocabulary of words and terms is chosen, and their occurrences in the specific document are count. This term-frequency would then be compared to an inverse document frequency count, which measures the number of occurrences of a word in the entire corpus. The result of this method is a term-document-matrix with the tf-idf values for each term-document relation. Shortcoming of this approach is that it reveals little in the way of inter- or intra-document statistical structure (Blei et al. 2003).

Latent semantic indexing (LSI) is one approach with the aim to address this shortcoming. LSI uses a singular value decomposition of the term-document-matrix to reduce the number of terms while preserving the similarity structure within the documents. The rationale is that documents which have frequently co-occurring terms will have a similar representation in the latent space, even if they have no terms in common (Hofmann 1999). One progress regarding tf-idf according to Deerwester et al. (1990) is that LSI can capture some aspects of basic linguistic notions such as synonymy and polysemy. According to Hofmann (1999), LSA has some deficits which are mainly due to its unsatisfactory statistical foundation. Thus he presents the probabilistic LSI (pLSI) model, also known as the aspect model, as an alternative to LSI. The pLSI approach models each word in a document as a sample from a mixture model, where the mixture components are multinomial random variables that can be viewed as representations of “topics”. Thus each word is generated from a single topic, and different words in a document may be generated from different topics. This distribution is the “reduced description” associated with the document (Blei et al. 2003). Though, Hofmann’s work does only provide a probabilistic model on the term level but not on the document level. In pLSI, each document is represented as a list of numbers (the mixing proportions for topics), and there is no generative probabilistic model for these numbers. This leads to the problem that it is not clear how to assign probability to a document outside of the training set. All presented methods are based on the “bag-of-words” assumption – that the order of words in a document can be neglected. In the language of probability theory, this is an assumption of exchangeability for the words in a document (Aldous 1985). Moreover, these methods also assume that documents are exchangeable, so that the specific ordering of the documents in a corpus can also be neglected. LDA bases on the assumptions that any collection of exchangeable random variables has a representation as mixture distribution, so that LDA provides a mixture model that captures the exchangeability for both words and documents. Though, it is a false conclusion to interpret exchangeability as such that the random variables are independent and identically distributed. It is more like that they are “conditionally independent and identically distributed” (Blei et al. 2003). Due to the probability model on the document level, it is possible to allocate documents, or in this case processes, to multiple topics with a specific distribution.

2.2 Business Process Variants and Clustering

Cluster analysis comprises a range of methods for classifying multivariate data into subgroups. Generally there are hierarchical and non-hierarchical cluster-techniques (Everitt et al. 2012). The method proposed in this paper can be associated to the non-hierarchical techniques. Multiple methods for process clustering have been researched and published, though most of them focus on the clustering of process instances. Thaler et al. (2015) provide an overview of these techniques in a comparative analysis. Based on a morphological box they describe the characteristics of multiple methods. One of these characteristics is named “Distance Measure” and describes the “numerical value, calculating the distance between two objects” (Thaler et al. 2015). Accordingly the authors assume that a clustering is always based on the comparison of two processes. As all reviewed methods could be arranged into the morphological box, we can conclude that none of these methods use text classification techniques on a document basis, due to the fact that these do not directly compare two single processes. Furthermore, all of these methods are used for process instance clustering, not for process model clustering. Many papers originate due to the trend of business process mining (e.g. de Leoni et al. 2014), although in many companies huge process model collections exist, which have to be managed. One paper using clustering techniques on process models is Fettke (2015). Within this paper, the author describes a method for business process integration. After analyzing the similarity of the processes he builds clusters using hierarchical-clustering techniques and using a predefined classification as indication for the clustering. Multiple structures, though, cannot be represented using hierarchical clustering as we have seen before.

3 Method

The aim of the algorithm is to cluster the processes regarding their thematic orientation. A single process therefore can cover multiple topics. For example a business process which describes the workflow of the buying department may consist of technical and strategic workflow-steps which cover different topics. Whereas the strategic purchasing is related to market analysis and financials, the technical purchasing is related to volume planning etc. Based on this fact processes cannot be assigned to one specific topic, but moreover can be assigned to multiple topics. In the case of thematic clustering of business processes, one cluster represents one topic. The method is based on four steps, whereas each step is represented by one subsection. The steps are performed in sequential order, i.e. label extraction is the first step and process clustering is the last step.

1. Label extraction

In the first step the labels are extracted from the business processes. During experimenting with the processes it showed up, that filler words and stop words partly have been associated towards clusters, although they are no valuable representation of a topic. In order to avoid LDA identifying relationships with these, we removed them by using a list from the extracted labels. Furthermore special characters are removed but for hyphen, as this may declare compound-words.

2. Parameter estimation

For LDA three parameters are unknown: The number of clusters and the hyperparameters α and β from the Dirichlet prior. For choosing the number of topics the literature uses in general cross-validation, non-parametric mixture priors and marginal likelihood (Airoldi et al. 2010). The hyperparameters are estimated using a variational EM procedure (Blei et al. 2003).

3. LDA for Topic Extraction

In the third step we use Latent Dirichlet Allocation to discover topics within the processes. Therefore we assume one process to be a document, whereas a process consists of a sequence of steps (e.g. events and activities) with each label consisting of a sequence of words. As the order of the steps and words respectively will have no effect on the following processing of the method, there is no need to keep the order. Thus each of the M processes in the corpus is considered as a vector of N_d words $\boldsymbol{w} = (w_1, \ldots, w_{N_d})$, where w_n is the n-th word in the process d. Furthermore we assume that a process covers a set of k latent topics z. Each topic z_n represents one cluster which is modeled as a multinomial distribution θ over the process. α and β are Dirichlet prior hyperparameters. We assume the following generative process for each process $\boldsymbol{w}$ in a corpus D in alignment to Blei et al. (Blei et al. 2003):

- For a topic z a multinomial parameter ϕ_z is sampled from the Dirichlet prior $\phi_z \sim Dir(\beta)$
- For a process d a multinomial parameter θ_d is sampled from the Dirichlet prior $\theta_d \sim Dir(\alpha)$
- For each of the N words w_n choose a topic z_n from the multinomial distribution θ_d
- For each of the N words w_n choose a word w_n from $p(w_n|z_n, \beta)$, a multinomial probability conditioned on the topic z_n

A k-dimensional Dirichlet random variable θ can take values in the $(k-1)$-simplex (a k-vector θlies in the $(k-1)$-simplex if $\theta_i \geq 0, \sum_{i=1}^{k} \theta_i = 1$), and has the following probability density on this simplex:

$$p(\theta|\alpha) = \frac{\Gamma(\sum_{i=1}^{k}\alpha_i)}{\prod_{i=1}^{k}\Gamma(\alpha_i)}\theta_1^{\alpha_1-1}\dots\theta_k^{\alpha_k-1},$$

where the parameter α is a k-vector with components $\alpha_i > 0$, and where $\Gamma(x)$ is the Gamma function. Given the parameters α and β, the joint distribution of a topic mixture θ, a set of N topics $\boldsymbol{z}$, and a set of N words $\boldsymbol{w}$ is given by:

$$p(\theta, z, w|\alpha, \beta) = p(\theta|\alpha)\prod_{n=1}^{N} p(z_n|\theta)p(w_n|z_n, \beta),$$

where $p(z_n|\theta)$ is simply θ_i for the uniqe i such that $z_n^i = 1$. Integrating over θ and summing over z, we obtain the marginal distribution of a process:

$$p(w|\alpha, \beta) = \int p(\theta|\alpha)\left(\prod_{n=1}^{N}\sum_{z_n} p(z_n|\theta)p(w_n|z_n, \beta)\right)d\theta$$

4. Process Clustering

Despite a simple Dirichlet-multinomial clustering model, LDA allows a three-level clustering so that a process can be associated with multiple clusters. These clusters can be interpreted as thematic classification of the processes which can be used for tagging purposes.

4 Technical realization

The technical implementation has been realized by using the RefMod-Miner[2] and the Stanford Topic Modeling Toolbox (TMT)[3]. These tools have been chosen based on the following reasons: (1) Both tools are matured in their discipline and (2) by choosing the TMT we can focus on the application of the method on business processes instead of reinventing the wheel. We used the RefMod-Miner to extract the labels from the processes. As input format we used processes modeled with AML or EPML. AML is the XML standard for ARIS Architect, a process modeling tool, and EPML is the XML format of an Event-driven Process Chain (EPC). After extraction the exported CSV-file needed to be restructured, so that all labels of a process are represented in one line and column of the file, for further processing. We extracted the EPC-ID, which is the unique identifier for a process, and the directory ID, which is a unique identifier for the path of the process. These directories serve as classification in the evaluation (see 5). The labels of the process are then associated with the process ID in the CSV document so that backtracking is possible later on. By extracting the labels from the processes we used filters to avoid misinterpretation by the LDA algorithm. First, we remove all symbols from the labels. Second, we remove stop-words via a list. In text classification scenarios, words with three characters and less are also removed. Though, the labels of business processes are designed to be a short description of the event or the activity. Accordingly, there is an addiction to abbreviations which could be important for the understanding, e.g. “VAT” meaning “value-added tax”. Negative consequence is that by doing this we allow abbreviations like “sth” for “something”. The output is a file with one process in each line, i.e. EPC-ID, Dir-ID and all labels concatenated and separated by blank space. This file is loaded into the Stanford Topic Modeling Toolbox (TMT). Within there we specify the ID columns so that the reference stays intact. TMT allows us to specify the number of clusters as well as the two Dirichlet prior hyperparameters α and β. As output we receive a process-topic-matrix with the distribution of each process over the different topics. Furthermore we receive the top-terms representing each cluster.

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[2] http://refmod-miner.dfki.de/

[3] http://www-nlp.stanford.edu/software/tmt/

5 Evaluation

For evaluation we used appropriate processes of the IWi Process Model Corpus which has been described in (Walter et al. 2014). For the testing scenarios we used the SAP reference models. The SAP reference models can be seen as one of the most complete standardized models for an organization, so that it should comprise all necessary vocabulary.

The processes have been modeled using EPC modeling language. Accordingly most of the elements, and therefore labels, are events and functions. Assuming that the processes have been modeled correctly according to the modeling rules, we can estimate that there might be a ratio of 1:1 between events and functions. Incorporating trivial events, this fact might be important as the frequency of the terms used in the label description raises significantly and thus can lead to a higher probability calculated by LDA. Due to the 1:1 ratio, though, we can estimate that this should have no great effect.

The SAP reference models consist of 604 single processes. For evaluation the SAP models have been split up into 60 % (363 processes) training set and 40 % (241 processes) test set, whereas the allocation of the processes to training set and test set has been randomized. These processes cover all kinds of standard activities used in organizations, such as personnel management, production, financial accounting, sales etc. Due to the fact that the processes are used for an enterprise resource planning software, which cover per definition the activities of the whole economic value chain, we can assume that most activities are covered by the processes.

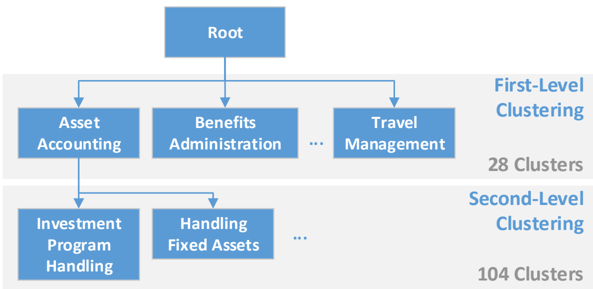

Figure 1. Partitioning of the comparative analysis

For the evaluation we used the predefined classification of the SAP reference models. The classification is a hierarchical path structure which is described by Kobler (2010) on a generic level. The hierarchy of the predefined classification is between one and two levels deep. We use this classification for comparison to the clusters identified by LDA and the allocation of the processes to these clusters. In order to estimate the accuracy of the method provided above we evaluated the processes on the two granularity levels provided by the predefined classification as depicted in figure 1.

1. The first level encompasses all 604 processes within 28 clusters. Respectively we will analyze all 241 processes of the test set and predefine the number of clusters to 28 for LDA.
2. The second level encompasses 604 processes within 104 clusters. Respectively we will analyze 241 processes of the test set and predefine the number of clusters to 104 for LDA.

5.1 First level evaluation results

As already described above we used 28 clusters for the training of LDA. Observing the distribution of the processes to the clusters, it shows that all clusters have been used for the allocation of the processes of the test set. Accordingly Due to the fact, that only a few clusters contain just a single process, we can conclude that the number of clusters used for training, should be near optimum. If the clusters would have been too high, some clusters would not have been used and if the clusters would have been too low, there would not be clusters with just a single process. Furthermore we observed the mean probabilities of all processes belonging to one cluster. What stands out is that all mean probabilities are higher than 0.5 and nearly 30 % are higher than 0.8. Accordingly the allocation seems to be appropriate.

In order to compute the matching of the built clusters to the predefined classification we count how many processes of the predefined classification are mapped to each cluster. After that we calculate (1) the ratio of this count to the total count of processes per predefined classification and (2) the ratio of this count to the total count of processes per identified cluster. If both ratios are 100 % the identified cluster is identical to the predefined classification. For illustration we calculated the mean of both ratios and colored the matrix as shown in Figure 2.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Asset Accounting	0	0	0	0.4	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0.4	0.1	0	0	0.2	0	0
Benefits Administration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0
Compensation Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0.7	0	0
Customer Service	0	0.3	0	0	0	0	0	0.3	0	0.2	0	0	0.3	0.2	0	0	0	0	0	0	0.1	0	0.1	0	0.2	0	0	0
Enterprise Controlling	0.1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0.1	0	0	0	0	0	0.5
Environment	0.1	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
Financial Accounting	0.1	0	0	0.3	0.5	0.2	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0	0	0	0	0.2
Inventory Management	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organizational Management	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Payroll	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Personnel Administration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0
Personnel Development	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Personnel Time Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0
Plant Maintenance	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0.6	0	0	0	0	0.2	0	0.1	0	0.5	0	0.6	0
Procurement	0	0.1	0	0	0	0	0	0	0.5	0	0	0	0.1	0	0	0	0	0	0	0.8	0.1	0	0	0	0	0	0	0
Product Data Management	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0
Production	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Production Planning and Procurement Plar	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0
Project Management	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0.1	0	0.8	0	0	0	0	0
Quality Management	0	0.1	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
Real Estate Management	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recruitment	0	0	0.4	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Retail	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Revenue and Cost Controlling	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0
Sales and Distribution	0	0	0	0	0.1	0	0	0.1	0.1	0.4	0	0	0.3	0.5	0.5	0	0	0	0	0	0	0.1	0	0	0	0	0	0
Training and Event Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0.2
Travel Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
Treasury	0	0	0.2	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0.8	0	0	0.1	0	0	0	0	0	0	0.2

no matching exact matching

Figure 2. Matching matrix of first-level evaluation

The predefined classification is noted in the rows and the identified clusters are noted in the columns. Per identified cluster there are two columns with the ratios described above. The red color shows the high ratios, whereas the yellow color marks the medium ratios. The dark red values illustrate a 1:1-mapping of a predefined cluster to a built topic-cluster. Accordingly none of the built clusters represents a 100% matching to a predefined classification. Though there are many values which are near to a full mapping. Cluster one represents the "Product Data Management" with a matching ratio of 0.77 and cluster seven represents the "Personnel Development" with a ratio of 0.92. Overall five mappings could be identified with a significance of 0.25.

The low matching and significance may result of two reasons: (1) the predefined classification does not represent semantic related sets of processes or (2) the terms which have been allocated to the clusters, on which the clustering of the processes is based, are too similar so that the difference of the clusters are too small. Therefore we have a look at some specific processes.

Although there are three predefined classifications, namely “Personnel Development”, “Personnel Administration” and “Personnel Time Management”, which seem to be semantically related, the identified clusters are distinct towards this classification. In order to identify the reason we have a closer look on the top terms that have been identified for the specific clusters. “Personnel Development” is mainly represented in Cluster 7, “Personnel Time Management” is fully represented in cluster 17. We ignore “Personnel Development” here because it has only one representative. None of the top terms identified by the method for cluster 7 (item, inventory, difference, stock, manually, confirmed, management, physical, automatically) and cluster 17 (cash, option, valuation, accrual, currency, date, proposal, netting, flows) seem to be related to “personnel management” or “personnel development”. They are rather related to financials than to something regarding personnel. In contrast, cluster 1 which has been associated to “product data management” has the top words: *product, distribution, structure, price, change, check, transactions, management, executed*. This might be an issue due to the chosen processes. The SAP process models cover the processes based on an enterprise resource perspective which have a tendency towards financials. This leads of course to the scenario that all processes have financial aspects, some more some less. This also could be seen by reviewing the number one top term of each cluster: What is even more surprisingly is that based on the identified terms of cluster 7, 100 % of the “Personnel Development” processes, i.e. six processes, have been associated to one cluster. Overall we could measure a mean matching of 0.318 with a variance of 0.055 and a standard deviation of 0.236.

5.2 Second level evaluation results

For the second level evaluation we defined 104 clusters for training. Though, it showed that the method allocated the processes only to 75 clusters which have been identified. Furthermore 16 clusters, i.e. roughly 20 %, have only one process allocated. It seems that this time the number of clusters is far too high for an optimal classification. With regard to the predefined classification, which consists of 104 clusters on the second level, we can assume that processes which cover similar topics have been split to different classifications. In comparison to the first level clustering, the probabilities of the second level clustering are much lower. 20 % of the probabilities are lower than 0.5 and only 13 % are above 0.8. Though, the matching of the clusters seems much more appropriate. Figure 3 shows an extract of the matching matrix with the ratios explained in 5.1. Although cluster 2 (first column) doesn’t have an exact matching to the provided categories, they seem semantically correlating when we observe the names of the predefined classification. All processes in cluster 2 are related to maintenance and repair processes (“Breakdown Maintenance Processing”, “Planned Maintenance Processing”, “Project Based Maintenance Processing”, etc.). Though, all processes in cluster 25 cover the topics maintenance and repair, too. It seems that the method split up one topic to two topics.

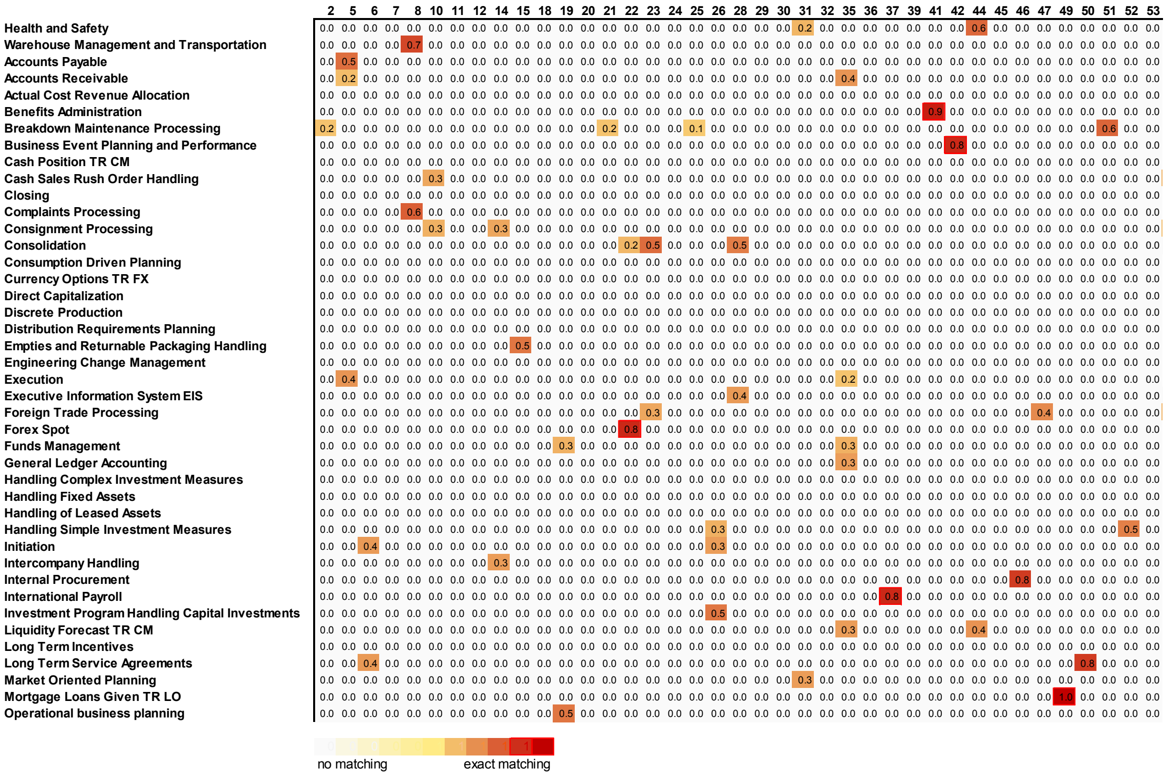

Figure 3. Extract of matching matrix for second-level evaluation

Cluster 104 does not have an exact matching but covers all processes related to options (“Options on Interest Rate Instruments and Securities TR DE”, “Currency Options TR FX”). Furthermore the algorithm identified a relationship between “Benefits Administration” and “Personnel Actions” and put them together in cluster 41, although they are clustered differently in the predefined classification. “Benefits Administration” covers the benefits of the personnel which is clearly correlated to “Personnel Actions”, so it seems that the classification proposed by the method seems more logical, than the predefined classification. A further interesting fact is the distribution of quality management. In the predefined classification there are three clusters namely “QM in Material Management”, “QM in Production” and “QM in Sales and Distribution”. LDA put one process of each classification in cluster 36 and the other processes in different clusters: the processes for material management in cluster 47, production in cluster 21 and sales and distribution in cluster 12. Consequently the method seems to identify that the processes have a common sense regarding quality management, but also that they are different in there application scenario.

Overall there are eleven exact matches of the identified clusters with the predefined classification. The mean matching is 0.455 with a variance of 0.059 and a standard deviation of 0.243. Accordingly we have a higher matching in comparison to the first level evaluation, although the number of clusters chosen in the first level evaluation seems much more appropriate. One possible conclusion might be that we have a higher matching due to the more fine grained classification or in other words, the hierarchy of the predefined classification seems inappropriate to thematic clusters. Analyzing the exact matches we could observe that the topics these clusters cover stand out from the other topics in the sense that they are much more distinct in the terms used. “Real Estate Management” for example is a rather exotic theme in comparison to the other economic activities. One reason could be that the more specific the wording of the process labels, the better the classification of the processes. Although, an exact match does not need to imply that we have a better classification, as we have seen.

6 Strengths and Limitations

In general the evaluation showed that the proposed method is capable of building clusters with semantic similar processes. When we have a look at the terms LDA assigned to these clusters, it shows that the terms are sometimes rather generic in the sense that they appear in many of the clusters, but sometimes they are also rather specific. Accordingly they seem to belong into the same thematic cluster, as the proposed method has done. This variance seems to originate from the strong financial orientation of the SAP processes. In some cases the wording is specific enough and in other cases only the financial aspects of the economic activities are neglected. Accordingly it seems that the method is strongly dependent on the vocabulary used for modeling the process. The more specific the vocabulary, the better the result.

Most of the clusters have no exact equivalent to the predefined clusters proposed by the SAP models. According to the observations it seems that the predefined clusters do not cover semantically equal processes. Good examples are the maintenance processes which we identified in the second level evaluation (see 5.2). The method identified some of the maintenance processes to be similar and some of the maintenance processes to be different. This could be a result of the deterministic clustering we did in the fourth step of the method (see 3.4). Probably the processes would have been covered in both clusters, under the condition that we used a multi-dimensional clustering. Although the method identified that the processes cover multiple topics we forced them into the most probable cluster.

Based on these facts we can draw two conclusions. On the one hand it shows that there is a lack of evaluating the quality of a clustering. Assuming that the predefined classification is not the preferred clustering, it is hard to show that the clustering performed by the method is more meaningful. On the other hand selecting the cluster with the highest probability contradicts to the benefit of the method, that processes can cover multiple topics. In order to have a reference to the quality of the built clusters we needed a one to one relationship between clusters and processes. One possible solution may be, to compare the distributions over topics in order to identify similarity between processes. Though, there is a lack of methods in order to perform such a comparison. The Kolmogorow-Smirnow-Test (Stuart et al. 1999) is not applicable due to its limitation on normal distributions or log normal distributions. Though, the results are neither normally distributed nor log normally distributed. One solution might be the Kullback-Leibler distance (Kullback and Leibler 1951). This has to be evaluated in further research.

Although we lost information due to the exact assignment of one process to one cluster, there are hints like the quality management processes (see 5.2) which show that the method is capable to identify whether processes are similar but not equal and identify the difference of the inequality. Especially this feature demonstrates the potential the method has for multi-dimensional clustering.

We also could observe in the evaluation that the accuracy of the matching rises the more fine grained the clustering is. This can result on the basis of three reasons: (1) The hierarchy which is used for the predefined classification is not structured well, so that on a more fine-grained level, there are less non-similar processes allocated to the same classification. With respect to the first level of the predefined classification this means, that similar processes are in different paths, whereas on the second level this wrong assignment is irrelevant. (2) This may be a result of the (for NLP techniques) small training set. As we have seen in the explorative evaluation, there is only a small range in which the number of clusters makes sense. Due to the small training set, the method could tend to inaccuracy, so that it is only a coincidence that the fine-grained classification fits better to the built clusters. The second reason might be of lower probability due to the fact that we could see in the explorative evaluation, that we have a much lower probability for process belonging to a cluster the higher number of clusters. The second reason can be reviewed by using a larger training-set. The challenge by choosing a different training set, though, is the evaluation itself. Due to the fact that the clustering of processes using LDA is different to for example structural processes, neither can we use the same evaluation techniques nor do we have a gold standard which is capable of representing semantic equality. The difference to other techniques in the evaluation is that LDA compares term associations and occurrences whereby other techniques make a comparison of the processes itself. Based on the premise that one process can cover multiple topics, thematic clusters are meaningful but they are not comparable to clusters incorporating similar processes, as they do not need to be similar.

A general statement about, which clustering is more reasonable, cannot be stated as this is strongly dependent on the aim of its usage. Though, this is exactly one reason to develop a multi-dimensional clustering as the allocation can then be chosen based on the aim afterwards.

7 Conclusion

Multi-dimensional clustering is an important step towards more flexibility and clarity in business process modeling. In this paper we presented a method to cluster business processes based only on the semantic contents of the processes. The evaluation showed that the hierarchical classification of the SAP reference processes does not correspond to the topic classification. Therefore interesting additions to the predefined classification might be of value. Furthermore we could prove that the proposed method is capable of identifying semantic relationships between processes. Although the proposed method is not capable of providing a tagging yet, or identifying process variants, it represents an important step towards a multi-dimensional clustering. For tagging as well as for ontology usages, we need to identify terms which describe the clusters identified. We have seen that the top words are not always capable to provide such terms. Furthermore we showed that the allocation is strongly dependent on the specificity of the terms used in the labels. Thus, it might be that the proposed method only makes sense to processes which show a higher variety of terms. Using organization specific processes might result in an even better classification, as we assume that more organization specific and domain specific terms are used in comparison to the SAP reference processes. In general reference processes might be too abstract to classify them appropriately, so that further evaluation has to be made.

The presented approach describes the clustering of processes only based on the labels, i.e. on the information in a textual representation. In contrast to a continuous text, business processes, which are represented in a semi-formal representation contain information which is on a meta-level, e.g. events, functions, relations etc. This information is not used in the presented approach as it would result in too many influencing factors, so that conclusions on the cause and effects are much more difficult to draw. In a next step, this information can be integrated in the algorithm.

By the described method, we now have a starting point to identify process variants based on their distribution over topics. As we described in section 6 the method needs to be extended in order to enable the comparison of the distributions of processes over topics.

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Modeling Complex Event Patterns in EPC-Models and Transforming them into an Executable Event Pattern Language

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Abstract

This paper proposes an approach to model complex event patterns in Event-driven Process Chain (EPC) models and to transform them into an executable Event Pattern Language (EPL). To do this, the paper first of all derives and examines characteristic event patterns considered in corresponding literature. Afterwards, the feasibility to model them using the standard EPC metamodel is evaluated and an extended EPC metamodel is proposed that allows for a comprehensive depiction of the derived patterns. Based on this foundation, the paper conceives a modeling technique and corresponding notation using the ARIS method and integrates it into the ARIS Business Process Analysis Platform for tooling support. Moreover, the paper proposes an approach that automatically transforms these models into executable EPL using Abstract Syntax Trees as an intermediate representation. Finally, the paper illustrates the modelling, extraction and transformation steps based on a running example originating from the ongoing research project iPRODICT within continuous casting in the steel manufacturing industry.

1 Introduction

With advancements in system integration and new technologies like the Internet of Things, real-time information availability, especially in manufacturing operations, has reached a new dimension (Bruns and Dunkel 2010). Consequently, myriads of internal and external business events become visible forming increasingly big data (Krumeich et al. 2014a). To turn this enormous quantity of low level events (such as single sensor signals) into business value (like a discovery of machinery failures or breakdowns), it is crucial to filter and analyze corresponding event streams to detect meaningful patterns that indicate important situations with a decisive impact on the control and efficiency of business processes (Luckham 2012). With Complex Event Processing (CEP) the required technology to detect such complex event patterns in real-time is already available. In this regard, CEP is considered to be an important driver to further advance the domain of business process management (BPM) (Dixon and Jones 2011). This has motivated numerous research efforts coining the term Event-Driven Business Process Management (ED-BPM) (Krumeich et al. 2014b).

However, considering existing research, it is still an obstacle to express complex event patterns within business process models in order to transparently illustrate their relation in terms of an event-driven business process control, i.e. describing reactions to complex event occurrences in business processes. Thus, domain experts are struggling to communicate event patterns, which are crucial for business operations, with technical CEP experts and vice versa (Schimmelpfennig et al. 2011). Hence, latest research call for integrated event modeling methods allowing to specify event patterns and their relations within process models as well as transforming this knowledge into executable Event Pattern Languages (EPL) (Krumeich et al. 2014b).

Conventional business process modeling languages like Business Process Modeling Notation (BPMN), Event-driven Process Chains (EPC) or Unified Modeling Language (UML) Activity Diagrams cannot express complex event patters such as sequential, temporal or spatial relations between single events (Vidackovic 2014). Whereas a few first extensions exist for the BPMN, there is a particular lack regarding a dedicated support in EPC. EPC are however a typical starting point for non-technical domain experts to model their associated business processes and are widely used in industry and research (Houy et al. 2014). Since also complex event patterns originate commonly from business scenarios for which non-technical experts are responsible for (Schimmelpfennig et al. 2011), EPC represent a promising means for depicting these patterns in relation to business processes. If such models are then automatically transformed into executable EPL, which can be consumed by CEP engines, this will contribute to an efficient as well as time and cost-saving implementation and adaptation of event-driven business processes resp. information systems.

To address this, the paper at hand first of all derives and examines characteristic event patterns considered in corresponding literature. Afterwards, the feasibility to model them using the standard EPC metamodel is evaluated and an extended EPC metamodel is proposed that allows for a comprehensive depiction of the derived patterns. Based on this foundation, the paper conceives a modeling technique and corresponding notation using the ARIS modeling method (Scheer 2000) and integrates it into the *ARIS Business Process Analysis Platform* for tooling support. Moreover, the paper proposes an approach that automatically transforms these models into executable EPL using Abstract Syntax Trees (AST) as an intermediate representation. Finally, the paper illustrates the modelling, extraction and transformation steps based on a running example originating from the research project iPRODICT within continuous casting in the steel manufacturing industry.

This paper applies a design-oriented research approach following the guidelines proposed by Hevner et al. (2004). Hence, the metamodel extension (cf. section 3), the corresponding modeling technique (cf. section 4) and the information extraction and transformation approach (cf. section 5) represent the design science artifacts (*Guideline 1*). The relevance for constructing them is pointed out in sections 1 and 2 (*Guideline 2*). To comply with *Guideline 3*, the paper demonstrates the artifacts' application by modeling a complex event pattern in section 5. By outlining how the relevant information can be extracted out of this model, represented in an intermediate representation using AST and finally transformed into executable EPL proofs the general implementability of the approach (*Guideline 4*). Following the principle of design as an iterative process (*Guideline 6*), the metamodel extension was conceived in a workshop paper by the authors (Krumeich et al. 2015). *Guideline 5* was accomplished by outlining the applied research methodology in section 1. The submission of this paper aims at fulfilling *Guideline 7*, the dissemination of research results.

2 Theoretical Foundation and Related Work

Event patterns represent templates which specify certain event combinations. They can be classified into various categories such as temporal, spatial, spatial-temporal, trend, modal and basic patterns where each category has various subcategories (Etzion and Niblett 2011). These patterns can be provided by experts or being automatically derived using machine learning algorithms. The detection of event patterns within continuously streaming data is realized through special predetermined queries. They are enabled by query processing techniques that are more evolved and differ from approaches applied to classical database analysis. To technically describe event patterns and rules Event Pattern Languages (EPL) are used. Yet there is no language standard, which results in diverse competing approaches (Krumeich et al. 2014b), which results in diverse competing approaches: e.g. data stream-oriented, rule-based or imperative script languages.

In the business process management domain, several process modeling languages have been proposed in the last two decades (Barros et al. 2007), such as BPMN, UML Activity Diagrams, EPC and many more. Their common goal is to graphically represent business processes in order to bridge the gap between business and IT perspectives. By providing a transparent view on business processes, process models can be used for optimization purposes and to have a blueprint for their technical implementation. As it is for example expressed by the name of the EPC, incorporating events within the flow of business processes is one key characteristic. However, despite of strong modelling abilities in terms of representing business processes, these languages commonly fall short in depicting complex event patterns as they are considered in the field of CEP (Vidackovic 2014).

This shortcoming again creates barriers between business and IT perspectives in terms of involving business users and process owners in CEP implementations (Schimmelpfennig et al. 2011). Thus, as already pointed out in section 1, methods to achieve an integrated event modeling within business process modeling are required. This could be a starting point for CEP experts to transform complex event patters from a conceptual level into precise and technical CEP specifications, which is more helpful than having them written down in a textual form (Schimmelpfennig et al. 2011). Thus, representing complex event patterns in process modeling notations, is a crucial step to take to progress ED-BPM, which has already motivated some research activities in recent years. However, in most cases these contributions propose an extension to BPMN for modeling goals, key performance indicators, high-level events or even whole business situations (cf. Decker et al. 2007; Kunz et al. 2010; Koetter and Kochanowski 2012). One recently presented concept copes with the integration of dedicated event stream processing units within the BPMN representation of the overall business process (cf. Appel et al. 2013). In contrast, some first approaches explicitly seek a graphical solution for the specification of CEP event patterns (cf. Decker et al. 2007; Kunz et al. 2010). Other concepts researched integration possibilities of business events (cf. Döhring et al. 2010) or BAM artifacts (cf. Friedenstab et al. 2011) with process or information models (cf. Mulo et al. 2013).

3 Modeling Complex Event Patterns in EPC Models

3.1 Support for Complex Event Pattern Representation in EPC models

This paper proposes a metamodel extension of EPC, which is a widely-used process modeling notation both in research and industry. Neither the standard EPC modeling notation (cf. Vidackovic 2014), nor proposed extension (cf. Schimmelpfennig et al. 2011), are able to depict event patterns that can be considered as complex ones. Even if simple event relations and hierarchies can be described, e.g. a composed event, such as "order checked", is decomposed into detailed events, such as "customer data checked" and "product data checked" (Loos and Allweyer 1998), these aggregations should not be confused with what is understand with complex event patterns. Although EPC models provide several modeling elements to link events and activities, including logical operators, there is e.g. no means to express temporal related correlations (Kim and Oussena 2012).

	Patterns	**Source**	**Definition**	**EPC support**
Logical Patterns	L1: Event Conjunction	(1 - 3)	Two or more events have to have taken place in order to trigger complex event L1.	+
	L2: Event Disjunction	(1 - 3)	Alternative events have to have taken place. In a special case, the occurrence of events needs to be mutually exclusive.	+
	L3: Event Cardinality	(1 - 3)	One or more events have to have taken place a specified number of times. The number can be fixed, variable or defined by a range.	–
	L4: Event Sequence	(1), (3)	Two or more events have to have occurred according to a specified sequence. **EPC support only by modelling them into a sequential flow, however this would contradict to EPC conventions (alternation of events and functions)*	–*
	L5: Event Exclusion	(1 - 3)	This event pattern is triggered, if one or more events have taken place while one or others have been absence. In this regard, both the occurring and the inhibiting events can be represented through a complex composition. ** EPC support only textual via event labeling.*	○*
Temporal Patterns	T1: Event Time Relation	(1 - 3)	One or more events have to have occurred within or outside a given time window. Windows can be defined as fixed intervals (e.g. Mon 8am – Fr 5 pm) or event intervals (starting event – [ending event OR expiration time offset = 1 day]).	–
	T2: Absolute Time Relation	(1 - 3)	One or more events have to have occurred before or after an absolute point in time.	–
Spatial Patterns	S1: Fixed Location	(3)	One or more events have to have occurred at a fixed location.	–
	S2: Entity Distance Location	(3)	One or more events have to have occurred within a range around a certain location.	–
	S3: Event Distance Location	(3)	One or more events have to have occurred at or within a range around a certain event happing.	–
Trend	TP: Trend Pattern	(3)	Two or more events have to have occurred that satisfy a (non-) increasing, (non-)decreasing or stable pattern.	–
Data	DP: Data Dependency Pattern	(1 - 2)	One or more events have to have occurred whose data properties match certain data dependencies. ** EPC support only textual via event labeling.*	○*
Key: + is fully supported ○ is partly supported – is not supported (1) Kim and Oussena (2012) (2) Etzion and Niblett (2011) (3) Barros et al. (2007)				

Table 1: Event patterns and their support in standard EPC models (cf. Krumeich et al. 2015)

Thus, the first step towards an extended EPC metamodel is to identify characteristic event patterns from literature. These patterns of common event correlation are depicted in Table 1 (cf. Krumeich et al. 2015). The patterns are derived from Kim and Oussena (2012), Etzion and Niblett (2011) and Barros et al. (2007) resulting in 12 patterns that partly also contain sub patterns. Patterns specifically dealing with technical characteristics of CEP engines, such as subscription and consumption time, are omitted as they will not be of interest to domain experts (cf. section 5 on limitations). Except for the patterns L1 and L2, EPC do not allow for model the identified patterns. Even if some patterns may be representable by a dedicated labeling, this would neither contribute to a comprehensible representation nor to a starting point for a (semi-) automatic transformation into EPL code.

3.2 EPC Metamodel

In order to provide a possibility to model the event patterns illustrated in Table 1, the standard EPC metamodel has to be extended. In this regard, a first version of such an extension was conceived in a previous workshop paper (cf. Krumeich et al. 2015). As a foundation, the metamodel proposed by Korherr and List (2006) had been chosen, which is represented by a UML Class Diagram (cf. Figure 1, grey elements). This metamodel is a frequently quoted one and includes all required rudimentary elements (cf. Houy et al. 2014). To reduce complexity, elements detailing the element "Function" are omitted as the conceived extension deals with a dedicated "Event" specification; "Functions" are not the focus of interest (for more information on the underlying metamodel it is referred to Korherr and List (2006) and Krumeich et al. (2015).

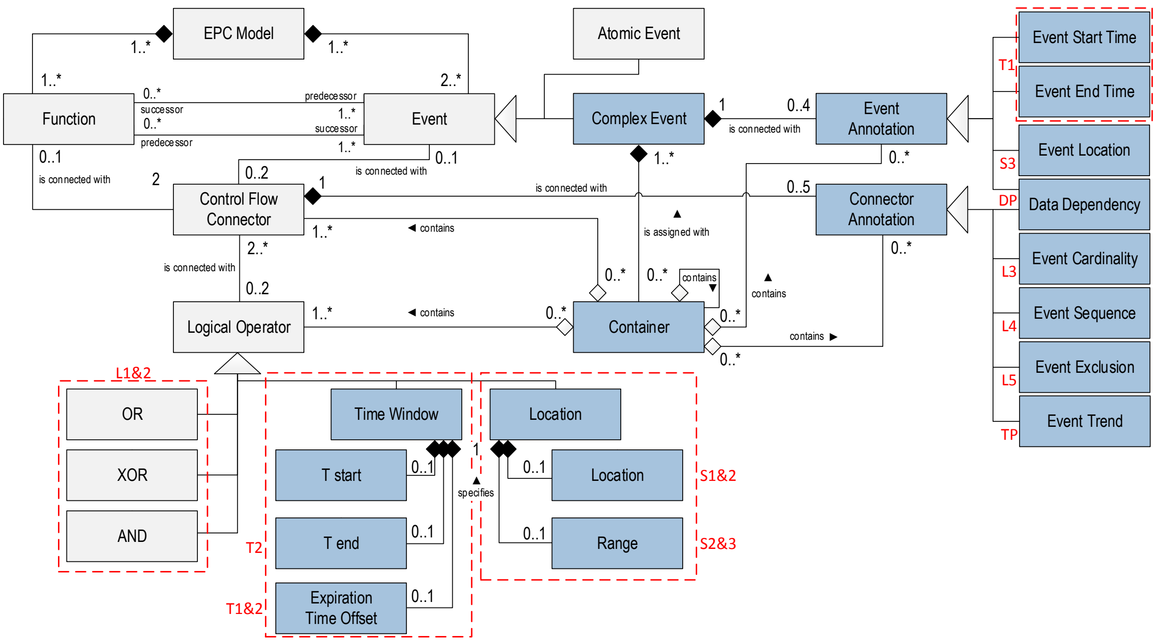


Figure 1: Extended metamodel of EPC to represent complex events (based on Krumeich et al. 2015)

As pointed out in Table 1—with few exceptions (L1 and L2)—none of the derived event patterns can be represented in standard EPC models. Thus, additional types of modeling element were required (cf. Figure 1, blue elements). First of all, the generic element "Event" is split into atomic events and complex ones. The latter can be connected with several "Event Annotations" that will be detailed introduced in Table 2. In addition, "Control Flow Connectors" can also be connected with "Connector Annotations" (cf. Table 2 regarding patterns L3-5, T1, S1-3, TP). Furthermore, the metamodel comprises a "Time Window" and a "Location" operator to define—with their linked properties—temporal and spatial relations on complex event patterns. Moreover, to express additional constraints in relation to event data, dedicated “Data Dependencies” can be connected to both “Complex Events” as well as “Control Flow Connectors”. In order to specifically combine complex event patterns, a dedicated “Container” element is established, which comprises complex events as well as associated concepts. Furthermore, a “Container” itself can be a part of another one and be further specified. As an inherent characteristic of “Complex Events”, the proposed model elements can be jointly combined in multiple, complex ways (cf. section 5 for an example).

Compared to the first version of the metamodel extension (cf. Krumeich et al. 2015), the revised version in the paper at hand contains primarily changes with respect to the “Logical Operator” respectively “Container” (cf. the elements “Time Window” and “Location”) as well as “Data Dependency” element.

4 Defining a Modeling Technique within the ARIS Modeling Method

4.1 ARIS Method Extension vs. Using the Existing ARIS Model Types

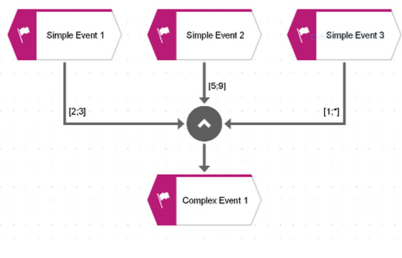
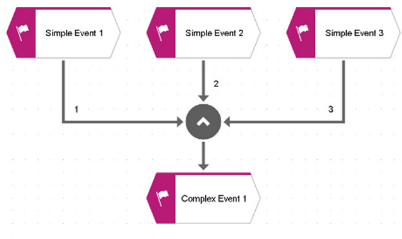
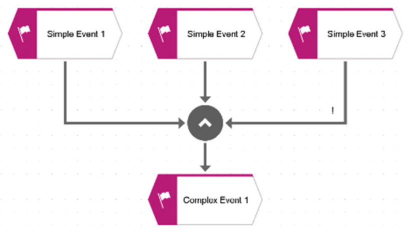
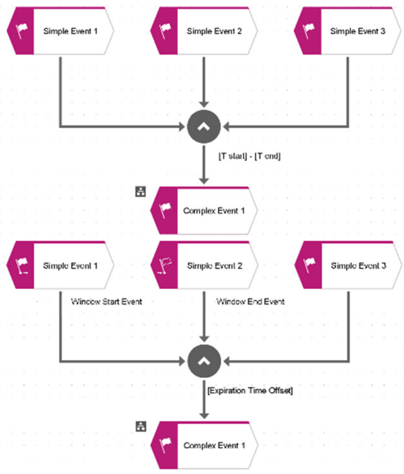
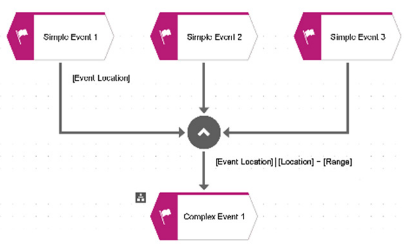
Having developed the metamodel described above, it has to be integrated into standard BPM tools in order to be usable in practice. In this regard, we choose the *ARIS Business Process Analysis Platform* as one of the leading and most widely used BPM tool. Here, the standard modeling method, which is called Architecture of Integrated Information Systems (ARIS, cf. Scheer 2000), has been developed to reduce model complexity; hence, extensions of the implemented method have to be reviewed carefully. This is also of particular importance, since a lot of companies have already documented their processes within ARIS and it has to be avoided to provoke a complete redesign or remodeling of existing business processes to add complex event patterns in order to finally meet an adapted method. Hence, existing EPC models should be reusable without further adjustment needed, which will additionally increase the acceptance of our approach in practice.

Thus, we refrained from implementing a dedicated method extension and mapped the metamodel elements using the existing method by combining available model types and functionalities in order to integrate complex event patterns into EPC models within the ARIS Modeling Method.

4.2 Modeling Technique and Corresponding Notation using the ARIS Modeling Method

First of all standard constructs of the EPC metamodel do not allow for a direct connection of two or more events. However a complex event is a result of combined events so they have to be directly connected to represent patterns. Therefore we decided to assign an Event Diagram Model (EDM) to the event that represents a complex one within the EPC. The assignment of the EDM also corresponds to the container element in the extended metamodel. Since a complex event pattern may consist of simple events as well as of complex ones, the EDM is assigned with the superior complex event. This allows for an unlimited number of nested complex events.

The subsequent Table 2 introduces a dedicated modeling technique and corresponding notation using the ARIS Modeling Method which is then capable of modeling the identified event patterns introduced in Table 1 (excluding L1 and L2 as they are already supported in EPCs).

	Relation to Metamodel	ARIS Notation
L3: Event Cardinality	To express event cardinalities, “Events” are connected with “Event Cardinality” annotations. These “Annotations” are labeled with the number resp. range of cardinality in square brackets. In ARIS, the “*connection role attribute*” is used to specify the “Event Cardinality” annotations, which is important for an automated information extraction.	
L4: Event Sequence	A specific sequential occurrence of “Events” can be expressed by “Event Sequence” annotations whose order is directly connected to the respective events. In ARIS, the “*connection role attribute*” is used to specify the “Event Sequence” annotations.	
L5: Event Exclusion	To indicate the necessity of absence of specific events, these events can be connected with “Event Exclusion” annotations. In ARIS, the “*connection role attribute*” is used to specify the “Event Exclusion” annotations.	
T1 & T2: Temporal Patterns	To express temporal relations between “Events” they are combined into “Time Windows” acting as a container. To indicate time intervals, the container is specified by a start time “T start” and an associated end time “T end” (cf. T1 pattern; using the operator’s “*condition attribute*” in ARIS). To represent event intervals (cf. T2 pattern; using the event’s “*remark/example attribute*” in ARIS), an “Event” is allocated as a start event, regarding the time window, and another one as the end event. Optionally, an “Expiration Time Offset” can be added (using the operator’s “*condition attribute*” in ARIS).	
S1 – S3: Spatial Patterns	Spatial relations are expressed by combining the respective events with a “Location Operator”. To specify the location at which the event pattern has to have occurred, the operator is detailed with a “Location” property (cf. S1 pattern; using the operator’s “*condition attribute*” in ARIS). In order to indicate a location range, the operator is additionally specified by a “Range” property (cf. S2 pattern). To satisfy pattern S3, events can be allocated by an “Event Location” event (using the event’s “*remark/example attribute*” in ARIS).	

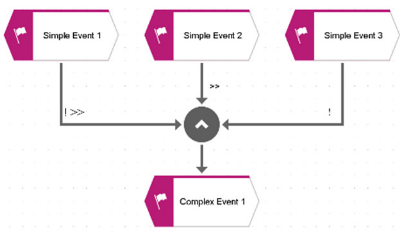
TP: Trend Pattern	To define relations between events in terms of a trend pattern, the concerning event whose trend value is under consideration is annotated by “Event Trend” symbols: >> ≙ increasing; << ≙ decreasing; ¬ >> ≙ non-increasing; ¬ << ≙ non-decreasing. Generally, specifying trend patterns is only reasonable if combined with a temporal relation. In ARIS, the “*connection role attribute*” is used to specify the “Trend Pattern” annotations.	

Table 2: Modeling Technique and Corresponding Notation using the ARIS Modeling Method

5 Model Extraction and Transformation into Event Pattern Language

5.1 Runnig Example

Based on a running example, this section illustrated how the previously introduced modeling technique can be used to represent an exemplary complex event pattern and how this pattern can be automatically transformed into executable EPL. The running example originates from the ongoing research project iPRODICT focusing a continuous casting process in the steel manufacturing industry. In this context, continuously occurring events from various heterogeneous sensors, which are attached to a production line, as well as information systems are examined to detect specific malfunction patterns that require to trigger certain actions in corresponding business processes.

As conventional business process engines typically only consider individual events, i.e. “it is checked on a per-message basis if a message matches a registered subscription and only one message is consumed in a *receive* or *onMessage* activity”, a CEP infrastructure dedicatedly considers complex event rules, i.e. patterns of events that have to be matched and which may stem from different process instances across time (Barros et al. 2007, 31).

The running example defines different conditions, i.e. events, which need to be fulfilled in order to match the “Complex Event Pattern 1”. This pattern represents a malfunction during continuous steel casting and requires to trigger the function “Increase Mould Oscillation Speed” (cf. Figure 2). The event pattern is modeled using hierarchically arranged EDM. This decomposition contributes to a better model understandability. On the lowest level (container n), an event exclusion (i.e. the sensor is not in “Calibration Mode”) is combined with the occurrence of a simple event (“Pressure Value out of Threshold”) within a time window of 60 seconds. One level above (container 2), this complex event is combined with an event cardinality meaning that this pattern has to have occurred on at least three different sensors (“[3; *]”). Additionally, this must take place in combination with at least five sensors (“[5; *]”) reporting a “Low Casting Speed Warning”. This pattern “Complex Event 2” indicates that the throughput of liquid metal within the mould is too less that frequently cause surface defects of the resulting steel bars. Thus, the first countermeasure is to increase the supplement of “Casting Powder” to the casting process. However,—as indicated in container 1—if “Complex Event 2” is detected in sequence after “Casting Powder” is added (“Complex Event 1”), then this first countermeasure will not be sufficient. In this case, the CEP engine triggers the function “Increase Mould Oscillation Speed” in the corresponding manufacturing process. Figure 2 shows the resulting models using the proposed notation in ARIS.

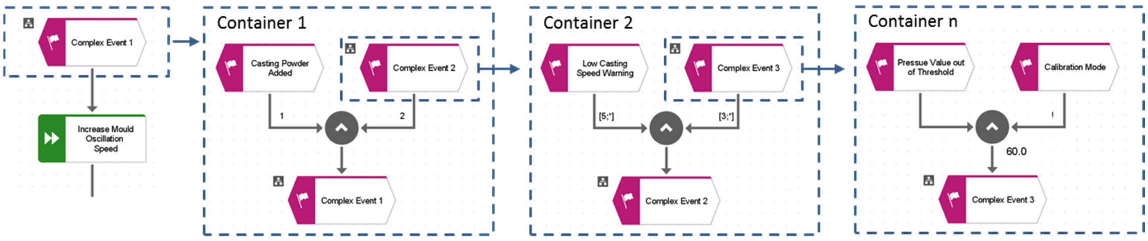


Figure 2: Exemplary complex event pattern modeled using existing ARIS model types

At this point, it should be explicitly pointed out that the resulting EPC model is not as expressive as the subsequent implementation in EPL (cf. section 2). Especially technical issues in terms of CEP implementations are omitted. Nevertheless, there is no claim to have a graphical modeling representation on the same level of detail as technical implementations, neither for business process representations and thus nor for complex event pattern representations in process models.

5.2 Information Extraction via ARIS Script and its Transformation

Having represented complex event patterns on a business level, the resulting EPC resp. EDM will be automatically transformed into executable EPL. As a starting point, ARIS itself comes with a built-in scripting API (*ARIS Script*) that is accessible via JavaScript. The API is capable of reading, writing and altering information of the business process models on ARIS servers.

In this section we propose an approach that uses the built-in API to extract all relevant information out of the modeled event patterns to build an intermediate representation (IR) and subsequently use this representation to generate meaningful code for a suitable target language. Using an IR for code generation has several benefits over using the tree-like model structure directly. First, authors of transformations to other target languages than *Apama EPL*—which we later choose—have not to cope with *ARIS Script*, since they can base their transformation on the IR. Second the IR is much more structured, since all information is explicitly given at the nodes of the tree. This allows faster understanding which in turn allows a faster implementation of transformations. Third, since we are dealing with JavaScript, the IR itself can serve as a suitable representation of complex event pattern with no extra effort by just using the JSON representation. Within our scenario we use *Apama EPL* as a target language that can be in turn imported into the *Apama CEP engine*.

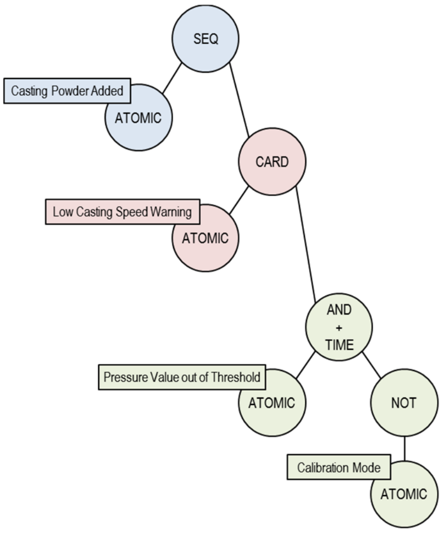
5.2.1 Information Extraction

The very basic structure of our modeling technique for complex event patterns exhibits a tree-like structure as shown in Figure 2. Each operator in the Event Diagram Models refers to a node in the tree; atomic events that do not break down into others refer to leafs in the tree structure. We use *ARIS Script* to recursively traverse the tree and collect explicitly given and also implicitly given information based on the chosen attributes. Time windows, as geolocations are explicitly given as attributes on the respective operator. Information about the operator type is given implicitly, depending on the annotations of the outgoing connectors of the operator. Using both implicit and explicit information we build an Abstract Syntax Trees (AST), as shown in Figure 3.

AST are known from compiler construction and serve as our intermediate representation (IR) (Jones 2003). In typical compiler construction an AST is built by a parser from textual input. In this case the parser simply traverses the model structure and builds the AST along the way. The AST serves a starting point for every transformation in an arbitrary target language.

5.2.2 EPL Transformation

Since most CEP engines use their very own language for complex event pattern descriptions there is no standard we can refer to (Krumeich et al. 2014b). To address this problem, we created the IR as explained above. This IR can be easily used to derive transformations to any event pattern description language. To provide an extensible framework, we implemented the visitor pattern in the IR, as proposed by Jones (2003). In our scenario, we implemented a concrete visitor class for code generation of *Apama EPL*. Figure 3 shows how the IR of the running example is translated into *Apama EPL* code. The resulting code can then be imported into Apama for a proper CEP engine configuration. In addition to the created Apama monitors, the EPL transformation algorithm also provides the required event definition templates (event definitions can be provided by domain experts using the event's "*description/definition attribute*" in ARIS).




```
monitor M_Complex_Event_1 {
    action onload() {
        on all Casting_Powder_Added() -> Complex_Event_2() {
            route Complex_Event_1();
        }
    }
}
```

```
monitor M_Complex_Event_2 {
    integer Complex_Event_3_Counter;
    integer Low_Casting_Speed_Warning_Counter;
    action onload() {
        Low_Casting_Speed_Warning_Counter := 0; Complex_Event_3_Counter := 0;
        on all Low_Casting_Speed_Warning() {
            Low_Casting_Speed_Warning_Counter := Low_Casting_Speed_Warning_Counter + 1;
            route Counter_Check_Event();
        }
        on all Complex_Event_3() {
            Complex_Event_3_Counter := Complex_Event_3_Counter + 1;
            route Counter_Check_Event();
        }
        on all Counter_Check_Event() {
            if Low_Casting_Speed_Warning_Counter >= 5 and Complex_Event_3_Counter >= 3 then {
                Low_Casting_Speed_Warning_Counter := 0;
                Complex_Event_3_Counter := 0;
                route Complex_Event_2();
} } } }
```

```
monitor M_Complex_Event_3 {
    action onload() {
        on all Pressure_Value_out_of_Threshold() and not Calibration_Mode() within(60.0) {
            route Complex_Event_3();
        }
    }
}
```

Figure 3: Abstract Syntax Tree of the running example and its automatically generated Apama EPL

Each node in the IR is translated into a dedicated event monitor containing one or more event listeners. In case the specified event listeners detect a certain event pattern, derived complex events are sent by a *route statement* to the front of the current context's input queue ensuring that their occurrence is correctly processed from a temporal perspective. Whereas event sequences are supported by Apama's standard notation (cf. the *"->" statement*), event cardinalities must be specifically implemented. The approach proposed in Figure 3 counts event occurrences in dedicated event listeners and routes counter check events which are consumed by a dedicated listener evaluating the cardinality restrictions. The given time constraint can be represented by a standard *within statement* which can be integrated in all event listeners.

```
monitor M_Complex_Event_3 {
    action onload() {
        on all at(0, 9, * , * , * ) {
            spawn startListener();
    }   }
    action startListener() {
        on all Pressure_Value_out_of_Threshold() and not Calibration_Mode() {
            route Complex_Event_3();
        }
        on all at(0, 10, * , * , * ) {
            die;
}   }   }
```

```
monitor M_Complex_Event_3 {
    action onload() {
        on all Complex_Event_3_Start() {
            spawn startListener();
    }   }
    action startListener() {
        on all Pressure_Value_out_of_Threshold() and not Calibration_Mode()
                -> Complex_Event_3_End() within(60.0) {
            route Complex_Event_3();
        }
        on all Complex_Event_3_End() {
            die;
}   }   }
```

Figure 4: Apama EPL code to represent "Complex Event 3" with temporal patterns T1 and T2

Figure 4 proposes two approaches to realize the temporal patterns T1 and T2. T1 includes absolute start and end times for the event monitor that are realized by using the Apama time notation "(minutes, hours, day of month, month, day of week [, seconds])". The *die statement* kills a monitor instance at the end time which was started by the *spawn statement*. The pattern T2 is realized by a listener that monitors the occurrence of a specific start event and kills a monitor instance when detecting the end event. The pattern should occur within the expiration time offset (*60 seconds*).

Indeed there can be further manual input needed, since the patterns specified in EPC models cannot and should not be as expressive as common EPLs (e.g. in the running example, the events considered by the cardinality constraints need to occur from different sensors which could not be represented in the extended EPC model). Hence, the transformation result in a blueprint that has to be detailed and complemented by CEP experts. This ensures the main goal of modeling complex events in EPC, since domain knowledge can be depicted in process models by business experts which can then be reused by CEP experts. Thus, the proposed transformation approach will significantly reduce the effort of CEP configuration and foster a knowledge transfer.

6 Conclusion and Future Work

This paper derived and examined characteristic event patterns considered in corresponding literature. Afterwards, the feasibility to model them using the standard EPC metamodel was evaluated and an extended EPC metamodel was proposed that allows for a comprehensive depiction of the derived patterns. Based on this foundation, the paper conceived a modeling technique and corresponding notation using the ARIS method and integrated it into the *ARIS Business Process Analysis Platform* for tooling support. Moreover, the paper proposed an approach that automatically transforms these models into executable EPL using AST as an intermediate representation. Finally, the paper illustrated the modelling, extraction and transformation steps based on a running example.

In ongoing research activities, the representation of further, even more complex real-world event patterns in the context of the research project iPRODICT is expedited in order to proof the feasibility of the proposed extension beyond the running example in section 5. In this regard, the involvement of domain and technical experts in the modeling and usage of extended EPC models will be specifically evaluated regarding its actual usefulness and understandability. Another interesting research question will be how to induce complex event patterns out of event stream instances and how to visualize them using the modeling technique proposed in the paper at hand.

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A Vector Space Approach to Process Model Matching using Insights from Natural Language Processing

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Abstract

Business process models have been widely adopted to support a variety of tasks regarding organizing, structuring and communicating business activities for many enterprises. As the number of models continually grows, methods to identify correspondences within existing model collection gain in importance. In this paper, we adopt the vector space model approach to the field of business process matching in order to leverage information from text statistics and, thus, to identify corresponding model elements. By using techniques from natural language processing, we seek to abstract from specific word forms or grammatical aspects like inflection to provide a higher level of abstraction. Furthermore, we use k-nearest neighbor classification of models to determine the significance of model elements per application domain, which is particular useful for cross-domain model collections. As a result, we present a semantic multi-phase matching algorithm as well as a prototypical implementation. The matching results produced by the algorithm have been evaluated in different domain settings to demonstrate the potential of the vector space approach in cross-domain model collections.

1 Introduction

Business process modeling has become an indispensable part of managing business activities and processes for many organizations across all industries (Woo and Song 2011). Describing business activities by formal or semi-formal modeling notations on the one hand helps to capture and document existing processes and, on the other hand, provides a common basis to discuss or redesign target processes (Dijkman et al. 2011; Fengel 2014). Typically, process models are stored in model collections or repositories, which manage access to and modification of the contained elements among multiple users in a collaborative environment (Uba et al. 2011). Against the background of a growing number of existing processes and process variants, methods for organizing, structuring and retrieving models become paramount.

Important challenges in that regard are the detection of duplicates or similar model variants within repositories and the determination of correspondences in the form of common substructures and shared elements between pairs of models. Establishing such correspondences is referred to as *process matching*, while the set of identified correspondences is typically called *mapping* (Becker and Laue 2012). As individual models may vastly differ in terms of structural composition as well as the language used to describe activities in the labels of a model, the task of mapping determination cannot be performed in a trivial way but is subject to ongoing research.

In this paper, we present a novel algorithm to business process model matching that builds on the concept of *vector space model*s (Salton et al. 1975). While this concept is well established in the discipline of information retrieval, its potential for the task of process model matching has not thoroughly been investigated so far. Our algorithm constructs two vector spaces to represent process models as well as model elements as vectors comprising textual descriptions of model activities. Correspondences between model elements can then be identified by using prevalent vector similarity metrics, thus leveraging information from text statistics. In addition, the algorithm aims to account for different domains within the set of models that are to be compared: by using *k-nearest neighbor* classification the model domain is considered a relevant factor for the determination of correspondences and, thus, has an important effect on the final mapping. To optimize the vector similarity scores, we further perform *natural language processing* on activity label texts in order to abstract from specific word order or grammatical aspects like inflection.

The approach has been implemented in the form of a software prototype and the matching results have been evaluated based on various model sets provided with dedicated matching gold standards. Furthermore, a preliminary version has been submitted to the Process Model Matching Contest 2015. This paper focuses on enhancement to the matching procedure that have been added subsequent to the contest and are based on the insights gained in the respective evaluation setting.

We base our research on a design-oriented research approach to create an innovative artifact in the form of an algorithm for process model matching (Hevner et al. 2004). In addition to a conceptual result presentation, we provide a prototypical software implementation, which follows the ARIS methodology for information systems. In ARIS, the overall process of software design and implementation is divided into the three phases *requirements definition*, *design specification* and *implementation* (Scheer 1994). Finally, the matching results produced by the algorithm have been evaluated in different settings and on different datasets, thus, yielding a comprehensive assessment of its performance in varied fields of application.

The *structure* of this paper is as follows. After this introduction, section 2 presents related work. Then, section 3 provides a detailed overview of the vector space approach to business process model matching along with the intended use case and technical details on the present implementation. After that, the setting as well as the results from the evaluation are illustrated and discussed in section 4. Finally, section 5 concludes the paper and provides an outlook on future work.

2 Related work

2.1 Business process matching

Research in the field of *business process matching* is performed for a variety of reasons, among the most prevalent ones are the subsequent application of distance or similarity measures in order to determine the closeness of two models (Dongen et al. 2008) and the identification of frequent model parts, which is relevant in reference model creation (Rehse et al. 2015). In general, *process matching* describes the identification of correspondences ("matches") according to a certain understanding of correspondence between two process models m_1 and m_2, as for instance subsumption, equality or similarity (Weidlich and Mendling 2012). Correspondences can either be determined between entire models, model substructures that comprise multiple components, or individual process elements like activities, events, resources or any other elements that are provided by a specific modeling notation (Thaler et al. 2014). Identified matches can be differentiated in terms of cardinality, which describes the number of elements that are part of a single match. While *1:1 matches* link each element of m_1 to at most one element of m_2, in an *1:n match* scenario, an element from m_1 might be linked to multiple elements from m_2 (Weidlich et al. 2010). The set of all matches between two process models is referred to as the *mapping* between those models (Becker and Laue 2012). Throughout this paper, we define a mapping as a set of correspondences between individual process elements where only 1:1 matches are considered such that the mapping is unambiguous.

In order to address the problem of determining mappings automatically, a plethora of different approaches has been proposed. As many of these approaches are closely related to the concept of *process similarity*, they can be classified into the same three major dimensions (Abbas and Seba 2012): (1) *structural approaches*, which consider model graph structures, the order of nodes and control flows, (2) *semantic approaches* that are based on textual information contained in the models and (3) *behavioral approaches*, which take into account the models' execution semantics.

An important aspect that is subject to many discussions relates to the question of how the quality of a mapping produced by a certain method can be evaluated and compared to other mappings. In that regard it is often not clear which criteria define a "good" mapping and how its quality should be assessed. To address this issue, a handcrafted *gold standard* is often used as a benchmark in practice. However, the task of establishing such a standard is highly subjective and dependent on the matching expert (Weidlich and Mendling 2012). Thus, a gold standard is always biased towards a personal mindset as the matching task depicts a decision problem and has no unique solution (Thaler et al. 2014). If a gold standard exists though, the quality of any given mapping can be evaluated by measures like *precision*, *recall* and *F-measure* (Cayoglu et al. 2013).

2.2 NLP and business process matching

Different algorithms that draw on semantics gathered through the analysis of textual information from the label nodes of a model by means of *natural language processing* (NLP) techniques have been presented. For instance, the *bag-of-words* technique has been adopted to the field of process matching and proposed to address the problem of matching labels that mostly vary in the order of words (Klinkmüller et al. 2013). By treating each label as a set of words and, thus, by not considering structural properties of model elements, this approach seeks to abstract from different grammatical structures to determine matches between labels. Moreover, approaches to combine ontology matching with linguistic information from labels to establish relations between business process models have been proposed (Fengel 2014).

In addition to identifying mappings, NLP has also been employed in the context of retrieving models related to a specific topic in order to narrow down the number of relevant models before applying methods for structural comparisons (Qiao et al. 2011) or to preprocess and unify model labels (Niemann et al. 2012). Other approaches have been proposed to identify *actions*, *business objects* and *resources* from textual descriptions within a label or to harmonize different modeling styles and levels of abstraction (Leopold et al. 2013). In order to handle synonymous label terms correctly, manually crafted lists of predefined synonyms (Woo and Song 2011) as well as the WordNet taxonomy (Pittke et al. 2013) have been employed.

The vector space model has been applied to represent business processes in different contexts. Jung et al. use vectors based on structural model properties to calculate model distances in order to create hierarchical clustering trees (Jung et al. 2009). Other approaches focus on causal footprints as behavioral process characteristics to build a vector space for model comparison (Dongen et al. 2008) or a combination of structural and semantic features (Chen et al. 2014). However, while the tasks of similarity assessment and process clustering have been studied before, no previous work has to the best of our knowledge investigated the potential of semantic feature vector specifically for the task of process matching. To address this issue, we present our vector-based approach to business process matching in the following section.

3 Vector-based Approach to Business Process Matching

3.1 Multi-phase matching approach

Following the ARIS methodology, we perform a requirements definition as a first step towards the development of our matching algorithm. As mentioned before, we focus on a pairwise comparison of process models to determine 1:1 matches. Hence, the following requirements have been defined to align further development steps: *(RQ1) A mapping must be determined for each pairwise combination of models* and *(RQ2) A mapping must only contain elementary 1:1 matches*.

The general matching procedure is defined as a multi-phase algorithm that is referred to as *multi-phase matching* (see Figure 1). It is an extension to the preliminary version that has been submitted to the 2015 edition of the process model matching contest (Antunes et al. 2015). Preparatory steps subsequent to phase 1 were subsumed in a dedicated preparation phase to conceptually separate preprocessing activities from matching activities. Furthermore, from a technical perspective this modularization also provides more flexibility for the implementation of a software prototype. In addition, new constraints and parameters enable more fine-grained adjustments to the overall matching procedure as well as better adaption to domain-specific process model collections.

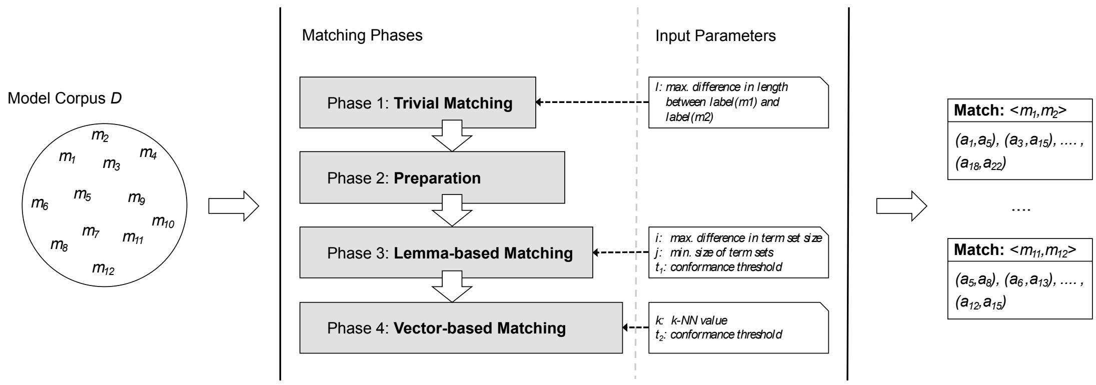

Figure 1: Overview of the Multi-phase Matching Process

The approach takes a set of process models ("model corpus") as input and returns a set of matches for every pairwise combination of those models. Each match within this set represents a mapping between two process models and is based on comparisons of every pairwise combination of all node labels that constitute the models. When determining the matches, structural information like the order of nodes is discarded and only activity nodes are considered (e. g. functions in EPC models or activities in BPMN models). Each phase in the matching procedure is intended to cover a certain type of label match, where the demanded *strictness* of similarity between the labels that are to be compared diminishes in later phases: While the similarity has to be very high in the first matching phase – i. e. the labels have to be identical or substrings – the last matching phase assumes less stringent similarity and aims to identify non-trivial matches based on partial label congruence. In general, a subsequent phase in the matching process is only reached if no appropriate match could be determined in proceeding phases, which means that phases 1 to 4 are not necessarily passed altogether in every label comparison step.

Phase 1: Trivial Matching. As a first step, a so-called *trivial matching* is performed to identify identical labels as well as label pairs where one label is a substring of the other one. This kind of similarity is valued most important since we assume that if two model elements are labeled identically or very similar they effectively describe the same activity. The matching step is called *trivial* because it naively compares the labels without taking further textual information into consideration. It is important to note that in general, label A being a substring of label B or vice versa is not necessarily an indicator for the labels to be equal and, thus, to be matched. For example, the label "*ordering of goods*" is a substring of "*formally reject ordering of goods*" but probably expresses a contrary action. To account for this issue, parameter l is introduced to indicate significant variations in the labels lengths, thereby acting as a constraint for the trivial matching. In summary, two labels A and B are matched in phase 1 according to formula (1):

$$A == B \; or \; (A \; is \; substring \; of \; B \; || \; B \; is \; substring \; of \; A) \;\; \&\& \;\; (|length(A) - length(B)| \; \leq \; l) \tag{1}$$

Phase 2: Preparation. As an extension to the trivial matching performed in phase 1, label texts are further processed to harmonize the set of label terms in the second phase. By applying NLP methods, the matching approach abstracts from specific word order and grammatical aspects like inflection (e. g. tense, number, case). First, label texts are split into constituting words – so-called *tokens* – and duplicates as well as *stop words* are removed such that a label is represented by the adjusted set of contained tokens. Second, *lemmatization* is performed to unify different inflected forms and to further reduce the set of tokens by combining identical basic word forms.

Phase 3: Lemma-based Matching. After the preparation steps in phase 2, labels are then compared based on their set of lemma in the third phase *lemma-based matching.* Therefore, the intersection of equal lemmatized tokens in the two label lemma sets is computed while neglecting specific word orders (*bag of words*). In order to retain high precision during matching and to prevent the risk of false positive matches, lemma-based matching is restricted by several parameters, which also allow for precise adaption to the specifics of a given model corpus. Parameter i indicates the amount of terms in which two lemma sets may differ while parameter j represents a lower bound for their size (that is the amount of elements contained in each set). The ration between identical lemma and the size of the union of lemma set depicts a threshold t_l. As this matching phase primarily aims to identify "mostly identical" labels with different order or inflection of words, thresholds have been set carefully. Specifically, values for i, j and t_l have been determined in an iterative way using all available data sets in the present use case scenario in such a way that the overall performance is maximized in terms of F-Measure (see section 4.2). Formula (2) summarizes the phase 2 matching method for two sets of label tokens L_1 and L_2:

$$\frac{|L_1 \; \cap \; L_2|}{|L_1 \; \cup L_2|} \; \geq \; t1 \quad with \;\; |L_1 - L_2| \leq i \;\; and \;\; |\, L_1| \; \geq j \;\; and \;\; |L_2| \; \geq j \tag{2}$$

Phase 4: Vector-based detail matching. While the previous phases serve to determine matches between labels that are very similar in wording and mainly differ in terms of word order, tense or grammatical number, the *vector-based matching* is the main contribution of this paper. It is based on the *vector space model* approach, which describes a concept for representing text documents as term vectors. Following this approach, every token from the models' sets of lemma created in phase 2 is represented by a dedicated vector dimension where one vector exists per model. In this context, model representations are called *documents* and the set of vectors representing models from corpus *D* is denoted as model vector space VS_{model}. To determine concrete values for vector dimensions, *term frequency-inverse document frequency* (tf-idf) is used to calculate token weights (Ramos 2003): For every token *t* in document *d* within corpus *D*, the term frequency $tf(t,d)$ is defined as the number of occurrences of that term in *d* and multiplied by the inverse document frequency $idf(t,D)$, which is defined as the fraction of documents that contain term *t* and the total number of documents in *D*. Formula (3) summarizes the calculation scheme including logarithmic scaling:

$$tfidf(t,d,D) = tf(t,d) \times idf(t,D) = count(t \in d) \times log\frac{|D|}{df(t,d)} \tag{3}$$

Building on this preparatory work, the matching procedure is three-part: *First*, for every combination of two process models m_1 and m_2 that are to be matched, their *k-nearest neighbors* (k-NN) are retrieved from the model corpus *D* (Kramer 2013). Therefore, the *cosine similarity* is computed between m_1 respectively m_2 and all model vectors in *D*, yielding a ranked list from which the top-k records are considered neighbors of that particular model. Depending on the corpus size, parameter *k* can be adjusted to a reasonable value. *Second*, given the sub corpus D_{sub} of k-NN for a combination of two process models, an additional vector space VS_{labels} is constructed. The vectors in VS_{labels} are built per label and span across the label pair (m_1,m_2) that is currently considered, i. e. the number of vector dimensions is equal to the sum of distinct lemma in the two labels. To weight vector dimension, the joint k-NN sets of m_1 and m_2 are considered a new sub-corpus, which is in turn used to calculate *tf-idf* values for every lemma according to formula (3). *Third*, cosine similarity sim_{cos} is subsequently calculated between label vectors *v* and *w* and checked against a predefined threshold (parameter t_2) as depicted in formula (4) to decide on whether the labels are matched.

$$t_2 \leq sim_{cos}(\theta) = \frac{\sum_{i=1}^{n} v_i \times w_i}{\sqrt{\sum_{i=1}^{n}(v_i)^2} \times \sqrt{\sum_{i=1}^{n}(w_i)^2}} \tag{4}$$

By using this procedure as the ultimate step in the overall matching process, the approach seeks to exploit statistical information from word occurrences and, thus, to reflect the importance of specific terms within the corpus. Focusing on the k-NN of models, it further seeks to broaden the scope of consideration in order to obtain more significant information about term distributions. Hence, the approach is based on the assumption that considering the *k* most similar models of m_1 and m_2 a new sub corpus D_{sub} yields a more accurate result when calculating tf-idf values for individual terms than using the whole model corpus *D*. This assumption seems to hold according to our evaluation since k-NN classification tends to construct clusters in *D* that align with the different application domains contained in the corpus (see section 5). Because the models in D_{sub} are similar by design, they are expected to be better suited for predicting the importance of a label term in a specific domain as compared to the whole corpus. This effect will most likely increase in dependence of corpus size and the number of different application domains contained, thus, adjusting the value of *k* opens up potential for customization to corpus specifics.

3.2 Implementation

The multi-phase matching procedure presented in the previous section has been implemented in the form of a software prototype in order to demonstrate the applicability of the concept. In accordance with the ARIS methodology, we first developed a design specification that serves as a basis for the subsequent implementation process. It allows us to specify the functional behavior as well as to create the individual modules of the final software implementation. Figure 2 depicts the design specification that the implementation is based on in a pseudocode representation.

```
for each pairwise combination of models M1 and M2 in corpus D do
    extractActivities(M1,M2);
    buildModelVectors(m1,m2);
    determineKnn(m1,m2);
    for each pairwise combination of activity labels <A,B> do
        if(M1 == M2 || (substring(A,B) || (substring(B,A)) && (|length(A)-length(B)| ≤ 1)) then
            return true;
        else
            tokenize(A,B);
            removeStopwords(A,B);
            lemmatize(A,B);
            if(lemmaMatch(A,B) ≥ T1)
                return true;
            else
                buildLabelVectors(A,B);
                if(vectorMatch(A,B)) then
                    return true;
                else
                    return false;
```

Figure 2: Design specification of the matching algorithms in pseudocode

Technically, the prototype was implemented as a Java application and provides import functions for the most common process model formats like *Business Process Modeling Notation* (BPMN, in the *.bpmn* format), *Event-driven Process Chains* (EPC, in the *.epml* format) and *Petri nets* (in the *.pnml* format). After importing, process models are transferred into a simplified internal model structure, which abstracts from structural properties and is implemented using standard Java classes. The tokenization method is manually implemented while we use a publicly available English stop word list as well as a free implementation of TreeTagger for lemmatization. To finally store the identified mappings, we employ the format which is provided by the Alignment API that was originally developed to save ontology alignments but is well suited for our purpose.

4 Evaluation and Discussion

4.1 Evaluation Scenario

In order to evaluate the presented matching approach and to point out its characteristics as well as implications, this section describes an exemplary use-case scenario that was used for evaluation. The scenario is based on the setup of the second edition of the Process Model Matching Contest (PMMC) and was extended by own data that we provided in preparatory work prior to the evaluation. As for model corpora, we draw on three datasets that depict different problem domains and were publicly available at the time of evaluation (Leopold et al. 2015). Table 1 elaborates on each dataset and presents some statistics.

(1) University Admission Processes. The first dataset contained 9 models representing the admission process for Master's programs at German universities. It was provided in *.bpmn* file format along with a corresponding gold standard containing 232 matches in total. Models were compared pairwise in all combinations, thus yielding a total of 36 mappings.
(2) Birth Registration Process. A set of 9 models in *.pnml* file format describing the process of birth registration in different countries constitutes the second model corpus. A gold standard, containing 583 matches, was also provided. Again all pairwise combinations were matched, resulting in 36 mappings.
(3) SAP reference models. In the third model corpus, a set of 36 model pairs derived from the non-public SAP Reference Model Collection was provided in *.epml* file format. Each pair consisted of *source*/*target* models that were matched, i. e. 36 mappings have also been determined in this set. While there was no gold standard provided during the time of developing the algorithm, an "official" version has been made available subsequent to the PMMC.

Table 1: Evaluation datasets adopted from Process Model Matching Contest 2015

In order to thoroughly evaluate mapping results on the third dataset, we created an additional gold standard supplementing the one provided after the PMMC. Therefore, four individual raters manually defined matches for 9 model pairs each and discussed their results afterwards with the other raters to obtain a commonly agreed mapping and to mitigate rater subjectivity. For the majority of matches, the raters quickly reached an agreement, however there were some cases where a decision was not trivial. This refers to the general problem of *non-existence of reference matches* that has already been discussed in literature (Thaler et al. 2014). As can be seen from the evaluation results presented in the next section, the two gold standards for dataset 3 greatly differ in terms of the matches contained and yield very different results in our evaluation.

4.2 Results

Based on the three datasets and the corresponding four gold standards, we calculated *precision* and *recall* measures to assess the quality of our matching implementation. As each match in a given mapping can be clearly classified true positive (TP), true negative (TN), false positive (FP) or false negative (FN), precision is calculated as the share of correct matches (TP) in the set of all matches (TP + FP), while recall is the share of correct matches (TP) in the set of all identified matches (TP + FN). In addition, *F-measure* is calculated as the harmonic mean of precision and recall in order to provide a single measure for matching quality. We discuss some implications of the chosen measures in section 4.3.

To obtain a first impression of the matching results, we iteratively determined optimal values for parameters i, j, k, l, t_1 and t_2 (see section 3.1) per dataset by testing all parameter configurations and selecting the configuration with the highest F-measure (configuration P1). The results are shown in the left part of table 2 where dataset 3-1 denotes the evaluation conducted with our own gold standard and 3-2 denotes results based on the official gold standard provided subsequent to the PMMC. As the optimal parameter values differ across all datasets, the results certainly do not allow for a general assessment of the matching performance. Instead, they essentially depict an upper bound for the evaluations metrics, as a common parameter configuration for all datasets is expected to yield lower values for respective measures.

	(P1) optimal parameter configuration			(P2) on-average parameter configuration		
dataset	*precision*	*recall*	*F-measure*	*precision*	*recall*	*F-measure*
1	0.69	0.39	0.50	0.21	0.47	0.29
2	0.41	0.43	0.43	0.32	0.45	0.37
3-1	0.81	0.81	0.81	0.70	0.84	0.77
3-2	0.83	0.50	0.63	0.73	0.53	0.61

Table 2: Evaluation results with optimal and on-average parameter configurations.

As a second step, we determined a parameter configuration that performs best on average across all datasets, i. e. we tested all parameter combinations and picked the one that maximized the sum of individual F-measure values (configuration P2). In summary, P2 puts a strong emphasis on phase 4 of the presented matching procedure as matches determined by vector-based matching contribute a large share of the final mapping. The results are shown in the right part of table 2. In general, it can be noted that both precision and F-measures decline for almost all model datasets in comparison to the first matching evaluation with optimal parameter configuration. At first glance, this is not surprising and consistent with our initial assumption. It is, however, remarkable that precision and F-measure are considerably lower for dataset 1 in the second setting while the differences are not that significant for dataset 2 and 3-1 and even less distinct for dataset 3-2. This can be explained with the different types of matches that are prevalent in the respective datasets.

Dataset 1 comprises many “trivial” matches where (mostly) identical labels are mapped according to the given gold standard. This issue favors a parameter configuration, which focuses on phase 1 and 3 of the presented matching procedure. Vector-based matching in phase 4 is totally disregarded in this configuration since it introduces noise to the produced mapping that on the one hand increases recall but on the other hand severely impacts precision. Hence, F-measure values greatly differ between the parameter configurations (0.50 in P1 compared to 0.29 in P2).

As for *dataset 2*, F-measure values also drop comparing configurations P1 and P2, even though the difference is not as big as for dataset 1. We explain this by a large share of “permutation” matches in the form of changing word orders, which in turn favors the lemma-based matching in phase 3 of our matching procedure. While the drop in precision is relatively intense (0.41 in P1 in comparison to 0.32 in P2), the gain in recall however is low: 0.43 in P1 compared to 0.45 in P2.

For *dataset 3*, the algorithm yields the highest values for precision, recall and F-measure but the results show great differences with respect to the different gold standards. Using our own gold standard (dataset 3-1), we obtain high values for all measures while the influence of different parameter configurations on F-measure is relatively low (0.81 in P1 vs. 0.77 in P2). In contrast, with the “official” gold standard (dataset 3-2), F-measure strongly declines but is again nearly invariant with respect to parameter configuration (0.63 in P1 vs. 0.61 in P2). Interestingly, this decline can fully be attributed to lower recall as precision is even above the level of dataset 3-1.

As a last step, we also compared our results to the results of other 11 submissions to PMMC which are publicly available (Antunes et al. 2015). Since matching performance is relatively low in dataset 1 – which can be attributed to the on-average parameter configuration chosen for the contest (compare remarks above) – this only yields the second last position in the total ranking of algorithms with a F-measure value of 0.29 compared to the best achieved value of 0.67. In contrast to that, results are much more competitive for datasets 2 (0.43 vs. best value of 0.57 and 4th position out of 12) and dataset 3 (0.60 vs. 0.68 respectively 7th position out of 12).

4.3 Discussion

As can be seen from the results presented in table 2, the matching performance of the algorithm presented in this paper strongly depends on the model datasets. As dataset 1 and 2 contain models from the same domains and are very similar in terms of modelled issues, the algorithm does not benefit from the k-NN classification performed in phase 4. As domain-specific relevance of individual terms in the model cannot be leveraged, the weights for respective vector dimensions, thus, cannot be optimized. Furthermore, the types of matches prevalent in those datasets favor phases 1 and 2 of the algorithm as discussed in the previous section. However, the situation is different for dataset 3, which comprises models from a variety of different domains: k-NN classification of similar models helps to better determine the relevance of terms within the two models that are to be compared and to create more detailed vector representations. As a result, precision, recall as well as F-measure are considerable higher than in the other datasets.

In the light of these differences, we believe a *general* or *on-average* parameter configuration to be limited by design since the types of matches prevalent in a dataset cannot be anticipated in advance. To account for this issue, we propose a semi-automatic learning approach, which requires a random subset of the model collection (e. g. 5% of the models) to be manually matched. The exemplary subset mappings can then be used to learn the matching parameters in order to optimally reproduce the manually annotated results. Hereby, the algorithm can be adjusted to dataset specifics to yield more accurate results for future model comparisons. We further want to make two remarks on the expressiveness of the F-measure criterion that we used to evaluate our algorithm. While the criterion is well suited as a first indicator on matching performance it also entails important implications that become relevant in process matching.

Remark 1: In contrary to the context of information retrieval, where F-measure is extensively used to evaluate the performance of retrieval components, the requirements in process matching scenarios might be different. Depending on the intended use of the produced mapping, maximum precision at the expense of lower recall values and vice versa might be more important than overall F-measure. Consider for instance the automated derivation of a reference model from a set of individual models: in this case, an exhaustive mapping (with maximum recall) is key to derive a comprehensive reference model whereas additional noise added in consequence of lower precision might be acceptable. In summary, the F-measure value of a given algorithm must always be interpreted against the background of its intended application scenario.

Remark 2: The calculation formula for precision and recall and, thus, for F-measure values do not explicitly consider matches that were classified as true negative (TN). We illustrate this problem in a small example. Consider the mapping of model m_1 (10 elements) and m_2 (10 elements), which at most contains 100 matches (pairwise combination of the 10 elements per model). Further assume the number of TP to be 30 and the numbers of FP and FN to be 10 each. Hence, the number of TN is determined as 50 to add up to the maximum of 100 matches. The F-measure for this scenario can then be calculated as 0.75. Now consider a second mapping of model m_1 (again 10 elements) and model m_3 (100 elements), which has a theoretical maximum of 1,000 matches. Further assume the number for TP, FP and FN to remain the same (30/10/10), which will implicate the number of TN to be 950. However, the F-measure also remains at 0.75 although the amount of correctly matched TNs is much higher. In a real-world setting though, the amount of correctly classified TNs is a valuable indicator for deciding between two matching algorithms.

5 Summary and Future Work

In this paper we presented a multi-phase matching procedure that adopts the vector space model approach from information retrieval to the field of business process matching. At the core of the procedure is a component that identifies semantic correspondences between model elements based on vector-representations. We use k-NN classification and natural language processing to augment vectors with information about the models' application domains gained by statistical as well as linguistic analysis of text labels. Following a design-oriented research approach, we developed an innovative artifact in the form of a software implementation of the matching algorithm, which is based on a requirements analysis and a conceptual design specification. Matching results produced by the algorithm have been evaluated on different datasets from various domains, particularly indicating the approach's potential for the matching of models in cross-domain collections. We further plan to investigate the possibilities of semi-automatic adoption of parameter configurations to dataset specifics by learning approaches. As the findings from our preliminary evaluation presented in this paper clearly show, optimal parameter configurations per dataset perform much better than general configuration without optimization. We thus seek to extend our approach by learning components, the development of which will be based on further detailed evaluations considering additional datasets and model corpora.

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Teilkonferenz
Business Intelligence, Analytics und Big Data

In den letzten Jahren hat der Bereich der integrierten IT-basierten Management- und Entscheidungsunterstützung (Business Intelligence, BI) wieder erheblich an Aufmerksamkeit gewonnen. Insbesondere sind strategische, überbetriebliche und explorative Einsätze der BI in den Mittelpunkt der Diskussion gerückt. Mit diesen einher gehen eine intensivere Beachtung poly-strukturierter Datenquellen etwa aus sozialen Netzwerken, eine stärkere Integration anspruchsvollerer Analyseverfahren (Advanced und Predictive Analytics) sowie eine Orientierung an Agilitätsaspekten. Im Zusammenspiel mit der parallel vorangetriebenen Prozessintegration ergibt sich die Notwendigkeit zur Überarbeitung etablierter Architektur-, Governance- sowie Betriebskonzepte. Die Teilkonferenz „Business Intelligence, Analytics und Big Data" widmet sich diesen Fragestellungen. Die präsentierten acht Beiträge adressieren dabei ein breites Spektrum an hier einzuordnenden Themen, das von Fragen der Datenintegration in Zeiten von Big Data über neue Ansätze für einen agileren und stärker automatisierten BI-Betrieb bis hin zur systematischen Einbindung innovativer Datenanalyse-Ansätze reicht.

Henning Baars

(Teilkonferenzleitung)

Automatische Klassifizierung von Data-Warehouse-Daten für das Information Lifecycle Management

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Abstract

Information Lifecycle Management (ILM) zielt darauf ab, Daten über ihren gesamten Lebenszyklus möglichst effizient und unter fachlichen Gesichtspunkten effektiv zu verwalten. Ein Kernaspekt betrifft die Frage, wo Daten gespeichert werden sollen, da hiermit unterschiedliche Kosten und Zugriffszeiten verbunden sind. Hierzu müssen Daten klassifiziert werden, was heute entweder in aufwändiger Weise manuell geschieht oder unter Rückgriff auf nur wenige Datenattribute, insbesondere die Zugriffshäufigkeit. Im vorliegenden Beitrag wird für den Kontext von Data-Warehouse-Systemen eine automatisierte und damit schnelle und kostengünstige Datenklassifizierung für das ILM vorgestellt, die eine Vielzahl von Datenattributen berücksichtigt und damit zu ähnlichen Ergebnissen wie menschliche Experten kommt. Dazu werden mehrere Verfahren anhand von realen Daten aus dem Automobilbereich verglichen. Neben der Klassifizierungsgenauigkeit wird in den Verfahrensvergleich auch einbezogen, welche Arten von Fehlklassifizierungen auftreten, da dies im ILM wichtig ist.

1 Hintergrund, Motivation und Forschungsfragen

Business Intelligence (BI) unterstützt die Erreichung der Unternehmensziele durch systematische Analyse und Bereitstellung von Daten zur Entscheidungsunterstützung (Anandarajan et al. 2004). Data-Warehouse-Systeme (DWS) stellen eine wesentliche Komponente von BI-Systemen dar, indem Sie die umfangreichen Datenbestände unterschiedlicher Quellsysteme integrieren und mittels Analysewerkzeugen deren Aufbereitung, z.B. in Form von Berichten für Entscheider unterstützen. Die Verlagerung von Daten in den Hauptspeicher (In-Memory-Technologien) oder die Verwendung leistungsstarker und teurer Hardware können Antwortzeiten der Datenanalysen verringern. Ebenso stellt in jüngster Zeit die Verlagerung von Daten in die Cloud eine neue Option der Datenspeicherung dar. Da Forderungen nach kurzen Antwortzeiten im Allgemeinen mit höheren Kosten für Datenspeicherung und Zugriff verbunden sind, muss der Speicherort zweckmäßig gewählt werden.

Diese Problematik gehört zum Themenbereich des Information Lifecycle Management. ILM verfolgt das Ziel, Daten zu bewerten, in Klassen einzuteilen und gemäß dieser Einteilung zu verwalten (Maier et al. 2005, 254-257; Thome und Sollbach 2007, 151-152). Gemäß dem ILM durchlaufen Daten verschiedene Lebensphasen von der Erstellung über Nutzung bis hin zur Archivierung (Thome und Sollbach 2007, 22), in denen Bedeutung, die Zugriffshäufigkeit und Anforderungen bezüglich Zugriffszeiten variieren. Im Zuge abnehmender Zugriffshäufigkeiten steht am Ende des Lebenszyklus von Daten deren kostensenkende Speicherung im Vordergrund, weswegen Daten über den gesamten Datenlebenszyklus hinweg analysiert werden, um eine geeignete Speicherklasse zu bestimmen. Die klassifizierten Daten müssen, je nach Klassenzugehörigkeit, auf den dafür sinnvollsten Speichermedien bereitgestellt und verwaltet werden (Bhagwan et al. 2005; Chen 2005; Maier et al. 2005, 254-257). Daten sollen schnell verfügbar vorgehalten werden, wenn sie häufig verwendet werden (Online) und können archiviert werden, sofern kaum Zugriffe zu erwarten sind. Daten, die mittlere Zugriffshäufigkeiten aufweisen, können in DWS im Nearline Storage gespeichert werden (Liu et al. 2004). Sie verbleiben im direkten Zugriff, die Datenanalysen nehmen jedoch mehr Zeit in Anspruch, da eine kostensenkende, z.T. komprimierte Speicherung erfolgt. Die Verlagerung der Daten vom Online- in den Nearline- oder Offline-Speicher senkt die Kosten, jedoch erhöhen sich die Antwortzeiten. Die Klassifizierung (Einteilung in die Klassen Online, Nearline, Offline und Löschen) der Daten stellt somit eine Kernaufgabe des ILM dar. Diese ist ohne Automatisierung kaum durchführbar und wirtschaftlich nicht sinnvoll (Kosler et al. 2008, S. 130). Benötigt werden dazu Verfahren, die eine entsprechende Wertzuweisung für die Klassifizierung vornehmen. Bisher publizierte Konzepte berücksichtigen die Besonderheiten von aggregierten, strukturierten Daten eines DWS nur ungenügend (Thome und Sollbach 2007; Matthesius und Stelzer 2008). Insbesondere werden in den meisten Publikationen nur Dateien behandelt. Es fehlen auch geeignete Maße für die automatische Klassifizierung (Wertzuweisung) von Daten in DWS im Sinne des ILM.

Für die Klassifizierung im ILM können verschiedene Kriterien herangezogen werden. Die primäre Herausforderung an eine Klassifizierungsmethode stellt somit das Aufstellen geeigneter Kriterien dar (Thome und Sollbach 2007). Klassifizierungsverfahren nutzen derzeit hauptsächlich die Zugriffshäufigkeit als Entscheidungskriterium, um den geeignetsten Speicherort festzulegen (Bhagwan et al. 2005; Chen 2005; Shah et al. 2006). Da dieses Kriterium allein oft zu kurz greift, bleibt eine Einteilung der Daten nach geeigneten Speicherorten, sowie die Abwägung der Vor- und Nachteile einzelner Speichermethoden in der Praxis häufig Systemnutzern oder Experten vorbehalten. Um eine aus Wirtschaftlichkeitsgründen notwendige, automatisierte Klassifizierung zu gewährleisten, sollten Kriterien automatisiert erhoben und verarbeitet werden (Chen 2005, Turczyk et al. 2008). Die Einteilung sollte außerdem multifaktoriell unter Verwendung messbarer Indikatoren geschehen und den Kontext heutiger DWS berücksichtigen. Insbesondere sollten auch die in einem DWS vorhandenen Metadaten für die Klassifizierung herangezogen werden, die zur Klassifizierung von Dateien nicht zur Verfügung stehen (wie später z.B. in Tab. 2 dargestellt).

Das Ziel dieses Beitrages ist es, ein automatisches Klassifizierungsverfahren im Sinne des ILM für Daten in einem DWS zu entwickeln. Dazu sollen folgende Forschungsfragen beantwortet werden:

- Welche Kriterien eignen sich zur automatisierten Klassifizierung in DWS?
- Wie genau können Klassifizierungsverfahren eine Klassifizierung von Daten in DWS automatisiert vornehmen und damit Anwender- und Expertenwissen abbilden?
- Wie gut kann der entwickelte Klassifizierungsalgorithmus im Vergleich zu einer Bewertung ausschließlich auf Basis von Datenzugriffen klassifizieren?

Nachfolgend wird zunächst der Stand der Forschung bezüglich Datenklassifizierung im ILM kurz umrissen. Anschließend werden die verwendeten Praxisdaten sowie unser Vorgehen bei der Auswahl der Klassifizierungsverfahren im DWS-Kontext erläutert. Der weitere Ablauf zur Beantwortung der Forschungsfragen orientiert sich am Prozessmodell des Knowledge Discovery in Databases nach Fayyad et al. (1996). Der Beitrag endet mit einer kurzen Zusammenfassung und Reflexion der Ergebnisse sowie einigen Ansatzpunkten für weitere Forschung.

2 Kurzer Überblick zum Stand der Datenklassifizierung im ILM

Die Forschung hat sich bzgl. der Klassifizierung von Daten im ILM bislang vorrangig mit Dateien beschäftigt (z.B. Turczyk et al. 2008). Um betriebliche Vorgaben und Regeln abzuleiten, wie bestimmte Dateien zu speichern sind, wird in der Literatur beispielsweise eine Geschäftsprozess-analyse vorgeschlagen. So kann das Wissen von Experten, Systemnutzern sowie -administratoren berücksichtigt werden. Entsprechende Konzepte werden beispielsweise in Santry et al. (1999), Bhagwan et al. (2005), Mont und Beato (2007) sowie Kaiser et al. (2008) vorgestellt.

Häufig wird das Zugriffsverhalten der Nutzer auf die Daten untersucht. Insbesondere Zugriffs-häufigkeit sowie Zugriffszeitpunkte sind aussagekräftige Maße für die Informationsnutzung (Chen 2005, Matthesius und Stelzer 2008, Turczyk et al. 2008). Auf Basis von Zugriffsverläufen in Dateisystemen wurden Verfahren für die Klassifizierung von Dateien entwickelt. Einige Autoren schlagen als weitere Möglichkeit vor, einen monetären Wert von Daten festzulegen (Glazer 1993, Moody und Walsh 1999). Andere Verfahren bilden Klassen anhand verschiedener Merkmale wie Alter, Sicherheitsanforderungen oder Risiko. Entsprechende Einteilungen werden z.B. in Thome und Sollbach (2007), Liu et al. (2009) und Shen (2010) verwendet. Eine Methode zur automatischen Wertzuweisung der Daten fehlt in diesen Beiträgen allerdings. Einen Überblick über Publikationen zur Informationsbewertung im ILM geben Matthesius und Stelzer (2008). Sie stellen fest, dass entsprechende Klassifizierungskonzepte für DWS bisher kaum vorhanden sind.

Kosler et al. (2008) stellen ein Klassifizierungskonzept für Daten eines Data Warehouse vor. Basierend auf dem Zugriffsverhalten auf Datenobjekte werden die Speicherung auf Online-, Nearline- oder Offline-Medien oder die Löschung der Daten vorgeschlagen. Ein ähnliches Konzept beschreiben Heinrich und Stelzer (2009). Eine Berücksichtigung der Systemantwortzeit bei Analyseprozessen oder der Datenaktualität finden nicht statt. Auch gegebenenfalls vorhandenes Anwender- und Expertenwissen fließt nicht ein. Außerdem bleiben die meisten DWS-Metadaten (außer den Zugriffsverläufen) unberücksichtigt.

3 Auswahl von Verfahren zur Datenklassifizierung

3.1 Datengrundlage und Konkretisierung der Zielstellung

Im Rahmen der Klassifizierung für das ILM sollen DWS-Daten automatisch in die möglichen Klassen Online, Nearline, Offline und Löschen eingeteilt werden. Gesucht wird ein Verfahren des überwachten Lernens, das heißt in der Trainingsphase werden Datensätze vorgegeben, zu denen die korrekte Klassifizierung bekannt ist (Cleve und Lämmel 2014, 55).

Aus diesem Grund wurden für ein Praxissystem Experteneinschätzungen zu den darin enthaltenen Datenobjekten erhoben. Es standen ein SAP BI-System und verschiedene Metadaten zur Verfügung. Untersucht wurden reale Daten eines großen Automobilzulieferers, dessen SAP BI-

System die Daten von etwa 50 Werken aus vier ERP-Quellsystemen konsolidiert. Im Wesentlichen werden die Logistik (Einkauf, Bestandsführung, Produktion, Verkauf) und Finanzdaten (Rechnungswesen, Controlling) abgebildet. Das betrachtete System umfasste zum Zeitpunkt der Untersuchung 366 GB Daten, 144 Nutzer und 159 Datenobjekte. Zu jedem der Datenobjekte (multidimensionale Strukturen ebenso wie flache Datenobjekte) liegt eine eindeutige Zuordnung in die Klassen Online, Nearline, Offline und Löschen durch Experten (langjährige DWS-Anwender und BI-Berater, die das System betreuen) vor. Das gesuchte Verfahren soll auf diesem impliziten Domänen- und Geschäftsprozesswissen aufbauen und dieses automatisiert abbilden können.

3.2 Literaturanalyse zu anwendbaren Data-Mining-Verfahren

Um herauszufinden, welche Verfahren zur Klassifizierung von Daten in DWS geeignet sind, wurde eine Literaturanalyse nach Webster und Watson (2002) durchgeführt. Dabei wurden neben spezifischen Textbüchern insbesondere wissenschaftliche Beiträge in einschlägigen Datenbanken, wie beispielweise IEEE-Xplore, SpringerLink, Web of Science und ACM Digital Library gesucht. Es wurden die Suchbegriffe „Data-Mining Classification“ „Machine Learning Classification“ sowie eine Erweiterung der Suchbegriffe um „Methods“ oder „Algorithms“ verwendet. Beiträge, die nach Titel und Abstract geeignet erschienen, wurden genauer analysiert. Dabei wurden mittels einer Vorwärts- und Rückwärts-Suche nach Webster und Watson (2002) auch weitere Beiträge auf Basis der bereits gefundenen Quellen identifiziert.

Die so gefundenen Beiträge wurden dahingehend untersucht, welche Verfahren zum Einsatz kommen und welche Rahmenbedingungen vorlagen (Instanzen, Attribute, Skalenniveaus der Daten, Anzahl der Klassen). Es wurden insgesamt 182 Anwendungsfälle gefunden. Auf eine nähere Darstellung muss hier aus Platzgründen verzichtet werden. Aus diesen wurden anschließend die Anwendungsfälle selektiert, die unserer Problemstellung ähneln und für den DWS-Kontext geeignete Größenordnungen darstellen. Die Anzahl der Klassen soll größer zwei sein, um ein Multiklassenproblem zu behandeln, aber auch kleiner zehn Klassen. Die Anzahl der Attribute soll zwischen zehn und einhundert betragen und die Anzahl der Instanzen soll kleiner als eintausend sein. Weiterhin müssen die ausgewerteten Datensätze sowohl nominale als auch numerische Daten enthalten. Dann wurden Beiträge aussortiert, die eine große Anzahl an Verfahren und Datensätzen auswerteten, aber keine nachvollziehbare Auswertung publizieren oder ausschließlich andere Metriken als Genauigkeit verwendeten. Im Folgenden fand eine Beurteilung anhand der erreichten Genauigkeit statt, indem den 20 Anwendungsfällen mit der höchsten Genauigkeit Punkte zugeweisen wurden (höchste Genauigkeit = 20 Punkte; geringste Genauigkeit = 1 Punkt). Daraus wurden die drei Verfahren mit der höchten Punktzahl ausgewählt, da sie für die Klassifizierung am erfolgversprechendsten erscheinen: Multilayer-Perzeptron (MLP), Support Vector Machine (SVM) und Entscheidungsbaumverfahren (C4.5-Algorithmus).

4 Durchführung der automatischen Datenklassifizierung im ILM

4.1 Überblick und Data-Mining-Werkzeug

Wir orientieren uns bei der weiteren Durchführung an dem Prozessmodell des Knowledge Discovery in Databases nach Fayyad et al. (1996, 41). Demnach werden die Schritte Datenselektion, Daten-Vorverarbeitung und Datentransformation (s. Abschnitt 4.2), Durchführung der Datenklassifizierung (s. Abschnitt 4.3 bis 4.5) sowie Interpretation (s. Anschnitt 4.6) und Evaluation (s. Abschnitt 4.7) ausgeführt. In der Datenselektion wird zunächst der Ausgangsdatensatz aus den verschiedenen Quelldatensätzen erstellt. In der Daten-Vorverarbeitung und Datentransformation wird der Ausgangsdatensatz von irrelevanten, redundanten Attributen und solchen mit fehlenden Werten bereinigt. Dann erfolgt die Durchführung der Datenklassifizierung. Die Ergebnisse werden anschließend für jedes Verfahren dargestellt. Abschließend wird das am besten Geeignete der drei Verfahren ausgewählt und die Ergebnisse werden final evaluiert.

Für die Durchführung der Klassifizierung wird als Werkzeug das Data-Mining-Tool WEKA der University of Waikato, Hamilton, New Zealand verwendet (WEKA, 2014). Die Auswahl für diese Software wurde aufgrund der Vielzahl inplementierter Funktionen zur Vorverarbeitung, Klassifizierung sowie Visualisierung gewählt. Zudem wird dieses Werkzeug in den meisten der für die Arbeit ausgewerteten wissenschaftlichen Beiträge, wie beispielsweise Kotsiantis et al. (2007), Wald et al. (2013a) und Chakchai et al. (2014), verwendet.

4.2 Datenselektion, -vorverarbeitung und -transformation

Der zur Verfügung stehende Gesamtdatensatz enthält 159 Datenobjekte mit 115 Attributen. Bei diesen Attributen sind allerdings sehr viele redundante und irrelevante Werte enthalten. Die Verteilung der Instanzen auf die einzelnen Klassen gemäß Experteneinschätzung ist nicht gleichverteilt. Es gibt 68 Instanzen der Klasse Löschen, 41 Instanzen der Klasse Offline, 42 Instanzen der Klasse Online und 8 Instanzen der Klasse Nearline. In einem solchen Fall spricht man von nicht ausgeglichenen Daten oder unbalanced data (Chawla, 2010, 875).

Im Schritt der Datentransformation wurden einige Attribute abgeändert, um für die Anwendung der Klassifizierungsverfahren einsetzbar zu sein. Das betrifft v.a. Datumswerte, die durch Differenzbildung, also die Relativierung eines Datumswertes auf ein Bezugsdatum, in Tagen umgerechnet wurden. Als weitere Transformationsmethode wurde die Normalisierung angewendet, die alle Merkmalsausprägungen eines Attributes auf die Werte einer stetigen, numerischen Skala [0;1] transformiert (Cleve und Lämmel, 2014, 212).

Im Schritt Data Cleaning wurde eine manuelle Sichtung und Entfernung von doppelten Attributen vorgenommen. Dies war möglich, da die Autoren über das Domänenwissen des Praxissystems verfügten. Dabei wurden 25 Attribute bestimmt, die für diese Arbeit nicht relevant sind. Im nächsten Schritt wurden alle Attribute daraufhin überprüft, ob sie Werte enthalten und ob diese Werte unterschiedlich sind. Alle Attribute, bei denen keine Werte eingetragen waren, wurden entfernt. Alle Attribute die jeweils denselben Wert annehmen, wurden ebenso entfernt. Im Anschluss wurden alle Attribute entfernt, die generell keine Relevanz für eine ILM-Analyse haben, wie zum Beispiel Namensfelder oder der Name des letzten Änderers. In unserer Analyse werden also nur Kriterien untersucht, die unabhängig vom betrachteten Praxissystem verwendet werden können, womit die Ergebnisse dieser Arbeit auf andere Anwendungsfälle des ILM übertragbar sind. Das manuelle Vorgehen in einem solchen Fall ist nicht unüblich, da, sofern der Datensatz überschaubar und das notwendige Domänenwissen vorhanden ist, dies eine effektive Methode darstellt (Witten et al. 2011, 60). Nach der manuellen Säuberung der Daten von Attributen mit irrelevanten, falschen und doppelten Werten blieben 39 Attribute übrig.

4.3 Datenreduktion und Attributselektion

Die Datenreduktion hat das Ziel, die Komplexität, die sich aus der Anzahl der Attribute ergibt, weiter zu reduzieren (Cleve und Lämmel 2014, 206), um den Aufwand für die Durchführung der Klassifizierung zu verringern. Durch das Löschen wenig aussagekräftiger Attribute ergibt sich nicht nur eine Verringerung des Aufwandes, sondern auch eine Verbesserung des Ergebnisses (Chizi und

Maimon, 2010, S. 84). Es wurden folgende acht Verfahren als aussichtsreich identifiziert und angewendet: die Ranking-Based-Verfahren RELIEF und Chi-Squared, da mit diesen Verfahren gute Ergebnisse für die Klassifizierungsverfahren SVM und MLP erzielt wurden (Khoshgoftaar et al. 2010; Nguyen und de la Torre 2010), weiterhin das Wrapping mit den Klassifizierungsverfahren SVM, Entscheidungsbaum und MLP, sowie Naive Bayes und Logistic Regression (LR), da hier für SVM und MLP gute Ergebnisse erzielt wurden (Wald et al. 2013b). Zum Vergleich wurde schließlich noch das Subset-Filter-Based-Verfahren CFS eingesetzt (Wald et al. 2013b).

Als Ergebnis liegen nach dieser Attributselektion acht neue Datensätze mit einer reduzierten Attributanzahl zwischen 5 und 20 Attributen vor. Die Ergebnisse der Attributselektion lassen bereits Rückschlüsse bzgl. der Wichtigkeit der einzelnen Attribute zur Datenklassifizierung zu.

4.4 Anwendung der drei ausgewählten Klassifizierungsverfahren

Im Folgenden werden die zuvor ausgewählten Verfahren (Entscheidungsbaum, SVM, MLP) eingesetzt, um den Praxisdatensatz zu klassifizieren. Alle drei Verfahren werden sowohl für alle Datensätze mit reduzierter Attributzahl als auch den ursprünglichen Datensatz mit allen Attributen ausgeführt und die Ergebnisse hinsichtlich der Genauigkeit überprüft. Genauigkeit meint die Anzahl der richtigen Klassifizierungen, geteilt durch die Gesamtanzahl der zu klassifizierenden Instanzen multipliziert mit 100. Sollten sich zwei Verfahren diesbezüglich nicht unterscheiden, so wird der AUC-Wert (Olson und Delen 2008) als weiteres Kriterium herangezogen. Er zeigt den Kompromiss zwischen richtigen und falschen Vorhersagen eines Klassifizierungsmodells an. Je höher der AUC-Wert, umso weniger Fehler werden bei der Klassifizierung gemacht. Der Wert liegt zwischen 0 und 1. Ein AUC-Wert von 1 beschreibt ein perfektes Modell.

Als Validierungsmethode wurde die k-Fold-Cross-Validation-Methode mit k=10 eingesetzt. Dieses Verfahren wurde in fast allen ausgewerteten wissenschaftlichen Beiträgen ebenfalls verwendet (z.B. Chakchai et al. 2014; Jantan et al. 2011; Kotsiantis et al. 2007; Wald et al. 2013a). Das 10-Fold-Cross-Validation-Verfahren hat sich besonders bei kleinen Datensätzen mit wenigen Instanzen als sinnvoll erwiesen (Olson und Delen 2008, 143). Der Übersicht in Tab. 1 sind die Ergebnisse aller 27 Versuche für die Metriken Genauigkeit und AUC-Wert zu entnehmen. Der beste Wert für jede Spalte ist fett markiert. Mittels Attributselektion lässt sich die Genauigkeit der hier verwendeten Verfahren teils deutlich steigern. Das gilt besonders für den Entscheidungsbaum. Zudem wird nicht für alle Verfahren mit dem gleichen Attributsatz das beste Ergebnis erreicht. Insgesamt liefert der Datensatz „Relief Top20“ die besten Klassifizierungsergebnisse.

	Entscheidungsbaum		**SVM**		**MLP**	
Datensatz	Genauigkeit	AUC	Genauigkeit	AUC	Genauigkeit	AUC
Full	74,20%	0,88	83,60%	0,91	81,10%	0,94
MLP-Wrapping	80,50%	0,87	75,50%	0,87	**83,60%**	0,94
SVM-Wrapping	80,50%	0,88	83,00%	0,91	82,40%	0,95
LR-Wrapping	83,60%	0,89	74,80%	0,85	81,10%	0,93
NB Wrapping	84,30%	0,91	76,70%	0,85	78,60%	0,90
C4.5-Wrapping	**86,80%**	0,92	73,00%	0,82	81,10%	0,92
CFS	79,20%	0,88	70,40%	0,84	78,60%	0,92
Chi-Squared Top20	82,40%	0,90	79,20%	0,87	80,50%	0,95
Relief TOP20	**86,80%**	**0,93**	**86,20%**	**0,93**	80,50%	**0,94**

Tabelle 1: Ergebnisse Gesamtübersicht alle Datensätze

4.5 Überprüfung der relativen Attributwichtigkeit

Nachfolgend soll die relative Wichtigkeit der einzelnen Attribute näher untersucht werden, um die erste Forschungsfrage zu beantworten. Bei der Herangehensweise „Entfernen und Zurücklegen“ wird bei allen drei Klassifizierungsverfahren jeweils ein Attribut aus dem Gesamtdatensatz entfernt und die verbliebene Genauigkeit gemessen. Dieser Vorgang wird für jedes Attribut des Datensatzes durchgeführt. Es werden so temporär 20 neue Attributsätze mit jeweils 19 Attributen erzeugt. Der Grundgedanke besteht darin, dass Attribute, deren Entfernen die Genauigkeit des Verfahrens deutlich verringert, wichtige Attribute für das jeweilige Verfahren sind. Da auch untersucht wird, ob sich die Genauigkeit durch das Entfernen verbessert, kann gleichzeitig auch eine weitere Attributselektion vorgenommen werden. Wird ein Attribut gefunden, dessen Entfernen aus dem Attributdatensatz zu einer Verbesserung der Genauigkeit geführt hat, so wird dieses entfernt und der Test mit dem reduzierten Datensatz erneut durchgeführt. Die Reduktion des Datensatz um ein oder mehrere Attribute wird so lang durchgeführt bis kein Attribut mehr identifiziert wird, dessen Entfernung eine Verbesserung der Genauigkeit mit sich bringt.

Eine zweite, alternative Herangehensweise beschränkt sich verfahrensbedingt auf den Entscheidungsbaum. Ein Entscheidungsbaum verwendet zur Modellbildung das Pruning (Vereinfachung eines bereits erstellten Baums), wodurch automatisch nicht alle zur Verfügung stehende Attribute im gebildeten Modell enthalten sein müssen. Es werden von uns nur die Attribute in einen neuen Attributsatz übernommen, welche im Entscheidungsbaum nach dem Pruning noch enthalten sind. Der so reduzierte Datensatz wird dann ebenfalls zur Bildung eines neuen Entscheidungsbaums verwendet und auf seine Attributbestandteile überprüft. Wenn dieser Baum genauer ist als der Vorgängerbaum, wird dieser Vorgang wiederholt, bis alle im Datensatz verbliebenen Attribute im Baum enthalten sind. Abschließend wird noch eine Überprüfung durch „Entfernen und Zurücklegen“ durchgeführt.

Attribute (eines Datenobjekts)	Beschreibung / Wertebereich / Beispielausprägungen	C45	SVM18	MLP5	Anzahl
Tage seit der letzten Änderung	Zahlenwert	x	x	x	3
Existieren Queries auf dem Datenobjekt?	ja / nein; Querys sind multidimensionale Berichtsdefinitionen	x	x	x	3
Alter in Tagen	Zahlenwert	x	x		2
Tage seit letztem Zugriff	Zahlenwert	x	x		2
Zugriffswert nach Heinrich und Stelzer (2009)	numerischer, berechneter Wert anhand der Zugriffe	x	x		2
Bereich	Fachbereich / Organisationseinheit, z.B. Vetrieb, Controlling	x	x		2
Verbindungsgrad	numerischer, berechneter Wert anhand der Verbindungen zu anderen Datenobjekten, vgl. Heinrich und Stelzer (2009)	x	x		2
Navigationsintensität	beschreibt, wie oft in einem Bericht flexibel navigiert wird; Navigationsintensität von 1 bedeutet, Berichte werden nur starr ohne OLAP-Funktionen verwendet; ein Wert > 1 bedeutet einen zunehmenden Anteil flexibler Nutzung	x	x		2
Tage seit letzter Verwendung	letzte Lese- oder Schreiboperation		x		1
Typ des Datenobjekts	multidimensionaler Cube, flaches Datenobjekt		x		1
Ebene nach Heinrich und Stelzer (2009)	vgl. Heinrich und Stelzer (2009)		x		1
Empfohlene Speicherebene nach Heinrich und Stelzer (2009)	vgl. Heinrich und Stelzer (2009)		x		1
Werden Daten aus dem Objekt fortgeschrieben?	ja / nein		x		1
Mit Quellsystem verbunden?	ja / nein		x		1
Ebene nach Oßmann (2008)	vgl. Oßmann (2008)		x		1
Zugriffswahrscheinlichkeit nach Heinrich und Stelzer (2009)	vgl. Heinrich und Stelzer (2009)		x		1
Klasse des Datenobjekts	z.B. Extraktionsebene, Transformationsebene, Datenbereitstellungsebene, Berichtsebene		x		1
Anzahl Querys auf dem Objekt	Zahlenwert			x	1
Anzahl Nutzer, die auf das Objekt zugegriffen haben	Zahlenwert			x	1
Datenbeladungen pro Tag	Zahlenwert			x	1
Informationslebenszyklustyp	z.B. fallender Zugriffsverlauf, konstante Zugriffe über die Zeit		x		1

Tabelle 2: Übersicht wichtiger Attribute für die automatische ILM-Klassifizierung

Mit der Kombination von Pruning und „Entfernen und Zurücklegen“ wurde beim Entscheidungsbaumverfahren der finale Datensatz (C45) generiert. Die finalen Datensätze der anderen beiden

Klassifizierungsverfahren werden als SVM18 und MLP5 bezeichnet. Die Anzahl der gefundenen, wichtigen Attribute variiert zwischen den Verfahren (Tab. 2) - von 5 Attributen bei MLP über 8 beim Entscheidungsbaum bis zu 18 Attributen bei SVM. Zwei Attribute sind in allen drei Verfahren als wichtig eingestuft: die „Tage seit der letzten Änderung“ und „Existieren Queries auf dem Datenobjekt?“. Sechs weitere Attribute sind in zwei der drei Verfahren enthalten.

Tab. 2 dokumentiert die Ergebnisse. Einige Attribute werden in Heinrich und Stelzer (2009) sowie Oßmann (2008) bereits erwähnt, z.B. Ebene, Zugriffswert, Zugriffswahrscheinlichkeit und Verbindungsgrad. Dort sind auch nähere Beschreibungen zu finden. Andere Attribute werden in der Tabelle kurz beschrieben oder sind selbsterklärend.

4.6 Ergebnisse der Klassifizierungsverfahren

In diesem Abschnitt werden die Ergebnisse beschrieben, die mit den einzelnen Verfahren und den dazugehörigen Datensätzen erzielt wurden. Für jedes der drei Verfahren wird eine Konfusionsmatrix erstellt und ausgewertet (Tabellen 3 – 5). Eine Konfusionsmatrix stellt dar, welche Instanzen des Datensatzes einer Klasse zugeordnet worden sind - und gleichzeitig wie sie hätten zugeordnet sein müssen. Die Spalten stellen dabei die tatsächliche Zuordnung nach dem Verfahren dar. Alle Instanzen in einer Zeile gehören in diese Klasse. Aber nur die Instanzen, die sowohl in der Spalte und in der Zeile zu der gleichen Klasse eingeordnet sind, sind auch richtig klassifiziert. Dadurch ergibt sich in der Diagonale von links oben nach rechts unten die Darstellung der Werte, die richtig klassifiziert wurden.

Loeschen	Offline	Nearline	Online	<-- classified as
64	3	0	1	Loeschen
3	35	0	3	Offline
0	1	3	4	Nearline
2	1	0	39	Online

Tabelle 3: Konfusionsmatrix Entscheidungsbaum

Loeschen	Offline	Nearline	Online	<-- classified as
64	2	0	2	Loeschen
3	33	0	5	Offline
0	1	4	3	Nearline
1	0	2	39	Online

Tabelle 4: Konfusionsmatrix SVM

Loeschen	Offline	Nearline	Online	<-- classified as
63	4	0	1	Loeschen
0	39	0	2	Offline
0	2	0	6	Nearline
1	3	0	38	Online

Tabelle 5: Konfusionsmatrix MLP

Die Verfahren bieten mit 88,7 % Genauigkeit für den Entscheidungsbaum und 88,1 % Genauigkeit für die SVM und MLP eine nahezu identische Genauigkeit bei der Klassifizierung. Dennoch lassen sich anhand der Konfusionsmatrizen einige Unterschiede herausstellen.

Die genaueste Vorhersage der stark unterrepräsentierten Klasse Nearline wird durch das SVM-Verfahren erreicht. Das Entscheidungsbaumverfahren sagt diese Klasse auch noch relativ gut voraus, während das MLP-Verfahren diese Klasse nur falsch vorhersagt. Dafür hat das MLP-Verfahren den insgesamt besten Wert bei der Fehlklassifizierung der Klasse Offline. Hier schneiden der Entscheidungsbaum und das SVM-Verfahren wesentlich schlechter ab.

4.7 Auswahl und Evaluation des finalen Klassifizierungsverfahrens

Für die endgültige Entscheidung, welches Klassifizierungsverfahren am geeignetsten im gegebenen Kontext ist, reicht die Genauigkeit als alleiniges Kriterium nicht aus. Daher wird im Sinne des ILM betrachtet, WIE die Instanzen falsch klassifiziert wurden. Es wird unterschieden, ob die Fehlklassifizierung in eine angrenzende Klasse geschieht oder nicht. Der Grundgedanke ist, dass eine Klassifizierung in eine angrenzende Klasse weniger schlecht ist als in eine entferntere Klasse. Die Reihenfolge der Klassen entspricht dabei dem ILM-Speichermodell Online, Nearline, Offline und Löschen. Für eine Falschklassifizierung wird je ein Fehlerpunkt pro falsch klassifizierte Instanz bei angrenzenden Klassen vergeben. Erfolgt die Fehlklassifizierung in eine weiter entfernte Klasse, so wird je dazwischen liegender Klasse ein weiterer Fehlerpunkt addiert. Für eine Fehlklassifizierung in die Klasse Löschen wird ein zusätzlicher Fehlerpunkt vergeben, da eine Fehlklassifizierung in diesem Fall einen weitaus höheren Schaden anrichtet als das bei anderen Klassen der Fall ist. Zur Berechnung der Fehlerpunkte werden die Konfusionsmatrizen der einzelnen Verfahren ausgewertet.

Für das Verfahren Entscheidungsbaum ergeben sich nach dieser Verfahrensweise 33 Fehlerpunkte. Für das SVM-Verfahren werden 34 Fehlerpunkte errechnet und für das MLP-Verfahren 29 Fehlerpunkte. Die in der Gesamtgenauigkeit fast identischen Verfahren zeigen nach der Bewertung der „Fehlerschwere“ jetzt abweichende Ergebnisse. Auf Basis dieser Berechnung wird das MLP-Verfahren als am besten geeignet für die Aufgabenstellung erachtet.

Um die Genauigkeit der Ergebnisse besser einschätzen zu können, wurden zwei weitere, recht simple Klassifizierungsverfahren angewendet. Zum einen wurde nach der Moore’schen Regel bestimmt, welche Klasse gewählt werden sollte. Demnach werden die Objekte lediglich nach dem Alter klassifiziert, wobei nach je 90 Tagen eine Verlagerung auf das nächste Speichermedium (Online -> Nearline -> Offline -> Löschen) erfolgt. Da für alle Datenobjekte des Praxissystems das Alter bekannt war, kann jeweils die Klasse gemäß dieser einfachen Regel bestimmt, sowie die Genauigkeit gegenüber der Experteneinschätzung und die Fehlerpunkte gemäß der vorigen Vorschrift berechnet werden.

Als zweite Vergleichsklassifizierung wird auf Basis der Datenzugriffe klassifiziert. Alle Objekte wurden anhand ihrer Zugriffshäufigkeit sortiert und gemäß der Verteilung der Klassen in der Experteneinschätzung klassifiziert, um eine möglichst hohe Übereinstimmung zu erreichen. D.h. es wurden die 68 Objekte mit den geringsten Zugriffen der Klasse Löschen zugeordnet, die folgenden 41 der Klasse Offline, weitere acht Objekte der Klasse Nearline und die 42 Instanzen mit den meisten Zugriffen der Klasse Online. Nach dieser Klassifizierung entspricht also jeweils die Anzahl der Instanzen in jeder Klasse genau der Experteneinschätzung.

Das Verfahren nach Moore liefert für den Praxisdatensatz eine Genauigkeit von 51,6 % und 197 Fehlerpunkte. Das rein zugriffsbasierte Verfahren erzielt eine Genauigkeit von 62,3 % und 98 Fehlerpunkte. Da bisher für den DWS-Kontext keine passenden Verfahren publiziert wurden, können nur diese trivialen alternativen Klassifizierungsverfahren herangezogen werden. Die

Ergebnisse zeigen, dass die von uns verwendeten Verfahren mit Berücksichtigung der DWS-Metadaten (Attribute) eine deutlich bessere Klassifizierung im Sinne des ILM ermöglichen.

5 Fazit und kritische Betrachtung

Ein Kernaspekt im Information Lifecycle Management betrifft die Frage, wo Daten gespeichert werden sollen, da hiermit unterschiedliche Kosten und Zugriffszeiten verbunden sind. Die manuelle Klassifizierung scheidet als zu aufwändig aus. Im vorliegenden Beitrag konnte gezeigt werden, dass eine qualitativ gute automatische Klassifizierung von Daten in DWS-Systemen im Sinne des ILM möglich ist. Dazu wurden Verfahren des überwachten Lernens eingesetzt. Anhand einer Auswertung wissenschaftlicher Beiträge wurden durch Analogieschluss die drei Verfahren Entscheidungsbaum, SVM und MLP als geeignet ausgewählt. In Anlehnung an das Prozessmodell von Fayyad et al. (1996, S. 42) wurden die eingesetzten Praxisdaten selektiert, transformiert und reduziert. Durch Datenreduktion mittels Attributselektion und die Bestimmung der Attribute mit großer Bedeutung für die Verfahren konnte die Vorhersagegenauigkeit für die einzelnen Verfahren jeweils (zum Teil stark) verbessert werden. Ein weiteres Ergebnis dieser Selektion ist, dass für jedes der drei Verfahren Attributsätze mit teils unterschiedlichen Attributen zielführend sind. Lediglich zwei Attribute sind für alle drei Verfahren wichtig.

Zur Auswahl des am besten geeigneten Verfahrens wurde eine Methode gewählt, die einerseits die Genauigkeit der Klassifizierung beinhaltet, andererseits auch betrachtet, welche Auswirkungen Fehlbewertungen haben. Das Verfahren MLP mit fünf Attributen aus den DWS-Metadaten schnitt auf dieser Basis am besten ab und erreichte eine Genauigkeit von 88,1 %. Das hier erzielte Ergebnis ordnet sich damit bei den eingangs in der Literatur identifizierten, grob vergleichbaren Data-Mining-Szenarien unter den besten fünf ein. Zur Evaluation wurden weiterhin zwei Datenklassifizierungen, die auf dem Alter bzw. den Zugriffshäufigkeiten basieren, für den Praxisdatensatz bestimmt. Alle von uns eingesetzten Klassifizierungsverfahren auf Basis von DWS-Metadaten erzielten hier im Vergleich klar bessere Ergebnisse, was ein starkes Argument darstellt, die DWS-Metadaten zukünftig für die automatische Klassifizierung im ILM zu nutzen, um eine mit Experteneinschätzungen vergleichbare Klassifizierungsleistung zu erzielen. Mit der erreichten Genauigkeit und der Evaluation der Modelle kann bestätigt werden, dass eine automatisierte Datenklassifizierung von Daten in DWS möglich ist. Die von uns getesteten Verfahren erscheinen grundsätzlich unabhängig vom hier betrachteten Einzelfall und auf andere DWS-Kontexte im ILM übertragbar, sodass sie zur Kostenreduktion von DWS über die Domäne Automobilsektor hinaus eingesetzt werden könnten.

Kritisch anzumerken ist, dass der zur Verfügung stehende SAP-Datensatz lediglich 159 Instanzen enthält. Die Genauigkeit eines Klassifizierungsverfahrens hängt grundlegend von der Größe verfügbarer Daten ab, auf deren Basis das Modell erstellt wurde. Hinzu kommt, dass hier Realdaten eines Kunden aus der Automobilbranche verwendet wurden. Bei Datensätzen aus anderen Brachen könnten die Ergebnisse eventuell hinsichtlich der Bedeutung einzelner Attribute variieren. Dies sollte in Folgeuntersuchungen überprüft werden. Hinzuweisen ist auch auf die ungleichmäßige Verteilung der Instanzen auf die verfügbaren Klassen in unseren Praxisdaten. Weiterhin wäre es sinnvoll, in regelmäßigen Abständen die Expertenklassifizierungen überprüfen zu lassen. Die Ergebnisse dieser Arbeit könnten zudem durch eine Integration neuer Speicherkonzepte wie In-Memory- oder Cloud-Technologien sowie einer Berücksichtigung weiterer, qualitativer Merkmale wie etwa gesetzlicher Vorgaben vertieft werden.

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MetaSimLab: Ein Labor zur Validierung und Kalibrierung agentenbasierter Simulationen für die betriebswirtschaftliche Entscheidungsunterstützung

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Abstract

Lösungsansätze der betriebswirtschaftlichen Entscheidungsunterstützung werden häufig mithilfe von Simulationen entwickelt und bewertet. Hängt das Ergebnis von der Interaktion unabhängiger Akteure ab, bieten sich agentenbasierte Simulationsmodelle an. Ein Beispiel ist das Zusammenspiel von Anbietern und Kunden bei der automatisierten Erlössteuerung.

Um verlässlich zu sein, müssen agentenbasierte Simulationen vor ihrer Verwendung empirisch kalibriert und validiert werden. Die Kalibrierung ermittelt Eingangsparameter, die Validierung misst die Abweichung zwischen Simulationsergebnissen und empirischen Daten. Da existierende Ansätze der Kalibrierung kaum automatisiert, und daher zeit- und kostenaufwendig sind, werden neue Methoden und ein Werkzeug zu ihrer Bewertung benötigt.

In diesem Beitrag stellen wir die Laborumgebung MetaSimLab vor, um die Effizienz und Anwendbarkeit von Kalibrierungsansätzen zu bewerten. MetaSimLab kann Kalibrierungsansätze im Zusammenspiel mit austauschbaren Simulationsmodellen, Validierungsansätzen und Datensätzen vergleichend bewerten. Ein numerisches Beispiel für den Einsatz von MetaSimLab und ein Ausblick auf weitere Forschung runden den Beitrag ab.

1 Einleitung

Killerwale, die ihre Beute verfolgen, Krebszellen, die mutieren und sich verbreiten und Unternehmen, die transorbitalen Tourismus etablieren wollen, sind nur einige Beispiele für akteursgetriebene Systeme (Macal & North, 2010). Die langfristige Entwicklung derartiger Systeme und die Konsequenzen von Eingriffen sind schwer vorherzusagen, da sie sich aus den Entscheidungen der heterogenen Akteure ergeben: Wale, Krebszellen und Unternehmen. Akteure beobachten ihre Umwelt und passen sich an, sie treffen Entscheidungen und setzen diese um. Während sie individuelle Ziele anstreben, determinieren sie als Gruppe gleichzeitig das makroskopische Verhalten des Systems (Gilbert & Troitzsch, 2005). Bei dem Versuch, komplexe und nichtlineare Entscheidungsregeln abzubilden, werden analytische Modelle schnell unübersichtlich und unlösbar.

Die nächste Generation der Entscheidungsunterstützung beruht auf Business Analytics: Die traditionelle Idee des Operations Research, Probleme durch mathematische Modellierung und Optimierung zu lösen, ergänzt Business Analytics durch Methoden der deskriptiven und prädiktiven Datenanalyse (Liberatore & Luo, 2010). So setzt sich auch die betriebswirtschaftliche Entscheidungsunterstützung mit durch heterogene Akteure getriebenen Planungsproblemen auseinander.

Beispielsweise optimiert die Erlössteuerung die Preise von Produkteinheiten basierend auf Nachfrageprognosen (Cross, 2011). In einem automatisierten Reservierungssystem treffen Kundenanfragen auf Tarifverfügbarkeiten. Während Unternehmen den Erlös maximieren wollen, wollen Kunden den gezahlten Preis für das präferierte Produkt minimieren. Zu diesem Zweck vergleichen sie Angebote, überwachen Preise, tauschen sich aus und entscheiden sich schließlich. Somit bilden Unternehmen und Kunden ein Bilderbuchbeispiel für heterogene Akteure.

Ein weiteres Beispiel findet sich in der Lieferwegsplanung (vgl. Fleischmann et al., 2004): Die Reisezeit eines Lieferwagen hängt sowohl von Straßenkapazitäten und Reiseaufkommen als auch von den geplanten Anlieferzeiten ab. Das Reiseaufkommen wird vom Verkehrsverhalten beeinflusst; dieses ist die Summe der Aktionen einzelner Fahrer, die sich die Straße teilen. In Abhängigkeit von individuellen Präferenzen und verfügbaren Information können Fahrer Staus vermeiden oder zu ihnen beitragen.

Die Entscheidungsunterstützung löst derartige Probleme mit vereinfachten mathematischen Optimierungsmodellen. Agentenbasierte Simulationen können die berechneten Lösungsvorschläge unter realistischeren Konditionen bewerten: Sie modellieren das individuelle Verhalten der heterogenen Agenten und die daraus entstehenden emergenten Phänomene, bewerten die Konsequenzen der durch den Lösungsvorschlag verursachten Eingriffe ceteris paribus, und berechnen die langfristige Entwicklung des ganzen Systems (Macal & North, 2010).

Um für die Unternehmenspraxis verlässlich zu sein, müssen Simulationsmodelle rigoros empirisch validiert werden. So betonen beispielsweise North & Macal (2007): “before appropriate verification and validation, models are toys; after appropriate verification and validation, models are tools”. Die Autoren nennen das Verhalten von Agenten, ihre Interaktionen und die resultierenden emergenten Phänomene als Herausforderungen für die Validierung.

Ein Simulationsmodell ist valide, wenn seine Struktur und Parameter so kalibriert wurden, dass Eingangsdaten oder Ergebnisse nur noch um eine akzeptablen Spanne von den empirischen Beobachtungen abweichen (Zeigler et al., 2000). Leider lassen gerade komplexe, agentenbasierte Simulationen häufig keine Validierung der Eingangsdaten zu (Railsback & Grimm, 2011). Außerdem sind die Validierungsergebnisse häufig mehrdeutig – verschiedene Eingangsparametern führen zum gleichen Ergebnis. Diese Umstände erschweren die Kalibrierung und reduzieren somit den Nutzen agentenbasierter Simulationen.

Als Beitrag zur Überwindung dieses Dilemmas, stellen wir das virtuelle Labor MetaSimLab vor. MetaSimLab kann Kalibrierungsansätze für agentenbasierte Simulationen der betriebswirtschaftlichen Entscheidungsunterstützung systematisch bewerten. So evaluierte Kalibrierungsansätze können Simulationen glaubwürdiger und verlässlicher machen und damit ihre Akzeptanz als Forschungswerkzeug erhöhen. Das MetaSimLab soll also neue Kalibrierungsansätze aus der Forschung für die verbesserte Nutzbarkeit von Simulationen in der Wirtschaft evaluieren. Unsere

Forschung folgt dem gestaltungsorientierten Paradigma nach Hevner et al. (2004): Durch die Entwicklung und den Einsatz von MetaSimLab verfolgen wir die Erweiterung der menschlichen und organisationalen Fähigkeiten durch die Entwicklung innovative Artefakte. Das übergreifende Ziel ist, die Methodik agentenbasierten Simulationen in der Betriebswirtschaft der von naturwissenschaftlichen Simulationen anzunähern.

Es folgt eine kurze Literaturübersicht zu Rolle und Kalibrierung von agentenbasierten Simulationen in der betriebswirtschaftlichen Entscheidungsunterstützung. Anschließend stellen wir MetaSimLab und seine Funktionsweise vor. Zur Illustration dokumentiert der vierte Abschnitt die Kalibrierung und Validierung einer beispielhaften Simulation. Im Abschluss fassen wir die Möglichkeiten von MetaSimLab zusammen und beschreiben die geplante Weiterentwicklung und eine Agenda für die zukünftige Forschung.

2 Literatur

Zahlreiche Forschungsbeiträge zu agentenbasierten Simulationen betonen die Rolle von Kalibrierung und Validierung: Kleindorfer et al. (1998) bezeichnen die Validierung von Simulationen sogar als ethisches Problem. Crooks et al. (2008) zählen die Kalibrierung von Modellen zu den größten Herausforderungen der Simulation zur sozialwissenschaftlichen Forschung. Hofmann (2013) betont die Notwendigkeit – und den zweifelhaften Status – der Validierung von Simulationen für die Entscheidungsunterstützung.

Das Thema Kalibrierung wurde zwar in Hinblick auf diskret-ereignisorientierte Simulationen bereits seit vielen Jahren untersucht, bleibt jedoch voller Herausforderungen (Sargent, 2013). Agentenbasierte Simulationen können als Spezialfall von ereignisorientierten Simulationen gelten (Nance und Sargent, 2002). Doch die Notwendigkeit, die Entscheidungsregeln individueller Agenten zu parametrisieren, erschwert die Anwendung von Methoden, die für klassische ereignisorientierte Simulationen entwickelt wurden (Midgley et al., 2007).

Wie Troitzsch (2009) betont, müssen Forscher bei der Validierung agentenbasierter Simulationen stets deren Zweck bedenken. Eine Simulation, welche kausale Zusammenhänge untersuchen soll, wird mit anderen Ansprüchen konfrontiert als eine, die Vorhersagen über das Verhalten eines Systems treffen soll. Die Validierungsansprüche an Simulationen zur Entscheidungsunterstützung sind hoch: Das Modell muss möglichst konkrete Vorhersagen über den zu erwartenden Erfolg verschiedener Lösungsansätze treffen, die die Reaktion der involvierten Akteure berücksichtigen.

Fagiolo et al. (2007) stellen einige theoretische Ansätze zur Simulationskalibrierung vor. Sie diskutieren Vor- und Nachteile jeder Alternative in Hinblick auf die benötigten Daten. Im Fazit weisen die Autoren auf Dilemma hin, die besonders für agentenbasierte Simulationen als Werkzeug der betriebswirtschaftlichen Entscheidungsunterstützung gelten: Wenn die Zahl der Parameter die verfügbaren Beobachtungen übertrifft, kann mehr als ein Parametersatz zu validen Ergebnissen führen. Den Umfang eines Simulationsmodells abhängig von den verfügbaren Daten strikt zu limitieren, kann jedoch die potentiellen Erkenntnisse und damit den Nutzen der Simulation vorab limitieren.

Nur wenige existierende Beiträge setzen sich konkret mit systematischen Ansätzen zur Kalibrierung von Simulationen auseinander. Eine Variante, die auf kritischem Realismus basiert, wird von Werker und Brenner (2004) vorgeschlagen. Die Autoren weisen jedoch darauf hin, dass diese Art der Kalibrierung Modelle betrifft, die das generelle Verständnis eines Systems unterstützen und nicht quantitative Voraussagen über sein Verhalten machen sollen. North & Macal (2007) empfehlen die Verwendung von Daten, um die Werte von Modellparametern zu schätzen, gehen jedoch nicht genauer darauf ein, wie diese Werte geschätzt werden sollen. Rand & Rust (2011) betonen den Wert der empirischen Validierung für agentenbasierte Simulationen im Marketing und verweisen auf stilisierte Fakten, empirische Daten und die Verwendung bereits validierter Teilmodelle. Während die Autoren die Risiken einer zu großen Zahl von Parametern und die Bedeutung der Kalibrierung betonen, schlagen sie keine spezifischen Ansätze vor.

Um die Entscheidungsregeln von Agenten zu spezifizieren, empfehlen Midgley et al. (2007), sowohl Eingangs- und Ausgangsdaten zu kalibrieren, als auch den Umfang von Modellen zu limitieren. Die Autoren schlagen einen genetischen Algorithmus als Mittel zur destruktiven Verifikation, Validierung und Kalibrierung vor. Das unterliegende Konzept geht auf Miller (1998) zurück. Einen genetischer Algorithmus verwenden auch Vock et al. (2014), um agentenbasierte Simulationen für die Erlössteuerung zu kalibrieren. Entsprechende Algorithmen ließen sich auch im MetaSimLab evaluieren und weiterentwickeln.

Literatur zur Entscheidungsunterstützung dokumentiert idealerweise die Kalibrierung im speziellen Fall, untersucht aber kaum deren generelle Implikationen. Beispielsweise beschreiben Flötteröd et al. (2011) primär die Kalibrierung von Nachfragemodellen für Verkehrssimulationen, während Sun und Elefteriadou (2012) eine derartige Simulation als Teil eines Algorithmus für die Berechnung von automatisierten Spurwechseln einsetzen. Flötteröd et al. (2011) schlagen eine Bayes-Methode zur Nachfragekalibrierung für Verkehrssimulationen vor. Diese Methode stellt mittels Kreuzvalidierung sicher, dass unterschiedliche Datensätze für die Kalibrierung und Validierung herangezogen werden. Es bleibt allerdings unklar, wie erfolgreich eine ähnliche Herangehensweise unter anderen Voraussetzungen zu Daten und Modell wäre. Das gleiche gilt für die von Sun & Elefteriadou (2012) sowie Vock et al. (2014) vorgeschlagenen Ansätze. Die Entwicklung von MetaSimLab soll die weiterführende Evaluation derartiger bereits im Einzelfall erfolgreicher Ansätzen ermöglichen.

3 MetaSimLab

MetaSimLab wurde als Labor zur vergleichenden Bewertung von Validierungs- und Kalibrierungsansätzen konzeptioniert. Daher beinhaltet es neben einer Steuerungskomponente drei austauschbaren Komponenten zu Simulation, Validierung und Kalibrierung. Abbildung 1 gibt einen Überblick über die Interaktion der verschiedenen Komponenten.

MetaSimLab wurde in der Programmiersprache Java entwickelt. Die Umsetzung in einer weit verbreiteten, objektorientierten, plattformunabhängigen Sprache erleichtert die Adaption durch neue Nutzer und Entwickler. Auch für die Entwicklung von agentenbasierten Simulationen werden objektorientierte Paradigmen empfohlen (Gilbert, 2008). Die Möglichkeit, Interfaces zu implementieren, stellt darüber hinaus sicher, dass unterschiedliche Varianten der austauschbaren Komponenten mit dem Gesamtsystem kompatibel bleiben.

3.1 Überblick und Programmdurchlauf

Als *Simulationskomponente* kann eine beliebige Simulation, die ein festes Set von Eingangsparametern in eine definierte Menge von Ergebnisindikatoren umwandelt, eingesetzt werden.

Die *Validierungskomponente* besteht aus einem Algorithmus, der einen Simulationsdatensatz und einen empirischen Datensatz miteinander vergleicht und Abstandsindikatoren berechnet.

Die *Kalibrierungskomponente* besteht aus einem Algorithmus, der aus historischen Simulationsparametern, -ergebnissen und Validierungsindikatoren neue Simulationsparameter berechnet.

Die *Steuerungskomponente* setzt die Abbruchbedingungen für Simulations- und Kalibrierungs-experimente. Darüber hinaus können empirische Datensätze, Simulationen, Validierungs- und Kalibrierungsansätze ausgewählt und für Validierung und Kalibrierung erforderliche Parameter gesetzt werden. Die Steuerungskomponente stellt sicher, dass alle Schnittstellen auf das von der Simulation benötigte und erzeugte Datenformat ausgerichtet sind.

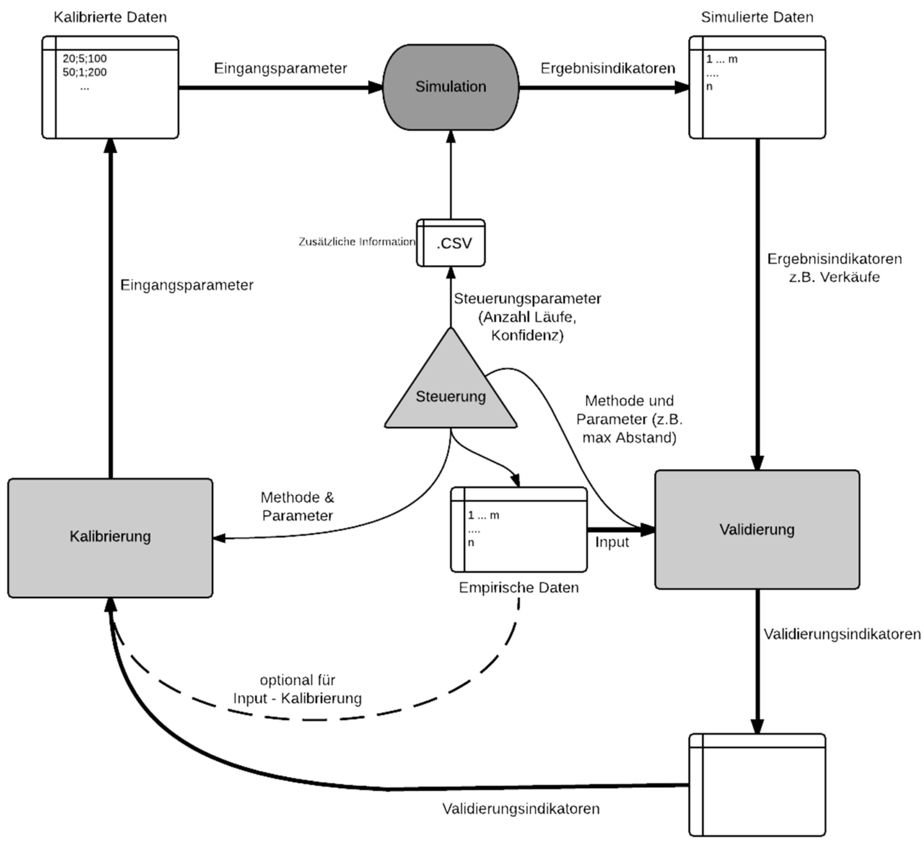

Abbildung 1: MetaSimLab Überblick

Ein Programmdurchlauf enthält folgende Schritte:

1. Der Nutzer wählt ein Simulationsmodell aus und parametrisiert die Durchführung.
2. Der Nutzer wählt aus den auf das Simulationsmodell anwendbaren Kalibrierungs- und Validierungsansätzen jeweils einen aus.
3. Der Nutzer wählt einen empirischen Datensatz aus.
4. Der Nutzer legt als Abbruchkriterien die gewünschte Validierungsgüte sowie eine maximale Anzahl an Kalibrierungsläufen fest.

5. Die Steuerungskomponente teilt den empirischen Datensatz in Lern- und Validierungssätze auf, um die Überkalibrierung des Systems zu vermeiden.
6. Auf Basis des Lerndatensatzes erstellt die Kalibrierungskomponente einen ersten Parametersatz und übergibt ihn der Simulationskomponente.
7. Die Simulationskomponente führt die vorgegebene Zahl von Simulationsläufen mit den von der Kalibrierungskomponente vorgegebenen Parametern durch. Die Ergebnisindikatoren werden an die Validierungskomponente weitergeleitet.
8. Die Validierungskomponente vergleicht die Ergebnisse der Simulation mit dem empirischen Datensatz und erzeugt Validierungsindikatoren. Diese werden an die Steuerungskomponente und von dort ggf. an die Kalibrierung weitergeleitet.
9. Die Steuerung vergleicht Validierungsindikatoren mit den Vorgaben des Nutzers, um die Abbruchsbedingung zu überprüfen: Sind der gewünschte Maximalabstand oder die maximale Zahl an Kalibrierungsläufen nicht erreicht, werden Simulationsergebnisse und Validierungsindikatoren an die Kalibrierung weitergeleitet.
10. Die Kalibrierungskomponente leitet aus den alten Eingangsparametern, Simulationsergebnissen und Validierungsindikatoren neue Eingangsparameter für das nächste Simulationsexperiment ab. Indem diese an die Simulationskomponente weitergeleitet werden, beginnt der nächste Programmlauf.

3.2 Schnittstellen und Datenspeicherung

Um austauschbare Komponenten zu ermöglichen, implementiert MetaSimLab jeweils Interfaces für Kalibrierung, Validierung und Simulation. Die enthaltenen Methoden müssen von jeder Komponente implementiert werden und stellen kompatible Formate sicher.

Das Interface *Calibrator* definiert zwei Methoden für jede Kalibrierungskomponente.

Die erste Methode erzeugt Eingangsparameter für die Simulation und speichert diese persistent. Ihr Rückgabewert ist ein java.io.File-Objekt, welches die so generierte Datei repräsentiert. Der implementierte Algorithmus zur Berechnung der Eingangsparameter ist abhängig von der Methodik der jeweiligen Komponente.

Die zweite Methode verwaltet empirische Daten und Validierungsergebnisse. Da die Kalibrierung auf die bisherigen Ergebnisse der Validierungskomponente zurückgreifen kann, werden diese nach jeder Validierung an die Kalibrierungskomponente übergeben.

Das Interface *Validator* definiert ebenfalls zwei Methoden für alle Validierungskomponenten.

Eine Methode implementiert den Validierungsansatz der Komponenten. Durch den Abgleich von Simulationsergebnissen mit empirischen Daten misst die Validierung die Nähe des Simulationsmodells zu realen Instanzen. Die Ergebnisse werden an die Steuerungskomponente weitergeleitet.

Eine weitere Methode verwaltet die Daten für die Validierung: Sie liest empirische Daten und Simulationsergebnisse ein. Die Steuerungskomponente entscheidet bei der Unterteilung von Lern- und Validierungsdaten darüber, welcher Teil des empirischen Datensatzes jeweils zu verwenden ist. Nach Ablauf der Simulation werden alte Ergebnisse durch neue überschrieben.

Zur Speicherung von Validierungs- und Kalibrierungsdaten existieren abstrakte Klassen, die das Format der jeweiligen Ergebnisse nicht näher spezifizieren, es jedoch erlauben, in dem beschriebenen Interface *Calibrator* eine Methode zur Speicherung der Ergebnisse zu definieren. Jede konkrete Kalibrierungs- und Validierungskomponente muss Klassen enthalten, die von diesen abstrakten Klassen erben und es ermöglichen, die Ergebnisse in einem entsprechenden Format abzulegen.

Wie zuvor erläutert, soll MetaSimLab austauschbare Simulationsmodelle integrieren können. Zu diesem Zweck stellt ein in der Steuerungskomponente definierter Regelsatz sicher, dass die Eingangsparameter und Ergebnisindikatoren jeder Simulationskomponente den Anforderungen von Validierung und Kalibrierung genügen.

Sowohl Eingangsparameter als auch Ergebnisindikatoren werden in externen Dateien abgelegt. Diese Vorgehensweise geht mit Laufzeitverlusten einher, hat aber den Vorteil, einen archivierbaren Datensatz zu erzeugen. Dieser kann auch nach Abschluss eines Kalibrierungsexperiments extern, z.B. mit R, ausgewertet werden. Auf diese Weise können außerhalb von MetaSimLab Einsichten in den Erfolg von Kalibrierung und Validierung gewonnen werden. Durch die Erweiterung oder Neuentwicklung der existierenden Komponenten können diese Einsichten wieder in MetaSimLab eingehen.

4 Numerisches Beispiel

Um den Ablauf eines Kalibrierungsexperiments zu verdeutlichen, beschreiben wir einen einfachen Versuchsaufbau. Nach der Beschreibung des Simulationsmodells definiert ein Unterabschnitt die von der Validierung implementiertem Abstandsmaße. Der dritte Unterabschnitt präsentiert den implementierten Kalibrierungsalgorithmus. Den Abschluss bildet eine beispielhafte Analyse der numerischen Ergebnisse.

4.1 Simulationsmodell: Kaufentscheidungen kommunizierender Kunden

Für dieses numerische Beispiel implementieren wir eine minimalistische Marktsimulation, ähnlich dem in Buwaya & Cleophas (2015) vorgestellten Modell. Darin bietet ein Anbieter mehrere substituierbare Produkte zu verschiedenen Preisen an, während die Kaufentscheidung der Kunden u.a. von ihrer Kommunikation in einem Netzwerk abhängt. Abbildung 2 zeigt den Ablauf der Simulation, der im folgenden kurz zusammengefasst wird.

Vor Start eines Simulationslaufs wird aus einer Zufallsverteilung gezogen, wie viele Kunden mit welcher Zahlungsbereitschaft und welchen Produktpräferenzen eine Kaufentscheidung treffen werden. Diese Kunden werden durch eine Warteschlange modelliert, in der die ersten Käufer die späteren informieren und so beeinflussen.

Durch von Kommunikation abhängige Kaufentscheidungen bilden die hier modellierten Kunden ein schönes Beispiel für akteursgetriebene Systeme. Eine Weiterentwicklung könnte auch das Angebot als Entscheidung des Anbieters, welcher die Reaktion der Nachfrage auf sein Angebot lernt, abbilden. In der hier beschriebenen Variante ist die Anbieterentscheidung statisch: Vor Beginn eines Simulationslaufs wird festgelegt, welches Produkt zu welchem Preis angeboten wird. Dieses Angebot entspricht demjenigen, auf dessen Basis die empirischen Daten entstanden.

Kunden kaufen, wenn der Nutzen des Produkts, bewertet durch ihre Präferenzfunktion abzüglich des Preises, ihre Zahlungsbereitschaft überschreitet. Das heißt, dass Kunden bereit sind, für ein hochgeschätztes Produkt mehr zu zahlen.

Entscheidet sich ein Kunde zum Kauf, so geht dieser in die Ergebnisindikatoren der Simulation ein. Gleichzeitig kommuniziert der Kunde seine Entscheidung an einige noch in der Warteschlange befindliche Kunden. So beeinflusst er deren Zahlungsbereitschaft positiv oder negativ.

Die Eingangsparameter der Simulation definieren die Gesamtzahl der Kunden sowie eine Reihe von Kundentypen. Pro Kundentyp werden der Anteil, die Zahlungsbereitschaft, Präferenzen sowie Erwartungswert und Streuung der Ankunftszeit definiert.

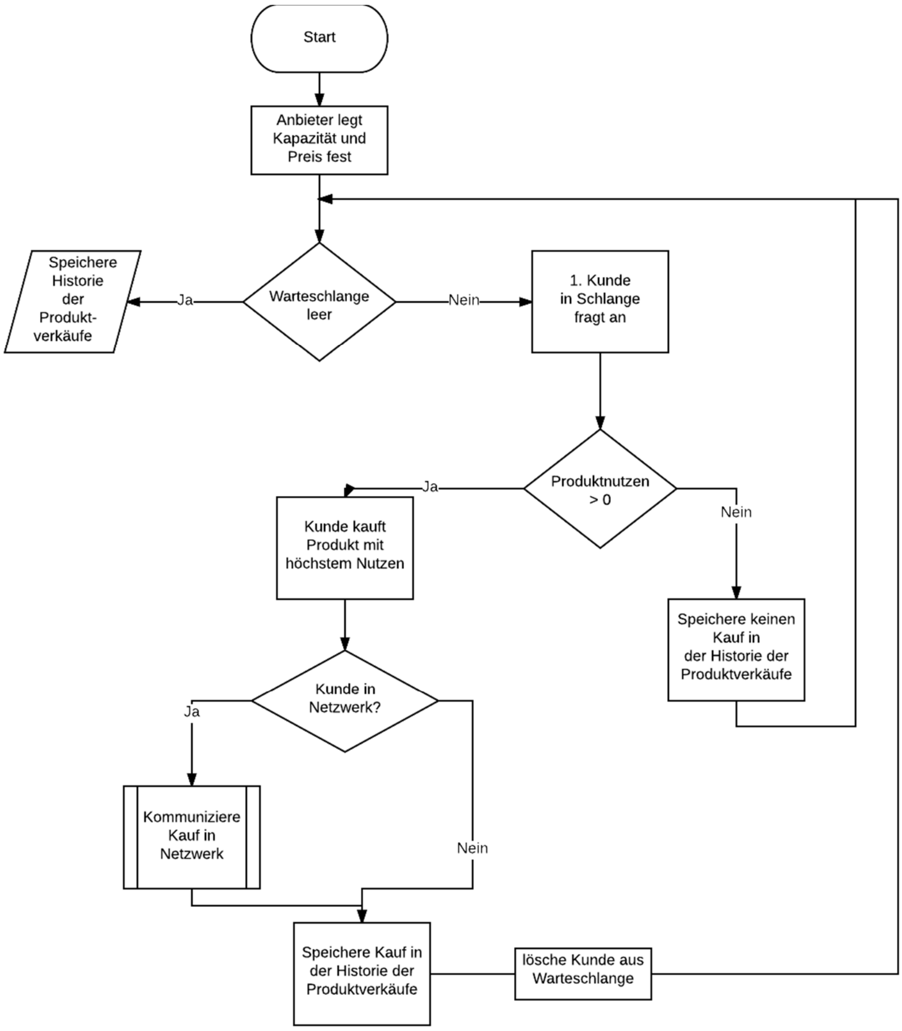

Abbildung 2: Ablauf der Simulation

4.2 Validierung

In diesem Beispiel misst die Validierung den Abstand von empirischen Daten zu Simulationsergebnissen mittels des *Mean Absolute Percentage Error (MAPE)*. In den empirischen Daten seien $n \in N$ Werte mit E_i, $1 \leq i \leq n$. Die Werte der simulierten Daten werden analog mit S_i bezeichnet. Der *MAPE* ergibt sich dann als:

$$M = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{E_i - S_i}{E_i}\right|$$

Die Kennzahl repräsentiert den Abstand von Simulationsergebnissen und empirischen Beobachtungen mittels einer Prozentzahl M. Je niedriger der prozentuale Abstand, desto höher wird die Validität der Ergebnisse eingeschätzt. Die potentielle Division durch 0,für $E_i = 0$ wird wie folgt umgangen: In diesem Fall wird nicht durch den konkreten Wert E_i, $1 \leq i \leq n$ geteilt, sondern durch den Durchschnitt aller Werte $\bar{E}$ (vgl. Goodwin & Larson, 1999).

$$\bar{E} = \frac{1}{n}\sum_{i=1}^{n} E_i$$

Im hier beschriebenen Beispiel vergleicht die Validierung die Ergebnisse der Simulation mit ebenfalls durch die Simulation erzeugten pseudo-empirischen Ergebniswerten. Dieser Kunstgriff stellt sicher, dass die Struktur des Simulationsmodells mit der Empirie übereinstimmt, so dass die Abweichung zwischen Simulationsergebnissen und empirischen Daten allein auf die Eingangsparameter der Simulation zurückzuführen ist. Die pseudo-empirischen Werte wurden erstellt, indem 2.500 Kunden willkürlich so auf drei Kundentypen mit festgelegten Zahlungsbereitschaften und Ankunftszeiten verteilt wurden, so dass 1.500 über Zeit und Produkte gleichmäßig verteilte Käufe resultieren.

4.3 Kalibrierung

Der Einfachheit halber gehen wir in dieser Studie davon aus, dass die Zahl der Kundentypen und deren Parameter (Zahlungsbereitschaft, Produktpräferenzen und Kaufzeitpunkt) bekannt sind. Die Kalibrierung legt nur die Zahl der Kunden und die Anteile der Kundentypen fest.

Der implementierte Kalibrierungsalgorithmus initialisiert die Zahl der Kunden entweder mit einem minimalen Wert von 0, einem maximalen Wert von 5.000 oder einem Zufallswert. Auch Verteilung über drei Kundentypen wird zufällig initialisiert.

Jeder folgende Kalibrierungslauf verändert die Anzahl der Kunden um einen zufälligen Wert zwischen -250 und 250. Auch die Anteile der Kundentypen werden um einen zufällig erzeugten Wert zwischen -0.1 und 0.1 variiert, wobei natürlich die Summe der Anteile 1 ergeben muss.

Ab dem zweiten Kalibrierungslauf prüft die Kalibrierung, ob die Validierungsindikatoren verbessert wurden. Bei einer Verbesserung (hier: verringerter MAPE), bilden die unterliegenden Eingangsparameter der Simulation die Grundlage des nächsten Kalibrierungslaufs. Bei einer Verschlechterung (hier: gesteigerter MAPE), werden die Parameter auf das Ergebnis des vorletzten Laufs zurückgesetzt und erneut variiert.

In unserem Beispiel wird die Kalibrierung unabhängig vom Ergebnis über 200 Läufe wiederholt. Alternative Abbruchkriterien wären einerseits eine erzielte Güte der Validierung oder andererseits ein Steady State der Kalibrierung, in dem dauerhaft kein besseres Ergebnis erreicht wird.

4.4 Ergebnisanalyse

Abbildung 3 illustriert den durch die automatisierte Kalibrierung erzielten Verlauf des MAPE. Die Legende unterscheidet die drei getesteten Arten, die Kalibrierung zu initialisieren. Für jede Initialisierung werden zwei Verläufe angegeben: einerseits die tatsächliche, nicht monotone Entwicklung des MAPE, die aus der zufälligen Veränderung der Eingangsparameter resultiert, und andererseits die monoton sinkende Entwicklung des besten bisher erzielten MAPE.

Die Abbildung demonstriert Möglichkeiten der Auswertung von Kalibrierungsexperimenten: So können verschiedene Initialisierungsansätze der Kalibrierung, verschiedene Kalibrierungsansätze, die Bewertung nach unterschiedlichen Gütekriterien, deren Verlauf über mehrere Kalibrierungsläufe und damit die Geschwindigkeit der Kalibrierung miteinander verglichen werden.

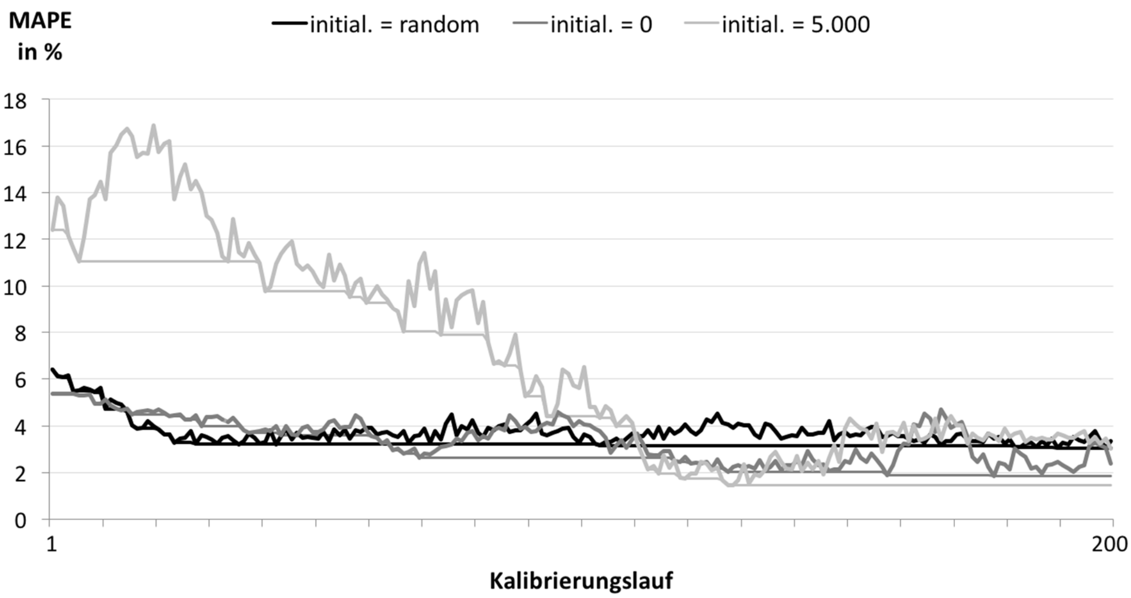

Abbildung 3: MAPE Verlauf über 200 Kalibrierungsläufe

Außerdem liegt bei Kalibrierungsansätzen, die ein stochastisches Element beinhalten, die Wiederholung von Kalibrierungsexperimenten zur Berechnung von Konfidenzintervallen nahe. Mit einer entsprechenden Berechnung könnte z.B. evaluiert werden, ob der im Beispiel durch die zunächst unterlegene Initialisierung mit 5.000 nach 200 Läufen erzielte minimale MAPE einen Ausreißer oder ein systematisches Ergebnis darstellt.

5 Fazit und Ausblick

Die Qualität von Kalibrierung und Validierung ist für den Wert agentenbasierter Simulationen in der betriebswirtschaftlichen Entscheidungsunterstützung von wesentlicher Bedeutung. Gleichzeitig ist die effiziente und effektive Kalibrierung derartiger Simulationen eine offene Herausforderung, da bisher kaum weit anwendbare und automatisierte Ansätze existieren.

Als Werkzeug für die vergleichende Bewertung neuer Ansätze stellten wir die Laborumgebung MetaSimLab vor. Diese kann austauschbare Simulationsmodelle mit beliebigen empirischen Datensätzen, Validierungs- und Kalibrierungskomponenten verbinden. Anhand eines einfachen Beispiels wurde die Funktionsweise und die Möglichkeiten von MetaSimLab demonstriert.

Die beschriebene Studie ist ein Beispiel für Kalibrierung unter idealen Gegebenheiten: Erstens stimmt die Struktur des Simulationsmodells mit der des realen Systems perfekt überein, zweitens sind nur wenige Parameter des Modells unbekannt und müssen kalibriert werden. Auf diese Weise lässt sich das theoretische Potential eines Kalibrierungsansatzes ermessen. Die Bewertung unter realistischen Bedingungen erfordert die Verwendung eines tatsächlichen empirischen Datensatzes, ohne dass die Struktur des empirischen Systems perfekt bekannt ist.

Die beispielhafte Bewertung der Validierung anhand des MAPE birgt die Gefahr, dass die Parameteranpassung nur ein einem lokales Optimum erreicht, Optima überspringt oder divergiert. Eine bessere Methodik wäre durch eine separate Forschungsreihe im Bereich der Validierung entwickelt werden. Diese kann dann durch das MetaSimLab geeignet getestet werden.

Neben weiteren Kalibrierungsansätzen ermöglicht MetaSimLab es auch, verschiedene Anteile manueller Eingriffe zu bewerten. So kann einerseits ein manuell kalibrierter Eingangsparametersatz als Grundlage für die weitere automatisierte Kalibrierung verwendet werden, andererseits kann eine manuelle Weiterentwicklung von automatisiert erstellten Eingangsparametern durch die Validierung bewertet werden.

Die besondere Herausforderung der Weiterentwicklung und des Einsatzes von MetaSimLab besteht in der Anwendbarkeit auf unterschiedliche Simulationsmodelle und deren Vergleich mit alternativen, datengetriebenen Ansätzen aus dem Bereich des Predictive Analytics. Hier gilt es, den Aufwand für das Einbinden neuer Komponenten zu minimieren.

Weitere Forschungsthemen, die mithilfe von MetaSimLab bearbeitet werden können, sind die Effekte von Abweichungen in der Struktur des Simulationsmodells, dem Umfang des empirischen Datensatzes, und der verwendeten Validierungsindikatoren. Strukturelle Abweichungen lassen sich durch die Generierung von pseudo-empirischen Datensätzen ähnlich der hier beschriebenen Studie gezielt variieren. Bei einer erfolgreich evaluierten Kalibrierung ließen sich die Konsequenzen einer Reduktion des Datensatzes mithilfe von Sensitivitätsanalysen messen. Zu guter Letzt können neben einfachen Abstandsmaßen auch die Konsequenzen disruptiver Eingriffe in das System validiert werden, wenn entsprechende empirische Daten vorliegen.

Ein weiterer geplanter Schritt für die Entwicklung des MetaSimLab ist die Anbindung an ein Simulationssystem im realen betrieblichen Einsatzumfeld. Im Rahmen einer Forschungskooperation mit einer großen europäischen Fluggesellschaft wird zu diesem Zweck aktuell eine Schnittstelle zu einer Revenue Management Simulation entwickelt.

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Ignored, Accepted, or Used? Identifying the Phase of Acceptance of Business Intelligence Systems

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Abstract

Business intelligence (BI) systems deliver value through the use of the provided information. Therefore, acceptance and continuous use of BI systems by the intended users are crucial for BI's value contribution. While various research contributions address questions regarding phases of acceptance and continuous use of information systems (IS) in general, up to now, no comprehensive work in the specific context of BI exists. We first build a model comprising antecedents for different phases of acceptance of a BI system by an individual. Subsequently, we employ case study data to test our model and derive implications for the management of BI, in particular for fostering continuous use of BI, BI user trainings, design of BI landscape, and BI investment decisions. Our research contributes an integrative framework on how to identify a particular BI acceptance phase and on how to enhance BI acceptance.

1 Introduction

"Information is the oil of the 21st century, and analytics is the combustion engine." (Gartner Inc. 2011). Today BI is recognized as an umbrella term for "technologies, applications and processes for gathering, storing, accessing and analyzing data to help its users make better decisions" (Wixom and Watson 2010, p. 14). Providing decision-supportive information for management, BI is widely considered to be a prerequisite for organizational success (Wixom and Watson 2010). By supporting, optimizing and partially automating the decision making-process, BI helps to improve the quality of business decisions. In order to realize the value inherent in BI systems, they need to be used by the business users for their daily work (Li et al. 2013). Hence, user acceptance and continuous use of BI systems are prerequisites for the value contribution of BI systems.

Managers often continue to base their decision on intuition rather than detailed business analysis even if a BI system is implemented and available. Therefore, it is not sufficient to just make a BI system available to an organization, but users also need to be capable and willing to actually use these resources. While capabilities can be trained and developed, willingness is more difficult to influence, since it includes intrinsic and extrinsic aspects. To foster continuous use of BI systems and increase its acceptance, it is crucial for BI managers to identify the phase of acceptance a BI system has reached among its users and to understand, which antecedents influence the acceptance process. In our research antecedents refer to characteristics of individuals indicating the phases of acceptance. Consequently, this paper addresses the following research questions:

1. What are antecedents for the phases of acceptance of a BI system by an individual?
2. How can continuous use patterns among BI users be fostered given a particular phase of BI system acceptance?

This paper contributes to the knowledge base on continuous use of BI systems and on the identification of phases of acceptance. Further, we support practitioners with assistance in fostering the use of BI systems by their potential users. This paper is organized as follows: in section two we build the conceptual basis for our analysis by defining continuous use and phases of acceptance. Section three introduces the antecedents for identifying phases of acceptance found in a comprehensive review of prior work. In section four we test the validity of our findings and provide empirical evidence on how they can be employed in practice through a confirmatory case study. In section five we discuss our results and derive implications on BI management.

2 Conceptual foundations

IS use has been an important research area for many years. According to Burton-Jones & Gallivan (2007), different researchers address the topic on an individual, group and organization level, conceptualizing it as behavior, cognition, affect or frequency, duration and intensity. This paper focuses on system usage at the individual level, defining it "as a user's employment of a system to perform a task" (Burton-Jones and Gallivan 2007, p. 659). System use is researched from two perspectives: *IS acceptance* and *IS continuance*. Both are "conceptually distinct behaviors in that the former refers to a user's first-time adoption of a new [IS], while the latter refers to their long-term use of an [IS] that is already in use" (Bhattacherjee and Barfar 2011, p. 4). As *IS acceptance* has been widely investigated, the researchers' attention has shifted to *IS continuance* and *post-acceptance* (Lin and Ong 2010) respectively. The general goal of research in this area is to predict actual and on-going behavior and not the intention of the same (Bhattacherjee and Barfar 2011).

Cooper and Zmud proposed a six-stage model of the IT implementation process (Cooper and Zmud 1990), which can often be found in the field of *IS continuance* research, since many researchers have used it as a framework for their analyses (e.g., Li et al. 2013; Hsieh and Wang 2007). According to Agarwal (2000, p. 90) "a strength of this model is that similar to research grounded in the diffusion of innovations paradigm, it explicitly recognizes the existence of a variety of post-adoption behaviors beyond the initial decision to adopt or reject the IT". We employ this model for structuring stages of the use process. The model comprises six stages: initiation, adoption, adaption, acceptance, routinization, and infusion (cf., Cooper and Zmud 1990). In the following we first introduce each of the stages and relate the model to our research context. The implementation process of an IS starts with the *initiation stage*. Organizations experience pressure to change evolving from organizational needs (pull) or technological innovation (push), or both. In the adoption stage the organization needs to support the implementation of a suitable solution. Negotiations are conducted, aiming at a decision to invest the necessary resources in order to accommodate the implementation effort. The subsequent *adaption stage* focuses on the technical realization of the new IS to exploit its full potential, the IS is available for use, and the maintenance process starts. In the acceptance stage the IS is available for productive use and organizational members are encouraged to get familiar with the new system and with the resulting changes. This stage includes the initial decision to use the newly implemented IS, and an existing "relationship between individual acceptance of an [IS] and significant individual-level outcomes such as improved work performance, enhanced productivity, and user satisfaction" (Agarwal 2000, p. 87) should be detected. The *routinization* stage is important for the assimilation of the new IS (Peijian et al. 2007). It describes the state where system use is institutionalized and therefore is recognized as normal activity, i.e., it is no longer perceived as out of the ordinary (Hsieh and Wang 2007). The last stage, *infusion*, reflects the extent to which an IS is embedded within the work processes of the individual and the broader organization in which the individual is situated (Agarwal 2000).

Since the first three stages of the model deal with the actual development of the system with often only limited user interaction, we combine theses stages into a phase called *pre-acceptance*. In literature, one often also finds the last two stages, routinization and infusion, to be grouped into one single phase called *post-acceptance*. In this context, it is important to notice that *routinization* and *infusion* "do not necessarily occur in sequence but rather occur in parallel." (Li et al. 2013, p. 661). Hence, for our research we differentiate three phases: pre-acceptance, acceptance and post-acceptance. Figure 1 illustrates the allocation of the three phases of acceptance to the six stages of the IT implementation process (Cooper and Zmud 1990) which is used for our research.

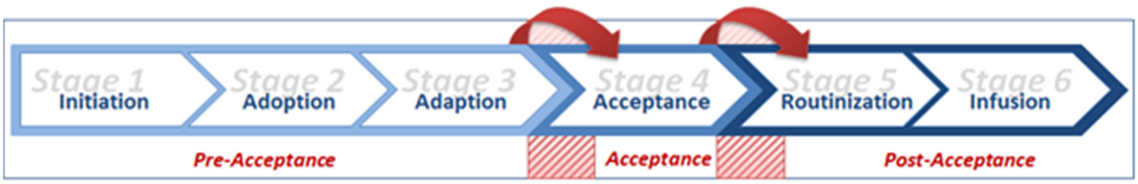

Figure 1: Phases of acceptance and stage model of IS implementation (cf., Cooper and Zmud 1990)

3 Antecedents for the phases of acceptance

This section introduces antecedents by means of which the different phases of the process of BI system acceptance can be identified. The antecedents can be distinguished as internal and external regarding the individual. Internal antecedents represent perception, emotions, and behaviors of an individual. External antecedents can be directly observed and influence an individual from outside.

3.1 Internal antecedents

The *Principles of Social Psychology* serve as a framework for the definition of internal antecedents. According to the disaggregated or tripartite view (Agarwal 2000), "human beings rely on the three capacities of *affect*, *behavior*, and *cognition*, which work together to help them create successful social interactions" (Stangor 2011, p. 26). These three interrelated components are referred to as *ABC model of attitudes*. Our analysis results in six internal antecedents: attitude with its components affect, behavior and cognition (ABC), as well as beliefs and type of motivation.

Antecedent 1: attitude. An attitude is a lasting, general evaluation of the attitude object (Solomon et al. 2006), i.e., the BI system. Attitude in the pre-acceptance and acceptance phase is primarily based on affective and cognitive information. In these two phases, individuals primarily have indirect experience with the new BI system and thus merely have little information concerning their past use behavior (Karahanna et al. 1999). On the contrary, attitude in the post-acceptance phase is primarily based on direct experience. At this point in time, more information about the new BI system may be available through information concerning past behavior and therefore individuals are able to evaluate the implemented BI system clearly and confidently (Karahanna et al. 1999). Due to this fact, attitude perceptions tend to fluctuate during the initial phases of IS use (Bhattacherjee and Premkumar 2004).

Antecedent 1.1: affect. The first component of attitude is affect, which results in what someone feels (Burton-Jones and Gallivan 2007). In general, these emotions help individuals to function efficiently and signal that things are going as planned or warn if they go wrong (Stangor 2011). In the post-acceptance phase individuals often struggle with the question of how to use the new system for their existing tasks (Hsieh and Wang 2007). In combination with the multifarious changes caused by the new implementation, this situation results in uncertainty as users may be unsure and anxious, leading to negative psychological reactions (Kim and Kankanhalli 2009). Individuals, therefore, often prefer to maintain their current systems in the pre-acceptance phase as they feel threatened by the new system and fear loss with its implementation (Kim and Kankanhalli 2009). After the BI system is available for initial use in the acceptance phase, affect is represented by unfamiliarity and insecurity (Hsieh and Wang 2007), and no long-term commitment has been formed yet. This changes in the post-acceptance phase, since users no longer perceive the use as something out of the ordinary and are increasingly familiar with the system. This is the foundation to explore new features (Hsieh and Wang 2007) and requires satisfaction, which thus represents an important emotion in this phase (Bhattacherjee 2001).

Antecedent 1.2: behavior. Behavior results in what an individual does (Burton-Jones and Gallivan 2007). Individuals "can exhibit a variety of different behaviors when confronted with a new information system: they may completely reject it and engage in sabotage or active resistance, they may only partially utilize its functionality, or they may wholeheartedly embrace the technology and the opportunities it offers" (Agarwal 2000, p. 86). Since the system is not yet available in the pre-acceptance phase, no such behavior can be observed. While behavior in the acceptance phase is mainly driven by reflected and deliberate cognitive processes, it is activated by triggers in the post-acceptance phase (Peijian et al. 2007). As the same decision is made repeatedly in response to the same recurring situation, reflected cognitive processing dissolves and individuals begin to act in an unthinking, reflexive and rather automated way (Bhattacherjee and Barfar 2011; Peijian et al. 2007). Therefore, behavior is non-reflected, effortless and efficient (Limayem et al. 2007), but still a function of evaluation and intention (Peijian et al. 2007). Individuals form a reference value and compare it with the achieved outcome, resulting in satisfaction or dissatisfaction (Peijian et al. 2007).

Antecedent 1.3: cognition. Cognition represents a mental activity of processing information in order to use the results for judgment (Stangor 2011), accumulating in what an individual thinks (Burton-Jones and Gallivan 2007). Hence, this antecedent sums up to an individual's beliefs, opinion, values, and knowledge (Bhattacherjee and Premkumar 2004). As cognition in the pre-acceptance phase is based on second hand information that may be exaggerated or unrealistic, it is less reliable or stable (Bhattacherjee and Barfar 2011). In the acceptance phase, on the other hand, cognition is based on active cognitive processing (Peijian et al. 2007). The link between stimuli and action is not fully developed at this point (Bhattacherjee and Barfar 2011), therefore individuals engage in rational decision making by performing a cost-benefit analysis of the change related to the new BI system. "Costs are represented by decrease in outcomes and increase in inputs while benefits are represented by increase in outcomes and decrease in inputs" (Kim and Kankanhalli 2009, p. 569). According to Kim & Kankanhalli (2009), the implied costs include transition costs incurred in adapting to the new situation, as well as uncertainty costs representing the perception of risk associated with the new alternative. It is unlikely for an individual to accept the new system in case she feels these costs to be greater than the expected benefits (Kim and Kankanhalli 2009). Like attitude, cognition in the pre-acceptance and acceptance phase is subject to change and stabilizes with increasing experience in the post-acceptance phase (Bhattacherjee 2001). In this third phase, no cognitive processing is prevalent (Peijian et al. 2007). As the linkage between stimuli and action is fully developed (Bhattacherjee and Barfar 2011), individuals solely require little, if any, conscious attention to react adequately to certain situations (Limayem et al. 2007).

Antecedent 2: beliefs. *Beliefs* differ from *cognition* as this antecedent represents the result (*beliefs*) of an individual's cognitive evaluation (*cognition*) of the consequences concerning the use or refusal of a BI system (Agarwal 2000). The two general *beliefs* of *perceived ease of use (PEU)* and *perceived usefulness (PU)* are consistent constructs across multiple papers for the *pre-acceptance* and *acceptance phase* (Agarwal and Karahanna 2000; Bhattacherjee and Barfar 2011). PU is defined as the extent to which individuals believe that using a particular BI system will enhance their job performance, while PEU is the extent to which users believe that learning, how to use the BI system and actually using it, will be relatively free of effort (Bhattacherjee and Barfar 2011). While PU is recognized to be a strong and consistent *belief* across all three phases, PEU has a declining effect and eventually becomes non-significant (Limayem et al. 2007; Bhattacherjee and Barfar 2011). Therefore, PU is one of the salient *beliefs* in the *post-acceptance phase*.

Further, Karahanna et al. (1999) propose a more comprehensive set of *beliefs* by adding *visibility*, *result demonstrability* and *trialability* to the already identified *beliefs* of PEU and PU for the *acceptance phase*. Bhattacherjee (2001) additionally proposed *expectation confirmation* to be a significant *belief* for *IS continuance*. Confirmation of user expectation leads to satisfaction, which reflects a user's affect and directly influences the intention to continue using the system (Bhattacherjee and Premkumar 2004). Negative disconfirmation, on the other hand, leads to eventual IS discontinuance (Bhattacherjee and Premkumar 2004). Alternatively, Karahanna et al. (1999) proposed *image* as a supplementary *belief* for the *post-acceptance phase*, representing the degree to which IS adoption/use is perceived to enhance one's image or status in one's social system. For our research, we included both suggestions resulting in the set *of beliefs* summarized in table 1.

Belief	Pre-acceptance	Acceptance	Post-acceptance
Perceived Ease of Use	x	x	
Perceived Usefulness	x	x	x
Result demonstrability		x	
Trialability		x	
Visibility		x	
Expectation Confirmation			x
Image			x

Table 1: Overview of beliefs across all acceptance phases

Antecedent 3: type of motivation. A distinction is made between intrinsic and extrinsic motivation. "Intrinsic motivation refers to the state in which a person performs an activity for the joy or satisfaction derived from the activity itself, and extrinsic motivation refers to the state in which a person performs an activity to gain external benefits (e.g., rewards, money) rather than simply partaking in the activity." (Li et al. 2013, p. 660) The *rich intrinsic motivation* (RIM) concept from social psychology separates intrinsic motivation *into intrinsic motivation toward accomplishment* (IMap), *intrinsic motivation to know* (IMkw), and *intrinsic motivation to* *experience stimulation* (IMst) (Li et al. 2013). Most studies in the field of *IS acceptance* identified extrinsic motivation as a dominant determinant for the *pre-acceptance* and *acceptance phase (Agarwal and Karahanna 2000; Li et al. 2013)*. Especially PU, focusing on utilitarian considerations, is mentioned in this context. According to the *functional theory of attitudes,* the *utilitarian function* relates to the basic principle of reward and punishment (Solomon et al. 2006) that strengthen an individual's behaviour via positive or negative consequences (Li et al. 2013). Based on the research by Li et al. (2013) PU, functioning as extrinsic motivator, is also dominant for routine use in the *post-acceptance phase*. IMkw and IMst, though, drive innovative use, which is typical for the *infusion stage*. However, no significant impact on routine or innovative use could be identified for IMap.

3.2 External antecedents

In the following we provide a brief introduction to three external antecedents as well as findings regarding the characteristics of the external antecedents in the different phases of acceptance.

Antecedent 4: BI system use. According to Venkatesh et al. (2008) "system use has been identified as the most important surrogate measure for IS success" (p. 484). System use is examined in terms of three key conceptualizations: duration, frequency and intensity (cf., Venkatesh et al. 2008). Nevertheless, no classifications according to the three defined phases were identified in literature for duration and frequency. Intensity strongly differs within all phases. In the beginning there is hardly any use as the system is not made available to the users, and intensity is reduced to testing and user training in the pre-acceptance phase (Cooper and Zmud 1990). In the acceptance phase observers will find simple, shallow use of a small number of features (Hsieh and Wang 2007). Intensity in the routinization stage can be characterized as standardized, automated, routinized or habitual (Peijian et al. 2007). Therefore, it is coined by exploitative actions to refine and extend the implemented system, allowing the creation of reliable experience (Li et al. 2013). In contrast, use in the infusion stage is characterized as innovative and integrated (Li et al. 2013). In general, an individual first engages in extended use, which refers to using more of the BI system's features to support his/her task performance (Hsieh and Wang 2007), resulting in a more effective utilization. Afterwards, an individual may engage in emergent use or experiments with the system, utilizing it in an innovative manner to accomplish work that was not feasible or recognized prior to the application of the BI system to the work system (Li et al. 2013).

Antecedent 5: learning curve. The external antecedent learning curve can be observed throughout all three phases. "The rationale is that using a new BI system for the first time requires overcoming significant learning barriers on the part of potential users." (Bhattacherjee and Barfar 2011, p. 7) Learning in the pre-acceptance phase primarily includes familiarizing with the new system and the new processes it incorporates (Cooper and Zmud 1990). Kim & Kankanhalli (2009) point out that "switching benefits […] need to be communicated clearly to users before the new system release" (p. 579) to increase the perceived value of the system. The pre-acceptance phase is therefore coined by user training, guidance, time and resources to learn the new system (Kim and Kankanhalli 2009). Even if the acceptance phase might also include additional user training, we assume it can be recognized by individuals to learn adapting their knowledge in order to perform their tasks. While learning in the routinization stage can be characterized by its little learning based on its standardized use, learning in the infusion stage includes a more dramatic expansion of user's knowledge regarding the potential of the BI system (Luo et al. 2012).

Antecedent 6: extent of social influence. The decision to accept a BI system and continue to use it is always made in the context of an individual's social environment (Agarwal 2000). Therefore, the last external antecedent is the extent of social influence, the importance of which has been acknowledged in a variety of IS research (Agarwal 2000; Kim and Kankanhalli 2009; Bischoff et al. 2014). Yet, the terminology concerning social influence varies among different models. Besides their different labels, all of these constructs implicitly or explicitly point out that individuals are influenced by their social environment. Furthermore, social information is conceptualized, suggesting that information received via an individual's social network influence their cognition about the target system (Fulk 1993). According to our findings, non-utilitarian factors such as social influence appear to be important only in the early stages of experience with the technology, when an individual's opinions are relatively ill-informed. However, with continued use, the role of social influence will erode over time and eventually become non-significant (Venkatesh et al. 2003; Peijian et al. 2007). For our research we therefore assume that social influence will be more salient in the pre-acceptance and acceptance phase than in the post-acceptance phase.

3.3 Summary of antecedents

In total, our findings consist of six internal and three external antecedents. *Attitude* includes the components *cognition*, *behavior* and *affect*. Besides these four antecedents, *beliefs* and the *type of motivation* are part of the internal group of antecedents. External antecedents include the *level of analysis*, *BI system use,* the *learning curve* and the *extent of social influence*.

4 Case study

Case study research is particularly appropriate for studying IS use (Darke et al. 1998). "A case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin 2003, p. 13). In this investigation, interviews are combined with this approach, allowing to test the literature based findings in an organizational context.

4.1 Case description and empirical setting

TR telecom (TR) is a family-owned midsize private limited company for telecommunication, security, and IT-networks in Germany serving a customer base of over 2,500 organizations. The CEO is supported by an in-house consulting team, consisting of the founders and two further employees. While the founders primarily support strategic questions based on their experience, the consultants engage in both strategic and operational tasks and are responsible for the design, implementation and maintenance of the enterprise-wide reporting infrastructure. On the next level of TR's organizational hierarchy the three functional areas sales, administration and engineering are located. For its management reporting purposes TR employs a classical BI landscape with the enterprise resource planning system (ERP) as the main source system, a data storage layer and a reporting layer. The reporting applications comprise a browser-based reporting portal as well as an Excel plug-in for self-service reporting and ad-hoc queries. The user base of the BI reports is very broad, since the top management, department heads, and operational staff work with management reports and lists generated from the BI system.

Empirical data for testing the antecedents was collected via interviews to gather differentiated, detailed descriptions and impressions from each interview partner (IP). The interviews were recorded and transcribed. The aim was to understand the individual subjective perception and use behavior regarding three different BI reports, namely: turnover report, sales performance report and unpaid items report. By placing this data into the context of the findings from our review of prior work, a specification of the acceptance phase for each individual and report is explored. Three managers and four employees from the operational level were chosen as interview partner (IP). Each of these employees is an expert, who possesses specific information and knowledge grounded in his/her position. Table 2 gives an overview of all IPs and the reports to which they were interviewed.

Interview	Level	[1] Sales Perfomance	[2] Turnovers	[3] Unpaid Items
1. CEO	Management	X	X	
2. Sales manager	Management	X	X	
3. Head of administration	Management		X	X
4. Salesman 1	Operational	X		
5. Salesman 2	Operational	X		
6. Salesman 3	Operational	X		
7. Accountant	Operational			X

Table 2: Overview of interviewees

For the sales performance report five employees were interviewed. This includes the CEO and sales manager as well as the rest of the operational sales team. Consequently, data from the management and operational level could be collected. In contrast, interviews regarding the second report were limited to management level, as no operational employee has direct access to this report. Only employees using the information of turnovers for decision making were questioned. Last, two users with access to the unpaid items were questions, representing the third report. This includes the head of administration as well as one employee responsible for accounts receivables. Every interview started with a short introduction, explaining the purpose of the interview and some organizational issues. All interviews were based on a questionnaire. Yet, improvisation was allowed, creating an authentic communication between the IP and researcher. The questionnaire was constructed of three sections. The first section served as an ice-breaker to create a situation in which the IP felt comfortable, the second section represented the main part of the interviews containing questions specifically aligned to the defined antecedents and the last section focused on a review of the content to explore, how specific changes influenced an individual's point of view concerning reporting, and how the IPs could be motivated to achieve a continuous use pattern in the future.

4.2 Data analysis

After conducting the interviews with the seven IPs, we fully transcribed the interviews for the subsequent data analysis which resulted in a total of 1,371 lines of transcription. During the data analysis, we reviewed each interview and assigned a rating for each antecedent: A for *acceptance* or P for *post-acceptance*. No rating for *pre-acceptance* was necessary, since all reports in our case were released and accessible to the IP for some time. The rating of either A or P was based on the fit of the answers regarding the operationalized antecedents to the respective phase. There were nine antecedents to rate the status of acceptance. After each interview was evaluated, we estimated the status based on the share of ratings A and ratings P. If there were more A ratings, we suggest the IP remained in the *acceptance phase*; if there were more P ratings we suggest the IP achieved *post-acceptance*.

Table 3 gives a consolidated overview of our data analysis for all interviews regarding the three reports. Table 3 shows for the respective report the evaluation of each antecedent per IP. In the bottom line the feasibility of each antecedents to identify the phase of acceptance is evaluated. Cells are left blank in Table 3, if we obtained no meaningful answers or if the answers did not give meaningful indication for a classification of the antecedent.

	Internal						External					
	Attitude	Affect	Behavior	Cognition	Beliefs	Type of Motivation	BI System Use	Lerning Curve	Extent of Social Influence			
[1] Sales performance										**∑A**	**∑P**	**Result**
IP I Management	P	P	P	P	A		P	P	A	2	**6**	Post-acceptance
IP II Management	A	A	A	A	A	P	P	P	A	**6**	3	Acceptance
IP IV Operational	P	P	A	P	P		P	P	A	2	**6**	Post-acceptance
IP V Operational	P	A	P	P			P	A	A	3	**4**	Post-acceptance
IP VI Operational	P	P	A	P	P		P	P	P	1	**7**	Post-acceptance
[2] Turnover										**∑A**	**∑P**	**Result**
IP I Management	A	P	A	A	A		A	P	A	**6**	2	Acceptance
IP II Management	A	P	A	A		P	P	P		3	**4**	Post-acceptance
IP III Management	P	P	P	P		P	P	P		0	**7**	Post-acceptance
[3] Unpaid items										**∑A**	**∑P**	**Result**
IP III Management	P	A	A	P	A	P	P	A	A	**5**	4	Acceptance
IP VII Operational	A	A	A	A			A	A		**6**	0	Acceptance
Feasibility of antecedent	**X**	**X**	**X**	**X**			**X**	**X**				

Table 3: Results of data analysis

For the sales performance report we suggest that IPs I, IV, V, and VI are in the *post-acceptance phase*. IP II on the other hand is the only IP who still remains in the *acceptance phase* based on our findings. For the turnover report our analysis shows that IPs II and III are in the *post-acceptance phase* and IP I is still in the a*cceptance phase.* IP II in particular agreed that his acceptance toward the unpaid items is, to a large extent, higher than his acceptance toward the sales performance report. In contrast, for IP I the interviews showed that the indicators are not yet as far developed as for the sales performance report. For the unpaid items report we suggest that both users are in the *acceptance phase*. While IP III shows strong indication to stand on the threshold to *post-acceptance*, IP VII shows strong indications for the early *acceptance phase* as she has neither accepted to (continuously) use the system nor decided to actively resist it.

After the data analysis to determine the phase of acceptance, the data was reviewed antecedent per antecedent in order to examine the feasibility of each antecedent for identifying the phase of acceptance. An antecedent is considered feasible, if more than 70% of the interviews delivered results, i.e., a clear indication for the rating of either A or P. Answers for the antecedents beliefs and type of motivation did not allow for distinctively assigning the antecedent to a certain phase. An interpretation in the context of the subjectivity of beliefs as well as of the intrinsic motivation of IPs would have violated the integrity of our analysis. According to the statements of three IPs, the *extent of social influence* was not strongly based on the status of acceptance but rather an individual's perception of the personality of the referee and on personal interests of the IPs. To sum up, six out of nine antecedents represent feasible indicators to classify the phase of acceptance regarding the three reports, namely: attitude, cognition, behavior, affect, BI system use, and learning curve.

5 Discussion and implications for BI management

To the best of our knowledge, this is the first investigation to theoretically derive a comprehensive overview of antecedents, which allows for classifying an individual's phase of BI acceptance. Our investigation combines aspects from a number of different studies in the field of *IS acceptance* and

IS continuance, provides preliminary evidence suggesting that there are four internal and two external antecedents that can be used to identify a user's phase of IS acceptance and thus IS use. We therefore contribute to IS use research by presenting theoretical findings that can be used to identify the status of IS use, to further analyze reasons for transferring from one use phase to another.

One challenging task that managers face today in business practice is how to foster system use. Our investigation supports practitioners on how to analyze the phase of acceptance regarding an implemented BI system. These results enable managers to derive action alternatives to support system use. Specifically for TR, this knowledge contributed to establish a basis for decision-making based on information, which provides transparency and decreases their dependency on certain employees. The findings of our case study provided TR with specific insights, which are used to enhance the BI reporting landscape as well as to develop skills and perception of the IPs in regard to the units of analysis. Different research streams identified factors that influence acceptance and continuous use of IS. IS acceptance was heavily researched by Davis (1989) and Venkatesh et al. (2012) whereas continuous use is based on a different set of theories and was researched by Bhattacherjee et al. (2008). Based on the users' current state of use different measures are suitable for influencing their acceptance and continuous use behavior, respectively. Consequently, it is crucial to use the antecedents identified above for determining the current acceptance phase, before appropriate measures can be derived based on existing work on acceptance or continuous use of BI systems.

Further, we derive from the findings of our research that the determination of the status of BI use is an important measure in BI management as implications on different domains of BI management prevail. In particular, we deduct implications on BI user training and development, design and enhancement of BI landscape, and BI investments which we subsequently elucidate in detail.

The identification of the acceptance phase of certain BI user in regard to certain report or BI component obviously has implications on the BI user training and development. From the findings of our case study we derived training needs for certain employees as well as necessary training contents, e.g., the data analysis for the antecedent belief showed IP V has a lack of trust and misunderstandings regarding the sales performance report. Consequently, we concluded that training on the sales and data processes would eliminate the misunderstandings and enhance trust. On a larger scale, the characteristics of the antecedents can also be used to identify training needs and define training contents for BI user groups or company-wide training programs. Besides the training aspect, IP V also mentioned that use could be encouraged by providing the possibility to manually update the report. This correlates with the answer provided by IP VI, who suggested that data currency could support *IS continuance*. As the report is provided once a week, it can only serve information purposes for the salesmen. According to IP VI, the report could support the decision-making process on operational level if it was updated once a day. This example from our research project illustrates how the antecedents and their application can support design and enhancement of the BI landscape and of single reports, since shortcomings and room for improvement can be uncovered.

In regard to BI investments, our research provides valuable insights concerning investments in new as well as in existing technologies. The status of BI use regarding the existing BI landscape needs to be accounted for when considering an update of existing or investing in new technology. By taking the phase of acceptance into account valuable information about timing, meaningfulness, sourcing (make or buy), and extent of investments can be obtained. On the contrary, even information for disinvestment decisions regarding a BI landscape, system, or functionality can be gained.

6 Limitations and conclusion

The results of our research should be evaluated in light of its empirical limitations. To start with, the limited size of our case study needs to be mentioned in this context. Consequently, this analysis derived general assumptions from a low number of interviews, which limits its validity. Moreover, our case study solely provided reports focusing on indicators for the *acceptance* and *post-acceptance phase*. In context of the research approach, reliability and objectivity also need to be mentioned. In general, reliability focuses on reproducibility and the implied steadiness of data collection (Yin 2003). Yet, this quality factor is viewed critically for the qualitative approach of using interviews. The interviews conducted in our research were partly standardized – a questionnaire was available to support the interview processes. However, in certain interviews some of the questions were skipped by reasons of maintaining the flow of conversation, which reduces the overall reliability of our analysis. Lastly, the interpretations and analysis were conducted as objectively as possible. Nevertheless, intersubjective confirmability might not be given in some cases. Furthermore, the results are strongly based on the perception of the IPs. No perceptions of others' or cross-check questions are integrated. All these factors impact objectivity of our analysis.

Our research closes the identified gap existing in research on the antecedents for phases of acceptance of BI system use. We contribute a foundation for identification and establishment of continuous use patterns of BI systems to theory and practice. Our exploration is based on an extensive review of related work that is discussed in the context of BI and structured in regard to BI users. Further, we validate our findings in a case study and derive the feasibility of the antecedents. The results of our research provide guidance for a purposeful management of BI systems.

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Eine Balanced Scorecard für das systematische Datenqualitätsmanagement im Kontext von Big Data

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Abstract

In diesem Beitrag wird eine Balanced Scorecard zur Unterstützung für das systematische Datenqualitätsmanagement im Kontext von Big Data entwickelt, welche abhängig vom jeweiligen Zweck der Analyse und den unterschiedlichen Herausforderungen den zu adressierenden Anforderungen angepasst werden kann. Die Anforderungen bzw. Herausforderungen wurden dabei durch eine systematische Literaturrecherche und Untersuchung von Beiträgen durch induktive Kategorienbildung eruiert. Es konnten fünf Hauptherausforderungen identifiziert werden, welche über Dimensionen und entsprechende Messmetriken operationalisiert werden, so dass sie zur Strategieformulierung und Strategiedurchführung in Big Data Szenarien verwendet werden können. Limitationen sind in der nur anhand eines fiktiven Anwendungsbeispiels durchgeführten Evaluation zu sehen. Dennoch stellt die in diesem Beitrag vorgestellte Balanced Scorecard ein Werkzeug dar, welches sowohl für die Wissenschaft als auch für die Praxis zahlreiche Vorteile aufzeigt. So können bspw. Daten im Kontext von Big Data bewertet sowie Verbesserungen aufgedeckt werden. Dieser Beitrag beinhaltet somit ein Werkzeug das Datenqualitätsmanagement im Kontext von Big Data über einen holistischen Ansatz durchzuführen.

1 Motivation

Durch Verarbeitung und Analyse großer, heterogener und schnell wachsender Datenmengen aus unterschiedlichen Quellen sollen Informationen zur Generierung von Wettbewerbsvorteilen gewonnen werden (King 2014), wobei der Wert der gewonnenen Informationen abhängig von der Qualität der genutzten Daten ist (Felden 2012)**.** Qualitativ minderwertige bzw. fehlerhafte Daten verursachen schätzungsweise jährlich Kosten in Höhe von 600 Milliarden Dollar für die amerikanische Wirtschaft (Eckerson 2002). Daher sind Datenqualität und Datenqualitätsmanagement (DQM) ein wichtiges Themengebiet im Kontext von Big Data. Einer Studie der AIIM zufolge, identifizieren 46% der Befragten mangelnde Datenqualität als ein Problem von Big Data (AIIM 2013). Die Herausforderungen im Bereich Big Data DQM sind noch weitestgehend unklar, werden jedoch als wichtiger Aspekt erachtet (Omikron Data Quality GmbH 2012).

Je nach Anwendungsfall von Big Data variieren jedoch die Anforderungen an die Datenqualität (Madsen et al. 2013), wodurch ein System zum DQM die Kontextabhängigkeit und Dynamik unterstützen muss, um die Datenqualität gezielt bewerten und kontrollieren zu können. Bisherige Modelle und Studien im Bereich Datenqualität konzentrieren sich meist auf Master oder Enterprise Data Management (Otto et al. 2012; Ofner et al. 2013a; Ofner et al. 2013b). Im Kontext dieser Arbeit soll der Einfluss der Herausforderungen von Big Data auf die Datenqualität näher erörtert werden. Durch eine systematische Literaturanalyse sollen die Herausforderungen von Big Data identifiziert und deren Einfluss auf die Datenqualität analysiert werden. Die resultierenden Anforderungen werden anschließend in eine Balanced Scorecard überführt, welche die Entwicklung einer Strategie zum DQM ermöglichen soll.

Dieser Beitrag ist in sieben Abschnitte unterteilt. Zunächst wird im zweiten Abschnitt eine einheitliche Wissensbasis erarbeitet. Anschließend wird im dritten Abschnitt die Forschungsmethodik erläutert und im Abschnitt vier die verwandten Arbeiten zum Status Quo von Big Data Datenqualität dargestellt. In Abschnitt fünf werden Herausforderungen von Big Data identifiziert und deren Einfluss auf die Datenqualität über Qualitätsdimensionen spezifiziert, welche im sechsten Abschnitt in eine Balanced Scorecard überführt werden. Abschnitt sieben schließt mit einer Zusammenfassung, offenen Forschungsfragen und Limitationen.

2 Theoretische Grundlagen

Big Data bezeichnet das stetige Wachstum von großen Datenvolumina, gepaart mit einer Vielfalt und Komplexität von strukturierten als auch unstrukturierten Datenquellen und dem Ziel der Gewinnung wertvoller Informationen aus diesen Daten (BITKOM 2012; Baron 2013). Es gibt keine eindeutigen Informationen über den Ursprung des Begriffes „Big Data“ im heutigen Kontext (Klein et al. 2013) und keine einheitliche Definition (IBM 2012), jedoch gibt es zahlreiche Ansätze Big Data anhand dessen Eigenschaften zu definieren.

(Laney 2001) definierte die heutzutage weithin akzeptierten drei Dimensionen *Volume*, *Velocity* und *Variety* als Kerncharakteristika von Big Data. Als *Volume* werden große Datenmengen, die auf das Wachstum des Internets und dem steigenden Konsum digitaler Medien zurückzuführen sind, bezeichnet. *Velocity* beschreibt zum einen die steigende Geschwindigkeit mit der Daten generiert werden und zum anderen die zeitnahe Verarbeitung. Die Verarbeitung in Echtzeit stellt dabei eine große Herausforderung von Big Data dar (BITKOM 2012; Amato und Venticinque 2014). Als *Variety* wird die Heterogenität der Daten verstanden, welche in strukturierter, unstrukturierter und wenig strukturierter Form vorliegen können und dadurch in technische sowie methodische Herausforderungen generiert (BITKOM 2012; Nguyen et al. 2014). Diese drei Dimensionen wurden über die Zeit erweitert, z.B. um *Veracity* – das Problem der Unschärfe und Glaubwürdigkeit der Daten (IBM 2012; Saporito 2014) und *Value* – der Mehrwert, der aus der Analyse der Daten für einen bestimmten Anwendungsfall gewonnen werden kann (Saporito 2014). Weniger prominent sind Faktoren wie *Volatility* (Unbeständigkeit) und *Viability* (Realisierbarkeit), die einem schwach abgesicherten, praktischen Umfeld entstammen und daher nicht ausführlicher betrachtet werden. Der Mehrwert von Big Data ergibt sich aus der Analyse von Datenmengen, die für eine strukturierte Datenhaltung zu umfangreich sind (Amato und Venticinque 2014; Nguyen et al. 2014).

Datenqualität wird beschrieben als „Gesamtheit der Ausprägungen von Qualitätsmerkmalen eines Datenbestandes bezüglich dessen Eignung, festgelegte und vorausgesetzte Erfordernisse zu erfüllen.“ (Gebauer und Windheuser 2008). Dies wird auch als Verwendungstauglichkeit bezeichnet („Fitness for Use“), wobei die Tauglichkeit von dem Kontext bzw. dem Kreis der Nutzer abhängig ist (Teuteberg und Freundlieb 2009). Datenqualität stellt somit die Eignung von Daten dar, die Realität zu beschreiben und als Grundlage für Entscheidungen zu dienen. Somit besteht eine direkte Abhängigkeit zwischen Datenqualität und Entscheidungsqualität (Felden 2012).

Datenqualitätsmanagement umfasst alle qualitätsorientierten organisatorischen, methodischen, konzeptionellen und technischen Maßnahmen um Daten im Sinne eines Vermögenswertes für Unternehmen zu steuern und zu verwalten (Wende 2007). DQM ist somit als Prozess zur Steuerung und Sicherstellung der Tauglichkeit der Daten auf Basis von definierten Qualitätsansprüchen zu verstehen. Die jeweiligen Ansprüche an die Qualität der Daten können von dem Qualitätsniveau abhängen, welches derjenige Kontext bzw. diejenige Zielgruppe vorgibt (Teuteberg und Freundlieb 2009). Auf Basis dieser Qualitätsansprüche können Qualitätsziele abgeleitet werden, um eine Strategie zum DQM zu entwickeln (Teuteberg und Freundlieb 2009).

Die Balanced Scorecard (BSC) ist ein Instrument, welches zum einen zur Zielformulierung als auch zur Zielüberprüfung eingesetzt wird und hauptsächlich als Instrument zur Strategieumsetzung im Bereich der Performance-Messung genutzt wird (Kaplan und Norton 1997). Bei der Balanced Scorecard werden Kennzahlen berücksichtigt, welche nicht nur monetärer Natur sind. Diese Kennzahlen werden in verschiedenen Perspektiven (traditionell: Finanz-, Prozess-, Potenzial- und Kundenperspektive) zusammengefasst, wobei das Ziel ist, ein Gleichgewicht in den verschiedenen Perspektiven zu erzeugen.

3 Forschungsmethodik

Um einen Überblick über den derzeitigen Stand in der Wissenschaft wiederzugeben, wurde eine systematische Literaturanalyse durchgeführt (Webster und Watson 2002). Die Zielsetzung der systematischen Literaturanalyse ist es, den Status Quo in der bisherigen Forschung zur Thematik der Datenqualität und des Big Data DQMs aufzuarbeiten und einen Überblick über bisherige Ansätze zu schaffen. Die Literaturrecherche wurde mit den Schlüsselwörtern *"Big Data" AND "Data quality"*, *"Big Data" AND "Data Quality Management", "Big Data" AND "Data Cleaning"* und *"Big Data" AND "Inconsistencies"* durchgeführt. Da Big Data eine noch sehr junge Thematik ist beschränkt sich die Literaturrecherche auf den Zeitraum ab 2010. Die Suche wurde in den Datenbanken Ebscohost, Web of Science, Science Direct, IEEE Xplore, Springer Link, sowie der AIS Electronic Library durchgeführt. Da die gesichtete Literatur überwiegend in den Jahren 2013 bis 2014 publiziert wurde, erwies sich eine Vorwärtssuche als wenig erfolgreich. Auch die Rückwärtssuche ergab keine relevanten Ergebnisse, da die zitierten Quellen sich zumeist auf Lösungen oder Ansätze aus dem Bereich Business Intelligence (BI) bzw. relationale Datenmodelle bezogen oder die per Rückwärtssuche gefundene Literatur schon Teil der vorherigen Treffermenge war. Die Ergebnisse der Literaturrecherche werden in Abschnitt 4 aufgearbeitet.

Um die Anforderungen an Big Data zu identifizieren, wurde die Literatur aus der Literaturrecherche systematisch auf Anforderungen bzw. Herausforderungen von Big Data untersucht. Hierbei wurde die induktive Kategorienbildung nach (Mayring 2010) angewandt. Der Gegenstand der Kategorienbildung wurde auf die Ergebnisse der Literaturrecherche beschränkt, mit dem zuvor definierten Ziel, die Herausforderungen von Big Data zu identifizieren. Als Selektionskriterium wurden Ausführungen zu Herausforderungen bzw. Anforderungen an Big Data gewählt, wobei sinnverwandte Herausforderungen aggregiert wurden. Sobald eine Herausforderung im Material identifiziert wurde, wurde diese entweder als neue Anforderung definiert oder unter bisherigen Herausforderungen subsumiert (Mayring 2010).

4 Verwandte Arbeiten

Insgesamt konnten 27 relevante Beiträge identifiziert werden (die Zusammensetzung der Ergebnisse kann unter www-assist.uwi.uos.de/frehe/BigDataDQM_Literatur_Quellen.pdf eingesehen werden). Viele Ergebnisse behandeln das Thema Big Data Datenqualität, nur wenige das Thema Big Data DQM.

(Mohanty et al. 2013) halten traditionelle Ansätze zur Datenqualitätssicherung im Kontext von Big Data (wie z.B. Data Profiling und Data Cleaning) für schwer umsetzbar, da Big Data zu komplex sei und ein zu großes Volumen an Daten aufweise, als dass traditionelle (langsame) Technologien zur Datenbereinigung Anwendung finden könnten. (Zhang 2013) nimmt eine multi-dimensionale Betrachtung der Herausforderungen an Big Data, aus wissenschaftlicher und technischer Perspektive, vor und identifiziert vier Typen von Inkonsistenzen: temporale Inkonsistenzen, räumliche Inkonsistenzen, textbasierte Inkonsistenzen und funktionale Inkonsistenzen. (Che et al. 2013) sehen ebenfalls eine ideale Lösung in einem Multi-Modell-Ansatz, der die einzelnen Datenstrukturen individuell integriert, die dynamische Entwicklung der Daten berücksichtigt und lernfähig ist.

(Fan und Huai 2014) beschreiben einen Ansatz für ein regelbasiertes System zum DQM, welches fehlerhafte Daten, sowohl auf Basis von zuvor definierter Regeln, als auch auf Basis abgeleiteter Regeln aus den Abhängigkeiten der Daten, aufdecken und systematisch bereinigen kann. (Saha und Srivastava 2014) beschreiben einen Ansatz eines kontextabhängigen Regelsystems, welches die Regeln zur Bereinigung auf Basis der Daten selbst herleitet, und verdeutlichen den Kompromiss zwischen Effizienz und Fehlerfreiheit. Die hohe Komplexität der Aufbereitung der Daten führt zu einer geringeren Effizienz und dadurch zu geringerer Aktualität der Daten. (Maślankowski 2014) definiert auf Basis einer Fallstudie eine Liste von Datenqualitätsdimensionen und deren Relevanz und Wichtigkeit im Kontext von Big Data. Zudem verdeutlicht (Maślankowski 2014), dass die Qualität von Big Data ein Resultat der Vertrauenswürdigkeit der Datenquellen ist und schlägt eine Liste von Regeln zur Verbesserung der Datenqualität in den Datenquellen vor.

(Tien 2013) definiert die Big Data Datenanalyse und Verarbeitung als eine komplexe Thematik, welche noch am Anfang der Forschung steht. Die Problematik der Datenqualität wird seiner Meinung nach durch die Masse an Daten überwunden (Tien 2013). (Nguyen et al. 2014) beschreiben Big Data Datenqualität im Kontext von Smart Grids, wo Datenquellen auf Tauglichkeit bewertet und gegebenenfalls für die weitere Verarbeitung ausgeschlossen werden. (Tang 2014) gibt einen Überblick über Ansätze zu Data Cleaning, mit dem Fokus auf Methoden zur Fehlererkennung, Algorithmen zur Reparatur der Daten sowie einem Data Cleaning System.

Zusammenfassend lässt sich festhalten, dass in den Publikationen diverse Ansätze zur Datenqualität im Kontext von Big Data skizziert werden. Die beschriebenen Ansätze bedürfen weiterer Forschung im Bereich der Verarbeitung von unstrukturierten und verteilten Daten, da keine ganzheitlichen Überlegungen zur konkreten Messbarkeit und Bewertung der Big Data Datenqualität in Abhängigkeit vom Anwendungsbezug existieren und keine eindeutige Eingrenzung der relevanten Herausforderungen in Hinblick auf die Datenqualität gegeben werden konnte.

5 Analyse der Qualitätsanforderungen an Big Data

5.1 Identifikation von Herausforderungen an Big Data

(Mohanty et al. 2013) vertreten die These, dass die Entwicklung eines Datenqualitätsansatzes für alle Typen von Daten nicht zweckführend sei, da diese zu heterogen in ihren Anforderungen seien und immer von mehreren Einflussfaktoren abhängen würden. Deshalb wird in diesem Beitrag ein abstrakterer Ansatz gewählt, indem zunächst grundlegende Herausforderungen an Big Data identifiziert werden und darauf aufbauend deren Einfluss auf die Datenqualität analysiert wird.

Eine Analyse und Kategorisierung (vgl. Abschnitt 3) der Beiträge nach (Mayring 2010) zeigte bereits nach der ersten Revision Ergebnisse, welche beim zweiten Lauf nicht mehr erweitert werden mussten, da sich die Herausforderungen in der Literatur stark ähneln. Als Resultat wurden sieben Herausforderungen an Big Data identifiziert. Die Herausforderungen „Privatsphäre und Datenschutz" sind in dem Kontext von Big Data Datenqualität zu vernachlässigen, da sie neben Datenqualität eigenständige Domänen darstellen. Die Zugänglichkeit der Daten wird unter der Herausforderung der Komplexität der Daten zusammengefasst, da diese die Anforderungen und Probleme umfasst, die bei der Verarbeitung von Daten aus verschiedenen Datenquellen entstehen. Die verbliebenen 5 Herausforderungen (vgl. Tabelle 1) lassen sich unter den 5V's von Big Data – Volume, Velocity, Variety, Veracity und Value – integrieren. Im weiteren Verlauf des Beitrags werden daher lediglich die 5Vs als Herausforderung genannt.

Dimension	Herausforderung
Volume	Verarbeitung großer Datenvolumen
Velocity	Dynamik und großes Wachstum der Daten sowie schneller Datenfluss
Variety	Komplexität der Daten aufgrund ihrer Heterogenität bezüglich der Struktur und dem Datentyp, sowie unterschiedlichen Datenquellen Zugänglichkeit der Daten
Veracity	Qualität der Daten in Bezug auf Unsicherheit und Glaubwürdigkeit
Value	Anspruch der Generierung eines Mehrwertes aus der Analyse der Daten
-	Privatsphäre und Datenschutz

Tabelle 1 – In der Literatur identifizierte Herausforderungen im Bereich Big Data

Diese Liste von Herausforderungen wurde auf Basis der Verbreitung der Dimensionen in der Literatur evaluiert. Dafür wurde die Literatur systematisch auf die Termini der 5V's untersucht (www-assist.uwi.uos.de/frehe/BigDataDQM_Herausforderungen_Literatur.pdf). Die 2001 von (Laney 2001) definierten 3V's *Volume*, *Velocity* und *Variety* haben die größte Verbreitung und stellen die Grundanforderungen von Big Data dar. Die Termini *Veracity* und *Value* werden nur teilweise in der Literatur genannt, jedoch werden die damit verbundenen Herausforderungen häufig umschrieben.

5.2 Ableitung von Qualitätsdimensionen

Voraussetzung für ein effektives DQM ist die Bewertung der Datenqualität (Lee et al. 2006). Zur Bewertung und besseren Beschreibung der Datenqualität wird diese anhand von Qualitätsdimensionen spezifiziert (Hildebrand et al. 2011), welche eine Menge von Datenqualitätsattributen sind, die einen Aspekt oder ein Konstrukt der Datenqualität abbilden (Wang und Strong 1996). Auf

Basis der zuvor in Abschnitt 5.1 ermittelten Herausforderungen soll deduktiv hergeleitet werden, durch welche Datenqualitätsdimension sich diese abbilden lassen.

Volume: Da die Größe von Daten direkt quantifizierbar ist, wird diese im Folgenden als *„Umfang“,* die Summe der Größen vorliegender Datenfelder in einem Datensatz, definiert. Die traditionelle Qualitätsdimension „*Angemessener Umfang*“, welche die Relation zu einer Anforderung definiert (Hildebrand et al. 2011) wird nicht genutzt, da eine Bewertung stets anwendungsbezogen ist. Ein rudimentärer Ansatz zur Messbarkeit des Umfanges der Daten wird in Formel 1 aufgeführt, wobei die aus der Anzahl der Datenfelder (=N) resultierende Komplexität nicht abgebildet wird.

$$Umfang = \sum_{i=1}^{N} Größe\ des\ Datenfeldes\ i$$

Formel 1: Metrik zur Berechnung des Umfangs der Daten

Velocity: Diese Herausforderung umfasst die Dynamik und das rapide Wachstum der Daten, welche dennoch zeitnah analysiert werden müssen, da der Wert der Informationen stark von der Aktualität der Daten abhängig ist (Chen et al. 2014). Die von Wang und Strong vorgeschlagene Dimension „Timeliness“ (Wang und Strong 1996), also *„Aktualität“,* spezifiziert diese Anforderung. Sie beschreibt Daten als aktuell, „wenn sie die tatsächliche Eigenschaft des beschriebenen Objektes zeitnah abbilden“ (Hildebrand et al. 2011). Formel 2 stellt einen Ansatz zur Messung der Aktualität dar und basiert auf den Überlegungen von (Klier 2008). A stellt dabei ein Attribut und w ein Attributwert dar. $Alter(w, A)$ bemisst das Alter des Attributwertes, welches sich „aus dem Zeitpunkt der Messung und dem Zeitpunkt der Datenerfassung errechnet“ (Klier 2008). Zudem sei $Verfall(A)$ die „(ggf. empirisch ermittelte) Verfallsrate von Werten des Attributs A“ (Klier 2008), welche angibt, „wie viele Datenwerte des Attributs durchschnittlich innerhalb einer Zeiteinheit inaktuell werden“ (Klier 2008).

$$Aktualität(w, A) = e^{-Verfall(A) * Alter(w,A)}$$

Formel 2: Metrik zur Aktualität von Daten (Klier 2008)

Variety: Eine von (Wang und Strong 1996) durchgeführte Erhebung von Datenqualitätsdimensionen identifiziert unter anderem die Qualitätsdimension „*Variety of Data Sources*“ (dt. „Vielfalt an Datenquellen“). Da die Anzahl an Datenquellen einen wichtigen Faktor für die Komplexität der Datenbasis darstellt (IBM 2012; King 2014) wird *„Vielfalt an Datenquellen“* (als Anzahl der Datenquellen, vgl. Formel 3) als wichtige Metrik erachtet und spezifiziert zusammen mit der traditionellen Dimension „*Einheitliche Darstellung*“ („consistent representation“) (Hildebrand et al. 2011) die Heterogenität und Komplexität der Daten. Die in Formel 4 aufgeführte Metrik zur Dimension „*Einheitliche Darstellung“* beschreibt die Konsistenz der Daten anhand von zuvor definierten Regeln. Ein Datenfeld *j* wird demnach untersucht und die Funktion *brokeRule(i)* beschreibt dabei, ob die zuvor definierten Regeln eingehalten werden (Funktionswert 1) oder nicht (Funktionswert 0). *M* ist dabei die Gesamtheit an Regeln zu einem Datenfeld und *N* die Anzahl der Datenfelder in einem Datensatz. Diese Metrik setzt jedoch die Definition von Regeln für die Überprüfung der Datensätze voraus und ist deshalb kritisch zu betrachten.

$$Vielfalt\ an\ Datenquellen = \sum_{i=1}^{N} Datenquellen$$

Formel 3: Metrik zur Vielfalt der Datenquellen

$$Einheitliche\ Darstellung = \frac{\sum_{j=1}^{N} \frac{Datenfeld_j\left(\sum_{i=1}^{M} brokeRule(i)\right)}{M}}{N}$$

Formel 4: Metrik zur einheitlichen Darstellung der Daten (Teuteberg und Freundlieb 2009)

Veracity: Die „Glaubwürdigkeit“ stellt eine etablierte Qualitätsdimension dar, welche Daten als glaubwürdig bemisst, „wenn Zertifikate einen hohen Qualitätsstandard ausweisen oder die Informationsgewinnung und -verbreitung mit hohem Aufwand betrieben werden“ (Hildebrand et al. 2011). Unter Qualität wird hier die Freiheit von Fehlern und Inkonsistenzen, sowie die Vollständigkeit der Daten verstanden. Zum einen lässt sich durch den Grad der *„Fehlerfreiheit“* messen, dass Daten fehlerfrei sind „wenn sie mit der Realität übereinstimmen“ (Hildebrand et al. 2011). Zum anderen gibt die *„Vollständigkeit“* an, dass die Daten „zu einem bestimmten Zeitpunkt in einem benötigten Umfang für den jeweiligen Nutzer/Prozess zur Verfügung stehen“ (Teuteberg und Freundlieb 2009). Die hier dargestellten Ansätze von Qualitätsindikatoren (Formel 5 bis Formel 7) bieten zwar eine normierte Quantifizierung der jeweiligen Qualitätsanforderungen, jedoch sind diese nicht ohne weiteres automatisiert anwendbar. Beispielsweise wird die Glaubwürdigkeit eines Datenfeldes i über die Funktion $rate(i)$ gemessen. Diese „ist 1, wenn das Datenfeld aus einer absolut glaubwürdigen Quelle kommt“ und „0 falls komplett unglaubwürdig“ (Teuteberg und Freundlieb 2009), mit entsprechenden Zwischenwerten, wobei eine subjektive Bewertung der Glaubwürdigkeit notwendig zugrunde liegt (Teuteberg und Freundlieb 2009).

$$Fehlerfreiheit = 1 - \left(\frac{Anzahl\ fehlerhafter\ Daten}{Anzahl\ an\ Daten}\right)$$

Formel 5: Metrik zur Fehlerfreiheit von Daten (Lee et al. 2006)

$$Vollständigkeit = 1 - \left(\frac{Anzahl\ unvollständiger\ Daten}{Anzahl\ an\ Daten}\right)$$

Formel 6: Metrik zur Vollständigkeit von Daten (Lee et al. 2006)

$$Glaubwürdigkeit = \frac{\sum_{i=1}^{N} rate(i)}{Anzahl\ an\ Daten}$$

Formel 7: Metrik zur Glaubwürdigkeit von Daten (Teuteberg und Freundlieb 2009)

Value: Diese Herausforderung wird als eine der wichtigsten Dimensionen von Big Data beschrieben (Saporito 2014), da sie die Anforderung beschreibt, die durch einen Beitrag zur „Wertschöpfung“ und durch die „Relevanz“ für den betrachteten Kontext, einen Mehrwert aus der Analyse gewinnt. Daten werden nach Hildebrand et al. als wertschöpfend bezeichnet, „wenn ihre Nutzung zu einer quantifizierbaren Steigerung einer monetären Zielfunktion führen kann“ (Hildebrand et al. 2011). Die Relevanz der Daten hingegen ist davon abhängig, ob „sie für den Anwender notwendige Informationen liefern“ (Hildebrand et al. 2011). Da der Wert von Informationen eine subjektive Größe darstellt (Laux et al. 2012) führt dies zu Problemen bei der

Messbarkeit in Bezug auf die Datenqualität. Ähnlich wie bei der Dimension Veracity ist auch die Bewertung der Wertschöpfung und Relevanz der Daten stark von dem Kontext und der subjektiven Einschätzung abhängig (Floridi 2014).

Die Herausforderungen in Bezug auf Big Data Datenqualität sind über die hergeleiteten Qualitätsdimensionen bewertbar und bieten die Grundlage zum systematischen Big Data DQM. Um eine detailliertere Betrachtung vorzunehmen und eine automatisierte Bewertung der Qualitätsdimensionen zu ermöglichen, müssen diese anhand von Datenqualitätsmetriken bewertbar sein. Die im Kontext dieser Arbeit durchgeführte, exemplarische Betrachtung der Messbarkeit zeigt, dass die Metriken häufig eine Definition subjektiver Schwellenwerte oder bestimmter Regeln vorsehen. So besteht beispielsweise Unklarheit über die objektive Ermittlung zutreffender numerischer Werte für die Glaubwürdigkeit einer Datenquelle (Teuteberg und Freundlieb 2009). Demnach ist eine detailliertere Betrachtung und Forschung notwendig, um je nach Anwendungsfall bestimmte Messgrößen für die Datenqualitätsdimensionen zu definieren.

6 Entwicklung einer Big Data DQM Balanced Scorecard

Auf Basis der identifizierten Herausforderungen und Messgrößen soll im Folgenden ein Werkzeug zum systematischen Big Data DQM erstellt werden. Entgegen traditioneller DQM-Ansätze, welche einen kontinuierlichen und systematischen Prozess zur Verbesserung der Datenqualität vorsehen (Wende 2007; Felden 2012), liegt der Fokus bei Big Data eher auf einer kontextabhängigen Differenzierung der Datenqualitätsstrategie, abhängig von den jeweiligen Einflussfaktoren und dem Zweck der Analyse (Mohanty et al. 2013; Floridi 2014). Da für das DQM im Bereich Big Data verschiedene Datenqualitätsdimensionen abgeleitet werden konnten, welche in fünf Perspektiven (Volume, Velocity, Variety, Veracity und Value) aggregiert werden können, wurde die Balanced Scorecard (BSC) als Instrument zur Zielformulierung auf Basis gegebener Umstände und Einflüsse genutzt (Kaplan und Norton 1997). Dabei werden bereits existierende Ansätze zur Nutzung der BSC im Kontext der Datenqualität berücksichtigt (Talburt und Campbell 2006; Wright 2010). Die BSC dient hier als ein Werkzeug, in welchem die Herausforderungen an Big Data über Qualitätsmetriken quantifiziert werden und dadurch kontrollierbar und vergleichbar gemacht werden. Ähnlich wie von (Floridi 2014) beschrieben, soll dabei besonders der Einfluss der Absicht der Big Data Analyse auf die Datenqualität abgebildet werden. Der Vorteil dieses Ansatzes gegenüber anderen Methoden (z.B. ROI (Ravenscroft 1960)) zeigt sich daran, dass nicht nur monetäre Kennzahlen gemessen und zur Strategieformulierung/-erreichung genutzt werden, gerade auch da Qualitätsaspekte schwer mit messbaren finanziellen Werten zu belegen sind (Experian Data Quality 2014).

Abbildung 1 zeigt das entwickelte Modell. Die zuvor identifizierten Herausforderungen an Big Data bilden die Zielgrößen und werden über die in Abschnitt 5.2 erläuterten Qualitätsdimensionen spezifiziert und über die Qualitätsmetriken quantifiziert (kursiv dargestellt). Eine Erweiterung des Modells, z.B. durch Adaption weiterer bereits in der Literatur identifizierter Dimensionen und Metriken, ist dabei kontextabhängig möglich. In Abbildung 1 wurde dies durch eine Integration von nicht weiter untersuchten Dimensionen in kursiv dargestellt (Wang und Strong 1996; Gebauer und Windheuser 2008; Maślankowski 2014).

Die Qualitätsdimensionen bilden sowohl den Ist-Zustand der zu verarbeitenden Daten als auch einen Soll-Wert ab. Jede Dimension kann in Bezug auf das Gesamtziel gewichtet werden und es können Schwellen- bzw. Minimalwerte festgelegt werden. Die Soll-Werte dienen somit der

Steuerung und Kontrolle der Ziele und können zudem bei der Auswahl der Datenquellen als Entscheidungskriterium herangezogen werden.

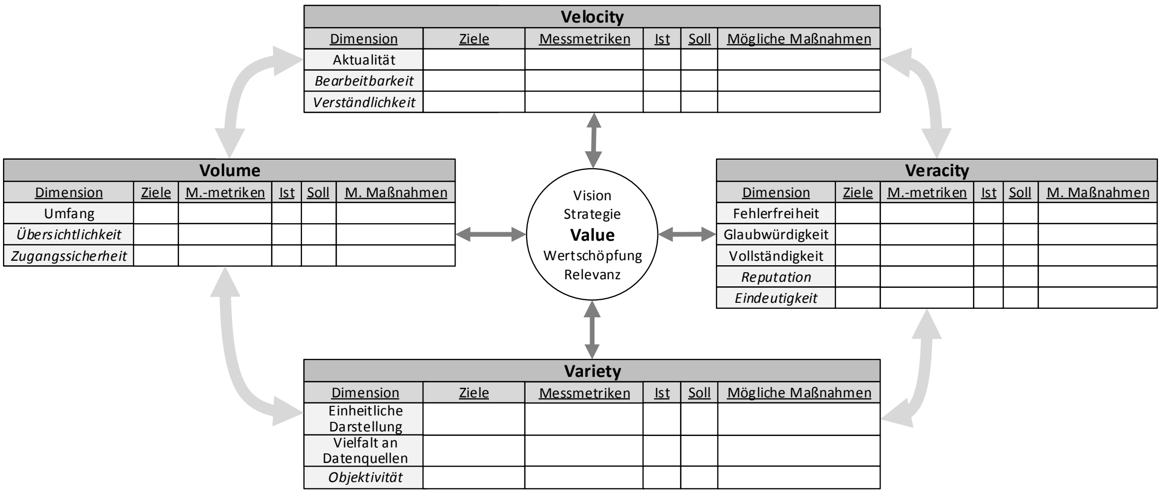

Abbildung 1 – Balanced Scorecard für das systematische DQM im Kontext von Big Data

Das Ziel der Analyse von Big Data ist es, einen Mehrwert aus den Daten zu gewinnen, um die geleisteten Investitionen in das Big Data Projekt zu legitimieren und ggf. Wettbewerbsvorteile durch die gewonnenen Informationen zu generieren (Saporito 2014). Somit kommt der Zielgröße „*Value*“ bei der Big Data Analyse eine zentrale Bedeutung zu und sie ist stets zu optimieren. Um den Wert der gewonnenen Informationen zu optimieren, müssen je nach Kontext bzw. Anwendungsfall verschieden starke Ausprägungen der Zielgrößen *Volume*, *Velocity*, *Variety* und *Veracity* in Betracht gezogen werden und der Einfluss der unterschiedlichen Dimensionen aufeinander zu beachten. So wird in der Literatur beschrieben, dass bei Big Data Anwendungsszenarien die häufig geringe Qualität der Daten über die Quantität der Daten relativiert wird (Mohanty et al. 2013; Tien 2013). So kann bei der Analyse großer Datenmengen die Unschärfe einzelner Datensätze vernachlässigt werden, da diese statistischen Ausreißer bei der Identifikation von Mustern keine Relevanz haben und übergangen werden.

In Tabelle 2 wurde die Balanced Scorecard beispielhaft für eine fiktive Gesundheitsorganisation, welche mit Big Data Epidemien voraussagen möchte, angewandt. Hier lässt sich einsehen, wie die Dimensionen und Messmetriken dazu genutzt werden können mögliche Maßnahmen für die Erreichung der Ziele abzuleiten. Das detaillierte Szenario inklusive einer erweiterten Darstellung der BSC, welche alle 4 Perspektiven berücksichtigt, kann unter www.assist.uwi.uos.de/ frehe/BigDataDQM_Evaluation.pdf abgerufen werden.

Wie von (Mohanty et al. 2013) festgestellt, ist Big Data Datenqualität nicht verallgemeinerbar, sondern stets vom Anwendungsfall abhängig. So verändert sich das Zielsystem je nach vorliegenden Datenquellen bzw. dem Ziel der Analyse und den Zielgrößen kommt je nach Kontext eine andere Bedeutung und Gewichtung zu. Auf Basis der Balanced Scorecard kann ein umfangreiches DQM umgesetzt werden, welches die Datenhaltung in den jeweiligen Phasen des Big Data Workflow auf Basis der Qualitätsdimensionen und abhängig vom Kontext kontrolliert.

Veracity					
Dimension	Ziele	Messmetriken	Ist	Soll	Mögliche Maßnahmen
Fehlerfreiheit	Mind. 85% der Daten sollen der Realität entsprechen.	Grad der Fehlerfreiheit	0,7	0,85	- Quellen mit fehlerhaften Daten ausschließen. - Qualitätsprüfung der Daten. - Integration weiterer Datenquellen.
Glaubwürdigkeit	Die Glaubwürdigkeit der Daten soll um 10% erhöht werden.	Grad der Glaubwürdigkeit	0,8	0,9	- Integration von Daten aus Quellen mit hohem Ansehen (z.B. Newsportale von Zeitungen, Fernsehsendern, Bundesagenturen). - Reduktion des Anteils unglaubwürdiger Datenquellen (z.B. soziale Netzwerke (Facebook, Google+, etc.) ausschließen).
Vollständigkeit	Daten sollen am Montag und Donnerstag für Analyse vorliegen.	Gemittelter Grad der Vollständigkeit der beiden Zeitpunkte	0,6	1	- Neue Ressourcen für schnellere Datenbeschaffung bzw. Data Cleaning. - Zeitpunkt der Datensammlung vorverlegen. - Outsourcing von ETL-Prozessen. - Identifikation neuer Datenmarktplätze.
Reputation	Daten aus Quellen mit hohem Ansehen sollen sicher transportiert werden.	Anzahl von Quellen die unverschlüsselt Daten senden	3	0	- Nutzung anderer Quellen / Ausschluss von Quellen. - Absprache der Nutzung von Verschlüsselungsalgorithmen. - Einführung eines IT-Sicherheitsmanagement (z.B. nach Vorgaben des BSI).
Eindeutigkeit	Daten sollen in Englisch sein und immer einen Bezug zu einem Land haben.	Grad der Eindeutigkeit = 1 – (Anzahl unzureichender Daten / Anzahl Daten gesamt)	0,7	0,99	- Ausschluss nicht englischer Daten. - Anpassung Data Cleaning Prozess auf Ausschluss von Daten ohne Landesnennung. - Überprüfung der Quellen, ggf. Komplettausschluss.

Tabelle 2 – Beispielhafte Nutzung der BSC aus der Perspektive Veracity

7 Fazit und Ausblick

In diesem Beitrag wurde die Datenqualität abhängig von den Herausforderungen an Big Data betrachtet. Eine Literaturanalyse ergab, dass Datenqualität im Kontext von Big Data aktuell ein kontrovers diskutiertes Problemfeld darstellt und noch keine ganzheitlichen Ansätze zum Thema Big Data DQM existieren. Um die Herausforderungen an Big Data bezüglich der Datenqualität zu analysieren, haben wir grundsätzliche Anforderungen auf Basis der Literatur identifiziert und deren Bezug zu Datenqualität über Datenqualitätsdimensionen abgeleitet. Die resultierenden fünf Herausforderungen Volume, Velocity, Variety, Veracity und Value wurden daraufhin mit exemplarischen Messgrößen in eine Balanced Scorecard überführt, welche zur Strategieformulierung und Strategiedurchführung in Big Data Szenarien verwendet werden kann. Die BSC ermöglicht ein systematisches DQM eines Big Data Anwendungsfalles abhängig von dem Zweck der Analyse und den unterschiedlichen Herausforderungen.

Limitationen der Arbeit sind in der Überführung der Inhalte der Beiträge in Herausforderungen, und Qualitätsdimensionen zu sehen, da diese auf der subjektiven Einschätzung der Autoren basieren. Aufgrund der Integration von drei Wissenschaftlern wird von einer ausreichenden Interrater-Reliabilität ausgegangen. Weiterhin wurde lediglich der Rahmen des strategischen Werkzeuges (BSC) geschaffen, es wurde aber nicht umfassend auf die Messbarkeit der einzelnen Metriken und auf die Interdependenzen im Zielsystem eingegangen.

Diese Arbeit deckt diverse Felder für zukünftige Forschung auf. So besteht Forschungsbedarf im Bereich der Messbarkeit von Big Data Datenqualität, so dass verschiedene Metriken auf Eignung zur Bewertung und Kontrolle der Datenqualität in Form eines systematischen DQM untersucht

werden. Zudem wird oft das Problem der (regelbasierten) Datenbereinigung (Fan und Huai 2014) und fehlende Algorithmen, welche eine Erkennung und Bereinigung von qualitativ minderwertigen Daten ermöglichen (Saha und Srivastava 2014), genannt. Erste Ansätze für einzelne Datenstrukturen existieren (Zhang 2013; Tang 2014), jedoch fehlt ein holistischer Ansatz.
Die Evaluation der BSC sollte zudem anhand eines realen Beispiels durchgeführt werden um die praktische Relevanz kritisch beurteilen zu können.

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Towards Game-based Management Decision Support: Using Serious Games to Improve the Decision Process

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Abstract

The domain of business intelligence and analytics has seen major contributions concerning the analysis of data, the design of data warehousing infrastructures as well as decision support systems that in essence all share a common goal: Supporting decision-making in organizations. However, surprisingly few publications originating from an information systems perspective deal with decision-makers themselves, leaving a great opportunity for the field to focus on. This study therefore proposes to improve the skills necessary in the decision process by using serious games as a form of experiential learning. For this purpose, we perform a systematic literature review that shows which skills needed in the decision process are already addressed by publications that deal with serious games. This study therefore provides business intelligence researchers with a novel perspective on decision support and shows which specific skills need further investigation. Decision-making practitioners and management education programs might also benefit from this study, because it highlights several serious games that may be used or adapted in order to train decision-making deliberately.

1 Introduction

Can we become better decision-makers by playing video games? At first, this question might seem controversial, even provocative. This is because video games are rather associated with leisure time than with managerial decision-making. However, games are used in many disciplines to convey knowledge and increase the capabilities of players, which is commonly referred to as "serious games" (Legner et al. 2013).

The domain of business intelligence (BI) and analytics has seen major contributions concerning the analysis of data, the design of decision support systems as well as data warehousing infrastructures that in essence all share a common goal: Supporting decision-making in organizations (Chen et al. 2012). However, surprisingly few publications deal with the skills of decision-makers (Debortoli et al. 2014), leaving a great opportunity for the field to focus on.

With a vast amount of data available, increasingly dynamic environments, and complex processes (Baars et al. 2014), managerial decision-making has become more challenging than ever. Hence, besides more advanced BI software, the individual skills of decision-makers are getting crucial for success. These skills can be improved by target-oriented learning to help decision-makers cope with the challenges of their environment.

We thus argue that learning and the individual skills of decision-makers should be considered an important topic in the domain of BI and analytics. In addition, we propose the use of serious games as a form of experiential learning, which is often regarded as an effective means to increase knowledge and skills (Liu et al. 2013).

Due to an increasing number of publications concerning gamification, serious games as well as related topics (Blohm and Leimeister 2013; Liu et al. 2013), there is a need to survey and synthesize prior research. In general, scientific work becomes more and more complex as there is a need to invest more time for investigating literature. Failing this causes a danger to waste valuable resources because of performing the same investigations several times as well as a danger of neglecting crucial facts. Moreover, analyzing patterns in existing literature may reveal new beneficial research questions (Webster and Watson 2002).

Given the motivation for more people-centric decision support as well as the just described methodological issues, the core of this study is a systematic literature review that addresses the following two research questions:

1. Which skills required in the decision process are often addressed by serious games?
2. Which skills required in the decision process are rarely addressed by serious games and thus reveal a need for further research?

In detail, the literature review indicates which skills needed in the decision process are addressed by publications that deal with serious games. For this purpose, we first outline the theoretical background of this investigation in section 2. The method of this literature review is explained in section 3. In section 4, the results of the review are described. The study concludes with a discussion of results, a conclusion as well as an outlook on future research in section 5.

2 Theoretical Background

2.1 Skills Required for Managerial Decision-making

To identify the skills that are necessary for managerial decision-making, we investigate the underlying decision process. A generic decision process for organizations, that is composed of several decision phases, has initially been proposed by Simon (1965) and was extended by Mora et al. (2003). It consists of five consecutive phases: Intelligence, design, choice, implementation and learning (Mora et al. 2003, p. 63). These decision phases can further be divided into several decision steps (see Table 1).

Decision Phase	Decision Step
Intelligence	Data Gathering
	Problem Recognition
Design	Model Formulation
	Model Analysis
Choice	Evaluation
	Selection
Implementation	Presentation of Results
	Task Planning
	Task Tracking
Learning	Outcome-Process Link Analysis
	Outcome-Process Link Synthesis

Table 1: The generic decision process presented by Mora et al. (2003)

During the intelligence phase, decision makers observe reality, gather information and therefore gain an understanding of the problems and possibilities at hand (Mora et al. 2003, p. 59-60). In the design phase, they construct a decision model which consists of possible actions, decision criteria, uncontrollable events and relationships between these variables. This decision model serves as a basis for the choice phase, in which decision makers evaluate possible alternatives and hence generate recommended actions. In the implementation phase, decision makers weigh possible consequences and gain confidence about their decision, plan the tasks needed to realize the decision and execute this plan. In order to improve their decision behavior as well as assessing decision situations, decision makers observe the outcomes of the decision and connect it to their decision behavior in the learning phase.

In this study, we assume that each of the decision steps described above requires one specific skill. Hence, the skills required for managerial decision-making are equivalent to the decision steps mentioned above (e.g., the skill of data gathering or the skill of model formulation).

2.2 Serious Games and Business Games

Serious games are gaining increasing attention in the domain of business and information systems engineering due to the rising popularity of gamification (Blohm and Leimeister 2013). Since these two types of using games and game elements for serious purposes are often not clearly differentiated in business practice (Bogost 2015), they are briefly delineated in the following.

Gamification can be defined as using game design elements (like points, badges and leaderboards) in non-game contexts (Deterding et al. 2011). In contrast to using just game elements, serious games employ full-fledged games (Deterding et al. 2011) that often draw on learning and motivation theories (Grund 2015). They are commonly defined as games which are not limited to the purpose of entertainment but also focus on improving skills and teaching players educational content (Abt 1987). In order to accommodate the different purposes of serious games, they are defined in this study as games that seek to entertain players as well as to improve their skills or knowledge. Business games are a specific type of serious game that aims to increase skills and knowledge in the business domain, commonly by simulating whole companies and letting players compete in a virtual marketplace (Faria et al. 2009).

3 Method

This literature review aims to clarify which of the capabilities required in the decision process of managers are commonly addressed by serious games. In accordance with Webster and Watson (2002), we will first introduce our search strategy in this section, followed by a structured concept matrix for analyzing our results in section 4. With regard to the taxonomy of literature reviews presented by Cooper (1988), this study aims to identify central issues from a neutral perspective, based on research outcomes in representative publications. It is arranged conceptually and targets general as well as specialized scholars in the domain of BI and analytics.

Since serious games are comprised of technology (i.e., software) and desired learning outcomes, this review draws selectively from multiple research areas, focusing on leading journals and conferences. To cover the technology-related aspects of serious games, the Information Systems (IS) domain is considered. The domain of management learning is included to see to what extent serious games are already used for managerial education. Last, the domain of serious games itself is incorporated because it examines the intersection between the technology used and the desired learning outcomes. In the following, we will describe the selection of outlets from these domains as well as the different search types that result from the domains' focus.

To consider the IS domain, a manual investigation of relevant research articles in the AIS Senior Scholars' Basket of Journals which consists of the "European Journal of Information Systems" (EJIS), the "Information Systems Journal" (ISJ), "Information Systems Research" (ISR), the "Journal of the Association for Information Systems" (JAIS), the "Journal of Information Technology" (JIT), the "Journal of Management Information Systems" (JMIS), the "Journal of Strategic Information Systems" (JSIS), and "Management Information Systems Quarterly" (MISQ) was conducted. Additional sources from the IS domain are the journal "Decision Support Systems" (DSS) and the "International Conference on Information Systems" (ICIS). The AIS Senior Scholars' Basket of Journals was considered since it comprises a widely accepted set of top journals in the field of IS research. The journal DSS was selected because of its relation to decision making and decision support, which is the focus of this study. Last, the ICIS was considered since it provides current publications from manifold research communities, such as human computer interaction. In this manual search, every publication title as well as (in case of relevant terms) every heading is searched for formulations that indicate the use of serious games.

Since this literature review also aims to address the field of management learning, the journals "Management Learning" (ML) and the "Journal of Management Education" (JME) are additionally investigated. As these journals focus more on education than on technology, we want to identify any publication that suggests the use of games for management education. Hence, the abstracts of these publications are searched for the term "Gam*", which includes terms from "gaming" to "game-based learning".

To account for the specific domain of this literature review (i.e., serious games), the journals "Simulation and Gaming" (S&G) as well as the "International Journal of Serious Games" (IJSG) were added to the search space. Since these journals explicitly focus on using serious games and business games, a more narrow type of search was employed. Thus, these journals were used for a keyword search with the terms "Serious Games" and "Business Games".

In order to emphasize recent findings, the investigation period for all searches covers the years 2009 to 2014. An overview of the search setup is provided by Table 2.

Source		Search Type (Period: 2009 – 2014)	# Results	# Articles
Information Systems	AIS Basket	Manual search	1	1
	DSS		5	5
	ICIS		3	3
Management Learning	ML	(Gam*) IN Abstract	0	0
	JME		7	3
Serious Games	S&G	(“Serious Games” OR “Business Games”) IN Keywords	24	21
	IJSG		19	16
Total			59	**49**

Table 2: Search space and sample size of this literature review

As Table 2 shows, the structured search initially yielded 59 results in total. However, 6 publications from the IJSG as well as from S&G have been removed since these are no original articles, and 4 publications from the JME have been removed because these articles do not refer to using games for management education. After these publications have been removed, 49 articles remain in the literature sample for this review, which is analyzed in the following section.

4 How Serious Games Improve the Decision Process

The results of examining the literature sample for relevant skills in the decision process are depicted in Table 3. A regular entry (i.e., “X”) means that the specific skill is mentioned by the authors, either as a learning goal or as an observed learning outcome. Bracketed entries (i.e., “(X)”) refer to activities players had to fulfill that resemble the decision steps. While these activities might lead to improvements in the respective decision steps, this is not as nonambiguous as opposed to concrete learning goals. Publications that neither aim at improving particular skills nor do mention activities that might lead to their acquisition are removed from the literature sample. In the following sections, we will describe entries in Table 3 grouped by the phases of the decision process.

Publication	Skills Required in the Decision Process										
	Intelligence		Design		Choice		Implementation			Learning	
	Data Gathering	Problem Recognition	Model Formulation	Model Analysis	Evaluation	Selection	Presentation of Results	Task Planning	Task Tracking	Outcome-Process Link Analysis	Outcome-Process Link Synthesis
Alklind Taylor et al. (2012)	(X)									X	X
Basole et al. (2013)	X	(X)				(X)					
Ben-Zvi (2010)	(X)	(X)				(X)	(X)			(X)	
Borrajo et al. (2010)						(X)				X	X
Chorianopoulos and Giannakos (2014)										X	
De Gloria et al. (2014)	X				(X)	(X)		(X)		(X)	
Douma et al. (2012)		X				(X)				(X)	
Enfield et al. (2012)	(X)	(X)			(X)	(X)	(X)				
Harteveld et al. (2010)	X	X					X				
Imbellone et al. (2015)	X	X	X		X	X	X	X	X	X	
Karriker and Aaron (2014)	X					(X)					
Katsaliaki and Mustafee (2014)		X				(X)					
Krom (2012)		X				X					
Lainema (2010)	(X)				(X)						
Legner et al. (2013)		(X)				(X)	(X)			X	X
Lewis and Grosser (2012)							X	X	X		
Lopes et al. (2013)							(X)	(X)		X	X
Mayer (2009)		X	(X)		(X)					(X)	
Monk and Lycett (2011)						(X)					
Oksanen and Hämäläinen (2014)						(X)					
Pannese and Morosini (2014)	(X)					(X)		(X)		X	X
Procci et al. (2014)										X	X
Smith (2010)								(X)			
van der Zee et al. (2012)	X				(X)	(X)				X	

Table 3: Skills in the decision process mentioned by the publications

4.1 Intelligence Phase

Publications in the literature sample often include the intelligence phase. However, only 5 publications mention both data gathering and problem recognition. In a training simulation game for levee inspectors presented by Harteveld et al. (2010), data gathering and problem recognition are essential. The player gathers data by measuring symptoms of a levee failure and has to recognize failures, which equals problem recognition. Imbellone et al. (2015) investigate 30 different serious games that each are built to address one specific skill needed in non-routine tasks. Since they also empirically survey the skills that are needed in these situations, this publication directly addresses most skills of the decision process. They describe the skill “initiative”, which includes actively seeking new information (i.e., data gathering) and the skill “openness to change”, which includes realizing the need for change (i.e., problem recognition). By introducing the serious game “Health Advisor”, Basole et al. (2013) provide an approach for letting players experience difficult health-related tradeoffs. Players can access different information resources, which in an empirical evaluation they came to understand and learned how to use best (i.e., data gathering). In addition, players had to assess and monitor healthcare needs of virtual clients, hence problem recognition was also addressed. Ben-Zvi (2010) investigates the efficacy of business games in creating decision support systems. Students have to build a decision support system in a simulated business environment to see how their company performs. They gather data and recognize problems because they analyze the company’s history as well as different management situations. A serious game concerning the diffusion of innovations theory is presented by Enfield et al. (2012). The player has to persuade the staff of a junior high school to adapt peer tutoring. In so doing, they have to look at the personal information of staff members (data gathering) to identify what adopter type the staff members are (problem recognition).

The literature sample contains 6 publications that focus exclusively on data gathering. De Gloria et al. (2014) aim to present the state of the art of serious games for education and training, referencing a study that demonstrated an increased focus on information gathering activities by high-achieving players. Karriker and Aaron (2014) investigate two business games and enforce data gathering by encouraging their students to use different strategic maps in a so-called “Competitive Intelligence” tool. A conceptual modeling framework that supports the creation of simulation-based serious games is presented by van der Zee et al. (2012). They claim that using games may enhance students’ ability to formulate good questions, which is required for data gathering. Alklind Taylor et al. (2012) introduce the coaching cycle in serious games and mention an example of a crime scene investigation, where players have to gather information that the instructor has placed beforehand. Lainema (2010) discusses the role of time in business games, suggesting that players have the task to identify relevant information. Pannese and Morosini (2014) discuss two serious games for training in the health sector, declaring the exploration of situations in order to gain better knowledge (i.e., data gathering) as one of the cores of the games.

The remaining 5 publications concerning the intelligence phase cover only problem recognition. Douma et al. (2012) present a barge handling algorithm to staff at a port by using a simulation game. One of their aims is to enhance a comprehensive understanding of a complex system, which can be interpreted as problem recognition. Katsaliaki and Mustafee (2014) perform a literature review about serious games for teaching sustainable development and hereby cite publications claiming that games lead to increased problem recognition. Krom (2012) uses the social game “FarmVille” to complement an accounting course. They argue that the resulting active learning contributes to comprehension and retention of complex material, which can be seen as problem recognition. Mayer (2009) provides a review of using simulation games in public policy making. He addresses problem recognition by referring to the simulation games “Fish Banks” and “Harvest” that familiarize players with the complexity and urgency of ecological problems. Legner et al. (2013) propose using business games that are based on enterprise resource planning systems and develop a corresponding curriculum for management education. Players may practice problem recognition by analyzing transactional data from standard reports and BI applications.

4.2 Design Phase

The design phase is rarely addressed by the publications in the literature sample. Only 2 publications mention the design phase, while solely focusing on model formulation. Imbellone et al. (2015) list the skill of "strategic thinking" which involves identifying opportunities that can increase the organization's competitiveness. Mayer (2009) mentions the model formulation step as a part of using simulation games for public policy making. He suggests that policy makers should gain an understanding of their decision alternatives as well as the possible states of nature by trying out different solutions in a simulated environment. In this environment, several real persons also take part, since computer simulations often cannot simulate human behavior.

4.3 Choice Phase

The choice phase is mentioned by many publications in the literature sample, with 4 publications addressing both evaluation and selection. As one of few publications, Imbellone et al. (2015) directly refer to the skills required in the choice phase. They describe the skill "decision making" that includes evaluation of consequences and risks (i.e., evaluation) as well as making good decisions in complex situations (i.e., selection). De Gloria et al. (2014) show that both evaluation and selection are covered by serious games, describing an example from the health sector in which players integrate evidence into decision making (i.e., evaluation) and ultimately take decisions (i.e., selection). Enfield et al. (2012) address both evaluation and selection in their diffusion simulation game, since players have to first identify and then select efficient diffusion activities. According to van der Zee et al. (2012), players have to make balanced and founded pricing decisions.

The evaluation step is described by 2 publications. Lainema (2010) mentions that players have to identify correct solutions in simulation gaming and Mayer (2009) shows that in political exercises, scenario-based free form games force players to evaluate strategic alternatives in terms of the values at stake.

Last, 11 publications refer to the selection step. Krom (2012) claims that players learn how to allocate costs among products or departments. The remaining publications simply state that players have to make decisions, for example by choosing their next steps (Basole et al. 2013; Ben-Zvi 2010; Borrajo et al. 2010; Douma et al. 2012; Karriker and Aaron 2014; Katsaliaki and Mustafee 2014; Legner et al. 2013; Monk and Lycett 2011; Oksanen and Hämäläinen 2014; Pannese and Morosini 2014).

4.4 Implementation Phase

Only 10 publications in the literature sample directly address the implementation phase. In addition, only 2 concern all steps of this phase. Imbellone et al. (2015) include the presentation of results in the skill "decision making" (i.e., presenting logical, reasoned, constructive critical comments and arguments). Task planning and task tracking are summarized in the skill "planning", that includes defining priorities and anticipating progress of actions and resources required. The serious game "Change Game" focuses on difficulties that arise from resistance to change (Lewis and Grosser 2012). In this classroom game, students are randomly divided into two groups: Managers and workers. The managers' task is to deploy a new seating order that would result in workers having to change their seats. The workers, however, are incentivized not to do so. Hence, players learn about the importance for communication when leading change and improve their skills in planning and coordination.

Lopes et al. (2013) cover two decision steps as they provide an overview of business games that enhance leadership skills. By briefly describing the interactivity in the selected games, they reveal that in the game LEADER, players have to present the justifications for their decisions and in the game VIRTUAL LEADER, they have to prioritize tasks or define the activities to be performed.

There are 4 publications in the literature sample that only cover the presentation of results. In the training game for levee patrollers presented by Harteveld et al. (2010), presentation of results is important because the correct reporting of failures is vital for the control procedure. Ben-Zvi (2010) describes that students had to present their results in an oral presentation as well as with a written report. In the diffusion simulation game, players can choose between different presentation-related activities, for example giving presentations or using mass media to convince other people about an innovation (Enfield et al. 2012). Legner et al. (2013) asked players to provide justifications for their decisions and present their synthesis to the other teams.

Task planning is emphasized by 3 publications. In the healthcare setting presented by De Gloria et al. (2014), players have to plan changes to cancer-screening delivery. Pannese and Morosini (2014) also describe exploring what to do, in what order and why as one of the cores of the two healthcare games they discuss. In his overview of the history of gaming in military training, Smith (2010) shows that games have been used to plan invasions or attacks.

4.5 Learning Phase

The learning phase is mentioned by 13 publications, while 6 publications address both steps in this phase. Alklind Taylor et al. (2012) describe debriefing as essential for allowing players to reflect upon and generalize from experience. Borrajo et al. (2010) list analyzing the "cause-effect" relationship of decisions (i.e., consequences of actions taken) as a learning objective. Legner et al. (2013) claim that players can understand the market dynamics and compare themselves to their competitors. Lopes et al. (2013) specifically address the skill of focusing on the relationship between cause and effect in a decision-making process in games for leadership development. Pannese and Morosini (2014) directly refer to fostering reflection and the player's ability to self-regulate their training. These games also aim to enable good decisions when the player is confronted with a similar real life occurrence. In a serious game for military training, Procci et al. (2014) show players short cinematics of catastrophic failures in decision-making. Thus, players can analyze which actions led to problems and reflect on implications for their lives.

The remaining 7 publications focus only on outcome-process link analysis, which means reflecting about how one's actions affected the decision outcomes. Chorianopoulos and Giannakos (2014) discuss a serious game for teaching basic math to children. They argue that games help players to recognize their exact mistakes and what they could have done differently. Imbellone et al. (2015) stress the need to be able to learn from own experience. The influence of pricing decisions on customer behavior is addressed by van der Zee et al. (2012). In the business game presented by Ben-Zvi (2010), students have to evaluate their decision. In the serious game about healthcare presented by De Gloria et al. (2014), a summary screen indicates which decisions the player has implemented and their effect on the clinic's screening rate, thus allowing reflecting on the decisions afterwards. In the barge handling simulation (Douma et al. 2012), players can experience the consequences of their decisions rapidly. Mayer (2009) emphasizes the usefulness of games in urban planning, as players make decisions in synthetic cities, observe the consequences and make new decisions.

5 Discussion, Conclusion and Future Research

This review shows that, in regard to research question 1, most of the capabilities required in the managerial decision process may be acquired or improved by playing serious games. These games should hence be considered a viable approach for fostering decision-making skills. Surprisingly, however, only few games actually utilize dedicated BI software when fostering skills in the intelligence phase. Instead, most of the games either use custom-crafted simplified reports (e.g., Basole et al. 2013) or do not specify which kind of reporting is used (e.g., Alklind Taylor et al. 2012). The only game that uses actual BI software is presented by Legner et al. (2013). However, in their proposed curriculum, the focus is set clearly on enterprise resource planning systems. Hence, according to our literature sample, a game that emphasizes BI software and reporting seems to be still missing. Important learning outcomes, like evaluating different reporting tools or proper information visualization, might therefore not be addressed. A possible approach to solve this issue is presented by Ben-Zvi (2010), where students have to build their own decision support systems. However, in this particular study, most students used Microsoft Excel, which shows that they were not introduced to dedicated reporting software. The review also reveals that the decision phases design and implementation are left out many times. In many business games, players do not formulate decision situations by themselves, and the games implicitly assume that any decision made by the player will be executed without any difficulties. Since no single game addresses all of the decision steps, educators who want to improve decision-making with serious games might be left with the problem to fill these gaps.

Referring to research question 2, this study shows the need for future research. First, serious games that focus on BI issues, reporting software, and information visualization might be developed in order to take full advantage of game-based management decision support. Second, there is need for serious games that tackle the decision steps model formulation, model analysis and task tracking, since they are scarcely mentioned in our literature sample. Last, this study invites the field of BI and analytics to broaden its focus and take into account the capabilities of individual decision-makers who decide based on the insights provided by BI software.

A limitation of this study is the focus on selected leading journals and conferences. On the one hand, this should ensure a high quality of findings. On the other hand, a lot of valuable and even more recent facts may be found in other sources with less scientific reputation, in particular results of workshops or working papers. This will be a focus of further research. Regarding the results of this study as well as the highlighted need for future research, we conclude that focusing on learning and the individual skills of decision makers by using serious games might be a fruitful avenue for extending BI and analytics research.

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Instance Selection Method Identifying Relevant Events with Domain Knowledge and Less Human Involvement

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Abstract

Nowadays, a huge amount of events is captured in any context of decision support. But, their relevance and due to this, their effect on a target variable during model training is hard to obtain. Here, contemporaneous events and not specified market latencies lead to a fuzzy defined training data set. To achieve a successful prediction, a training data set is needed containing representative instances. But traditional instance selection methods do not consider fuzzy effects and fail. The paper introduces an alternative approach. Here, the relevance of an event is deduced from the effect it caused on a target variable after its publication. Such an additional business domain knowledge should allow a more precise selection of instances and thus a successful prediction. The application is presented within the natural gas market and has shown that no other method identified more relevant tickers. This approach contributes to the scientific discussion by integrating domain knowledge into instance selection. By now, only a few approaches exist and all demand costly human involvement. Our approach is automatic, thus analysts can safe costs and time.

1 Introduction

As a result of the Big Data era, more and more training examples are used in knowledge discovery in databases (KDD) projects (Zhu et al. 2015). Without a proper selection, the time and memory complexity of model learning becomes impractical (Liu and Motoda 2002). Preprocessing techniques are used to reduce a training set *T* to a subset *S*. Those methods are called instance selection (IS) methods. They aim a classification accuracy approximately equal or better for *S* (García et al. 2012). Here, representative instances of each class are selected or generated from *T*. Due to the increased application of KDD techniques, a vast veracity of such methods evolved (Olvera-López et al. 2010). But, analytical tasks have changed and traditional methods are not always sufficient (Liu and Motoda 2002). One reason is that various data sources are usually linked in Big Data projects. E.g. the effect of a single event (image, video, news, tweet, purchase, delivery, or failure) on a target variable has to be predicted. (Pospiech and Felden 2014) Imaginable scenarios are cash flow prediction, stock forecasting, or sales projections. The amount of such events is high and can be subdivided into relevant and irrelevant ones (Liu and Motoda 2002). But, the effect of an event is hard to obtain and harder to define automatically within a training data set. The reason is that the latency between event occurrence and accompanied effect is unknown and it remains unclear, whether other contemporaneous published events might have caused the effect (Pospiech and Felden 2015). As a consequence, the training set becomes fuzzy, because irrelevant examples are selected as relevant ones, vice versa. The existing approaches are only heuristic and do not consider the fuzzy effect of unstructured events on a target variable. They are not able to identify representative training instances and the model performance decreases (Brodley and Friedl 1999). It is the paper's goal to introduce and discuss an alternative IS method that allows the selection of relevant and irrelevant events within a fuzzy data set.

Several authors proposed possible solutions. IS methods considering their business domain allow a more precise identification of relevant events, because the causality between event and target variable is better explained (Leyva et al. 2015). But approaches considering domain knowledge to identify relevant instances are based on pre-classification or pre-defined keywords. Here, the initial definition of such artefacts is done by humans and is time and cost intensive. (Forman et al. 2006) The reusability and generalizability to other application fields is limited, too. Considering the amount and changing contents of events in modern KDD projects, a continual update of this artefacts is required. This leads to rising costs and due to this to inefficient projects. (ibid.) Traditional approaches mostly rely on distance measures. Here, the focus lies on the consolidation, filtering, or selection of challenging instances within the space. Example rows are identified to compare predicted and actual class labels. But, events could have been assigned to wrong classes before training, because of contemporaneous events or an unclear latency. Thus, a comparison between predicted and actual classes will lead to wrong selections (Brodley and Friedl 1999). Our approach contributes to the scientific discussion by deducing business domain knowledge of a historic effect caused by an event affecting a target variable by alteration and time. Dependent on the event, various feature extraction methods for images, text, or audio exist, that transform the event into a machine readable format (Bhatt and Kankanhalli 2010). Thereby, this feature extraction methods and scenarios are independent from our proposed approach. Regarding this domain knowledge, our method should outperform traditional heuristic IS approaches. The identification supports the development of a high quality training data set to allow a precise prediction of classes within the domain of unstructured events. In addition, the approach requires a minimum human involvement, allows an automatic repeatable execution to address new contents, and is generalizable to any field, wherever the effect of a specific event on a target variable has to be forecasted. Thus, time and cost savings for data scientist and analysts are achievable within projects.

The paper is organized as follows: after a literature review, the development of our IS approach is shown. Using a case study our method is applied within trading and compared to existing approaches. The results are discussed, and implications are highlighted.

2 Literature Review

In an initial perspective, our introduced *durability* concept (Pospiech and Felden 2015) allowed IS, regarded domain knowledge, and required a minimum human involvement. But, too many irrelevant instances remained within the training data. Due to this reason, we searched for alternatives provided by literature.

In the past, relevant and irrelevant instances were selected by human experts. Here, either pre-defined rules or manual assignments generated an appropriate training set. (Forman et al. 2006) Time and cost savings were obtained by techniques like ranking or clustering. Only a sub-sample was labeled manually and machine learning assigned the classes to the remaining training examples (Yang and Liu 1999). Nevertheless, topics of news, or images (events) changes fast. Domain experts must classify the instances continuously to keep an actual model (Forman et al. 2006). Considering time and cost savings, automatic methods identifying irrelevant and relevant events are demanded. In rare cases, an automatic assignment is possible (Lavrenko et al. 2000). Here, published events were linked to three possible class manifestations (up, stable, or down) - or more precise to price alteration appearing hours later. Such a questionable effect will lead to a huge amount of irrelevant instances and will generate a fuzzy training set. The reasons are overlapping events and unknown market reaction latencies (Pospiech and Felden 2015). Thus, the challenge is an automatic identification of representative relevant and irrelevant training examples out of a huge amount of data with minimal human involvement. One possible strategy could be the selection or generation of examples. Such approaches belong to traditional IS methods. Recently, several detailed literature reviews were published (García et al. 2012; Olvera-López et al. 2010), where more than 80 different approaches are debated. We will provide an overview of the most discussed techniques.

For example, condensation algorithms are incremental methods adding instances from the training set T to a new data set S insofar they increase accuracy. Condensed Nearest Neighbor Rule (CNN) selects randomly one instance in T of each class into S. Afterwards, each instance in T is classified by nearest neighbor rule using S as training set. All misclassified instances p are included to S. Thus, instances similar to p in T will be predicted correct and a minimal consistent training set S will remain. (Hart 1968) Within Neighborhood Graph Editing (RNGE) the decision surface of a 1-NN algorithm determines a Gabriel Graph, where all instances of T are represented. If two instances (vortex) are neighbors and belong to the same class, one will be removed. Monte Carlo (MC1) repeats a random selection (n times) and selects the example set achieving the highest accuracy (Skalak 1994). Noise filters are decremental algorithms. Instances are removed from the training set, which do not agree with the majority of the k nearest neighbors. Edited Nearest Neighbor (ENN), Repeated ENN (RENN), All-KNN are typical examples (Tomek 1976). Prototype construction methods focus on the generation of new instances, which are representatives of the whole data set. Learning Vector Quantization (LVQ) and Weighted LVQ (WLVQ) are based on neural network techniques (Blachnik and Duch 2011). They will determine the closest prototype vector for each instance and will align the prototype position closer to the instance, if the classification is true and removes it, in case of false. Random Mutation Hill Climbing (RMHC) creates and transfers prototypes into a binary string. A single bit mutation occurs in each iteration. If the mutation improves the accuracy, the new solution will be kept (Skalak 1994). Clustering algorithms extract and label prototypes. A typical representative is Fuzzy C-Means (FCM) (Pedrycz 1996). Evolutionary algorithms chose and evaluate by a fitness function. The best instances are selected in order to be combined and mutated for generating new instances (García et al. 2012).

As demonstrated, all methods are based on heuristics. It is doubtful, whether such techniques can identify relevant examples as long as the effect of the event is fuzzy. Several authors raised the need for domain-oriented IS methods (Leyva et al. 2015). But, this methods are missing generalizability and are time and cost intensive (Forman et al. 2006). According to that, we propose a new approach.

3 Development of the Impact Selection Approach

We assume that relevant events trigger an alteration on a target variable (like prices or trends). Models trained with representative instances are able to predict the target variable, insofar similar events will occur in the future (Lavrenko et al. 2000). To illustrate the proceeding of our approach, we will focus on a trend forecasting by news tickers. In fact, it is vague whether and how fast a trend development will show a response to an event. Some will need minutes, others seconds until a price adjustment occurs. A time interval (market latency) needs to be specified by domain experts (Pospiech and Felden 2014). The mapping of event and target variables is challenging within the training set development. Lavrenko et al. (2000) developed Backward Mapping (BM) and Pospiech and Felden (2015) Forward Mapping (FM) to deduce classes.

Backward Mapping: BM assumes that a trade transaction (buy or sell) is caused by a historic message (Lavrenko et al. 2000). First, trends needs to be calculated. Based on historical trade transactions, possible manifestations/classes are derived for all examples. Thus, an example will belong to the class UP, if the price of the previous transaction is lower than the following one and vice versa to the class DOWN. The class STABLE represents a no remarkable price change between two trade transactions. Because applications differ from each other, domain experts have to specify an alteration representing a meaningful development. Based on a given trade transaction, each historical news ticker is linked, which is published within a defined time period prior (market latency) the price change so that it belongs to a training instance. As a result, tickers with no trade transactions within the specified time period are regarded as irrelevant and are not reused anymore.

Forward Mapping: FM assumes that a news ticker will cause a future transaction within a specific time frame. In contrast to BM, all messages are selected and mapped to the previous trade transaction. In fact, the FM procedure requires another trend calculation, because the news ticker itself forms the central artifact. Thus, the trend is not estimated between two trade transactions any longer. Instead, it is calculated by the different prices of the previous trade transaction (from the news ticker) and the status after (market latency) publication. If no transaction occurred after the time interval, the ticker is labeled as STABLE. The reason is that no reaction after publication was observable. In addition, STABLE will be labeled, if a minimum alteration is not achieved. The FM has one important drawback: all news tickers are used, even irrelevant ones.

The model accuracy will increase, if relevant training examples are chosen (Khandar and Dani 2010). Nevertheless, a short time price alteration (e.g. price rises and drops immediately) implies a small effect by news tickers. Relevant events will lead to a permanent price change. Our already mentioned *Durability* conept addresses this need (Pospiech and Felden 2015). It represents a time length to define the period within a specific trend statement remains true. Thus, the effect of a target variable caused by an event. But, the approach contains some disadvantages. We considered only the time effect of an event on a target variable. The impact over time is not regarded. Thus, a news ticker causing a price alteration of 5.00 price points for more than ten minutes is treated in the same way as a news ticker causing 0.20 price points in the same time period. We did not consider a natural noise within the price alterations. Imagine a price drop for a few seconds, an instance is labeled as DOWN. This even when the price increases instantly afterwards. So, two errors arise: A wrong label and a wrong *durability*. As a result, a wrong training examples selection will lead to a lower model performance (Leyva et al. 2015). Another issue results from the free rider effect. Here, the *durability* of a ticker can be caused by a previous news and not by the event itself. While the first one is of high relevance, the target variable will rise or drop over a long time. Thus, the following ticker(s) are affected by the previous ticker and will achieve a high *durability*, whereby the content might hold no relevance. Here, irrelevant tickers are marked as relevant ones.

3.1 New Instance Selection Approach

Compared to our previous approach (Pospiech and Felden 2015) we propose three additional steps. First, we use average trend calculations to address the natural noise. Second, we determine the impact of UP/DOWN events not only by time, but also by resulting alteration (STABLE is treated unchanged). Third, tickers reaching a minimum impact or durability are forwarded. Here, the free rider effect is addressed by a classification.

The price average of the following transactions is computed within a specified time interval (like two minutes) and compared to the price of the considered transaction (BM). As shown in figure 1, T1 belongs to UP, because the average of T2, T3, and T4 is 52.00. Thus, a price raise of two points is achieved. Following the FM paradigm, the trend is calculated by the difference of the trade transaction before the message and the average of the trade transactions (in a specified interval like two minutes) after the publication. If no transaction occurs within the interval, the trend will be STABLE. The reason is that no alteration occurred after its publication. Nevertheless, there is an offset. The average calculation shifts the real price behavior a bit away, because the progression of the following trades is already included. However, we assume that a misclassification belongs to a bigger drawback and relevant events will cause a considerable effect, anyways. Another advantage of the average calculation belongs to the smoothing. Thus, less relevant examples (but labeled as UP or DOWN in the past) will belong to STABLE more likely, now.

Durability considered only the time dimension. To be able to determine the real impact of an event, the forced alteration has to be considered, too. Such an alteration can be obtained by the changes of the target variable (e.g. bottom of figure 1). Ticker 1 triggers a positive price alteration of three points in 119 seconds. Consequently, an area (A1) is stretched. A new trade transaction appears and the impact grows over time. The calculation and summation of the areas is continued until the original statement remains true (as in *durability*). Thus, Ticker 1 is labeled as UP with an initial price of 48.00. This remains true until T6, because the average price of T7 is lower than 48.00. Afterwards and similar to *durability,* examples with a high impact can be selected and remain in the training data. The determination of the event impact follows the trapezoidal rule.

$$T(f) = (b - a)\frac{f(a) + f(b)}{2} \tag{1}$$

The trapezoidal rule compute the area $T(f)$ under the curve $y = f(x)$ by trapezoids. Here, historic transactions can be described as sequence of lines. Thereby, *b* and *a* represent the interval on the x-axis (time distance). The function values $f(a)$ and $f(b)$ define the line below the curve. Applying the trapezoidal rule to our impact determination for a single training example, we have to design a formula (2) containing the sum of all areas stretched by the event Distance (3) and Difference (4).

$$Impact = \sum_{i=1}^{N} Distance_i \frac{Difference_i + Difference_{i+1}}{2} \tag{2}$$

$$Distance_i = Timestamp_{i+1} - Timestamp_i \tag{3}$$

$$Difference_i = \mid Start\ Price_1 - Price\ Average_i \mid \tag{4}$$

Except the number of applications (N), the formula works similar for FM and BM. Within BM, *N* belongs to the amount of the trade transactions between the first transaction and the last transaction, where the statement remains true. Following FM, *N* belongs to the amount of transactions after Ticker 1 and the last valued transaction. We changed the initial price of the *durability* calculation to avoid a premature breakup. E.g. following (Pospiech and Felden 2015), the start price of the *durability* calculation would have been 50.00 (see figure 1).

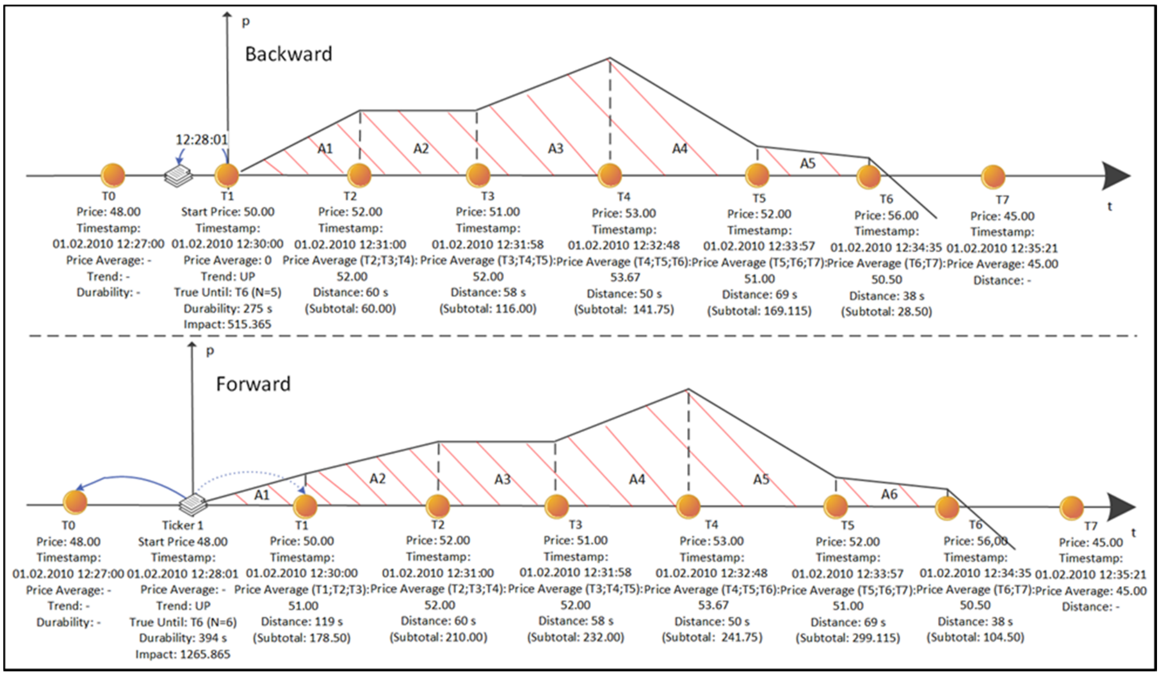

Figure 1: Impact Determination

However, if the price drops e.g. 49.50, the durability calculation will stop and the positive effect of the ticker (1.50 points) is neglected. Thus, we consider the first price after the news ticker as starting point and as long as the price is more than 48.00 the trend UP remains true. As illustrated in the top of figure 1, $Distance_1$ belongs to 60 seconds, $Difference_1$ to 0.0 and $Difference_2$ to 2.0. Thus, the first area (A1) achieves a value of 60.00 points. Summing all subareas together (*N*=6) a total impact of 515.365 points arises. The impact calculation is worth for UP and DOWN, but not for STABLE examples.

STABLE represents a no mover status and examples remain true as long as they are in the minimum alteration interval. For the subsequent classification, we need meaningful STABLE examples. A good STABLE example will not affect the target variable strong, but will remain as long as possible within the minimum alteration interval. Thus, for STABLE examples selections we are using our existing approach (Pospiech and Felden 2015), where examples with low *durability* are deleted. At least, all remaining STABLE examples (by FM or BM) are relabeled into IRRELEVANT. UP/DOWN examples linked by FM or BM are assigned to the class RELEVANT and must contain a minimum *impact* specified by a domain expert in order to assume relevance. Thus, only events with high *durability* or *impact* values remain in the training data set.

Afterwards, text mining techniques are applied (remember: different feature extraction concepts are possible) to the remaining training set to deal with the free rider effect. Terms have to be extracted to characterize a news ticker. Tokenizing, stemming, stop word lists, n-grams, and term-frequency-inverse-document-frequency (TD-IDF) are usually used. (Miner et al. 2012) As a result, all weighted and pre-processed examples are forwarded as input into the *Data Mining* phase. Based on historical data, the algorithms try to extract the patterns that belongs to the (irr-) relevant classes.

We assume that news with similar features are likely to achieve the same *impact* or *durability* as historic ones. RELEVANT marked, but by the free rider tickers effected tickers can contain a high *impact,* too. But similar and as IRRELEVANT marked news tickers sharing comparable features illustrate that this relevance is perhaps not given. Thus and as majority rule, the classification should tend to predict such tickers as IRRELEVANT. The data set needs to be split into training, validation, and test data to avoid a model's overfitting (Miner et al. 2012). Based on calculation time and classification results, suitable algorithms in text mining needs to be chosen.

Based on the prediction, four cases are possible. A former UP/DOWN document belongs to the class RELEVANT. Thus, the impact of the article and the historic similar ones was high. A huge probability of relevance exists and the example is selected as RELEVANT for further training. The former trend was UP/DOWN and the prediction is IRRELEVANT. Here, a free rider effect is likely, because similar historic tickers tend to be irrelevant (no selection). The former class was STABLE and the prediction is IRRELEVANT. This tickers are likely to cause no alteration of the target variable. Here, the example belongs to an ideal IRRELVANT example during training. At least, the former trend was STABLE and the prediction is RELEVANT. This case is fuzzy. It represents an incident, where no considerable price alteration was affected by the ticker, whereby similar historic documents tend to have a high impact. Explanations are: misclassification by algorithm, historic similar tickers were affectated by the free rider effect, or other market variables effected the trend. Domain experts needs to specify, whether such examples are used for training. Thus, the prediction supports the filtering of fuzzy instances. The remaining examples represent the final training set.

4 Application within the Natural Gas Stock Price Forecasting

The applicability of the proposed IS approach makes sense, insofar the effect of a specific event on a target variable is forecasted like sales projection or stock forecasting. In order to demonstrate our approach, we have chosen the forecasting of the natural gas price trends of our previous study as use case (Pospiech and Felden 2015). Here, gas trends were forecasted by news ticker, whereby our results suffered from too many irrelevant news ticker. We will use the proposed IS approach to identify representative training examples. Using the same training data from November 2011 until April 2013 as in our previous work the performance was evaluated by 10,000 unknown news ticker (May 2013-August 2013). We took this 10,000 news ticker and let them manually classify by a natural gas trader into relevant and irrelevant. Only 606 tickers are relevant.

We compared our approach to other automatic IS method to demonstrate its quality. The preferable approach should identify the most suitable training instances. This should lead to the best relevance prediction (Khandar and Dani 2010). Nevertheless, a basic classification for all IS methods is needed. We utilized the trend determination as shown in our approach for the training data. Trends are categorized into STABLE/DOWN/UP, because it represents, to our knowledge, the only method that achieves a reasonable labeling without manual selection. Afterwards, DOWN/UP are relabeled as RELEVANT and STABLE as IRRELVANT. A suitable IS method should negate the fuzzy nature of this labeling and provide a representative training set. Here, we link news article and trade transaction by BM and FM. Thereby, BM leads to 7,642 RELEVANT and 36,070 IRRELEVANT and FM to 7,471 RELEVANT and 103,562 IRRELEVANT instances. It remains unknown, which mapping paradigm is more successful. Thus, all techniques are applied for FM and BM.

Based on the IS method, different data sets are extracted. D1 uses the former *durability* approach, whereby an instance will only be selected, if the trend statement is true for at least 30 seconds (Pospiech and Felden 2015). In D2, instances are selected according to our impact calculation. The discussions with domain experts ended up in two different minimum impact values, because FM (Ø 3,798) and BM (Ø 2,022) tend to different impact mean values. Following the BM paradigm, we selected only DOWN/UP instances achieving an impact of at least 12.00 points (equivalent: durability of 80 seconds and a change of 3 points), whereby FM training examples should exceed 24.00 points. For STABLE instances, a minimum durability of 300 seconds is applied (BM & FM). Considering the free rider effect, the remaining instances are pre-classified using Naive Bayes, because the algorithm achieved proper results within text mining (Pospiech and Felden 2014). Involving domain experts, we decided to remove instances labeled as STABLE and predicted as RELEVANT, because otherwise more fuzzy elements would enter the later training set. In D3, we collect all instances of a mapping paradigm without any selection rule. Here, two different analysis scopes are considered. First, the data set is used as basis for the existing IS methods. Second, the training set is used for model training without any further IS technique. This allows the evaluation of the methods performance and the general mapping paradigms. Nevertheless, all data sets (D1, D2, D3) suffer from class imbalance. Under-sampling is conducted, because it achieved better results as former over-sampling (Japkowicz 2000). Afterwards, text mining techniques are applied.

D3 is used for IS methods identified during the literature review. Many methods exist and all of them vary their result quality in different domains (Grochowski and Jankowski 2004). Comparing all of them will go beyond the scope of the paper.

Analysis Focus	Precision Relevant	Precision Irrelevant	Recall Relevant	Recall Irrelevant	Accuracy	Instances
WLVQ(BM_D3)	28.61 %	94.72 %	15.68 %	97.45 %	92.52 %	2328
Durability(BM_D1)	28.13 %	94.76 %	16.67 %	97.25 %	92.37 %	10228
RMHC(BM_D3)	27.85 %	94.79 %	17.33 %	97.11 %	92.27 %	1032
MC1(BM_D3)	27.55 %	94.75 %	16.50 %	97.20 %	92.31 %	1032
Impact(FM_D2)	27.08 %	95.72 %	35.87 %	93.69 %	90.15 %	1632
WLVQ(FM_D3)	25.41 %	94.78 %	17.82 %	96.63 %	91.85 %	2596
RNGE(BM_D3)	24.71 %	94.28 %	7.26 %	98.57 %	93.04 %	11354
Impact(BM_D2)	21.59 %	94.83 %	19.31 %	95.48 %	90.90 %	726
ENN(BM_D3)	21.20 %	94.58 %	15.85 %	96.20 %	91.33 %	7620
Durability(FM_D1)	20.98 %	96.65 %	50.17 %	87.81 %	85.53 %	12828
All-KNN(BM_D3)	20.37 %	94.58 %	14.36 %	96.38 %	91.41 %	10338
RNGE(FM_D3)	18.76 %	94.82 %	19.97 %	94.42 %	89.91 %	11954
All-KNN(FM_D3)	16.90 %	94.10 %	3.96 %	98.74 %	93.00 %	7494
RMHC(FM_D3)	15.33 %	94.92 %	24.26 %	91.16 %	87.29 %	1152
MC1(FM_D3)	14.70 %	94.72 %	20.13 %	92.46 %	88.08 %	1152
All(BM_D3)	14.56 %	94.12 %	4.95 %	98.17 %	92.48 %	13970
ENN(FM_D3)	14.42 %	94.40 %	12.38 %	95.26 %	90.24 %	5420
RENN(FM_D3)	13.16 %	94.41 %	13.53 %	94.24 %	89.35 %	4846
RENN(BM_D3)	11.64 %	94.02 %	2.80 %	98.63 %	92.82 %	4714
LVQ(BM_D3)	10.16 %	94.02 %	3.13 %	98.21 %	92.45 %	478
LVQ(FM_D3)	6.04 %	92.14 %	9.88 %	0.87 %	6.81 %	86
All(FM_D3)	0.00 %	93.94 %	0.00 %	100.00 %	93.94 %	12986
FCM(FM_D3)	0.00 %	93.94 %	0.00 %	100.00 %	93.94 %	62
FCM(BM_D3)	0.00 %	93.94 %	0.00 %	100.00 %	93.94 %	108

Table 1: Results of Instance Selection Methods

We have chosen different techniques based on sub-groups (noise filters, prototype construction, condensation algorithms, clustering, neuronal network, random selection, and hill climbing), whereby only successful methods of previous studies are selected. While text mining requires high-dimensional computing, evolutionary algorithms are discarded. Their time consumption is quite overwhelming (Liu and Fu 2012). Within the noise filter group, ENN achieved remarkable results, whereby LVQ (neuronal network), MC1 (random selection), and RMHC (hill climbing) were comparable in the other groups. All-KNN performed successful within the condensation group. (Grochowski and Jankowski 2004) Özsen and Ceylan (2014) concluded that FCM can achieve top marks. RNGE (García et al. 2012), RENN (Grochowski and Jankowski 2004), and WLVQ (Blachnik and Duch 2011) are considered too, because they were successful in past as well.

In a next step, models are trained with the Data Mining tool RapidMiner. We focus on Naive Bayes, because it achieved the best results within this use case (Pospiech and Felden 2015). The models are trained fifty times with different parameter settings, whereby the best model for each data set is kept. Besides accuracy, recall and precision are considered, too, because most of the news tickers are irrelevant. Table 1 shows the results. Here, the analysis scope is compound by IS method (MC1), mapping paradigm (BM), and data set (D3). We sorted the results according to the precision of relevant instances, because only cases predicted as relevant will be forwarded to decision makers. The system will lose acceptance, if too many false positive predictions occur. The same will be true, if less relevant instances are identified. Methods reaching a minimum precision of 20.00 %, and identifying more than 90 relevant instances are considered as practical (grey shaded) by our domain experts. The column instances represents the used training examples (both classes are balanced).

5 Discussion

The domain knowldege models identified up to 50.17 % of all relevant instances (recall) and achieved a precision of 28.13 % within the class RELEVANT (see table 1). In contrast, a random selection would lead to 6.06 % precision. Considering that every fourth relevant event is identified and that we deduced the classes from the historic alteration of the target variable, with less human involvement, the results are promising. Thus, time and cost savings become possible. But not all relevant news ticker will trigger a price alteration. In addition, not all instances aligned with DOWN/UP caused the change within the target variable by a news ticker, but rather by other factors like weather or gas storage (Pospiech and Felden 2015). Thus, an identification of all relevant instances is impossible. The accuracy of the most applied techniques is approx. 90.00 %, and decision makers are not overwhelmed by irrelevant tickers. Liu and Motoda (2002) mention three different functions an IS should achieve. Identification of relevant domain data so that search is more efficient. Cleaning of irrelevant/noisy/redundant data should lead to high quality predictions. Data reduction to improve time and memory complexity.

Identification: A successful selection of relevant training instances should lead to the identification of relevant instances (recall) during testing. Only 606 relevant out of 10,000 testing instances exist. Especially, approaches considering domain knowledge outperformed heuristic methods. Durability(FM_D1) identified 50.17 % of all relevant instances. Impact(FM_D2) reaches a recall of 35.87 % and Impact(BM_D2) 19.31 %. Thus, considering the historic alteration of the target variable allows the identification of relevant instances during the training. This domain knowledge enables a more representable selection of instances within fuzzy environments as traditional approaches. In fact, WLVQ(FM_D3) achieves a recall of 17.82 %. But the basics pre-classification for all traditional methods was given from us, without this results are impossible. The best recalls belong to the FM. Future use cases depending on a high recall should prefer this mapping paradigm.

Cleaning: A high quality data set should lead to a good prediction (accuracy and precision). The results confirm the basic deduction of the classes by event and historic behavior of the target variable. Even All(BM_D3), reaches a precision of 14.56 %. This sounds weak, but it is notable better as random and is achieved without any IS policy. Nevertheless, the approach is not practicable, because only 4.95 % of all relevant instances are identified. Thus, the instances remained too noisy and irrelevant. An IS method is needed. The same is true for All(FM_D3). All instances are predicted as IRRELEVANT. This is not surprising, because FM leads to many STABLE instances, which are selected randomly without any filtering rule. In a consequence, less representative instances are selected and the trained models become imprecise. Most of analyses focuses sharing the same challenge (table 1). Thus, 6 out of the top 9 analytic focuses belong to a BM data set. An effective cleaning by domain knowledge seems to compensate this drawback. Here, Impact(FM_D2) or Durability(FM_D1) reaches precisions over 20.00 %. Nevertheless, the whole accuracy of the latter one (85.53 %) is relatively poor. This leads to many forwarded tickers and overwhelmed decision makers. Impact(FM_D2) is noticeable better (90.15 %). But BM achieved the best results and is favorable if precision will become important within use cases. The best precision and accuracy is achieved by WLVQ(BM_D3), Durability(BM_D1), MC1(BM_D3), and RMHC(BM_D3). FCM and LVQ are not practical. That is maybe caused by the class distribution. E.g. FCM(FM_D3) contained 31 irrelevant and 4,569 relevant instances. Under-sampling leads to 62 instances, too small as representative training set. Here, we trained models with and without under-sampling but results remained weak. The traditional approaches are surprisingly successful in terms of accuracy and precision, but results differs very less.

Data Reduction: Especially within Big Data environments a high compression rate (instances after selection/instances before selection) is favorable to improve time and memory complexity. Again, the domain knowledge approaches achieve remarkable results. Impact(BM_D2) reaches a compression rate of 4.75 % (726/15284) and Impact(FM_D2) a rate of 10.92 % (1632/14942). Thus, the impact method allows an application within data intensive projects. But, RMHC(BM_D3) and MC1(BM_D3) are successful with 6.75 % as well. The durability approaches (Durability(BM_D1), Durability(FM_D1)) seem not to be efficient in terms of data reduction. More than 10,000 instances remain within the data set. The compression rates for WLVQ, LVQ, MC1, and RMHC are good, but strong dependent from parameter settings. Good compression rates are obtained from BM and FM. Thus, selecting a specific mapping paradigm will not reduce the time and memory complexity

To sum up, no IS method is dominating every category. But only a balanced (all aspects are fulfilled) technique is practical (Liu and Motoda 2002). Considering all aspects the best results are achieved by Impact(FM_D2). In fact, the precision is only 1.53 % less as the predictions of WLVQ(BM_D3). The recall with 35.87 % and an accuracy of 90.90 % represents the best classification in our study. In this context, 783 predictions are forwarded to a decision maker, whereby 212 are relevant. In contrast, the next best traditional approach ((WLVQ(BM_D3)) identified only 108 relevant instances. A compression rate of 10.92 % is ranked among the best and seems practical within Big Data applications. Impact(BM_D2) has the best compression rate within the practicable approaches. But, recall and precision are at a lower level than Impact(FM_D2). Durability achieved good results, too, but an application in terms of compression rate is not recommendable. The best traditional method belongs to RMHC(BM_D3). Accuracy, precision, and compression are good. But the recall is still too weak compared to any domain knowledge approach.

Nevertheless, in most of the cases the identification of relevant cases (recall) is more important (Leyva, 2015). In this context, we can assume the usefulness of our impact calculation.

6 Conclusion

We introduced a new IS method. In contrast to traditional approaches, our method deduces business domain knowledge from the historic progression of the target variable. The paper presented and confirmed the usefulness of this new perspective, while outperforming traditional methods in recall and compression rate. Except of a few parameters (like market latency or minimum impact), all steps are performed automatically and no human involvement is needed. Even a repeatable computation by the proposed approach is possible in order to add new contents within the training set. The potential of our method has been shown even in a challenging case, where only six percent of all instances are relevant. No other approach identified so many. The approach follows a simple formula, is generalizable, and easy to implement. In addition, the computation time of our approach outperformed all traditional techniques during model training. The approach allows the selection of relevant and irrelevant events in fuzzy environments with a minimum human involvement.

This becomes more important. Because, the most traditional approaches are not able to select representative instances within a fuzzy environment. Erstwhile, domain experts selected relevant training instances. But, the amount of captured events grows and contents changes. A continuous selection of relevant training instances is too time consuming. Here, the automatic deduction of relevance from the target variable adds a new perspective within research and questions the omnipotence of traditional methods. Analysts benefit from our approach, because the automatic identification of relevant examples allows a faster and less labor intensive KDD procession. No manual selection by humans is necessary. We showed the successful application of our method by unseen data. But, a more precise prediction of relevant instances is desirable. A possible explanation are tickers with high impact values. Whereby, in reality the impact was caused by market conditions (like weather). This training examples should be filtered in an automatic fashion. In addition, the application within different use cases should investigate the repeatability of our results. This should offer the ability that research measures time savings by our approach compared to labour intensive IS (domain knowledge) methods. Another challenge belong to the identification of relevant events, which caused no alteration. Many of the 606 manually labeled testing instances had just no effect on the target variable. This explains, why not all relevant instances were identified. In addition, general relevance of the event data source should exist, otherwise no causality between event and target variable is given. But, the results are promising. Even, if the precision is regarded as too low in possible scenarios, the method will be usable as filtering technique. Here, the results are forwarded to an expert, who needs to consider only a sub-sample.

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Ein Datenmodell zur Unterstützung der Datenintegration von Nutzeraktivitäten aus verschiedenen sozialen Netzwerken

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Abstract

Durch die Integration von Daten aus sozialen Netzwerken und Informationssystemen (IS) im Unternehmen können betriebliche Abläufe verbessert werden, indem neue und relevante Informationen über Kunden/Konsumenten zur Verfügung stehen und Prozesse durch Automatisierung beschleunigt werden. Das Forschungsziel des vorliegenden Beitrags ist die einheitliche Datenintegration von Nutzeraktivitäten verschiedener sozialer Netzwerke mit IS im Customer Relationship Management. Der Ergebnistyp ist ein Datenmodell für Nutzeraktivitäten, welches auf vorhandenen Konzepten basiert und nach gestaltungsorientiertem Forschungsansatz entwickelt wurde. Die Konkretisierung durch die Sicht auf die Daten, erweitert die wissenschaftliche Perspektive und ermöglicht die Implementierung einer Integrationslösung. In einem Softwareprototyp wurde das Datenmodell in einem Anwendungsfall erprobt und dafür verwendet, die unterschiedlichen Datenstrukturen der sozialen Netzwerke LinkedIn, Facebook und Twitter zu vereinheitlichen, um Nutzeraktivitäten plattformunabhängig zu filtern. Die generelle Praxistauglichkeit des Datenmodells in anderen Anwendungsfällen muss künftig durch weitere Einsätze aufgezeigt werden.

1 Einleitung

In den letzten Jahren haben soziale Netzwerke bei Internetnutzern hohe Popularität erlangt. Soziale Netzwerke gehören zur Gruppe Social Media (Kaplan und Haenlein 2010). Das sind Internet-anwendungen, die auf dem Web 2.0-Konzept basieren, welches die Vernetzung, Partizipation und Kollaboration von Nutzern sowie den Austausch von Inhalten über das Internet beinhaltet (Musser und O'Reilly 2007). Die hohe Anzahl an Nutzern zieht die Aufmerksamkeit von Unternehmen auf sich, die sich von der Nutzung von sozialen Netzwerken Vorteile erhoffen. Auf den ersten Blick können soziale Netzwerke genutzt werden, um mit nur geringem Aufwand Werbebotschaften zu platzieren, die viele Nutzer erreichen und damit eine hohe Reichweite erzielen und die Marketing-Effizienz steigern. Diese Sichtweise greift jedoch zu kurz. Bei näherer Betrachtung sind weitere Nutzenpotenziale möglich, die sich aus der Integration von sozialen Netzwerken mit betrieblichen Abläufen ergeben (Acker et al. 2011). Beispiele dieser Nutzenpotenziale sind die Reduktion der Supportkosten, Produktinnovationen, Neukundengewinnung und Verbesserung der Reputation

(Cappuccio et al. 2012; Fliess und Nesper 2012; Jahn und Kunz 2012). Gleichzeitig profitieren auch die Nutzer von sozialen Netzwerken von der Teilnahme der Unternehmen. Beispiele sind Vergünstigungen, personalisierte Sonderangebote und die Einflussnahme auf betriebliche Abläufe, wie z. B. eine Beschleunigung von Supportanfragen.

Eine Voraussetzung für die Realisierung der zuvor genannten Nutzenpotenziale ist die Integration von sozialen Netzwerken mit Informationssystemen (IS) im CRM (Woodcock et al. 2011; Rosemann et al. 2012; Williams 2014; Polonsky 2015). Bisherige Arbeiten stellen fest, dass die technische Datenintegration zwischen sozialen Netzwerken und IS im CRM zwar ein fortdauerndes Thema ist, existierende Lösungen aber noch unausgereift sind (Greenberg 2010b; Alt und Reinhold 2012; Trainor et al. 2013).

IS sind erforderlich, um die Social Media-Initiativen zu unterstützen, indem Funktionen zum Monitoring, zur Analyse und zur Nutzung von Daten aus sozialen Netzwerken und deren Integration mit bestehenden Unternehmensdaten bereitgestellt werden (Trainor et al. 2013). Social Business Intelligence (BI) ist eine Disziplin, bei der Data Warehouse-Techniken, wie klassischerweise die Schritte Extract-Transform-Load (ETL) und Online Analytical Processing (OLAP) eingesetzt werden, um auf der Basis der nutzergenerierten Daten in sozialen Netzwerken Stimmungen, Meinungen und Trends zu erkennen (Chen, Chiang und Storey 2012; Dinter und Lorenz 2013). Die Auswertungen helfen insbesondere bei der Planung, Anpassung und Optimierung von Maßnahmen im CRM, weil die gewonnenen Informationen Rückschlüsse auf das Verhalten von Konsumenten erlauben. Die Kombination von sozialen Daten mit Unternehmensdaten ist sinnvoll, um unternehmensspezifische Abfragen zu ermöglichen (z. B. Interessen von Kunden, Meinungen zu Produkten und deren Eigenschaften, Reaktionen auf Preisanpassungen und Effekte von Marketingkampagnen in sozialen Netzwerken). Aufgrund der Eigenschaften der Daten aus sozialen Netzwerken (hoch dynamisch, große Datenmenge, häufig unstrukturiert, unbekannte Datenqualität) ist die Integration in ein Social BI-System eine Herausforderung. Dinter und Lorenz (2013) identifizieren insbesondere Datenarchitekturen, Datenmodelle und Implementierungen als geeignete Forschungsergebnisse, um Lösungen zur Handhabung der Daten voranzutreiben.

Aufgrund der Vielzahl verschiedener sozialer Netzwerke besteht der Bedarf, mehrere gleichzeitig zu integrieren (Correia et al. 2014). Dabei muss ein konsistentes Verhalten zu Kunden in den jeweiligen sozialen Netzwerken und in den übrigen Kommunikationskanälen, wie z. B. E-Mail, Telefon und Chat, sichergestellt sein (Killian und McManus 2015). Dies ist eine Herausforderung, da die sozialen Netzwerke unterschiedlich sind hinsichtlich der Inhalte, Funktionen und Zugriffsmöglichkeiten. Posts, Tweets, Pins, Profile, Gruppen und Seiten, die erfasst, „posted“, „tweeted“, „pinned“, „liked“, geändert, hinzugefügt oder angesehen werden, sind nur eine kleine Auswahl. Es gibt keine gemeinsamen Datenstrukturen, auf denen Integrationslösungen aufsetzen könnten. Bild 1 veranschaulicht die Problemstellung und das Forschungsziel. Das Forschungsziel ist die einheitliche Datenintegration von Nutzeraktivitäten verschiedener sozialer Netzwerke mit IS im CRM. Die adressierte Forschungsfrage lautet: *Welche grundlegenden Strukturen haben die Daten aus Nutzeraktivitäten verschiedener sozialer Netzwerke gemeinsam?*

Zur Beantwortung der Forschungsfrage ist ein Datenmodell als Ergebnistyp geeignet, das einerseits einen Beschreibungsaspekt aufweist und damit Strukturen sichtbar macht und andererseits durch den Konstruktionsaspekt die Entwicklung einer Softwarelösung unterstützt. Eine Middleware-basierte Integration, wie in Bild 1 dargestellt, erfordert gemeinsame Datenstrukturen (Hasselbring 2000).

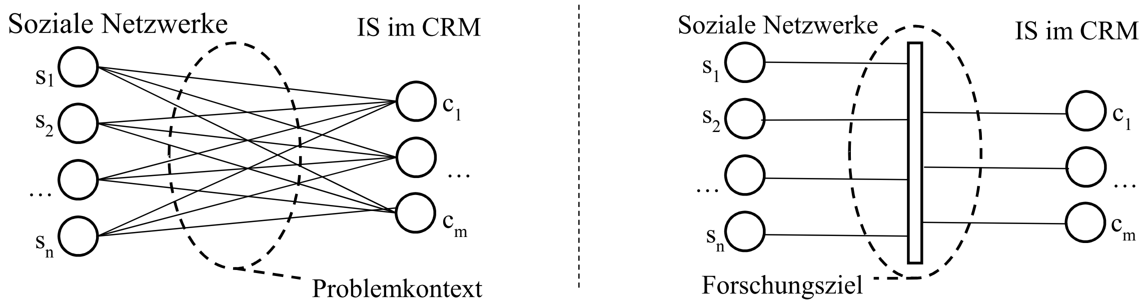

Bild 1: Problemkontext und Forschungsziel

Zunächst wird in Abschnitt 2 die Ausgangslage aus Sicht der Wissenschaft und der Praxis dargestellt. Abschnitt 3 stellt das Datenmodell der Nutzeraktivitäten von sozialen Netzwerken vor und beschreibt dessen Verwendung in einer prototypischen Softwareimplementierung. Abschließend werden die Ergebnisse diskutiert und ein Ausblick auf künftige Forschungsarbeit gegeben.

2 Ausgangslage

Da das Thema dieses Beitrags durch die Praxis motiviert ist, sollten bei der Betrachtung der Ausgangslage die Erkenntnisse der Wissenschaft um existierende Lösungen aus der Praxis erweitert werden. Dadurch soll sichergestellt werden, dass die Forschungsarbeit auf dem aktuellen Stand der Wissenschaft und auch der Praxis aufsetzt.

2.1 Stand der Wissenschaft

Im ersten Schritt haben wir eine Literaturrecherche zum Thema durchgeführt. Die Methode nach vom Brocke et al. (2009) umfasst die drei Schritte (1) Definition des Umfangs, (2) Konzeptualisierung des Themas und (3) Literatursuche. Die Schlüsselbegriffe des Themas sind Social Media, soziale Netzwerke und Nutzeraktivitäten. Daher haben wir für die Literatursuche den Suchterm *„social media“ OR „social network“ OR „soziale Netzwerke“) und („user actions“ OR „user activities“ OR „Nutzeraktivitäten“)“* auf die Datenbanken AISeL, EBSCO, Emerald, IEEE, JSTOR, ProQuest und Web of Science angewendet. Dabei wurden die Suchfelder Titel, Thema, Abstract, Keywords und Volltext berücksichtigt. Die Trefferliste haben wir aufgrund der Titel und Abstracts der Beiträge reduziert. Von den übrigen relevanten Publikationen wurden die Volltexte analysiert. Trotz der geringen Trefferzahl (10) ergeben sich aus der gefundenen Literatur wichtige Anhaltspunkte zum Verständnis von Nutzeraktivitäten in sozialen Netzwerken, welche teilweise unterschiedlich breit betrachtet werden.

Atig et al. (2014) definieren Nutzeraktivität als die Zeit, in der Nutzer in Social Media aktiv sind. Die Autoren klassifizieren Nutzer nach definierten Aktivitätsprofilen und unterscheiden dabei nicht weiter, was die Nutzer tatsächlich tun, während sie aktiv sind. Heinonen (2011) konzeptualisiert Nutzeraktivitäten anhand der Dimensionen Motivation und Teilnahme. Zum Beispiel sind der Aufbau und die Pflege eines sozialen Netzwerks durch die Motivation und den Wunsch nach sozialer Beziehung geprägt und erfordern das Erstellen eines Nutzerprofils und die Verlinkung mit Freunden (produktive Teilnahme). Allerdings ist das Rahmenwerk abstrakt und nicht dafür geeignet, die mit den Nutzeraktivitäten verbundenen Daten abzuleiten. Die Ontologie von Pankong et al. (2012) ist konkreter. In einem Entity-Relationship-Diagramm (ERD) sind einige Entitäten (z.B. Nutzer, Posts, Likes und Themen) und ihre Beziehungen (z. B. „ist“, „hat“ und „bezieht sich auf“) modelliert. Allerdings sind einige Entitäten nicht eindeutig (z. B. „Antwort“ und „Kommentar“ sowie „Teilen“ und „Retweet“). Zudem sind weitere Aspekte in der Ontologie für Nutzeraktivitäten nicht enthalten, wie z. B. das Ansehen/Betrachten von Inhalten und der Nutzerkontext (Zeit, Ort, Dauer etc.) in dem eine Aktivität ausgeführt wird. Dies ist damit zu erklären, dass die Autoren primär explizite und implizite Beziehungen von Nutzern untersuchen und kein vollständiges ERD angestrebt wird, ähnlich auch bei Yang et al. (2013). Allerdings sind Zeit und Ort wichtige Determinanten und hilfreich bei der Beurteilung, ob eine Nutzeraktivität für das Kundenbeziehungsmanagement relevant ist (Yu et al. 2014). Woerndl et al. (2011) analysieren den Nutzerkontext und greifen auf verfügbare Sensoren eines Smartphones zu (z. B. verpasste Anrufe, Position des Graphical Position System (GPS) Sensors und verbleibende Akkuleistung), um diesen genauer zu bestimmen. Richthammer et al. (2014) identifizieren 11 Nutzeraktivitäten von sozialen Online-Netzwerken (OSN). Beispiele sind „Nutzer erstellt Post“, „Nutzer sendet Nachricht an Kontakt“ und „Nutzer ist verlinkt zu Kommentar“. Diese Nutzeraktivitäten umfassen nur die „fundamentalen Nutzeraktivitäten in OSN“ und sind nicht vollständig. Zum Beispiel ist das Teilen, Löschen und Ändern von Inhalten unberücksichtigt.

2.2 Stand der Praxis

Um die Praxisrelevanz dieses Beitrags einzuschätzen, ist ein Blick auf bestehende Softwarelösungen notwendig, um deren Einschränkungen und fehlende Funktionalitäten zu erkennen. Küpper et al. (2014) haben eine Marktstudie mit 40 Softwarelösungen von Herstellern von Social Media-Tools durchgeführt. Die Gegenüberstellung der ermittelten Funktionalitäten ergibt, dass die meisten Tools Funktionen zum Erfassen und Analysieren von aggregierten Social Media-Daten anbieten. Das Erkennen und Auswerten von individuellen (personenbezogenen) Daten aus Nutzeraktivitäten, wie z. B. erstellte Beiträge, Benutzerprofile, verlinkte Benutzer, sowie die Integration der enthaltenen Social Media-Daten mit (bestehenden) IS werden nicht ausreichend unterstützt. Ein ähnliches Ergebnis wird durch die Untersuchungen weiterer Autoren erzielt (Reinhold und Alt 2011; Sarner et al. 2012). Insbesondere stellen Trainor et al. (2013) fest, dass die technische Interaktion zwischen CRM-Systemen und Social Media noch mangelhaft ist. Zum Beispiel werden zusammenhängende Kundendaten und Benutzerdaten aus Social Media nicht verknüpft.

Die Praxisrelevanz zeigt sich auch im Projekt OpenSocial von W3C Social Web Working Group (2015). Die Arbeitsgruppe definiert Datentypen für Social Media Entitäten mit dem Ziel, eine Standardisierung herbeizuführen. Die Arbeitsergebnisse haben zwar noch Entwurfsstatus, liefern aber bereits jetzt schon Details zu wesentlichen Daten und Funktionen einer idealtypischen Social Media-Plattform. Die prominenten sozialen Netzwerke, wie z. B. Facebook, LinkedIn und Twitter, haben jedoch jeweils eigene Datentypen definiert und folgen den Empfehlungen des Projekts OpenSocial bisher nicht. Die gemeinsame Integration dieser sozialen Netzwerke erfordert daher die Definition eines einheitlichen Datenschemas.

3 Datenmodell der Nutzeraktivitäten in sozialen Netzwerken

Nutzeraktivitäten sind eine Kombination von Nutzerkontext, Objekttyp und Aktion (Bild 2). Bei aggregierter Betrachtung der wesentlichen Aktionen, die Nutzer in verschiedenen sozialen Netzwerken ausführen können, kann eine strukturelle Übereinstimmung der Nutzeraktivitäten beobachtet werden.

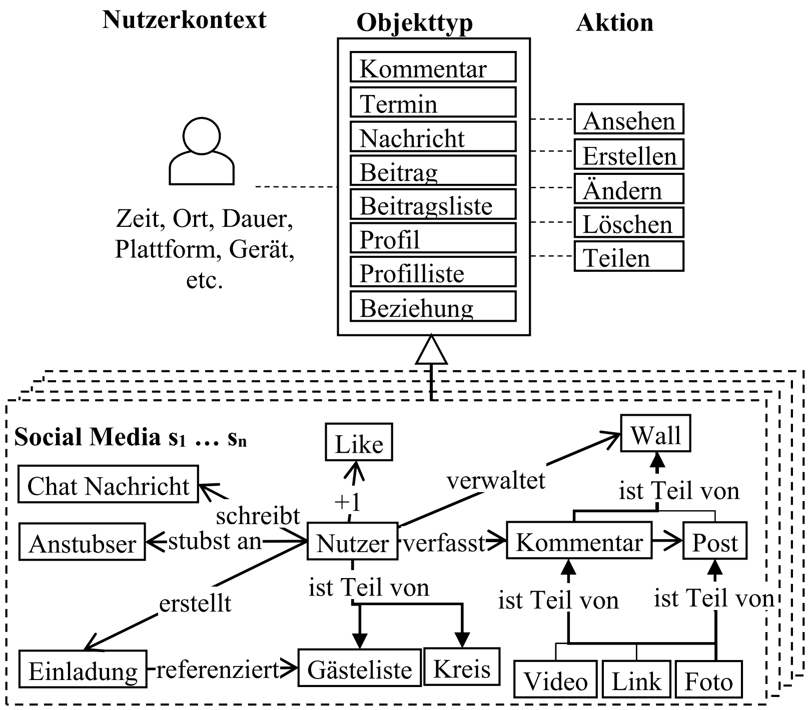

Bild 2: Nutzeraktivitäten in Social Media, in Anlehnung an Rosenberger, Lehmkuhl und Jung (2015)

Zur Beantwortung, *welche* Daten enthalten sind, ist dieses Modell allein allerdings nicht ausreichend und muss detailliert werden. Zur Konkretisierung schlagen wir ein Datenmodell vor, in dem die acht Objekttypen durch wesentliche Attribute und Beziehungen zu anderen Objekttypen ergänzt werden. Dazu haben wir die über die Application Programming Interfaces (APIs) gelieferten Datenformate von zehn prominenten sozialen Netzwerken untersucht und häufige Datenfelder, die bei mehreren sozialen Netzwerken vorkommen, als Attribute aufgenommen. So ist beispielsweise das Geburtsdatum ein wesentliches Attribut eines Benutzerprofils, da dieses als Datenfeld „date_of_birth“ bzw. „birthday“ bei den meisten sozialen Netzwerken vorkommt.

Bild 3 zeigt das objektorientierte Datenmodell, das aus den Nutzeraktivitäten in Social Media abgeleitet ist. Die Notation folgt den Empfehlungen für Klassenmodelle in Unified Modeling Language (UML). Die Attribute sind jeweils typisiert und die Beziehungen sind mit Kardinalitäten bzw. Multiplizitäten versehen. Der zentrale Objekttyp ist *Social Media Activity*, der im Wesentlichen durch *Object Type*, *Action Type* und mindestens einen *Actor* beschrieben ist. Die Attributen von *Social Media Activity* (z. B. *Start Time* und *End Time*) und *User* (z. B. *Timezone* und *Location*) ergeben den Nutzerkontext. *Message*, *Event*, *Profile-list*, *Profile*, *Post-list*, *Post*, *Relationship* und *Comment* sind Spezialisierungen des abstrakten Objekttyps *Social Media Object*.

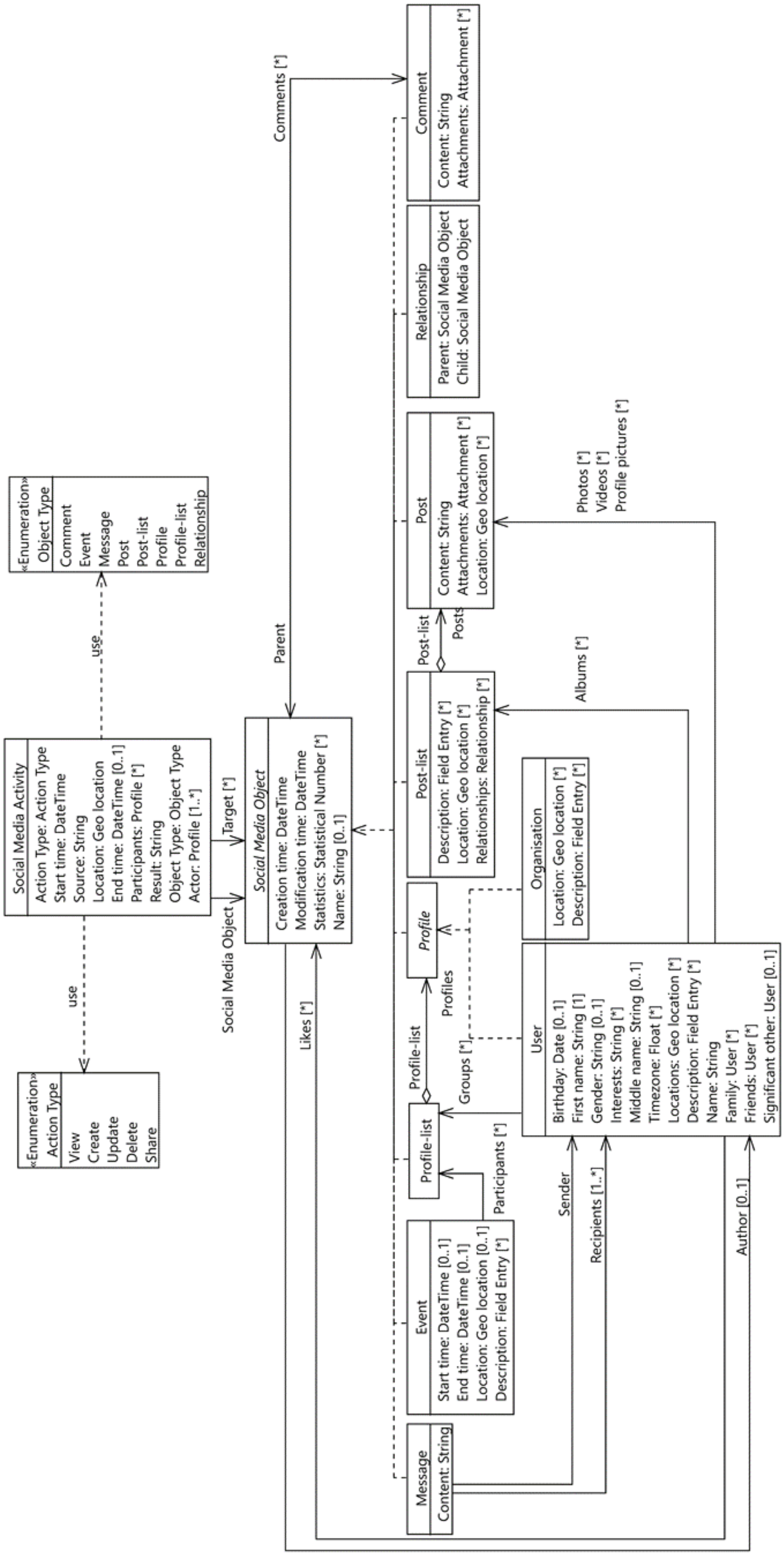

Bild 3: Datenmodell der Nutzeraktivitäten in sozialen Netzwerken

Die gemeinsamen Attribute sind Name, Creation time, Modification time und eine variable Anzahl an Kennzahlen vom Typ Statistical Number. Kennzahlen sind aggregierte Größen, wie z. B. „Anzahl der Aufrufe“, „Anzahl der Kommentare“ und „durchschnittliche Verweildauer“ und werden zum Teil von sozialen Netzwerken explizit bereitgestellt (Facebook 2015). User und Organisation sind eine Spezialisierung von Profilen in sozialen Netzwerken. Zwischen den Objekttypen bestehen Beziehungen (Assoziation und Aggregation).

Beispielsweise besteht ein Objekt vom Typ *Post-list* aus beliebig vielen Instanzen von *Post*. *Message* ist assoziiert mit *Sender* und einen oder mehreren *Recipients* vom Objekttyp *User*. Die Objekttypen *Event*, *User*, *Organisation* und *Post-list* haben das Attribut *Description* vom Typ *Field Entry [*]*. Durch die variable Anzahl von *Field Entry* sind beliebig viele beschreibende Datenfelder möglich, die jeweils aus einem plattform-übergreifenden Namen, einem plattform-spezifischen Namen und beliebig vielen Werten bestehen. Ein Beispiel ist das beschreibende Datenfeld von *User* mit dem plattform-übergreifenden Namen Religion, welcher frei vergeben werden kann, dem plattform-spezifischen Namen religion, welcher durch Facebook vergeben ist und den Werten christlich, muslimisch, hinduistisch, buddhistisch usw. Die konkreten Daten einer Nutzeraktivität, bei der ein Nutzer ein neues Foto einem bestehenden Fotoalbum hinzufügt, sind beispielhaft Name des Fotoalbums, Zeit und Ort der Nutzeraktivität und der Fotoaufnahme, Abmessungen und Dateigröße des Fotos und markierte Personen. Die Struktur der Daten ist unabhängig vom sozialen Netzwerk, auf dem die Nutzeraktivität stattgefunden hat. Die Entwicklung des Datenmodells erfolgte inkrementell. Insbesondere haben wir aufgrund der Erkenntnisse aus der prototypischen Implementierung der Integrationssoftware mehrmals Verfeinerungen durchgeführt. Zum Beispiel war *Name* zunächst jeweils ein Attribut der Objekttypen *Event, Post* und *Relationship*, das wir später als Attribut des abstrakten Objekttyps *Social Media Object* und damit nur einmal modelliert haben. Dadurch wird das Datenmodell aufgrund der Vererbung vereinfacht und flexibler, weil jeder Objekttyp (zukünftig) einen Namen haben kann.

4 Prototypische Implementierung und Evaluation

Im Kontext der Neukundengewinnung wurde der Software-Prototyp bei einem Beratungsunternehmen eingesetzt, um relevante Beratungsbedarfe und Projektausschreibungen in LinkedIn, Facebook und Twitter automatisiert an das CRM-System weiterzuleiten. Das Datenmodell diente als Grundlage für gemeinsame Datenstrukturen bei einem indirekten (mittelbaren) Datenaustausch über Datenschnittstellen. Die Lösung zur Datenintegration basiert auf Spring XD (Pivotal Software 2015) und wurde um Source-Modules, Transform-Processors, einen Filter-Processor und ein Sink-Module für die Anwendung SugarCRM (2015) erweitert (Bild 4). Spring XD ist eine einheitliche, verteilte und erweiterbare Plattform, die in der Programmiersprache Java geschrieben ist und stellt Funktionen zum Datenimport, -export und -integration, Echtzeit-Analyse und Batch-Verarbeitung bereit. Die entwickelten Source-Module stellen die Verbindung über die APIs der jeweiligen Plattformen her und ermöglichen den Zugriff auf die Daten der sozialen Netzwerke. Die Transform-Processors wandeln die plattform-spezifischen Rückgabewerte in eine gemeinsame Datenstruktur um, die sich am entwickelten Datenmodell orientiert. Der Filter-Processor wendet konfigurierbare Regeln auf die Daten der vereinheitlichten Nutzeraktivitäten an, um relevante Nutzeraktivitäten zu ermitteln. Im Prototypen wurden Posts in ausgewählten Gruppen/Seiten berücksichtigt, die die Schlagworte „Berater“ und „Projekt“ und „Enterprise Architecture“ oder „IT-Service Management“ in Inhaltsfeldern oder im Namen enthalten. Der Filter-Processor wendet dazu für alle Plattformen denselben XPath-Ausdruck auf den Nutzeraktivitäten-Strom an (W3C 2014). Dabei erfolgt zunächst die Selektion nach Herkunft, d.h. bestimmte Gruppen/Seiten, Objekttyp *Post* und Aktionstyp *Create*. Zu dem *Post*-Objekt werden das Attribut *Name* und alle variablen Felder des Attributs *Content* auf das Vorhandensein der Schlagworte geprüft. Das Sink-Modul für SugarCRM erzeugt aus den relevanten, gefilterten Nutzeraktivitäten einen neuen Lead (d. h. Verkaufschance) im CRM-System.

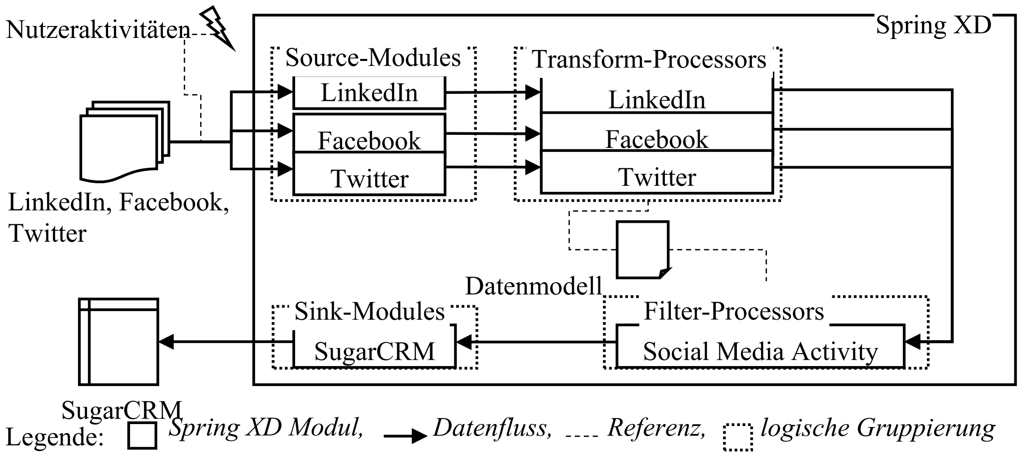

Bild 4: Architektur der Datenintegration von Nutzeraktivitäten in sozialen Netzwerken mit einem CRM-System

Im Zeitraum von vier Wochen wurden in drei Gruppen/Seiten 69 Beiträge beobachtet, von denen zwei zu einem Lead-Eintrag in SugarCRM führten. Der Umfang des Prototypen ist bewusst klein gewählt worden, um potenzielle Fehler bei der Verarbeitung leichter auf die jeweilige Ursache zurückführen zu können. In den ersten Versionen wurde insbesondere der XPath-Ausdruck iterativ verfeinert und später in eine Konfigurationsdatei ausgelagert, damit dieser zur Laufzeit ohne die Notwendigkeit eines Neustarts des Prototypen angepasst werden kann. Die Beziehungen von *Social Media Activity* zu referenzierten Objekten, wie z. B. *Actor* und *Post-list*, wurden nach dem Muster Lazy Loading als Proxies implementiert. Dadurch werden die Anzahl der Zugriffe auf die APIs und die Datengröße des *Social Media Activity* Objekts reduziert. Andererseits stehen dadurch nicht alle möglichen Werte direkt zur Verfügung. Z. B. wurden Kontaktdaten vom Erstellerprofil der Projektausschreibungen (häufig Vermittlungsunternehmen) nicht übernommen.

Das Datenmodell ist ein Ergebnistyp der gestaltungsorientierten Forschung, das primär zur Lösung der praktischen Problemstellung der Integration mehrerer sozialer Netzwerke dient. Die beiden grundlegenden Phasen sind Entwickeln und Evaluieren (Peffers et al. 2007). Evaluieren kann weiter unterteilt werden in Demonstration, Evaluation und Kommunikation. Durch die prototypische Implementierung wurde insbesondere demonstriert, wie das Datenmodell in einem konkreten Anwendungsfall genutzt wurde. Sonnenberg und vom Brocke (2012) empfehlen, dass die Evaluation eines Artefakts schrittweise erfolgt und bereits Teilergebnisse frühzeitig kommuniziert werden, um Konsens bezüglich Relevanz, Neuheit und Sinnhaftigkeit innerhalb der Zielgruppe zu finden. In diesem Sinne ist das konzeptuelle Modell der Nutzeraktivitäten in sozialen Netzwerken von Rosenberger, Lehmkuhl, und Jung (2015), ein erstes Teilergebnis, das als Grundlage für das Datenmodell (zweites Teilergebnis) diente. Dadurch, dass das Datenmodell die Entwicklung einer funktionierenden prototypischen Softwarelösung unterstützt hat, ist zumindest die Machbarkeit/Nutzbarkeit nachgewiesen („Eval 3“ nach Sonnenberg und vom Brocke (2012)). Weitere wesentliche Evaluationskriterien, wie z. B. Vollständigkeit, Realitätsnähe und Robustheit, bedürfen noch eines realen Einsatzes und geeignete begleitende Methoden zur Auswertung der Beobachtungen (Fallstudie, Experteninterview, Feldexperiment, etc.).

5 Diskussion und Ausblick

Die Daten aus den Nutzeraktivitäten in sozialen Netzwerken haben eine gemeinsame Struktur, die sich in einem Datenmodell aufzeigen lässt. Das Datenmodell unterstützt bei der Datenintegration verschiedener sozialer Netzwerke. Die Filterung relevanter Nutzeraktivitäten und die Weiterleitung der Daten an Zielsysteme (z. B. CRM-System) kann für mehrere Plattformen gemeinsam implementiert werden.

In der Wissenschaft werden Nutzeraktivitäten in sozialen Netzwerken unterschiedlich betrachtet. Einige Arbeiten definieren Nutzeraktivität als aktive Zeit eines Nutzers in Social Media, beschreiben die unterschiedlichen Motivationen eines Nutzers, aktiv zu werden, untersuchen den Kontext einer Nutzeraktivität und benennen wesentliche Nutzeraktivitätstypen. Die Konkretisierung der Nutzeraktivitäten durch die Sicht auf die Daten, erweitert die wissenschaftliche Perspektive und ermöglicht die Implementierung einer Integrationslösung. Das Datenmodell ist ein Kompromiss zwischen Komplexität der Datenstrukturen (Anzahl und Verschachtelung der Objekte und Attribute) und Einfachheit.

Durch den Prototypen wurde ein vergleichsweise einfacher Fall (d. h. Schlagwortsuche) im Kontext der Neukundengewinnung eines Unternehmens erprobt mit dem Ergebnis, dass das Datenmodell als Hilfestellung bei der Softwareimplementierung genutzt werden kann. Die gemeinsame Verarbeitung von Nutzeraktivitäten verschiedener sozialer Netzwerke ist möglich. Die generelle Praxistauglichkeit des Datenmodells in anderen Anwendungsfällen (insbesondere Nützlichkeit und Vollständigkeit hinsichtlich des unternehmensspezifischen Informationsbedarfs) muss erst noch durch weitere Einsätze aufgezeigt werden. Die Architektur des Prototypen ist um zusätzliche soziale Netzwerke und um weitere IS auf der Unternehmensseite erweiterbar. Denkbar sind beispielsweise auch Erweiterungen, um Daten von Smart- und Sportwaches und Gaming-Plattformen. Zur Echtzeitauswertung von großen Datenmengen können etablierte Streaming-Data-Werkzeuge, wie z. B. Kafka, als Source- bzw. Sink-Module eingebunden werden (Pivotal Software 2015). Allerdings entstehen durch die Automatisierung auch neue technische Herausforderungen, wie z. B. Duplikaterkennung, Definition der Filterregeln und Auswahl relevanter Datenwerte. In der weiteren Forschungsarbeit sollten Methoden zur Datenanalyse einbezogen werden, um eine komplexere Filterung der Nutzeraktivitäten vornehmen zu können (z. B. Identifikation der „Stimmung“ von Beiträgen und Selektion aller Aktivitäten von Nutzern der Zielgruppe auf Basis von Alter, Interessen, Orten etc.).

Je nach sozialem Netzwerk und Berechtigungseinstellungen der Nutzer stehen unterschiedlich viele Datenwerte zur Verfügung (Mohan et al. 2008). Die Zustimmung der Nutzer zur Verwendung der Daten sollte vorliegen, da ansonsten die Gefahr besteht, das Vertrauen der Kunden zu zerstören. Zudem variieren die zu berücksichtigenden rechtlichen Rahmenbedingungen zum Schutz der Privatsphäre in den Ländern (van der Aalst et al. 2005). Insbesondere ist es in Deutschland problematisch, wenn personenbezogene Daten ohne Notwendigkeit und Erlaubnis der Personen gesammelt, verarbeitet oder ausgewertet werden. Dies betrifft im Wesentlichen die Attribute des Objekttyps *User* und kann ein Hindernis für die Implementierung sein.

Eine Standardisierung der APIs verschiedener sozialer Netzwerke ist aus Sicht der Systemintegratoren wünschenswert, da dadurch der Schritt der Transformation von proprietären

Datenstrukturen in ein gemeinsames Datenschema obsolet würde. Erste Arbeiten in diese Richtung erfolgen bereits (W3C Social Web Working Group 2015).

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Metadatenmanagement in der BI – Ein strukturierter Literaturreview zum aktuellen Forschungsstand und Zukunftsperspektiven

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Abstract

Die zunehmende Diversifizierung der Datenquellen und Datenstrukturen im Kontext analytischer Informationssysteme forciert die Herausforderungen, die mit der Beherrschbarkeit komplexer unternehmensweiter BI-Lösungen verbunden sind. Dem Management der Metadaten fällt dabei eine zentrale Rolle zu. Der Beitrag beinhaltet eine systematische Aufarbeitung und Analyse des aktuellen Forschungsstands in den verschiedenen Facetten des Metadatenmanagements für die BI. Dies geschieht in Form eines strukturierten Literaturreviews, der das Fundament für die Identifikation und Strukturierung offener und vielversprechender Forschungsfragen legt. Der Beitrag liefert damit den Ausgangspunkt für weitere Forschungsaktivitäten in einem Feld der BI-Forschung von großer Zukunftsbedeutung.

1 Einführung

Die Dynamik der Entwicklungen im Kontext analytischer Informationssysteme hat durch Verbreitung von RFID-Technologien, integrierter Sensorik, Activity Streams sowie Social- und Multi-Media in den vergangenen Jahren kontinuierlich an Fahrt aufgenommen. Die neuen Technologien bringen eine Fülle von verschiedenen Datenformaten, -quellen und -strukturen mit sich (Geerdink 2013). Die systematische Verwaltung und die hierfür erforderliche Integration von Metadaten gewinnen aus diesem Grund eine zunehmend hohe Bedeutung. Für die Steuerung und Dokumentation technischer und fachlich-semantischer (Meta-)Daten und Datenintegrationsprozesse kommen im Rahmen der Business Intelligence (BI) entsprechende Systeme für das Metadatenmanagement (MDM) zum Einsatz (Melchert et al. 2002a). Sie dienen dem Zweck, den Aufwand für den Aufbau und die Weiterentwicklung von BI-Systemen zu minimieren, indem sie alle Prozesse der Metadatenentstehung und der Metadatennutzung möglichst lückenlos unterstützen (Vaduva and Vetterli 2001). Beispiele hierfür sind die automatische Dokumentation von Datenstrukturen oder die modellgetriebene Generierung von Data Marts (Kurze and Gluchowski 2010).

Auch in der Praxis ist der Bedarf an Lösungen für die aktuellen Herausforderungen der BI-Weiterentwicklung in den letzten Jahren stark gestiegen (Dinter et al. 2015). Dem gegenüber steht eine in den letzten Jahren deutlich zurück gegangene Zahl an qualifizierten Forschungsbeiträgen (siehe Abschnitt 3.1). Aktuelle Arbeiten analysieren darüber hinaus weitestgehend lediglich einige Teilaspekte und Problembereiche mit unterschiedlicher Schwerpunktsetzung. Gleichzeitig fehlt eine umfassende und systematische Forschungsagenda für das MDM in der BI.

In der Absicht, diese Lücken zu schließen und die MDM-Forschung in der BI zu revitalisieren, zielt die vorliegende Arbeit auf die systematische Aufdeckung vielversprechender Forschungspotenziale zur Weiterentwicklung des MDM in der BI. Dabei lassen sich zwei konkrete Forschungsziele unterscheiden: (1) Den aktuellen Stand der Forschung in Bezug auf BI-MDM zu identifizieren und die zugrundeliegenden Herausforderungen und Rahmenbedingungen aufzudecken. (2) Zukünftige Forschungspfade zu erkunden und methodische Handlungsempfehlungen für ihre Bewältigung zu skizzieren. Diese Ziele sollen durch die Formulierung der folgenden beiden Forschungsfragen präzisiert werden: (1) Welches sind die vorherrschenden Forschungsgebiete im MDM für die BI? (2) In welchen Gebieten liegen ungelöste Fragestellungen, die zukünftige Forschungsarbeiten motivieren?

Zur Beantwortung dieser Fragen ist der Beitrag wie folgt gegliedert: Im Anschluss an die Einleitung werden die terminologischen und theoretischen Grundlagen des MDM für die BI erläutert. Abschnitt drei liefert einen Überblick über den Gang der Forschungsarbeit, deren Ergebnisse im darauffolgenden vierten Kapitel präsentiert und diskutiert werden. Das abschließende Kapitel fasst die Ergebnisse zusammen und gibt einen Ausblick auf weitere Arbeiten.

2 Metadatenmanagement und Gestaltungsbereiche der Business Intelligence

2.1 Metadatenmanagement in der Business Intelligence

Das Metadaten-Verständnis der BI umfasst neben technischen und fachlich-semantischen „Daten über Daten“ auch Angaben über die einzelnen Datenverarbeitungsvorgänge und organisatorischen Zuordnungen (El-Sappagh et al. 2011; Hüner et al. 2011). Im Einzelnen beschreiben BI-Metadaten Inhalt, Typ, Struktur, Kontext und Bedeutung von Daten in einer BI-Systemarchitektur, beinhalten aber auch prozess- und organisationsbezogene Aspekte zu deren Verarbeitung, Verwaltung und Nutzung (Gluchowski et al. 2008). Dabei abstrahieren Metadaten von einzelnen Instanzen der Realwelt, indem sie die in einem BI-System enthaltenen Objektdaten sowie den zugehörigen Verarbeitungskontext auf einer Typebene repräsentieren (Melchert 2004). Allgemein gesprochen fallen alle Informationen, die für den Entwurf, die Konstruktion oder die Benutzung eines BI-Systems benötigt werden, in die Kategorie Metadaten (Bauer and Günzel 2013).

Zur Gewährleistung von Effektivität und Effizienz bei der Entwicklung, dem Betrieb und der Verwendung von komplexen BI-Systemen erweist sich ein adäquates Management der Metadaten als unerlässlich (Wu et al. 2001), um dadurch einerseits den Aufwand für den Aufbau und den Betrieb zu reduzieren und andererseits den Nutzen beim Gebrauch des Systems zu steigern (Shankaranarayanan and Even 2004). Erreichen lassen sich diese Ziele zum einen durch eine verbesserte Transparenz hinsichtlich des Zusammenspiels einzelner Systemkomponenten, zum anderen durch den Einsatz von Metadaten bei der Automatisierung der Systemadministration und, z.B. durch Abhängigkeitsanalysen, auch bei der Systemgestaltung (On 2006).

Entsprechend der Grundlagenliteratur zum MDM lassen sich grob drei unterschiedliche Einsatzbereiche des MDM voneinander abgrenzen: BI-Entwicklung, BI-Nutzung sowie allgemeine bzw. organisatorische Anwendungsgebiete (Schieder et al. 2015).

BI-Entwicklung. Vor allem im Bereich der BI-Entwicklung eröffnen sich vielfältige Verwendungspotenziale für Metadaten. In Zeiten zunehmender Agilitätsanforderungen an die BI unterliegen die Systeme einem fast permanenten Wandel. Als essentiell erweist es sich vor diesem Hintergrund, den Entwicklern schnell valide Informationen über die Auswirkung von Änderungen in vorgelagerten Systemkomponenten, wie beispielsweise in den Datenstrukturen der Quellsysteme, auf die nachgelagerten Architekturbestandteile aufzuzeigen (Impact Analyse). Weiterhin lassen sich Metadaten einsetzen, um aus Untersuchungen des Zugriffs- und Nutzungsverhaltens der Endanwender Performanceverbesserungen in Bezug auf das Antwortzeitverhalten zu erreichen. Auch zur Vermeidung von Fehlern und zur Erschließung von Rationalisierungspotenzialen bei der Entwicklung können Metadaten eingesetzt werden, beispielsweise im Rahmen der automatisierten oder teilautomatisierten Generierung von ETL-Prozessen oder Datenstrukturen (Klose and Kollas 2015). Ebenso kann die Nutzung von Metadaten beim BI-Betrieb erfolgen, so etwa zur Steuerung von ETL-Prozessen. Als weiteres Einsatzfeld lässt sich die Wiederverwendung von BI-Metadaten anführen, beispielsweise zur Erzeugung neuer Berichte, Data Marts oder ETL-Prozesse, die in Teilen mit den bereits vorhandenen Objekten übereinstimmen. Schließlich erweist sich auch das Identitätsmanagement als potenzieller Einsatzbereich von Metadaten, zumal durch eine globale Sicht auf Berechtigungsstrukturen Sicherheitslücken schneller identifizierbar sind.

BI-Nutzung. Neben der BI-Entwicklung eröffnet vor allem die BI-Nutzung zusätzliche Einsatzoptionen für die Verwendung von BI-Metadaten. BI-Landschaften erweisen sich heute als komplexe Gebilde, die sich aus Anzeige- und Speicherstrukturen auf der einen sowie aus Verarbeitungsprozessen auf der anderen Seite auszeichnen. Als Gegenstück zur Impact-Analyse bietet in diesem Kontext die Data Lineage einen umfassenden Herkunftsnachweis zu allen relevanten Datenobjekten. Für den Endbenutzer sind neben den technischen (z.B. technische Bezeichnungen und Wertebereiche von Datenobjekten und -strukturen) vor allem auch die fachlichen Metadaten (z.B. fachliche Definitionen und Berechnungsvorschriften, Berechtigungen und Verantwortlichkeiten) von großer Bedeutung, um die Aussage angezeigter Analyseergebnisse zweifelsfrei interpretieren sowie nachvollziehen zu können und sich im umfangreichen Informationsangebot zurechtzufinden.

Allgemeine bzw. organisatorische Anwendungsgebiete. Im Bereich der allgemeinen bzw. organisatorischen Anwendungsgebiete von BI-MDM erweist sich eine metadatenbasierte BI-Gesamtdokumentation mit fachlichen und technischen Inhalten als überaus wünschenswert, da sich hierdurch nicht nur die Systemtransparenz drastisch erhöht, sondern auch die Einarbeitung neuer Mitarbeiter erheblich verkürzt werden kann. Darüber hinaus gehören auch Kennzahlen zur Datenqualität (DQ) zu den Metadaten, die verwendet werden können, um eine dauerhafte DQ-Überwachung zu installieren und das Vertrauen der Mitarbeiter in die BI-Systeme zu erhöhen. Schließlich steigert auch die Vereinheitlichung der unternehmensweit eingesetzten BI-Terminologie durch ein MDM den Nutzen einer BI-Lösung.

Tabelle 1 fasst die Einsatzbereiche und Anwendungsgebiete zusammen und gibt die Verweise auf die MDM-Grundlagenliteratur an, in der das jeweilige Anwendungsgebiet erwähnt wird. Überblicksbeiträge und die allgemeine Grundlagenliteratur sind nicht Bestandteil des nachfolgenden Reviews, der auf normative Arbeiten zur Gestaltung des MDM zielt.

MDM Einsatzbereich	MDM Anwendungsgebiet	Quellbezug
BI-Betrieb	Impact Analysis	(Shankaranarayanan und Even 2004), (Stöhr et al. 1999) (Vaduva und Vetterli 2001), (Melchert 2004)
	Betriebsautomatisierung	(Melchert et al. 2002b), (Vaduva und Dittrich 2001), (Vaduva und Vetterli 2001), (Melchert 2004)
	Performanceoptimierung	(Melchert et al. 2002b), (Melchert 2004)
	Entwicklungsautomatisierung	(Melchert et al. 2002b), (Shankaranarayanan und Even 2004), (Vaduva und Vetterli 2001), (Melchert 2004)
	Datenschutz- und Datensicherheit	(Melchert et al. 2002b), (Shankaranarayanan und Even 2004), (Vaduva und Vetterli 2001), (Melchert 2004)
	Metadaten-Wiederverwendung	(Melchert et al. 2002b), (Shankaranarayanan und Even 2004), (Melchert 2004)
BI-Nutzung	Data Lineage	(Shankaranarayanan und Even 2004), (Vaduva und Dittrich 2001), (Vaduva und Vetterli 2001), (Melchert 2004)
	Dateninterpretation	(Vaduva und Dittrich 2001)
	Suchzeiten	(Melchert et al. 2002b), (Stöhr et al. 1999), (Vaduva und Dittrich 2001), (Melchert 2004)
Allgemein bzw. organisatorisch	Terminologie	(Vaduva und Dittrich 2001), (Vaduva und Vetterli 2001), (Melchert 2004)
	Datenqualität	(Melchert et al. 2002b), (Shankaranarayanan und Even 2004), (Vaduva und Dittrich 2001), (Melchert 2004)
	Systemtransparenz	(Melchert et al. 2002b), (Shankaranarayanan and Even 2004), (Melchert 2004)

Tabelle 1: Suchergebnisse der Literaturrecherche

2.2 Gestaltungsbereiche der Business Intelligence

Für die Kategorisierung der Forschungsgebiete des MDM in der BI findet ein Gestaltungsrahmen Verwendung, der sich am BI Framework von (Neil et al. 2011) orientiert und sich durch die sehr umfassende Betrachtung der BI im Unternehmenskontext gut für den Zweck der vorliegenden Untersuchung eignet. Der Rahmen gliedert sich in die drei Bereiche: „Stakeholder", „Prozesse" und „Technologien".

Stakeholder. Der Bereich „Stakeholder" setzt sich aus den drei Personengruppen „Anwender", „Analysten" und „Entwickler" zusammen. Das Aufgabenfeld der Analysten erstreckt sich auf die Konzeption und Durchführung domänenspezifischer Untersuchungen und Ad-hoc-Auswertungen. Anwender nutzen diese Untersuchungsergebnisse und die zugehörigen Informationen für Entscheidungen auf Fachbereichs- oder Unternehmensebene. Entwickler stellen eine tragfähige technische Infrastruktur zur Verfügung und sorgen für den reibungslosen Betrieb. Die Abgrenzung der einzelnen Stakeholdergruppen erweist sich bisweilen als unscharf, zumal sich die jeweiligen Aufgabenfelder überlappen oder in Personalunion durchgeführt werden können (Neil et al. 2011).

Prozesse. Der Sektor „Prozesse" beinhaltet eine Betrachtung der BI-relevanten Prozesse in einem Unternehmen und gliedert sich in „Entscheidungsprozesse", „Analyseprozesse" und „Infrastrukturprozesse". Entscheidungsprozesse führen zur Auswahl einer oder mehrerer verfügbarer Handlungsalternativen und münden in konkreten Umsetzungsmaßnahmen (Alpar et al. 2014). Die hierfür erforderlichen Informationen liefern die vorgelagerten Analyseprozesse. Als Input für die Analysen dient eine umfassende, qualitätsgesicherte und Governance-konforme Informationsinfrastruktur, die es durch die zugehörigen Prozesse zu etablieren gilt.

Technologien. Die unterschiedlichen Komponenten des Bereichs „Technologien" sollen möglichst harmonisch und ohne Brüche zusammenspielen und gliedern sich in „Präsentation", „Datenanalyse" und „Datenbereitstellung" (Gluchowski et al. 2008). Zunächst muss im Rahmen der Datenbereitstellung, die heute in der Regel durch eine Data-Warehouse- bzw. Data-Mart-

Architektur gegeben ist, das relevante Datenmaterial harmonisiert und integriert zur Verfügung gestellt werden. Hierauf können dann die Analysewerkzeuge zugreifen, die sich bei der zielgerichteten Datenauswertung mathematischer und statistischer Verfahren bedienen. Anschließend lassen sich die Ergebnisse anwenderfreundlich und mit Ausrichtung auf die jeweiligen Informationsbedarfe am Bildschirm präsentieren.

3 Literaturreview

3.1 Vorgehensweise der Recherche

Die Sammlung und Auswertung der relevanten Literatur zum BI-MDM folgt dem etablierten Vorgehen nach Webster und Watson (2002), um sowohl eine hinreichende Erkundung des Forschungsgebietes als auch die Identifikation wenig bearbeiteter Themenfelder für zukünftige Forschungsarbeiten zu gewährleisten. Ergänzend kommen die Handlungsanweisungen von vom Brocke et al. (2009) zum Einsatz, um die Systematisierung und Kategorisierung der Forschungsbeiträge anzuleiten.

Für die explorative Suche erfolgte der Zugriff auf die Literaturdatenbanken Google Scholar, EbscoHost, ACM Portal, AIS Digital Library, Web of Knowledge, IEEE Xplore und Science direct. Der Betrachtungszeitraum beschränkt sich auf Jahre 2000 bis 2014, da die Periode ab dem Jahr 2000 mit einem signifikant wachsenden Datenvolumen und der zunehmenden Durchdringung betrieblicher IT-Infrastrukturen mit analytischen BI-Anwendungen assoziiert wird (Davenport and Harris 2007). Die Suche basierte auf „und"-verknüpften Schlüsselwortsuchen der Begrifflichkeit „Metadata Management" (auch in seiner deutschen Entsprechung) in Kombination mit „Business Intelligence", „Business Analytics", „Data Warehouse", „Data Warehousing" oder „Data Warehouse System".

Der Suchraum wurde weiterhin auf hochrangige Journals (EJIS, ISJ, ISR, JAIS, JMIS und MISQ) sowie auf die spezifischen Konferenzen WI, MKWI, AMCIS, ICIS, ECIS, HICSS und PACIS eingegrenzt. Mit Hilfe der Datenbank IEEE Computer Society erfuhr die Suche eine Erweiterung um domänenspezifische IEEE Konferenzen mit dem Ziel, zu weiteren relevanten Forschungsbeiträgen zu gelangen. Eine zitationsabhängige Rückwärtssuche schloss das Vorgehen der Beitragssuche ab und förderte weitere potenziell relevante Publikationen zu Tage.

Die ersten Suchanfragen in den etablierten Fachdatenbanken durch die Volltextsuche der Beiträge, ohne die Berücksichtigung von weiteren Einschränkungen, ergab eine Anzahl von 3.964 Treffern. Durch eine Einschränkung des Suchraums auf Keywords, Abstracts und Beitragstitel verringerte sich die Trefferanzahl auf 85 Beiträge. Die Erkundung der IEEE Datenbank in analoger Weise führte zu insgesamt 75 weiteren, potenziell relevanten Beiträgen. Eine anschließende Einzelsichtung im Hinblick auf thematische Relevanz ergab letztlich insgesamt 55 Arbeiten, die als bedeutsam für die vorliegende Untersuchung eingestuft wurden.

3.2 Ergebnisse der Recherche

Das Histogramm in Bild 1 zeigt die Anzahl der in den Jahren 2000-2015 erschienenen Beiträge differenziert nach den Publikationsquellen. Als auffallend erweist sich die überproportionale Anzahl der Veröffentlichungen bei domänenspezifischen Konferenzen und Journalen, während das Thema bei den Top-Journals und -Konferenzen eine untergeordnete Bedeutung hat.

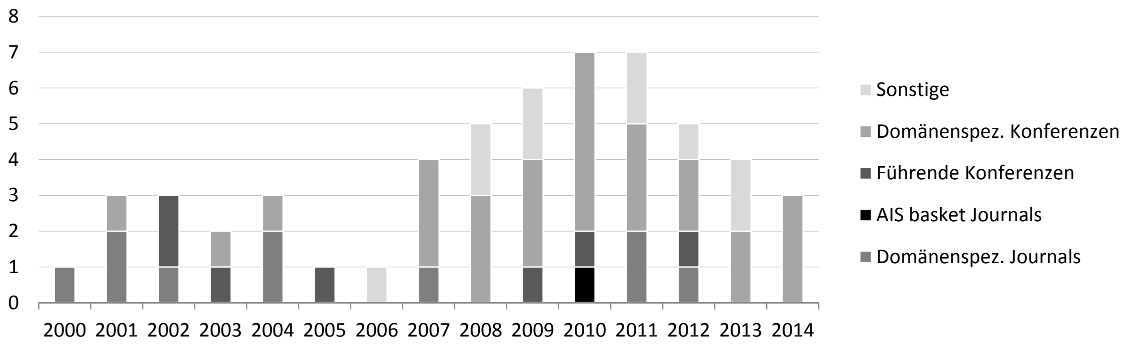

Bild 1: Anzahl der untersuchten Beiträge nach Publikationsoutlet

Das untere Diagramm (Bild 2) zeigt die Verteilung aktueller Forschungsbeiträge, welche den einzelnen oben genannten MDM Ausprägungen zugeordnet wurden.

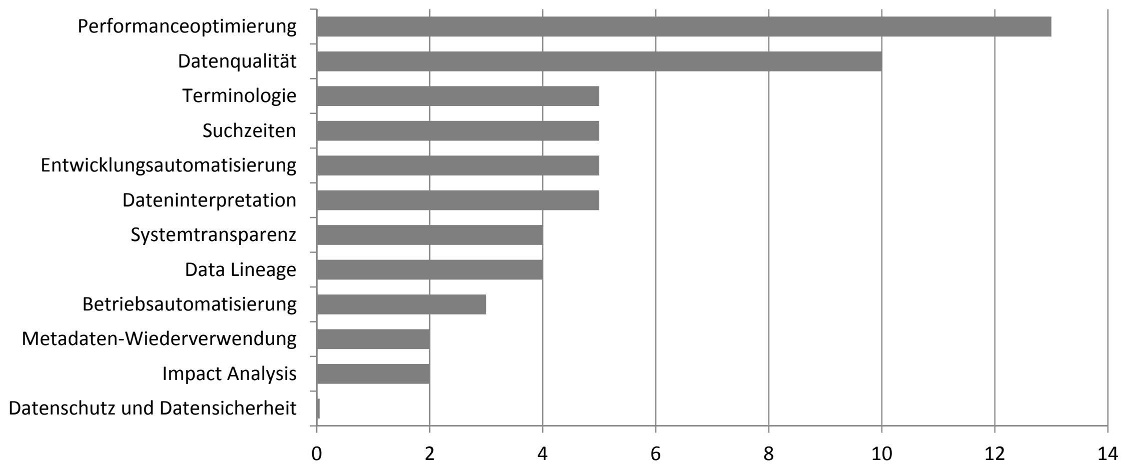

Bild 2: Anzahl der untersuchten Beiträge in den MDM Anwendungsgebieten

Ein Großteil der Beiträge (ca. 25%) setzt sich mit Aspekten der Performanceoptimierung auseinander, wie das Diagramm verdeutlicht. Mit Abstand folgen die MDM-Anwendungsgebiete Datenqualität und Dateninterpretation sowie die Metadaten-Wiederverwendung. Mit der Anwendung des MDM im Rahmen der Betriebsautomatisierung, der Impact Analyse und des Datenschutzes bzw. der Datensicherheit sowie dem Identitätsmanagement befassen sich die wenigsten Beiträge – letzteres Themenfeld wurde gar in keinem der untersuchten Beiträge explizit aufgegriffen.

4 Forschungsstand zum Metadaten Management in der Business Intelligence

Der nachfolgende Abschnitt beschreibt die Erkenntnisse aus den Analysen der identifizierten Beiträge. Die Struktur der Darstellung orientiert sich an den Einsatzbereichen des MDM in der BI wie sie in Abschnitt 2.1 eingeführt wurden. Eine Zusammenschau der Ergebnisse beschließt den Abschnitt.

BI-Betrieb. Als ein zentraler Anwendungsbereich des MDM erweist sich die Performanceoptimierung, die sich beispielsweise durch Abfrageoperationen mit schnelleren Reaktionszeiten und höherer Trefferquote erreichen lässt (Han und Sun 2010; Di Tria et al. 2012). Daneben ist auch das effiziente Speichern und die Aktualisierung von Metadaten auf Metadatenservern Gegenstand intensiver Forschung, wie die untersuchten Beiträge (Brandt et al. 2003; Weil et al. 2004; Feng et al. 2007; Fu et al. 2008; Xing et al. 2009; Xu et al. 2014) zeigen.

Für eine durchgängige Impact Analysis ist es unerlässlich, Metadaten der unterschiedlichen Komponenten einer BI-Lösung, beispielsweise eines ETL-Werkzeuges und eines Data Warehouse, miteinander zu verknüpfen (Vaduva and Vetterli 2001). Um die zugehörigen Zusammenhänge abbilden und besser konzipieren zu können, entwerfen bspw. El-Sappagh et al. (2011) einen Ansatz, realisiert in Form eines Entity Mapping Diagramms, um ETL-Prozesse grafisch mit den Datenstrukturen in Quellsystemen und dem DWH-Zielsystem zu verbinden. Um einen Austausch von Metadaten durchführen zu können, wird oftmals auf das Common Warehouse Metamodell (CWM) zurückgegriffen (Melchert et al. 2005; Di Tria et al. 2012).

Bestehendes Wissen über eine BI-Systemlösung kann durch Wiederverwendung u.a. zur Reduktion von Entwicklungsaufwand führen (Shankaranarayanan and Even 2004). Stojanovic und Handschuh (2002) präsentieren einen Ontologie-basierenden Metadaten-Ansatz, bei dem die Beschreibung automatisch aktualisiert und nach neuen Wissensquellen gesucht wird. Weiterhin identifizieren Hüner und Otto (2009) das Potential des Ausbaus von semantischen Wiki, um eine semantisch annotierte Metadaten-Wissensbasis aufzubauen.

BI-Nutzung. MDM ist häufigen, sowohl semantischen als auch technischen Änderungen ausgesetzt und bedarf daher eines flexiblen eigenständigen Metadatenspeichers, um lesende und schreibende Mehrfachzugriffe fehlerfrei zu gewährleisten (Shankaranarayanan and Even 2004). Eine endbenutzergeeignete Vereinfachung der Datenanalyse erleichtert Endanwendern die Dateninterpretation sowie das Verständnis der Zusammenhänge (Vaduva and Vetterli 2001). Hinsichtlich der Navigations- und Abfragetätigkeit stellen bspw. Wu et al. (2001) eine Benutzerschnittstelle mit einer Übersetzung von Zugriffsbefehlen in eine SQL-Syntax vor; Chee et al. (2011) diskutieren eine an fachlichen Prozessen orientierte BI-Prozessdokumentation.

Allgemeine und organisatorische Anwendungsgebiete. Eine stetige Überwachung und auch Verbesserung der Datenqualität unterstützen Metadaten durch die Definition und Prüfung von Gültigkeitsregeln und Einschränkungen (Farinha et al. 2009; Chee et al. 2011). Yeoh und Wang (2012) entwickelten eine technische Lösung für das BI-Datenqualitätsmanagements mit den wichtigsten Metadaten-Elementen. Eine einheitliche Terminologie ist besonders für global agierende Unternehmen Voraussetzung für unternehmensweite Analysen. Um diese globale Konsistenz zu gewährleisten, fordern Tan et al. (2003) die Etablierung eines eigenständigen zentralen Speicherplatzes für semantische Metadaten. Hüner et al. (2011) stellen hierfür einen fachlicher Metadatenkatalog mit aktuellen, detaillierten und konsistenten Metadaten auf der Basis eines Wikis vor. Zahlreiche Beiträge betonen die Bedeutung von MDM-Lösungen sowohl für den Erfolg bei Einführung und Nutzung von BI-Systemen insgesamt (Foshay et al. 2014), als auch in Bezug auf die zielgerichtete Unterstützung von Geschäftsprozessen im Speziellen (Gupta und Vijay 2011). Bei Verwendung eines konsequenten BI-MDM stellt sich sowohl ein qualitativer als auch ein quantitativer Nutzen ein (Stock und Winter 2011).

Zur Bewertung des Forschungsstands werden nun die Anwendungsgebiete des MDM orthogonal zu den Gestaltungsbereichen der BI angeordnet. Auf diese Weise entsteht eine Matrix des

Forschungsraums der MDM in der BI, die eine qualitative Einschätzung der Intensität bisheriger Forschungen im jeweiligen Sektor vornimmt.

Zunächst zeigt Bild 4, welchen Auswirkungsgrad der einzelne MDM Anwendungsbereich auf die jeweiligen BI-Komponenten in einem Unternehmen hat. Dies wurde aus verschiedenen oben genannten Grundlagenquellen der MDM-Literatur abgeleitet. Zur Visualisierung der Auswirkungsintensität soll ein einfaches Ranking von hoch (++), über gering bzw. mittel (+) bis keine ( ) dienen. Anhand der Schattierungsstärke wird dargestellt, wie häufig die identifizierte Literatur das MDM bezüglich der BI-Komponenten adressiert. Eine dunkle Schattierung zeigt eine häufigere Thematisierung dieser MDM-Ausprägung in der BI, wobei eine helle bzw. keine Schattierung auf eine geringe bzw. keine thematische Bearbeitung hinweist.

		Stakeholder			**Prozesse**			**Technologien**		
		Anwender	Analysten	Entwickler	Entscheidung-prozesse	Analyse-prozesse	Infrastruktur-prozesse	Präsentation	Datenanalyse	Datenbereit-stellung
BI-Betrieb	Impact Analysis		++	++		++	+		++	++
	Betriebsautomatisierung		+	++		+			+	+
	Performanceoptimierung			++		+			+	++
	Entwicklungsautomatisierung		+	++		+				++
	Datenschutz und Datensicherheit	+	+	++			+	+	+	++
	Metadaten-Wiederverwendung	+	++	++		+			++	++
BI-Nutzung	Data Lineage		+	++			++			++
	Dateninterpretation	+	++		+	++			++	++
	Suchzeiten	+	++	+	+	++		+	++	+
Allgemein & organisatorisch	Terminologie	++	+	++	++	++	++	++	+	++
	Datenqualität	+	++	++		++		+	+	++
	Systemtransparenz	++	+	+	++	+		+	+	++

Tabelle 2: Literaturabdeckung der MDM Anwendungsgebiete in Bezug auf BI Gestaltungsbereiche

5 Diskussion und Themen für zukünftige BI-MDM-Forschung

Die nachfolgenden Betrachtungen widmen sich den in der Literatur identifizierten MDM Konzepten und beleuchten deren Relevanz für die Komponenten „Stakeholder“, „Prozesse“ und „Technologien“ (vgl. Abschnitt 2.2), um so Forschungslücken und beispielhaft daraus resultierende zukünftige Forschungsthemen zu identifizieren

Stakeholder. MDM soll, so die Literatur, die Anwender vor allem hinsichtlich einer einheitlichen Terminologie unterstützen und dadurch unternehmensweit die verwendeten Begrifflichkeiten harmonisieren. Weiterhin erweist sich die Metadaten-Wiederverwendung für die Anwender als wichtig, da sich hierdurch neue Informationsbedarfe rasch abdecken lassen. Allerdings fokussieren nur wenige der untersuchten Beiträge diese Anwendungsbereiche explizit. Verbesserungen vor allem bei der Vereinheitlichung der verwendeten Terminologie mit dem Ziel einer eindeutigen Interpretierbarkeit und einfacheren Nachvollziehbarkeit der Daten lassen sich bspw. durch wiki-basierte Anwendungen erreichen (Chee et al. 2011). Weiterhin können zusätzliche Unterstützungspotenziale für den Anwender durch Hilfe beim Auffinden bereits vorhandener Informationen (z.B. vorhandener Analyseergebnisse) aktiviert werden, etwa durch freie Textsuchen bzw. -abfragen. Dies erfordert jedoch weitere Forschungsanstrengungen zu semantischer Wissensverknüpfung, wie durch Fellmann et al. (2010) mittels der Entwicklung semantischer Wikis.

Auch für die Analysten sind insbesondere die Metadaten-Einsatzbereiche im Bereich BI-Nutzung sowie bei der Terminologie, Datenqualität und Systemtransparenz von Relevanz. Bei der Betrachtung der untersuchten Literatur zeigen sich in diesen Themenfeldern noch kleinere Lücken. Darüber hinaus ist die Unterstützung der Personengruppe bei der Festlegung und Durchführung von Analysen noch ausbaufähig. Vorstellbar wären hierzu z.B. Überlegungen zur Wiederverwendbarkeit bestehender Auswertungen für domänenspezifische oder Ad-hoc-Untersuchungen.

Die Tätigkeiten der Entwickler zielen primär auf die Bereitstellung eines tragfähigen und bedarfsorientierten BI-Informationsangebots. Folgerichtig finden sich hier Einsatzpotenziale für Metadaten primär in den Feldern Systembetrieb, -verwaltung, -implementierung und -pflege. Vorhandene Forschungsansätze zeigen einen resultierenden Mehrwert für Unternehmen durch eine Verbesserung der Performance des MDM, wobei die Beiträge sich in der Regel auf das Metadatenspeichersystemen konzentrieren (Brandt et al. 2003; Weil et al. 2004; Feng et al. 2007; Fu et al. 2008; Xing et al. 2009; Xu und Arumugam 2013). Auch die Verwendung von Metadaten zur Sicherung und Verbesserung der Datenqualität wird sowohl seitens der untersuchten Grundlagenliteratur als auch durch die identifizierten Forschungsbeiträge ausgiebig adressiert. Letztere konzentrieren sich auf technische Lösungen im BI-Kontext hinsichtlich des Sammelns, des Verwaltens und der Bereitstellung von DQ-Metadaten.

Prozesse. Abgesehen von Anwendungsgebiet Data Lineage, finden sich bei den Prozessen in der Gesamtbetrachtung vergleichsweise wenige Forschungsbeiträge, obwohl insbesondere die Analyseprozesse erheblich von einem adäquaten MDM profitieren könnten. Vereinzelte widmen sich Ansätze der Dokumentation einzelner Vorgangsschritte sowie Beschreibungen den Abhängigkeiten zwischen domänenspezifischen und unternehmensweiten Modellen (Tan et al. 2003). Erheblicher Nachholbedarf stellt sich augenscheinlich bei den Infrastrukturprozessen im Bereich Terminologie ein. Dies erscheint nachvollziehbar, wenn die eher technisch ausgerichteten Mitarbeiter in diesem Bereich zur zielgerichteten Informationsbereitstellung auch über fachliche Zusammenhänge besser in Kenntnis gesetzt werden müssen.

Technologien. Bei den Technologien fällt auf, dass sich die wohl wichtigsten Anwendungsbereiche für das MDM in der Datenbereitstellung finden lassen, die allerdings auch sehr breit durch zahlreiche Forschungsansätze abgedeckt ist. Der naturgemäß technische Fokus der Beiträge zum MDM konzentriert sich hier auf Systemarchitekturen und Schnittstellen, welche bspw. einen Metadatenaustausch zwischen CWM Metamodellen unterstützen (Melchert et al. 2005). Zudem nimmt die performanceoptimierte Informationsbereitstellung durch effizienten Metadatenzugriff und -abruf eine bedeutende Rolle ein (Brandt et al. 2003; Feng et al. 2007; Fu et al. 2008; Xing et al. 2009; Xu und Arumugam 2013). Wie bei den übrigen BI-Komponenten stellen sich allerdings auch hier noch Defizite in Bezug auf das Einsatzfeld Terminologie ein, das zwar bereits ansatzweise bearbeitet wurde, der Forschungsstand allerdings noch nicht der Bedeutung des Forschungsgebiets entspricht. Im Hinblick auf die Präsentation finden sich vereinzelte Beiträge, so bspw. Datenqualitätsüberprüfungen mithilfe von Metadaten, visualisiert in einem BI-Dashboard (Chee et al. 2011). Auch im Bereich der Datenanalyse lassen sich einzelne Beiträge z.B. zur Dateninterpretation und zur Reduktion von Suchzeiten identifizieren.

Insgesamt ergeben sich zahlreiche MDM-Bereiche in der BI, die lediglich rudimentär und lückenhaft von den aktuellen Forschungsarbeiten abgedeckt werden. Den Anwendungsbereich der Systemsicherheit und des Systemschutzes greift keine der betrachteten Forschungsarbeiten als Thematik auf, weshalb hier großer Nachholbedarf zu lokalisieren ist. Konzepte zur Integration von Zugriffsberechtigungen, Benutzern und deren Rollen in das MDM wären erforderlich und wünschenswert. Handlungsfelder lassen sich auch in den Bereichen Dateninterpretation und Terminologie identifizieren.

6 Zusammenfassung

Der vorliegende Beitrag präsentiert ein umfangreiches Literaturreview auf der Basis von 55 identifizierten Veröffentlichungen zum Themenbereich MDM in der BI. Als Untersuchungsergebnis lässt sich festhalten, dass die betrachteten Forschungsarbeiten ein breites Spektrum unterschiedlicher Facetten des Themas behandeln, das von der technischen Konzeption umfassender MDM-Systeme und der Spezifikation von Schnittstellen für Austauschverfahren bis zur Verwendung der Metadaten in modernen Benutzeroberflächen reicht, allerdings auch noch weite Felder unbearbeitet sind.

Zur Strukturierung der einzelnen Teilaspekte eines MDM in der BI wurde einerseits ein Katalog von insgesamt zwölf Anwendungsfeldern aus der Literatur verwendet, die sich neben allgemeinen und organisatorischen Aspekten der BI-Nutzung und dem BI-Betrieb widmen. Weiterhin erfolgte die Betrachtung von neun Gestaltungsbereichen der BI, gruppiert zu den Blöcken Stakeholder, Prozesse und Technologien, in denen das BI-MDM zum Tragen kommt. Mittels der dadurch aufgespannten, insgesamt 108 Aktionsfelder umfassenden Matrix ließ sich anschließend auf der Basis der zugehörigen Grundlagenliteratur die Relevanz des BI-MDM feldbezogen visualisieren und mit den Häufigkeiten der thematischen Behandlung in den identifizierten Forschungsbeiträgen vergleichen.

Das gewählte Vorgehen weist naturgemäß Limitationen auf, die sich vor allem aus dem gewählten Suchraum für die Literaturbeiträge ergeben. Da die gewählten Suchbegriffe tendenziell eher technischer Natur sind, könnten fachlich orientierte Beiträge, die den Anwender oder die Entscheidungsprozesse in den Vordergrund stellen, durch das Raster gefallen sein. Auch finden sich möglicherweise Beiträge auf Konferenzen oder in Journalen, die hier nicht weiter betrachtet wurden.

Weiterführende Forschung zum Themenkomplex MDM und BI könnte sich speziell auf neue Strömungen und Erscheinungsformen der BI (z.B. Cloud BI, Self-Service BI, agile und mobile BI) und deren Anforderungen an MDM konzentrieren. Weiterhin dürften sich vor allem im Big-Data-Kontext zukünftig erweiterte und neue Formen von Metadaten vor allem für unstrukturierte und semi-strukturierte Daten einstellen, die es zu integrieren gilt.

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Teilkonferenz
Computational Mobility, Transportation and Logistics

Innovative Informations- und Anwendungssysteme spielen für moderne Mobilitäts-, Transport- und Logistikdienstleistungen (MTL) eine zunehmend wichtige Rolle. Eine Vielzahl moderner MTL wird erst durch (integrierte) Informations- und Anwendungssysteme realisierbar. Die Planung und Steuerung von modernen MTL bedarf einer ädaquaten Unterstützung durch Informations- und Anwendungssysteme. Diesen Trend wollen wir mit der Teilkonferenz „Computational Mobility, Transportation and Logistics“ aufgreifen und damit die Reihe der MKWI-Teilkonferenzen zu Informationssystemen in Transport und Verkehr fortsetzen.

Zu dieser Teilkonferenz konnten fünf Beiträge angenommen werden. Merting, Bichler und Karänke widmen sich der automatisierten Koordination von Zulieferern in der Handelslogistik. Der Beitrag von Soeffker, Ulmer und Mattfeld beschäftigt sich mit der effektiven Informationsbereitstellung für Probleme der dynamischen Tourenplanung. Nordsieck, Buer und Schönberger stellen eine Heuristik zur Lösung des Container-Transportproblems vor. Müller und Tierney (RiP) präsentieren ein Entscheidungsunterstützungssystem für das taktische Problem der fahrplangebundenen Containerschifffahrt. Wickboldt und Kliewer (RiP) beschäftigen sich schließlich mit der automatisierten Bestimmung von Marktpreisen von Flugzeugersatzteilen. Hinweis: bei den mit „RiP“ gekennzeichneten Beiträgen handelt es sich um Research-in-Progress-Beiträge, die nicht im Tagungsband abgedruckt werden, aber über die Konferenzwebseite abrufbar sind.

Wir hoffen auf eine spannende Diskussion und möchten an dieser Stelle allen KollegInnen für die Einreichung sowie die Begutachtung der Beiträge herzlich danken.

Jan Fabian Ehmke, Natalia Kliewer, Dirk Christian Mattfeld

(Teilkonferenzleitung)

Strategy-Proof Assignment of Bundles with Ordinal Preferences: An Application in Retail Logistics

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Abstract

Long waiting times at loading docks of retailers are a substantial problem in retail logistics. Congestion results from a lack of coordination among carriers. One possibility for reducing the waiting time of carriers at warehouses is to coordinate the carriers and retailers by a central timeslot management. Since carriers have to visit several warehouses in a special order, they have preferences over subsets of timeslots describing the retailers on a route, which we call bundles. Carriers need to get all relevant timeslots on a route. We are interested in coordination mechanisms that do not require monetary transfers. Matching with complementarities is an extension of the Capacitated House Allocation problem, where agents have preferences over bundles of objects. We present a generalisation of the Random Serial Dictatorship that is strategy-proof, symmetric, and computes Pareto optimal matchings.

1 Introduction

Growing importance of Just-In-Time-delivery for the reduction of storage costs at retailers and factories brought up new challenges for carriers. A survey among more than 500 transportation companies shows, that more than 69% have an average waiting time of more than one hour at the loading docks of retailers (Bundesverband Güterkraftverkehr Logistik und Entsorgung e.V. 2013). One reason for these waiting times is the uncoordinated arrival of trucks. A possible remedy for this problem is a centralized timeslot management. This means, the warehouses send available capacities for each timeslot and the carriers send preferences over subsets of these timeslots to a timeslot management system that assigns the trucks to timeslots at the warehouses or retailers. Existing timeslot management systems provide first-come-first-served reservation systems, where carriers enter single timeslots. Better solutions could arise if carriers specified a number of possible routes such that the coordinator can compute an optimal assignment of carriers to timeslots.

Auction mechanisms are a means to aggregate the preferences of carriers. Specific mechanisms allow maximizing social welfare and exhibit simple dominant strategies for carriers. Still, there are bid preparation costs for carriers, because they need to determine their willingness-to-pay for a set of timeslots. Ideally, carriers only need to specify ordinal preferences for different routes, i.e., subsets of timeslots, while the carriers would still have a dominant strategy to reveal their true preferences. This would minimize bid preparation costs and increase incentives to participate in a centralized coordination system.

Unfortunately, the design space for strategy-proof mechanisms with ordinal preferences is limited. Gibbard (1973) and Satterthwaite (1975) showed, that with general ordinal preferences every deterministic mechanism is susceptible to manipulation. Later, Gibbard (1977) has shown, that every strategy-proof mechanism is a lottery over deterministic mechanisms that are dictatorial. Therefore we are limited to a form of Random Serial Dictatorship (RSD). We propose *Bundled Random Serial Dictatorship (BRSD),* an extension of the well-known RSD allowing for preferences over bundles of timeslots. We show that BRSD is ex post Pareto optimal and strategy-proof. Furthermore, we discuss limitations regarding the fairness of the resulting assignments.

This paper is organized as follows: First, we model the problem formally as a Capacitated House Allocation problem with complementarities. In Section 3 we provide an overview of the literature about random priority mechanisms and extensions. Next, we present a strategy-proof algorithm and properties of this matching problem in Section 4. In Section 5 we discuss alternative approaches and conclude in Section 6.

2 Model

The Capacitated House Allocation problem (CHA) consists of two sets: A set of agents and a set of objects (houses). The objects have nonnegative capacities and the agents have ordinal preferences over the objects. The objective is to assign the agents to at most one object. For the loading dock coordination problem we generalize this model as follows.

There is a set of *warehouses* W and *carriers* C. We divide the time into discrete intervals of the same size. Each warehouse has a maximal number of carriers that can be served in each time interval depending on the number of loading docks and available staff. We call this the *capacity* of warehouses in this time interval. We denote triples of a warehouse, starting time and capacity as *timeslots*. Formally, we denote the set of available timeslots $TS = \{(w, t, cap(w,t)) \mid w \in W, t \in \mathbb{N}_0,\ cap: W \times \mathbb{N}_0 \longrightarrow \mathbb{N}_0\}$. For brevity, we denote the capacity of timeslot $ts \in TS$ as cap_{ts}.

In our setting carriers are the agents; and timeslots are the objects. The difference to CHA is that the agents do not have *preferences* over single objects, but over *bundles* of objects. We denote $(>_c)_{c \in C}$ as the *preference-profile* for agent $c \in C$. For two bundles $S, S' \in 2^{TS}$ we say c *strictly prefers* S to S' if $S >_c S'$. Let $Acc(c) \subseteq 2^{TS} \backslash \emptyset$ be the set of *acceptable* bundles of timeslots for c. For all bundles $S \notin Acc(c)$ we call S *unacceptable* and note $S =_c \emptyset$. Now, we can define what a (deterministic) matching is and what properties it can have.

Definition 1: (Matching) We call $M \subseteq \{(S,c) | S \in 2^{TS}, c \in C\}$ a matching if

1. $M(c) \in Acc(c) \cup \emptyset, \forall c \in C$,
2. $M(ts) \subseteq C, \forall ts \in TS$ and
3. $\forall c \in C \wedge ts \in TS: ts \in M(c) \Leftrightarrow c \in M(ts)$.

M is *feasible* if for all $ts \in TS$ $|M(ts)| \le cap_{ts}$. We denote the set of all feasible matchings for a given instance as $\mathcal{M}$. A Matching $M \in \mathcal{M}$ is *maximal* if there is no unassigned agent $c \in C$ with $Acc(c) \neq \emptyset$ so that there exists a $S \in Acc(c)$ with $|M(ts)| < cap_{ts}$ for all $ts \in S$. $M \in \mathcal{M}$ is called *trade-in-free* if there is no agent $c \in C$ with $\mathrm{M}(c) \neq \emptyset$ so that there exists a $S \in Acc(c)$ with $S >_c M(c)$ and $\left|\big(M\backslash(M(c),c)\big)(ts)\right| < cap_{ts}$ for all $ts \in S$. Thereby, $M\backslash(M(c),c)$ denotes the resulting matching if we delete the assignment of agent c from M.

A matching $M' \in \mathcal{M}$ *dominates* $M \in \mathcal{M}$ if for all $c \in C$ $M'(c) \geq_c M(c)$ and there is at least one $c \in C$ with $M'(c) >_c M(c)$. We denote a matching $M \in \mathcal{M}$ as *Pareto optimal* if there exists no matching $M' \in \mathcal{M}$ that dominates M. Pareto optimality means that no agent can be better off without making another agent worse off. This is not only an optimality criterion, but also a necessary fairness condition. Without Pareto optimality the agents would have incentives to subvert the matching to receive a better assignment.

One may also be interested in matchings with maximal size, i.e., matchings that assign as many agents as possible. We call a matching M *maximum* if it is Pareto optimal and $|M| \geq |M'|$ for all Pareto optimal matchings $M' \in \mathcal{M}$.

We focus on randomized mechanisms and call a matching a *lottery* L if we can achieve L by a convex combination of feasible (deterministic) matchings. We denote the set of all lotteries over deterministic matchings as $\mathcal{L}$. The outcome of a lottery L for an agent c is a probability distribution over bundles in $Acc(c) \cup \emptyset$. c prefers L to another lottery L' if the expected utility over $L(c)$ is higher than over $L'(c)$. Thereby, we assume that the utility u of an agent c over bundles S is consistent with the agent's' preference profile. That means that $u_c(S) > u_c(S')$ iff $S >_c S'$ and $u_c = u_{c'}$ iff $(>_c) = (>_{c'})$.

A *random matching mechanism* is a function $\sigma: (>_c)_{c\in C} \rightarrow \mathcal{L}$. A random matching mechanism σ with $\sigma((>_c)_{c\in C}) = L$ is *ex ante Pareto optimal* if no agent prefers L to any other lottery $L' \in \mathcal{L}$. We call σ *ex post Pareto optimal* if L is a convex combination of Pareto optimal matchings. A desirable property of mechanisms is that all agents are treated equally. We call a random matching mechanism σ *symmetric* if for every pair of agents c and c' with $(>_c) = (>_{c'})$ $L(c) = L(c')$. This means, if the two agents have the same preference profile, they also have the same outcome in expectation. A stronger condition is envy freeness. We call σ *envy free* if $u_c\big(L(c)\big) \geq u_c(L(c'))$ for all $c, c' \in C$. In words, the expected utility of the assignment of agent c is not less than the expected utility of every other assignment in L.

Finally, it is desirable that the agents submit their true preferences. A random matching mechanism σ is *strategy-proof* if $u_c\left(\sigma\big((>_c)_{c\in C}\big)(c)\right) \geq u_c\left(\sigma\big((>'_c), (>_{-c})\big)(c)\right)$, where $\big((>'_c), (>_{-c})\big)$ denotes the preference profile in which agent c submits an untrue preference profile and all other agents are telling the truth. This means, an agent cannot achieve a better matching by lying about the true preferences.

3 Related Work

We use a model that is a generalisation of the well-known House Allocation (HA) problem first introduced by Shapley and Scarf (1974). There, the agents have preferences over objects and want to get at most one object. The objects can be assigned to at most one agent and do not have preferences. Many extensions of the HA problem were introduced, like the Capacitated HA (CHA) problem (Hylland and Zeckhauser 1979), where objects can be assigned to more than one agent. Further extensions can be found in Manlove (2013).

The class of *random priority algorithms* satisfies strategy-proofness. Popular examples are the Random Serial Dictatorship (RSD) (Abdulkadiroğlu and Sönmez 1998) or the Top-Trading-Cycle algorithm with random endowments (Shapley and Scarf 1974). These algorithms compute deterministic matchings (not lotteries), but the underlying mechanisms are random. They have typically desired properties like strategy-proofness and ex post Pareto optimality, but in general they perform poorly in terms of fairness (Budish and Cantillon 2012). Hashimoto (2013) presented a generalisation of RSD called General-Random-Priority (GRP) algorithm for multiunit assignments without money and combinatorial auctions. GRP is shown to be feasible and strategy-proof. For obtaining feasibility, the algorithm withholds a fraction of ε objects, whereby ε goes to zero when the number of agents goes to infinity. Cechlárová et al. (2014) introduce a many-to-many CHA problem, where agents can obtain multiple objects. However, the agents can only rank the objects, but not different bundles of objects. Every agent has a virtual budget and every object a price. Now, bundles satisfying the budgets of the agents are computed, lexicographically ranked, and a generalisation of RSD is used to receive an allocation.

4 Bundled Random Serial Dictatorship

We restrict our attention to strategy-proof mechanisms. Gibbard (1977) has shown that every strategy-proof mechanism is a lottery over deterministic mechanisms, each of which either has not more than two alternatives or is dictatorial. In other words, in our setting with multiple possible bundles we are necessarily bound to a form of RSD if we want to maintain strategy-proofness. Therefore, we present a generalisation of the RSD called Bundled Random Serial Dictatorship (BRSD) in the algorithm below. BRSD orders the carriers randomly and assigns the most preferred bundle, which has sufficient capacities at all included timeslots, to each carrier in this order.

Algorithm: Bundled Random Serial Dictatorship (BRSD)

Input: carriers C with preferences over bundles of timeslots TS
order C randomly, $M = \emptyset$
forall $c \in C$ **do**
  $S \in Acc(c) \cup \emptyset$ – the bundle with highest preference,
    which satisfies: $\forall ts \in S : |M(ts)| < cap_{ts}$
  $M = M \cup (S, c)$
end for
Output: matching M

Next, we provide an example to illustrate the BRSD matching procedure.

Example 1: Suppose there are 4 agents $\{1, \dots, 4\}$ and 4 objects $\{A, \dots, D\}$ with the following capacity-vector: (2,1,2,2). The agents have the following preferences; all other bundles are unacceptable for the respective agents:

$$
\begin{array}{llcl}
1: & \{A,C\} & >_1 & \{B,D\} \\
2: & \{B,D\} & >_2 & \{B\} \\
3: & \{A,D\} & >_3 & \{C\} \\
4: & \{A,D\} & >_4 & \{C,D\}
\end{array}
$$

Now, we run BRSD on this instance. A possible order of carriers is $(1,2,3,4)$. Agent 1 choses bundle $\{A,C\}$, agent 2 $\{B,D\}$ and agent 3 $\{A,D\}$. Now, we have no more free capacities on objects $\{A,B,D\}$ why we cannot assign any acceptable bundle to agent 4. We receive the matching $M_1 =$

$\{(\{A,C\},1),(\{B,D\},2),(\{A,D\},3),(\emptyset,4)\}$. We see that this matching is Pareto optimal, but not maximum, because for the order $(1,3,4,2)$ we get the matching $M_2 = \{(\{A,C\},1),(\{B\},2),(\{A,D\},3),(\{C,D\},4)\}$. That is, the size of a solution to BRSD depends on the randomly selected order of the agents.

The central question is whether this extension of RSD still satisfies strategy-proofness, ex post Pareto optimality and symmetry. Strategy-proofness carries over from RSD (Gibbard 1977) so that we focus on ex post Pareto optimality and symmetry in our analysis. To show these properties we first provide an alternative characterisation of Pareto optimality in section 4.1 and then proof ex post Pareto optimality of BRSD in section 4.2.

4.1 Pareto Optimal Matchings

In this subsection we present a characterisation of Pareto optimality using conflict trees similar to the result of Sng (2008) for the CHA that will help us to proof Pareto optimality. Lemma 2.3.1 of Sng (2008) says that a matching is Pareto optimal iff it is maximal, trade-in-free and cyclic coalition-free, where a *cyclic coalition* for a matching M is a sequence of agents $A = (c_{i_0}, c_{i_1}, \dots, c_{i_{r-1}})$ for $r \geq 2$ with $M(c_{i_j}) \leq_{c_{i_j}} M(c_{i_{j+1\,mod\,r}})$. Note that in CHA $|M(c)| \leq 1$ for all agents c. We can rewrite the definition of a cyclic coalition as follows: A sequence of agents $A = (c_{i_0}, c_{i_1}, \dots, c_{i_{r-1}})$ for $r \geq 2$ is a cyclic coalition for a matching M if $M' = M \setminus \{(M(c_{i_{k\,mod\,r}}), c_{i_{k\,mod\,r}}) \mid k \leq j+1\} \cup \{(M(c_{i_{k+1\,mod\,r}}), c_{i_k}) \mid k \leq j\}$ is feasible for $j = 0, \dots, r-1$ and $M'(c_{i_j}) \geq_{c_{i_j}} M(c_{i_j})$ and $M'(c_{i_j}) >_{c_{i_j}} M(c_{i_j})$ for at least one j. That means, a cyclic coalition is a sequence of agents so that we can construct a better matching by iteratively deleting the current assignments up to the successor of agent *c*, and assigning another object to *c* such that the new object is at least as good as the old one. We generalize this idea to bundles. First, we define a conflict tree.

Definition 2: (Conflict Tree) *We call $T = (V, E, S)$ a conflict tree for a matching $M \in \mathcal{M}$ if T can be constructed by the following algorithm:*

```
1:  Set V_0 = V = c for arbitrary c ∈ C, E = ∅, V_j = ∅, for j > 0, i = 0
2:  M = M \ (M(c), c)
3:  while (V_i ≠ ∅) do
4:      forall c ∈ V_i do
5:          M = M ∪ S_c for a S_c ∈ Acc(c) ∪ ∅, such that M[⋃_{j=0}^{i+1} V_j] feasible
6:          S = S ∪ S_c
7:          forall c' ∈ C \ ⋃_{j=0}^{i+1} V_i do
8:              if (∃ts ∈ M(c') : |M(ts)| > cap_ts) then
9:                  V_{i+1} = V_{i+1} ∪ c'
10:                 E = E ∪ (c, c')
11:                 M = M \ (M(c'), c')
12:             end if
13:         end for
14:     end for
15:     i++
16: end while
```

Thereby, the expression $M\left[\bigcup_{j=0}^{i+1} V_i\right]$ in line 5 means that we do not consider the full matching M, but only the matching induced by the agents given in squared brackets. Informally, we get a conflict tree from a matching by iteratively deleting the assignment of an agent *c* and assigning another bundle to that agent. If the new matching is infeasible, we delete all other assignments of agents that are not in the conflict tree yet and include over-allocated objects; we reassign these agents to other bundles respecting the capacities of the objects. We say that these agents are in conflict. We repeat these steps until there are no further conflicts. In a conflict tree a new assignment does not have to be as good as the old assignment for every agent. With help of the conflict tree we can define a tree-coalition.

Definition 3: (Tree-Coalition) *We call $T = (V, E, S)$ a tree-coalition for a matching $M \in \mathcal{M}$ if T is a conflict tree, $S_c \geq_c M(c)$ for all $c \in V$ and $S_c >_c M(c)$ for at least one $c \in V$.*

Informally, a tree-coalition is a conflict tree so that the new assignment for every agent in that tree is as good as the old one, and at least one agent is assigned to a more preferred bundle. A matching is *tree-coalition-free* if there does not exist any tree-coalition. Note that checking this condition needs to generate all possible conflict trees whereof in general exponentially many exist.

A matching is maximal and trade-in-free if it is tree coalition-free. To see this, consider a matching that is not maximal, then, there has to be at least one unassigned agent c who can be assigned to an acceptable bundle S_c. Now we can construct a tree-coalition $T(\{c\}, \emptyset, S_c)$. If the matching M is not trade-in-free, we can find an agent c with $\emptyset \neq M(c) <_c S_c$ for an acceptable bundle S_c such that $M \setminus (M(c), c) \cup (S_c, c)$ is feasible. Again, we can construct a tree-coalition $T(\{c\}, \emptyset, S_c)$.

Obviously, a matching cannot be Pareto optimal if there is a tree-coalition, because with help of this tree-coalition one can easily construct a better feasible matching. Theorem 1 shows that both directions of this statement are true. Let us first provide an example to give some intuition for the definitions of conflict trees and tree-coalitions.

Example 2: Let the agents and preferences as well as the objects and capacities be like in Example 1. This example contains two parts to illustrate the differences between conflict trees and tree-coalitions.

a) Consider the matching $M_1 = \{(\{B, D\}, 1), (\emptyset, 2), (\{C\}, 3), (\{C, D\},4)\}$. We construct a conflict tree for M_1 with initial agent 2 (see left tree in Figure 1). Here, $V_0 = \{2\}$ and after deleting the assignment of agent 2 a new matching $M_1' = \{(\{B, D\}, 1), (\{C\}, 3), (\{C, D\},4)\}$ arises for the remaining agents. Now, we choose a new assignment $S_2 = \{B, D\}$ for agent 2 and receive $M_1'' = \{(\{B, D\}, 1), (S_2, 2), (\{C\}, 3), (\{C, D\},4)\}$. We see that the objects B and D are over-allocated. That's why agent 2 is in conflict with the agents 1 and 4. We delete the assignments of these agents and obtain $M_1''' = \{(S_2, 2), (\{C\}, 3)\}$ and $V_1 = \{1,4\}$. In the next iteration we assign new bundles $S_1 = \{A, C\}$ and $S_4 = \{A, D\}$ to the agents in V_1. After this iteration the algorithm stops with the left conflict tree shown in Figure 1 and $M_1'''' = \{(S_1, 1), (S_2, 2), (\{C\}, 3), (S_4, 4)\}$. Because of $M_1(1) <_1 S_1$, $M_1(2) <_2 S_2$ and $M_1(4) <_4 S_4$, this conflict tree is also a tree-coalition. In this example one also can see that a conflict tree not necessarily has to contain all agents.

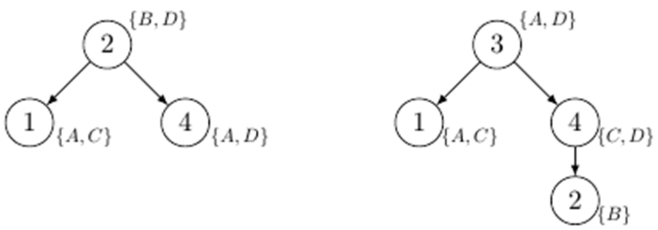

Figure 1: Examples of conflict trees

b) Consider $M_2 = \{(\{A,C\},1),(\{B,D\},2),(\{C\},3),(\{A,D\},4)\}$. Agent 3 is only assigned to his second preference in M_2, while all other agents are assigned to their first preference. That's why we can construct the right conflict tree shown in Figure 1 by starting with $V_0 = \{3\}$, deleting $(\{C\},3)$ from M_2 and assigning $S_3 = \{A,D\}$ to agent 3. We receive $M_2' = \{(\{A,C\},1),(\{B,D\},2),(S_3,3),(\{A,D\},4)\}$ and see that A and D are over-allocated. Because A and D are allocated to the agents 1 and 4 too, agent 3 is in conflict with these agents; so $V_1 = \{1,4\}$. Now, we delete the assignments of these two agents and get $M_2'' = \{(\{B,D\},2),(S_3,3)\}$. In the next iteration we can assign new bundles $S_1 = \{A,C\}$ and $S_4 = \{C,D\}$ to agents 1 and 4 so that the matching induced by agents 1, 3 and 4 keeps feasible. By assigning S_4 to agent 4, object C gets over-allocated in $M_2''' = \{(S_1,1),(\{B,D\},2),(S_3,3),(S_4,4)\}$. Therefore, agent 4 stands in conflict with the agents 1 and 2; though, we only consider agents that are not in the tree yet. That's why $V_2 = \{2\}$. After the second iteration we achieve the right conflict tree from Figure 1 by assigning $S_2 = \{B\}$ to agent 2. Since $S_2 <_2 M(2)$, this conflict tree cannot be a tree coalition.

Theorem 1: *A matching $M \in \mathcal{M}$ is Pareto optimal iff M is tree-coalition-free.*

Proof: Let $M \in \mathcal{M}$ be Pareto optimal, but not tree-coalition-free. We can construct a tree-coalition $T = (V,E,S)$ as defined in Definition 3. Now, we can construct a new matching $M' = M \setminus \{(M(c),c) | c \in V\} \cup \{(S_c,c) | c \in V, S_c \in S\}$. Because of the definition of M', it's obvious that M' dominates M, which is a contradiction to the Pareto optimality of M.

Now, let M be tree-coalition-free. Suppose M is not Pareto optimal. That means, it exists an agent $c^* \in C$ and a matching $M' \in \mathcal{M}$ with $M(c^*) <_{c^*} M'(c^*)$ and $M(c) \leq_c M'(c)$ for all $c \in C$. We compare M and M' for c^*. Let's take a look on $M'' = M \setminus (M(c^*),c^*) \cup (M'(c^*),c^*)$. Case 1: M'' is feasible. Then, we can construct a tree-coalition $T = (\{c^*\},\emptyset,M'(c^*))$, which is a contradiction.

Case 2: M'' is infeasible. Thus, there must be at least one $c' \in C \setminus c^*$ with $|M''(ts)| > cap_{ts}$ for at least one timeslot $ts \in M''(c')$. Since $M'(c') \geq_c M(c')$ for all such c', there has to exist an allocation $S_{c'} \in Acc(c')$ with $S_{c'} \geq_{c'} M(c')$ which does not affect the allocations of the other c' or c^*. Now, update M'' by replacing each allocation and restart the process at case 1. This process leads to a tree coalition $T = (\{c^*\} \cup C', E', S')$, where C' is the set of agents that are in conflict, E' the set of edges for each conflict between two agents and $S' = M'(c^*) \cup \bigcup S_{c'}$ the set of reassignments. This is a contradiction to the tree-coalition-freeness.

4.2 Pareto Optimality of BRSD

With this characterization of Pareto optimality we can proof properties of BRSD.

Theorem 2: *BRSD is strategy-proof, symmetric and computes a Pareto optimal matching in $O(|C| \cdot |TS| \cdot \overline{Acc})$, where $\overline{Acc} = max\{|Acc(c)| : c \in C\}$.*

Proof: For the Pareto optimality we draw on Theorem 1. We have to proof that BRSD produces a tree-coalition-free matching. Let M be the outcome of BRSD. Obviously, M is a feasible matching, because BRSD never over-allocates timeslots. Consider a carrier $c \in C$ in M. Now, we go backwards from c. If we would match c to another S' with $S' >_c M(c)$, there would be at least one predecessor c' in conflict with c. Next, consider c' and choose a new assignment that is at least as good as the old one. We repeat these steps until we come to a c^*, where we cannot find a better bundle (such a carrier has to exist, because $|C| < \infty$ and the first carrier becomes his first choice). This means, we have to assign c^* to a bundle with lower preference. That is, the constructed conflict-tree cannot be a tree-coalition; i.e., BRSD computes a Pareto optimal matching.

For every $c \in C$ we have to search the first bundle in $Acc(c)$ that satisfies all capacity constraints of the timeslots. This check will be done in $O(|TS|)$. Because every acceptable set's size is less than the size of the largest $Acc(c)$, the running time of BRSD is in $O(|C| \cdot |TS| \cdot \overline{Acc})$.

Since BRSD searches from the top of a carrier's preference-list downwards the first bundle that does not contain any full timeslot, reporting a wrong order or omit preferences would not improve the chance to get a higher ranked bundle. That's why BRSD is strategy-proof. Since every permutation of the agents has the same probability, BRSD is symmetric.

BRSD is only ex post Pareto optimal. Note that the outcome of BRSD can be quite different from a maximum matching and unfair. Consider an example, where each bidder has the highest preference for the set of all timeslots. If this was the case, one bidder would get all timeslots assigned. While the mechanism is strategy-proof and Pareto optimal, the outcome can be considered unfair. In our coordination problem this might be less of a concern, because carriers have a preference for timeslots on a specific route and do not value additional timeslots. Furthermore, the probability of receiving the timeslots one really needs decreases if preferences on unnecessary large bundles are submitted. In an application one could also filter for very large bundles to avoid unfair allocations.

5 Alternative Mechanisms

The randomness in RSD as well as the lack of strong fairness properties might be an issue for some applications. The theorem by Gibbard (1977) provides a clear guideline on what is possible in dominant strategies. In addition, Zhou (1990) has shown that no random mechanism can fulfil strategy-proofness, ex ante Pareto optimality and symmetry simultaneously.

Therefore, in order to achieve stronger notions of fairness, such as envy freeness, one has to give up or relax strategy-proofness or ordinal preferences. Popular examples for non-strategy-proof mechanisms are the Competitive Equilibrium with Equal Incomes (CEEI), presented by Hylland and Zeckhauser (1979), and the Probabilistic Serial (PS), introduced by Bogomolnaia and Moulin (2001). These algorithms have desirable properties like envy freeness and ex post Pareto optimality. Kojima and Manea (2010) and Azevedo and Budish (2012) showed that these algorithms are near strategy-proof if the instance is large enough.

Budish (2011) proposes a mechanism for matching with complementarities focusing on different notions of fairness of allocations with ordinal preferences of the agents. His approach is an approximation to CEEI called A-CEEI that assigns agents with approximately equal income. Here, 'income' does not mean monetary transfer or utility but is a virtual currency that helps to assign bundles to agents. The assignment is calculated by setting prices on objects and 'selling' the bundles to the agents. Since incomes are guaranteed to differ slightly, market clearing is ensured. In general A-CEEI is not strategy-proof, but for large markets it is approximately strategy-proof. Budish (2011) proposes two new characterisations of fairness and shows that A-CEEI meets these; e.g. A-CEEI bounds envy by a single good. This approach is only approximately ex post efficient and the market is cleared approximately only. The worst-case bound of the clearing error depends neither on the number of agents nor on the object capacities. A market clearing error denotes excess demand; that is, A-CEEI approximates feasibility and might allocate more objects than available.

Further approaches that approximate feasibility are presented by Nguyen et al. (2015). They provide two mechanisms for matching with complementarities; one for cardinal and the other for ordinal preferences. For both mechanisms they provide an approximate generalization of the Birkhoff-von Neuman theorem (Birkhoff (1946), von Neumann (1953)) to construct lotteries over allocations from probabilities. To reach efficiency they relax the feasibility constraints and allow objects to get over-assigned to at most $k-1$ agents, where k is the maximal number of objects in the agents' bundles. The mechanism for cardinal preferences, called OPT, maximizes the social welfare under supply, demand and envy freeness constraints. They model the assignment problem as a linear program, where variables stand for bundles and solve it in two steps. First, they calculate an optimal fractional solution so that the variables are in $[0,1]$. With help of the Iterative Rounding Algorithm they decompose this fractional solution in a second step into a set of integer solutions, each of which over-allocates no object more then to $k-1$ agents. The fractional solution represents a random matching and each integer solution stands for a deterministic matching. Thus, with help of these integer solutions one can construct a lottery that is equivalent to the random assignment determined by the optimal fractional solution. Nguyen et al. (2015) proof that this algorithm satisfies envy freeness and asymptotic strategy-proofness.

The second approach is a generalisation of PS (Bogomolnaia and Moulin 2001), called Bundled Probabilistic Serial (BPS). Informally, BPS works the following way: All agents 'eat' in $[0,1]$ simultaneous with the same speed their most preferred bundle as long as all included objects are available. As soon as one object is exhausted, every bundle containing this object is deleted, and the agents continue eating the next available bundle in their preference list. The duration every bundle was eaten by an agent specifies the probability for assigning this bundle to this agent. That is, BPS computes a random matching. Nguyen et al. (2015) show that BPS is ordinally Pareto optimal, envy free and weakly strategy-proof. The authors claim that one can implement this random matching as a lottery, where each matching over-allocates the objects at most $k-1$ times, but they do not specify an algorithm without cardinal preferences for this decomposition.

In the presence of cardinal preferences that are expressible as linear utility functions, we have the possibility to model the matching problem as a linear program. For linear programs we have many different exact algorithms and approximation schemes. Furthermore, one can simply add every additional condition, which is expressible as a linear equality, to the set of constraints without loss of the already existing properties. That is, in the presence of linear utility functions we can achieve very general algorithms and conclusions for the matching problem with complementarities. Moreover, the agents have the possibility to express their preferences as detailed as they want. This strength, however, is simultaneously the main weakness too, because expressing the preferences in a real-valued utility function can be impractical or impossible in some applications. In those cases it is more favourably to commit only the ordering instead of the full utility function. That is, we have to consider both classes of preferences and have to find mechanisms with desirable properties for each of them.

If the coordinator asks for cardinal bids and even allows for monetary transfers, then auction mechanisms allow for the maximization of social welfare in dominant strategies. The Vickrey-Clarke-Groves (VCG) mechanism satisfies all these design desiderata and it is the only efficient and strategy-proof mechanism (Holmström (1979); Green and Laffont (1979)), and it performs poorly in terms of fairness and seller revenue. Therefore, Karaenke et al. (2015) propose a core-selecting package auction and a suitable bidding language for the allocation problem of timeslots to carriers. This mechanism allows also for the maximization of the social welfare and ensures that the capacities of all timeslots are held. For minimizing incentives of untruthful bidding they use a payment rule that selects payments in the core with minimal distance to the suitable VCG-payment.

An outcome of an auction is in the core if there is no coalition of bidders strictly preferring another outcome that is also strictly better for the seller. Karaenke et al. (2015) evaluate their mechanism by simulation on generated transportation networks and observe that the waiting time on warehouses can be decreased significantly by their approach, in contrast to the previous methods like sharing of historical waiting times. However, the computational complexity is significantly higher and they considered only truthful bidders in the simulation, which does not hold for core-selecting auctions.

6 Conclusion

In this paper we have introduced the problem of coordinating service timeslots at warehouses as a matching problem with complementarities, where carriers have ordinal preferences over bundles of timeslots. We have shown properties of Pareto optimal matchings in this setting and have introduced an alternative characterisation of Pareto optimality with help of conflict trees. We have presented a generalisation of RSD called Bundled Random Serial Dictatorship that assigns carriers in a random order their most preferred bundle with still free capacities at all included timeslots. BRSD is strategy-proof, symmetric and ex post Pareto optimal. However, BRSD has disadvantages in terms of fairness and the size of the outcomes. In addition, the running time of BRSD depends on the size of the preference lists of the carriers; these lists can be exponentially large. These theoretical problems arise in worst-case scenarios and may not be severe in practical instances. We will investigate the empirical efficiency of BRSD in simulation experiments based on real-world data in future work. Furthermore, we will analyse if a better computational performance can be achieved by restrictions on the complexity of complementarities. These restrictions limit the maximum number of timeslots contained in bundles.

We also have discussed alternatives in the last section. These alternatives either require relaxing strategy-proofness, or need cardinal preferences or monetary transfers. Assuming cardinal utilities and quasilinear preferences, the Vickrey-Clarke-Groves mechanism achieves strategy-proofness and maximizes social welfare. Alternatively, one could trade in strategy-proofness against fairness of the allocation. An important open question is if we can achieve stronger notions of fairness like envy freeness by relaxing strategy-proofness to asymptotic strategy-proofness. For the coordination of carriers at retail warehouses, BRSD might be a simple solution that is strategy-proof and ex post Pareto optimal; it only requires carriers to specify ordinal preferences.

A natural extension of our setting is that the warehouses also have preferences over the carriers or their time of service. This leads to an extension of the Workers Firms problem (Kelso Jr and Crawford 1982). In addition, we know that the underlying problem is a graph theoretic problem. Can we use properties and algorithms from graph theory and applications to solve the allocation problem? One may also extend the problem to a setting of dynamic matching, where agents enter and leave the market stochastically; due to traffic congestion and other external influences carriers cannot always adhere to their matched timeslots and have to be reassigned. Though, dynamic matching markets have not gained significant scientific attention until quite recently. That is, it is an open research question if and how we can combine dynamics and complementarities.

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A Three-Phase Heuristic for a Multi-Size Container Transport Problem with Partially Specified Requests

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Abstract

The present paper studies a generalization of the less-than-truckload pickup and delivery problem. The problem at hand arises in the hinterland of a container terminal where empty and loaded containers have to be transported between a container depot and a set of customer locations. However, requests including empty containers are only partially specified. That is, either the pickup location or the delivery location of a request including the transportation of an empty container is a priori unknown. Customers who demand an empty container do not care which specific empty container is provided, i.e., while the delivery location is given, the pickup location is part of the problem's solution. To solve this problem, an iterated three-phase heuristic is introduced. The first phase completes the partially specified requests, the second phase solves a standard pickup and delivery problem, the third phase changes parameters of the objective function and the process iterates. Computational results on a set of 1,000 test instances are presented.

1 Introduction

The maritime container traffic increased from the year 2000 to the year 2010 by more than 40%. Containerization of transport processes is considered a world-wide success story. Nevertheless, it also leads to new problems. Due to trade imbalances, supply and demand of empty containers may significantly differ in different geographical regions. On the global level, for example, Asia exports significantly more goods to Europe and North America than vice versa. Therefore, a surplus of empty containers exists in Europe and North America while a shortage of empty containers exists in Asia. To balance supply and demand, the problem of repositioning empty containers has to be solved. This repositioning problem does not only arise on the global level between continents, but also on the local level among shippers or consignees in the hinterland of an intermodal container terminal like a seaport or a railway station. More importantly, those drayage operations are responsible for the bigger part of the transport costs of a global supply chain. Increasing the efficiency of drayage operations can therefore significantly contribute to reducing transportation related supply chain costs. In this paper, we study the problem of truck-based repositioning of empty containers in the hinterland of a container terminal between shippers and consignees of containers. We denote the problem as the *container pickup and delivery problem* (CPDP). From a research perspective, the CPDP is interesting, because it generalizes the well-known less-than-truckload pickup and delivery problem with time windows (PDPTW). In extension of the PDPTW, some of the requests in the CPDP are only partially specified. That is, for some requests either a pickup location or a delivery location has to be determined as part of the problem's solution. Depending on what decision is made to complete these partially specified requests, the total number of pickup and delivery requests is variable. In order to solve the CPDP an iterated three-phase heuristic is presented which solves the CPDP in a sequential way.

The remaining paper is organized as follows. Section 2 describes the CPDP and reviews related literature. Section 3 presents an iterative three-phase heuristic to solve the CPDP. The performance of the heuristic is evaluated in Section 4. Section 5 concludes the paper.

2 Hinterland Transportation of Loaded and Empty 20-foot and 40-foot Containers

A generalization of the well-known less-than-truckload pickup and delivery problem with time windows is presented in Section 2.1. It is denoted as the container pickup and delivery problem. Related literature to the container pickup and delivery problem is discussed in Section 2.2.

2.1 The Container Pickup and Delivery Problem

The CPDP generalizes the well-known PDPTW. For an in-depth discussion of the PDPTW and its variants we refer to literature reviews like, e.g., Savelsbergh and Sol (1995).

We first introduce the PDPTW. We are given a complete graph. The nodes of this graph consists of $i = 1,..,n$ customer locations and a vehicle depot $i = 0$. The distance between two nodes i and j is given by d_{ij}. We assume, one distance unit is equal to one unit of driving time. For each customer node i and the vehicle depot 0, a time window $[e_i, l_i]$ is given by the earliest e_i and latest l_i starting time of a service. The service duration required for handling of goods at customer i is given by s_i. The time window $[0_s, 0_e]$ of the single depot 0 defines the planning horizon of the problem which usually covers one working shift.

Let R denote a set of requests. A request $r \in R$ includes a pickup location r^+, a delivery location r^-, and a load of volume $c(r)$. The task of request r is to pickup the load $c(r)$ at node r^+ and transport it to node r^-. A finite set V of homogeneous vehicles is given. The maximum transport capacity of vehicle $v \in V$ is $\bar{v}$. The currently loaded capacity of v is denoted as v^c where $v^c \leq \bar{v}$ has to hold at every point in time. The arrival time of v at customer i is denoted as v_i^t. By assumption, the cardinality of V is large enough to fulfill all requests in R.

A feasible solution of the PDPTW requires that each request $r \in R$ is serviced by one vehicle. A vehicle $v \in V$ starts and ends its tour at the vehicle depot 0 and visits a set of customers. Vehicle v may leave the depot not earlier than 0_s and return no later than 0_e. A request $r \in R$ is fulfilled by only one vehicle and the pickup location r^+ has to be visited before the corresponding delivery location r^-. Each customer is visited only once, only during its service time window, and the vehicle capacity $\bar{v}$ is never exceeded. Different objective functions are discussed for the PDPTW. Popular is a lexicographic function where the number of vehicles required to fulfill all requests is minimized first and then the total operation time of all vehicles is minimized second. In this study, the goal is to find a feasible solution that minimizes the total operation time of all vehicles. The operation time of a vehicle v is calculated by the point in time v returns to the vehicle depot minus the point in time v left the vehicle depot.

As distinct from the PDPTW, the CPDP features the following additional characteristics. Only containers are considered as a means of transport. We focus on two container sizes, namely 20-foot and 40-foot containers. Containers may be *empty* or *loaded*. In addition to the vehicle depot we now also include a container depot.

In the CPDP, every request includes the transport of a container. There are three types of requests, which are described from the point of view of a customer (Schönberger et al., 2013):

- *Standard:* pick up loaded container at a given customer and deliver it to a given customer or the container depot.
- *Store:* pick up an empty container at a given customer location.
- *Provide:* deliver an empty container to a given customer location.

Standard requests are traditional PDPTW requests. In Schönberger et al. (2013) they were differentiated further into export and import request, in case they include the container terminal (at a sea port) as a delivery or a pickup location, respectively. Store and provide requests are, however, only partially specified. That is, either the delivery or the pickup location of such a request is missing and has to be determined while solving the CPDP. In that sense, store and provide requests are *incomplete* requests prior to planning. For a store request, the empty container may be transported to the container depot or to any other customer that has issued a provide request (if the container sizes of both requests are equal). On the other hand, for a provide request, the pickup location of an empty container may be the container depot or any customer that has issued a store request (again, if the container sizes of both requests are equal). We assume, the container depot has a sufficient storage capacity and that it is always possible to fulfill storage and provide requests of empty containers by means of the container depot. An example of a feasible solution of the CPDP is shown in Figure 1. Store requests are issued by customers 2 and 4, provide requests are issued by customers 5 and 6.

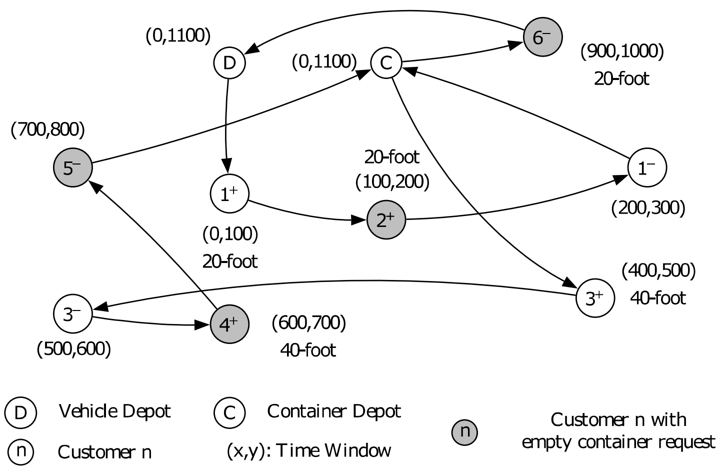

Figure 1: Example instance and solution of CPDP

Container size is measured in *twenty-foot equivalent unit* (TEU). Each request $r \in R$ requires a load of $c(r) = 1$ or $c(r) = 2$, where $c(r) = 1$ stands for a 20-foot container and $c(r) = 2$ represents a 40-foot container. The maximum capacity of a vehicle is $\bar{v} = 2$ and thus can carry a maximum of one 40-foot container or two 20-foot containers simultaneously. Consequently, a full truckload request includes the transportation of a 40-foot container (either empty or loaded) and a less-than-truckload request includes the transportation of a 20-foot container (either empty or loaded).

2.2 Related Literature

The repositioning of empty containers is a problem that arises due to trade imbalances. It is often studied from a global point of view in maritime transportation, where large trade imbalances between Asia and Western countries exist at the moment. However, the problem is also relevant on the local level, where it is studied in the context of the hinterland of a container terminal (for example, a dedicated container depot, a terminal at a seaport or an intermodal railway terminal). In these scenarios, the literature on vehicle routing problems is most relevant to the CPDP. Jula et al. (2005) were one of the first to investigate container drayage operations. It focuses on the transportation of containers between port terminals, intermodal facilities, and customers. Only full truckload requests are considered and all pickup and delivery requests are known a priori, i.e. incomplete requests are not studied. The objective function minimizes the total travel distance.

Sterzik and Kopfer (2013) formulate the inland container transportation problem. Empty and loaded 40-foot containers are considered as a means of transport, i.e. a full-truckload vehicle routing problem is studied. Incomplete requests are explicitly considered. The goal is to minimize the total operating time.

Braekers et al. (2014) study a vehicle routing problem for drayage operations. It includes loaded and empty 40-foot container movements, i.e. a full truckload vehicle routing problem is studied. The objective is to lexicographically minimize number of vehicles and the total travel distance. To deal with incomplete requests, an initial request completion phase is used to solve the problem. We borrow this idea of a request completion phase for our solution approach.

All previously mentioned papers consider full truckload transportation. In contrast to that, Vidovic et al. (2011) propose a model with less-than-truckload requests related to the VRP with backhauls. Empty and loaded container movements are considered. However, all empty containers are either picked up or delivered to the container terminal. That is, the possibility of including street-turns by using other customers as source or sink for empty containers is not considered.

Zhang et al. (2015) solve the container truck transportation problem for full and empty container drayage consisting of 20-foot and 40-foot containers. Inbound requests need the movement of a loaded container from a terminal and release an empty container after it is unpacked at the consignee. Outbound requests require an empty container to load the goods. These empty containers are picked up or delivered to a container depot or terminal. The utilization of a street-turn for empty container repositioning is not considered.

Schönberger et al. (2013) present a mixed integer model of the CPDP which takes into account that pickup or delivery locations for empty container requests have to be determined. However, a commercial solver was not able to compute solutions for instances of a practical relevant size in reasonable time. Recently, Funke and Kopfer (2015) propose a matheuristic approach for solving a multi-size container transportation problem. Partially specified requests as well as the use of a container depot and street-turns are considered. The model differs from the CPDP as it assumes that each container (empty or loaded, respectively) is immediately processed after arriving at the customer location and is hereafter available as loaded or empty container, respectively, and ready for onward transport by the vehicle.

3 An Iterated Three-Phase Heuristic

To solve the CPDP an iterative three-phase heuristic is introduced and referred to as I3PH. An overview is given by Algorithm 1. Sequentially, the heuristic first solves the problem of completing all partially specified requests (Phase 1, see Section 3.1). With all requests defined, a PDPTW is solved in Phase 2 (see Section 3.2). Finally, Phase 3 modifies some model parameters used during Phase 1 and all three phases are repeated (see Section 3.3) until a termination criterion is met.

Input: CPDP instance, no. of iterations
while *Weight Adjustment not completed* **do**
    Phase 1: Request Completion;
    Phase 2: Pickup and Delivery Problem;
    Phase 3: Weight Adjustment;
return feasible tour plan;

Algorithm 1: Overview of the iterated three-phase heuristic I3PH

3.1 Phase 1: Request Completion

In Phase 1, the provide and store requests are completed. Both types of requests are denoted as partially specified requests (PSR). They involve transportation of empty containers. For each container size - only 20-foot and 40-foot are considered here - a container assignment problem (CAP) is solved via a MIP-solver. Both instances of the CAP model are linked via weighting parameters related to the travel distance (i.e., δ_{20}, δ_{40}) and temporal closeness (i.e., τ_{20}, τ_{40}) between locations that demand or supply 20-foot or 40-foot containers. The following holds in all phases of I3PH: $\delta_{20} + \tau_{20} \equiv 1$ and $\delta_{40} + \tau_{40} \equiv 1$ with $\delta_{20}, \delta_{40}, \tau_{20}, \tau_{40} \geq 0$.

The CAP is related to linear assignment problems (see e.g. Burkard et al., 2009). CAP is defined by formulas (1) to (4) and assumes *homogeneous* container sizes. Therefore, the CAP is solved twice in Phase 1, once for all customers with 20-foot empty container requests and once for customers involving 40-foot empty container requests.

$$\min f(x) = \sum_{i=0}^{m} \sum_{j=0}^{n} (\delta \cdot d_{ij} + \tau \cdot t_{ij}^{w}) \cdot x_{ij} \quad (1)$$

$$\text{s.t.} \quad \sum_{j=0}^{n} x_{ij} = 1 \qquad i = 1, \dots, m \quad (2)$$

$$\sum_{i=0}^{m} x_{ij} = 1 \qquad j = 1, \dots, n \quad (3)$$

$$x_{ij} \in \{0,1\} \quad i = 0, \dots, m \quad j = 0, \dots, n \quad (4)$$

Let $1, \dots, m$ denote pickup locations of empty containers (given in the CPDP as part of a store request) and let $1, \dots, n$ denote delivery locations of empty containers (given in the CPDP as part of a provide request). Index 0 denotes a container depot. We assume the storage capacity of the container depot is sufficiently large and there are at least as many empty containers available so that each provide request may be serviced from the container depot. The decision variables (4) are binary. If $x_{ij} = 1$ an empty container at customer i (pickup location) shall be transported to customer j (delivery location), $x_{ij} = 0$ otherwise. The constraints (2) ensure that each store request with a given pickup location i is assigned to one delivery location j (either the container depot or a customer with a provide request). On the other hand, constraints (3) ensure that each provide request with a delivery location j is assigned to one pickup location i (either the container depot or a customer with a store request).

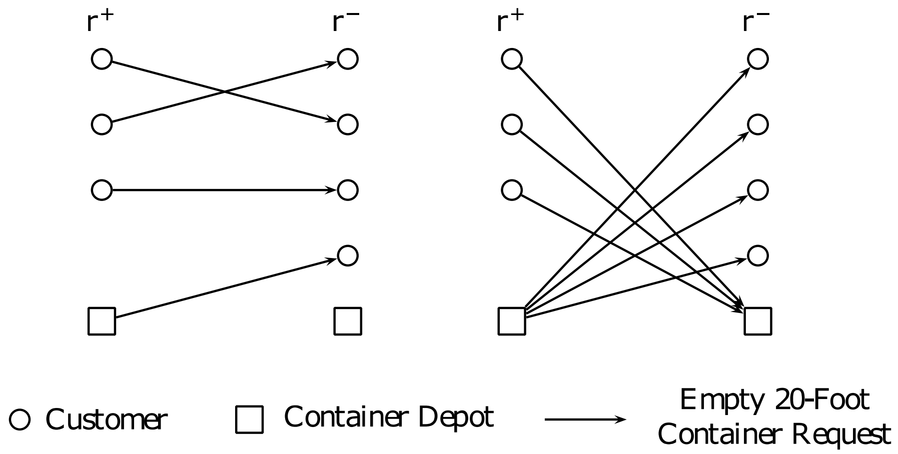

Figure 2: Two CAP solutions which complete empty container requests (left $\delta_{20} = 1$, right $\delta_{20} = 0$)

The objective function (1) minimizes the total assignment costs. They depend on two criteria: First, on the Euclidean distance d_{ij} between nodes i and j weighted by parameter δ. Second, on the waiting time t_{ij}^{w} of a vehicle that visits node j after node i weighted by τ. Note, while distances are given parameters in the CPDP, the minimum waiting time has to be calculated by the use of time windows and driving time.

Figure 2 shows two possible solutions when solving the problem for empty 20-foot containers with different weights. The purpose of the weights δ and τ is to balance the *geographical closeness* and the *temporal matching* (under time windows) of pickup and delivery locations. Furthermore, by setting other parameters of the CAP during preprocessing, it is easily possible to force or forbid assignments, e.g. because the involved time windows do not match or offer a clear disadvantage. The weights $\delta_{20}, \delta_{40}, \tau_{20}, \tau_{40}$ are updated in Phase 3 of the heuristic which results in a higher solution diversity. From computational tests, it appears that the completion of 40-foot container requests is significantly more critical with respect to the performance of the heuristic I3PH. This is reasonable, because a 40-foot container request is always a FTL pickup and delivery request. If such a FTL completion decision is bad from the CPDP routing point of view, it is much harder to fix it during Phase 2 than to fix a bad decision involving a 20-foot container which leads to LTL request that can be integrated in more ways into different tours.

3.2 Phase 2: Pickup and Delivery Problem

Phase 2 of the heuristic I3PH solves a standard PDPTW. Many sophisticated approaches are discussed in the literature that can deal very well with this subproblem of the CPDP. The approach used here is straight forward. At first, a set of feasible single-vehicle tours is generated by means of an insertion procedure. Afterwards, a subset of these tours is selected via solving a set covering problem. That is, a subset of tours is selected such that each request is fulfilled and the total operation time of all vehicles is minimized.

In order to generate feasible one-vehicle tours for pickup and delivery requests, three well-known neighborhood moves from Li and Lim (2003) are used. The first move is the *shift* operator. It selects a request and tries to insert it into another tour. The request is shifted to that tour which leads to the highest decrease of the total operation time t^o.The move is applied to every request. The second move is the *exchange* operator. It tries to move a request from the current tour to another tour and in return, remove a request from the other tour and insert it into the current tour. It is applied to every request. The exchange move which results in the highest decrease of the total operation time t^o is realized. The third move is the *rearrange* operator. It tries to switch the position of two customer nodes within a tour. The move with the highest decrease of the total operation time t^o is realized. The move continues with the next request in the current tour and continues with requests from other tours.

3.3 Phase 3: Weight Adjustment

As could be noticed from some preliminary computational experiments, it appears that the best values for the weighting parameters depend for the most part on the actual instance. Therefore, Phase 3 tries to tune these parameters at runtime of the heuristic I3PH . Phase 3 (see Algorithm 2) updates the weighting parameters δ and τ used in Phase 1 for request completion. In general, the change of these parameters leads to different types of requests and even a different number of requests. This diversity shall be exploited by changing the weighting parameters. Phase 3 begins adjusting the weights δ_{40} and τ_{40}, if the majority of the PSR include 40-foot containers, else δ_{20} and τ_{20} are adjusted first. The parameter δ_{40} is decremented by one fourth while δ_{20} is constant. The value for δ_{40} which leads to the best solution is fixed and the search modifies the values δ_{20}. Note, due to $\delta_{20} + \tau_{20} \equiv 1$ and $\delta_{40} + \tau_{40} \equiv 1$ the values for τ_{20} and τ_{40} change accordingly. Finally, when the best weight combination has been identified, one final run with a significantly higher number of iterations is performed.

Input: current operation time $f(x)$ of solution x, current minimum operation time $t^{o,best}$

$(\delta_{20}^{best}, \tau_{20}^{best}, \delta_{40}^{best}, \tau_{40}^{best}) \leftarrow (1,0,1,0);$

foreach $c \in (40,20)$ **do**

  for $i \leftarrow 0$ **to** $i = 4$ **do**

    $\delta_c \leftarrow 0.25 \cdot i;$

    $R \leftarrow Phase\ 1(\delta_c);$

    $x \leftarrow Phase\ 2(R);$

    if $f(x) < t^{o,best}$ **then**

      $t^{o,best} \leftarrow f(x);$

      $\delta_c^{best} \leftarrow \delta_c;$

Algorithm 2: Weight Adjustment in Phase 3

4 Results of Computational Experiments

In order to understand the performance of the heuristic as well as the effects of problem characteristics, a computational study was performed. Section 4.1 describes the setup of this study, Section 4.2 studies the effects of using different weights during Phase 1 of the heuristic, and Section 4.3 analyses the effect of different container sizes on the performance of the heuristic.

4.1 Setup of Computational Study

The heuristic was implemented in Java 8 and tested on an Intel Core I5, 2.5 GHz CPU with 8 GB system memory. Within Phase 2, 2,500 iterations to generate routes were used for 100 customer instances and 1,000 iterations were used for 200 and 400 customer instances.

There are no benchmark instances in the literature for the CPDP with heterogeneous container sizes. However, only recently Funke and Kopfer (2015) introduced instances which are related to CPDP but assume a slightly different model. Therefore, the well-known instances of Li and Lim (2003) for the PDPTW are extended. Six new sets of instances were generated based on the Li and Lim instances that include 100, 200 and 400 customers. From each original instance, for a percentage of *PSR-ratio* of requests either the pickup location or the delivery location has been deleted in order to generate partially specified requests. Also, the load of all requests were updated to either 1 TEU or 2 TEU.

To estimate the general performance of Phase 2, a comparison with solutions from the literature is possible. For some of the 100 customer instances, very good solutions with a deviation of less than three percent are computed by Phase 2. However, on average over all 100 customer instances, the performance is inferior compared to specialized state-of-the-art approaches for the PDPTW.

These drawbacks appear negligible, as the focus is on the integration of simultaneously routing loaded and empty containers of heterogeneous size, rather than developing a new heuristic for the well-known PDPTW.

4.2 Effect of Different Distance Weights on the Solution

The first test studies the effects of using different values for the weights δ_{20} and δ_{40} which are used in Phase 1. Table 1 shows the results for the chosen test instance *plc205* with 50 percent partially specified requests and 20 percent 20-foot containers. The planning horizon of this instance is rather long, i.e., the choice of the values for δ_{20} and δ_{40} have a high impact on the solution quality as more waiting times and thus longer operational times are possible.

The first column of Table 1 shows the current iteration, the second and third column present the used weights δ_{20} and δ_{40} used in function (1). Note, $\delta_{20} + \tau_{20} \equiv 1$ and $\delta_{40} + \tau_{40} \equiv 1$ always holds. Columns four to seven show performance criteria of a solution: overall operation time t^o, total travel distance d, total waiting time of all vehicles t^w, and the number of required vehicles n. The three rightmost columns show performance criteria which refer *only* to the partially specified requests of this instance. The no. of requests states the number of fully defined requests which are generated from the given partially defined requests during Phase 1. Column d^{PSR} gives the total travel distance for the set of the partially defined requests, column $t^{w_{PSR}}$ states the total waiting time when fulfilling the partially specified requests.

The presented weight combinations where chosen as follows: The initial values are $\delta_{20} = 1.0$ and $\delta_{40} = 0.0$. Giving those customers with 40-foot containers the highest priority, because 80 percent of the customers require a 40-foot container, the value for δ_{40} was increased in 0.25 steps. Among these five tests, the minimum overall waiting time t^o was achieved for $\delta_{40} = 0.25$. Now, the parameter δ_{40} is fixed to $\delta_{40} = 0.25$ while all remaining values for δ_{20} are tested in equidistant steps of 0.25. In terms of t^o the weighting $\delta_{20} = 0.75$ and $\delta_{40} = 0.25$ provided the best results.

	Weighting		Performance				PSR only		
iteration	δ_{20}	δ_{40}	t^o	d	t^w	n	no. of requests	d^{PSR}	$t^{w_{PSR}}$
1	1.00	0.00	26500	3254	10640	17	45	1361	2540
2	1.00	0.25	23620	2845	10868	13	45	1361	2540
3	1.00	0.50	23848	2665	11276	15	30	504	2360
4	1.00	0.75	24222	2696	11798	13	29	480	2408
5	1.00	1.00	28839	2920	16911	14	25	354	7851
6	0.75	0.25	23074	2712	9914	14	33	574	50
7	0.50	0.25	23103	3037	9619	13	33	574	50
8	0.25	0.25	23330	3040	9663	14	34	634	0
9	0.00	0.25	23314	2836	9669	15	35	668	0

Table 1: Effect of distance weights for the test instance plc205 (50% PSR, 20% 20-foot containers)

As Table 1 reveals, setting adequate weights is very important for the performance of the heuristic. The worst solution in terms of overall operation time and total travel time is up to 30 percent and 22 percent worse, respectively. The impact of changing δ_{20} appears to be smaller than changing δ_{40}, especially with respect to the waiting time t^w. This effect may be due to the low quota of 20-foot containers in this instance. Additionally, an inappropriate assignment of 20-foot containers has only a minor effect on the total waiting time t^w, because instead of waiting a vehicle transporting a 20-foot container can perform a second request at the same time. Therefore, minimizing the total travel distance becomes more important with an increasing number of 20-foot containers and the distance weight δ_{20} should be set to a higher value.

With respect to the distance weight of 40-foot containers, lower values are usually better, since a good performance for the transport of 40-foot containers depends on short waiting times. When transporting a 40-foot container, there is no other option but to deliver it to the assigned customer. If the time window of said customer is very different from the time window of the pickup node, the vehicle has no other option but to wait until the customer starts its service. Therefore, temporal closeness is very important for 40-foot container movements. However, if the value of the distance weight for 40-foot containers is $\delta_{40} = 0$ every provide and store request for a 40-foot container is served by the container depot. This leads to a significant increase in total distance d as shown by Table 1 because every empty container request is served by the container depot.

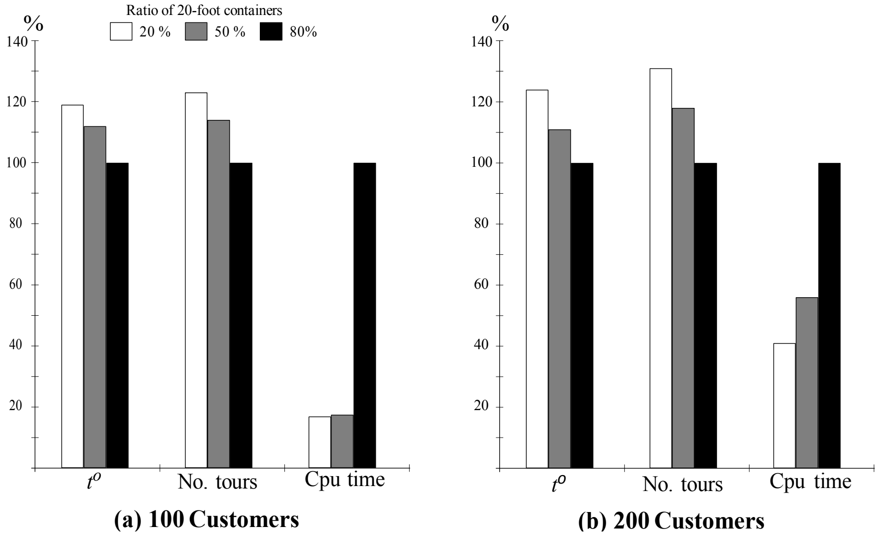

Figure 3: Influence of different percentages of container sizes on solution and performance

4.3 Effect of Different Mixtures of Container Sizes

The influence of an increasing ratio of 20-foot containers among all serviced containers is studied. Everything equal, more 20-foot containers implies more comprehensive options for routing which should increase the difficulty of an instance of the CPDP. For this test, the results from all test instances were aggregated over each subset of instances. Table 2 shows the median, mean and standard deviation for the total operation time t^o, the number of tours n and the required computing times in seconds.

The results reveal that the heuristic works as expected. An increasing ratio of 20-foot containers leads to a significant decrease of operation time t^o and in the number of required tours n. However, the computational time increases due to more options for routing. Figure 3 underlines this effect. It shows the averaged results over all 100 and all 200 customer instances at which the averaged results for the group of instances with 80 percent 20-foot containers was defined as 100 percent. Figure 3 emphasizes the significant influence of the percentage of 20-foot containers on the solution and performance of the algorithm. Again, the inability of carrying multiple 40-foot containers simultaneously is probably the main reason for higher operation times which are caused by higher waiting times. Two findings may be inferred from Table 2. First, considering the transport of heterogeneous container sizes like 20-foot and 40-foot containers simultaneously might increase the efficiency of planning significantly and lead to lower costs solutions. Second, in instances with heterogeneous container sizes, partially specified requests with a higher load (i.e., 40-foot containers) appear to have a significantly higher effect on the total performance of the algorithm than those with a lower load (i.e., 20-foot containers).

instance set			t^p			n			computing time (s)		
customer	PSR ratio [%]	20ft-ratio [%]	median	mean	deviation	median	mean	deviation	median	mean	deviation
100	25	20	4370,5	8002,7	7142,3	14,5	15,4	6,6	17,5	40,4	69,5
		50	4070,5	7517,7	6654,8	14,0	14,2	5,7	22,5	44,8	76,4
		80	3585,0	6666,2	5464,5	12,0	12,4	4,7	36,0	117,6	251,8
	50	20	3973,5	7517,8	6422,3	14,0	14,8	6,4	18,0	50,2	97,1
		50	3878,0	7056,6	5774,9	14,0	13,7	5,7	26,0	48,4	66,9
		80	3452,0	6398,4	4943,6	12,0	12,1	5,0	57,5	416,6	1256,9
200	25	20	22760,0	25008,3	15055,7	30,5	30,7	10,9	21,5	59,0	84,7
		50	20166,5	22199,3	12882,3	27,0	27,6	9,4	82,6	82,6	82,6
		80	16671,0	19641,0	11284,3	23,5	23,3	7,3	101,0	145,7	149,1
	50	20	20796,0	22489,9	12550,7	28,0	29,2	10,9	33,5	69,0	98,3
		50	17356,0	20474,0	11314,1	26,0	26,4	9,3	56,0	94,3	115,2
		80	16382,5	18670,4	9853,7	21,0	22,3	7,9	141,5	168,0	158,7
400	25	20	50989,0	56365,1	29759,1	56,0	59,5	22,1	41,0	209,2	450,6
		50	47493,0	51203,7	24784,4	52,5	53,1	19,6	106,5	269,6	496,5
		80	43280,0	44692,3	20861,7	44,0	45,7	16,3	222,0	559,7	1263,4
	50	20	48974,5	54931,9	29423,6	57,5	57,4	24,6	80,5	270,5	608,0
		50	49449,0	49923,9	22973,6	49,0	50,5	20,6	119,0	328,0	615,4
		80	39478,5	44121,4	21717,3	45,0	45,6	18,2	203,5	430,4	658,5

Table 2: Aggregatet results for different sets of test instances

5 Conclusion and Outlook

An iterated three-phase heuristic for the container pickup and delivery problem (CPDP) has been introduced. The CPDP generalizes the PDPTW and arises in the hinterland of an intermodal container terminal. It deals with the transportation of 20-foot and 40-foot containers which may be empty or loaded. To solve the CPDP, the heuristic has to deal with partially specified requests. The performance of the heuristic has been discussed on the basis of computational experiments for over 1,000 test instances. To improve the quality of the heuristic, future research should try to analyse solutions in more comprehensive way in Phase 3 and use this data to find better solutions to the request completion problem of Phase 1 in the sense, that a more efficient routing of the vehicles and containers is possible.

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Problem-Specific State Space Partitioning for Dynamic Vehicle Routing Problems

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Abstract

In many dynamic vehicle routing applications, anticipation of the future is essential for efficient and effective decision making. In order to incorporate possible future events into current decision making, it is necessary to evaluate every decision's impact to the overall objective. This is typically achieved by an evaluation of the post-decision state. For dynamic vehicle routing problems (DVRP), the size of the state space can be infinitely large. Therefore, states are often aggregated to enable an evaluation. In many cases, the aggregated state space has to be partitioned and values are assigned to partitions, i.e., sets of single states. The partitioning has a major impact on the solution quality. This paper presents a generic approach that exploits information about the problem characteristics for a problem-specific state space (PSP). The proposed approach is evaluated for a DVRP with one vehicle and stochastic customer requests (DVRPSR). Results show that the solution quality can be increased significantly by a problem-specific partitioning and that anticipatory decision making can be achieved efficiently.

1 Introduction

In many real world routing applications of parcel services, decisions have to be made under uncertainty since information only becomes available over the decision horizon. It is therefore necessary to adapt the current routing, i.e., to make decisions in successive points of time. Problems with this characteristic are modeled as DVRP. In every decision point, it is necessary to not only consider the immediate reward resulting from the decision, but also the possible future decisions and rewards. Perfect information about the future is not available. The value of the impact of a decision in a specific state therefore has to be approximated. Methods that approximate values for an anticipating decision making are provided by Approximate Dynamic Programing (Powell, 2011). However, the state space is often still large and the evaluation requires the storage of values for every state. The number of possible states can be infinitely large for two reasons: a) if many describing features are necessary to identify a state, b) if one of the describing features is continuous. By selecting relevant features of a state (e.g., point of time), states can be aggregated. The dimensionality of the state space is reduced which enables the above mentioned approximation of the value of a state. Since the aggregated state space is often still vast if, for example, one of the chosen features (like the time) is continuous, the aggregated state space is often partitioned. Typically, this is done in an equidistant and problem-independent way. These partitionings may not be efficient since some areas might be considered in too much detail and are therefore not observed frequently to achieve a reliable approximation while other areas might not be detailed enough and aggregate dissimilar states resulting in inefficient decision making. This paper therefore introduces a problem-specific state space partitioning approach. PSP exploits information about the problem and structures the state space partitioning such that areas are represented that are observed frequently and where a detailed representation is necessary for a reliable approximation.

In this paper, PSP is applied to the problem of a vehicle serving customer requests in a service area within a time limit. Some requests are known before the start of the tour and have to be served. Other requests occur during the day, neither the request time nor the request location are known before the request occurs. The objective of parcel services is to serve as many customer requests as possible. Due to the time limit, however, it is mostly not possible to confirm all customer requests. It is therefore necessary to confirm requests such that the number of confirmed requests over the day can be maximized. Customers far off the preliminary tour can lead to significant detours that consume more of the time limit than other requests. This negatively impacts the future possibilities to confirm requests.

For the given problem, Ulmer et al. (2015) proposed the aggregation approach Anticipatory Time Budgeting (ATB) to aggregate states to vectors of time and slack. This paper proposes to use ATB in combination with PSP to partition the state space according to observed characteristics of the problem. Results suggest that an efficient state space partitioning can be achieved.

This paper is organized as follows. This paper presents literature on DVRPs and on state space partitioning in Section 2. The problem and its Markov Decision Process model are described in Section 3. The concepts of Anticipatory Time Budgeting, Approximate Value Iteration (AVI, Powell, 2011), and PSP are presented in Section 4. Results are summarized in Section 5 and conclusions and ideas for future research can be found in Section 6.

2 Literature Review

The following literature review focuses on both the considered problem and the methodology. Therefore, literature dealing with dynamic vehicle routing problems or with state space partitioning is reviewed.

2.1 Dynamic Vehicle Routing Problems

In this paper, a dynamic vehicle routing problem is considered. This refers to vehicle routing problems where the availability of information changes over time which requires subsequent decision making. Literature in this research area is vast. For detailed reviews on dynamic vehicle routing problem research, the interested reader is referred to Pillac et al. (2013) and Psaraftis et al. (2015). A DVRP where requests occur stochastically in known customer locations is discussed for example in Thomas (2007). The author discusses waiting strategies that lead to promising results despite the unknown customer requests. For a dynamic vehicle routing problem with multiple vehicles, some unknown customer locations, and time windows, Bent and van Hentenryck (2004) propose an approach with multiple scenarios including already known and possible future requests.

The considered DVRPSR is described for example in Ulmer et al. (2015). The authors develop a heuristic called Anticipatory Time Budgeting that manages the vehicle's time budget anticipating the future.

2.2 State Space Partitioning

The partitioning of a state space is relevant not only in the Approximate Dynamic Programming (ADP) research, but also in the research area of reinforcement learning (e.g., Kröse and van Dam (1992)). As an example, Lee and Lau (2004) use reinforcement learning to learn state-actions pairs such that the overall rewards over the time horizon can be maximized. The authors use a temporal difference approach with adaptive vector quantization. Here, cells in the state space are created and new states are associated with the closest cell. The organization of the cells is managed by adding or merging cells.

Ulmer et al. (2015) discuss the issue of state space partitioning. The authors compare static and weighted lookup-tables with a new concept, the dynamic lookup-table. While this concept adapts its state space to the problem-specifics during the approximation process, it may require extensive memory if areas need to be considered in detail.

3 Dynamic Vehicle Routing Problem with Stochastic Customer Requests

In this section, the dynamic vehicle routing problem with stochastic customer requests is defined and modeled as a Markov Decision Process.

3.1 Problem

A vehicle starts its tour at a depot, serves customer requests in a service area within a time limit, and returns to the depot. Some requests for pickup services are known before the start of the tour, these have to be served. The remaining requests occur subsequently during the day. Neither request location nor request time are known beforehand, but they follow spatial and temporal distributions that are assumed to be known. These requests can be rejected. Typically, the time limit does not allow to confirm all customer requests. The situation of rejecting customers could be interpreted as forwarding them to other service providers or a backup service. This, however, is not desirable for a service provider.

3.2 Markov Decision Process

A Markov Decision Process can be used to model stochastic dynamic decision problems. The described problem is stochastic due to the probabilistic characteristics of the requests. It is also a dynamic problem due to the possibility of subsequent decision making. The Markov Decision Process in a decision point k consists of a state S_k, an action x, a reward $R_k(S_k, x)$, a post-decision state S_k^x, and a transition to the next state.

For this problem, a decision point occurs whenever the vehicle arrives at a customer. A state S_k is defined by the time t, the confirmed but not yet served customers (that is, their locations), the location of the vehicle, and the positions of the new requests. An action x consists of two parts. Every request has to be either confirmed or rejected. In addition, one confirmed customer has to be chosen as the next customer to be visited. It is also possible to wait at the current location. The reward R_k is the number of immediate confirmations defined by the state and the chosen action. The combination of state and chosen action defines the known post-decision state (PDS) S_k^x. A post-decision state consists of time, the vehicle's position, the confirmed but not yet served customers (who depend on the chosen action), and either the next customer to be visited or the decision to wait. After the post-decision state, a transition leads to the next state. The transition contains not only the travel to the next customer, but also all probabilistic customer requests that occur during the travel time.

The objective is to maximize the expected number of overall confirmations. This can be achieved by maximizing the sum of immediate confirmations and expected future confirmations. In every decision point, these expected future confirmations are defined as the value of the post-decision state $V(S_k^x)$. A policy π assigns an action to every state. An optimal policy chooses in every decision point the action that maximizes the sum of immediate reward and expected future rewards. This concept was formulated in Bellman's Equation (Bellman, 1957) and can be found in Equation (1).

$$X_k^{\pi^*}(S_k) = \underset{x \in X(S_k)}{\arg\max}\{R_k(S_k, x) + V(S_k^x)\} \tag{1}$$

The optimal policy π^* applies Bellman's Equation in every decision point.

4 Solution Methodology

The solution methodology will be explained in this section. The concept of ATB is described in subsection 4.1. The proposed approach PSP provides a problem-specific state space partitioning for ATB. The concept of PSP for ATB will be explained in subsection 4.2.

4.1 Decision Making: ATB

Due to the sizes of post-decision state space and transition space, values cannot be calculated exactly and have to be approximated (cf. Powell, 2011). ATB is an offline procedure since the approximation is an iterative process that requires more calculation time than is available in decision making. The approximation of values is therefore conducted in a learning phase. The approximated values then provide a policy which is applied in an execution phase. The concept of the value approximation in AVI is depicted in Figure 1. In AVI, states are evaluated using simulation. In every decision point within the simulation, the decision is determined by applying Bellman's Equation using the policy induced by the approximated values. The decision is applied in the simulation and the stored approximated values are updated after one simulated run using the realized value.

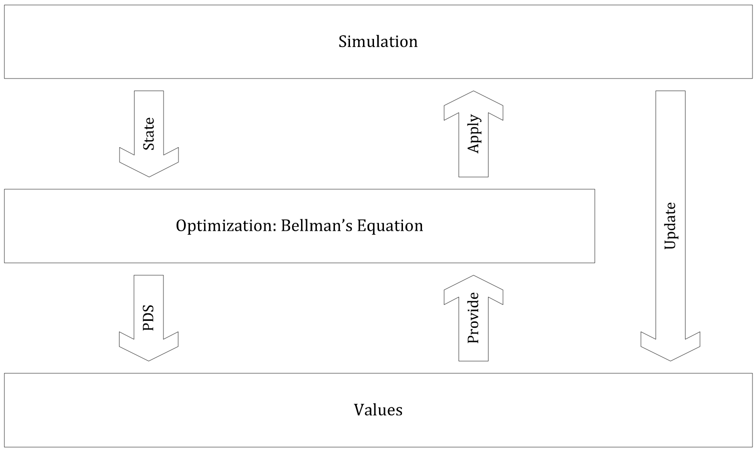

Figure 1: Value Approximation Process

Since an individual evaluation of post-decision states (in the following only called states) is not possible for the given problem due to the size of the state space, states have to be aggregated. It is important for the aggregation that only states are aggregated that are similar in terms of their value. To this end, the authors determined two main features that influence the value. One is the current time t because it describes how much time is still left. The other one describes how much of the time is actually free and not already needed for serving the customers that are confirmed but have not been served yet. This property of a state is called slack s and is an artificial key attribute derived by state properties and a planned tour. Using these two features, the state description can be aggregated to a vector to allow the application of AVI. For the given problem, the aggregated state space can still be large as time and slack are temporal attributes that are usually depicted minute by minute or even continuously. This aggregated state space can therefore be partitioned for a faster approximation process. One possible partitioning approach is a lookup-table, typically with partitions of equal length. The concept of lookup-tables, however, has some disadvantages. If the intervals are small, the memory consumption is problematic and the learning process may be impeded as the detailed states are visited only rarely. Further, adding additional state space features may lead to computational intractability. If the intervals are larger, dissimilar states are associated with the same partition and therefore the same value. Since it depends on the specific problem and instance which areas are needed in which detail, generic state space partitionings like lookup-tables may be both inefficient and ineffective.

4.2 Problem-Specific State Space Partitioning PSP

In order to provide a generic approach for the state space partitioning, exploitation of the problem structure is necessary. There is research done on adaptive state space partitioning, for example by Lee and Lau (2004). The state space is also adapted to the problem specifics to learn the value of state-action pairs. This is not applicable for problems in vehicle routing since both state and action spaces can be very large. It is therefore the objective to generate an approach that is also applicable to problems with state and action spaces of higher dimensionality. Due to this idea, the approach to be developed is applicable to problems with a state space which can include many different problem areas.

In this paper, PSP is presented as a problem-specific state space partitioning approach to evaluate post-decision states. To the best of our knowledge, such an approach is not available yet in the field of dynamic vehicle routing. The approach has three steps: a design phase, an approximation phase, and an evaluation phase. In the design phase, states are sampled in a simulation. These states are then clustered to find representatives. These representatives define the state space partitioning. In the approximation phase, the representatives are used and the values of the representatives are approximated using simulation. In the evaluation phase, the policy achieved in the approximation phase is applied. An example of this development for the presented problem can be seen in Figure 2. On the x-axis, time is depicted, while the y-axis represents slack. The squares (a.) represent a problem-unspecific and equidistant partitioning of the aggregated state space which could also be described by representatives which are depicted as blue circles (also a.). Since the slack cannot exceed the remaining time, only representatives below or on the diagonal in the (t, s)-plane are required in the design phase (a.). The lines of the squares in the diagram depict that the state space partitioning in the design phase resembles a lookup-table with intervals of equal length when using equidistant representatives. Since no further information about the problem is available, all representatives have the same value. The sampled states (b.) can be seen in the middle of Figure 2, they are depicted as yellow circles. After the sampling, the states are used for the clustering which leads to a new state space partitioning with representatives for the problem-specific partitions (c.). This partitioning of the aggregated state space is used for the approximation phase. The partitioning used in the approximation phase can be seen on the right side of Figure 2 and focuses on areas that appeared to be relevant for the problem. After the approximation phase, the approximated values are tested in the evaluation phase.

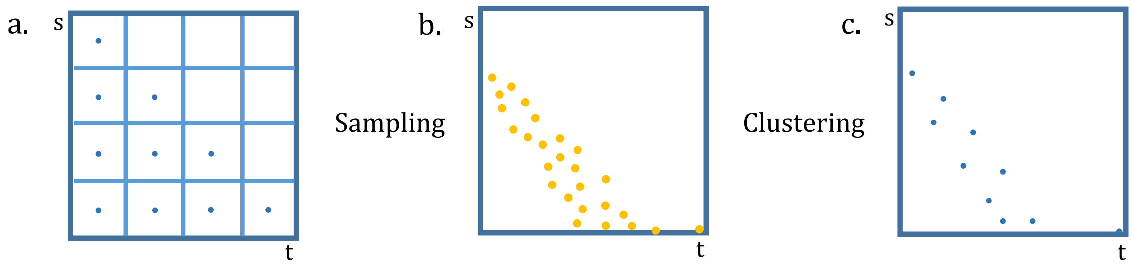

Figure 2: Problem-Specific State Space Design

5 Computational Evaluation

This section first presents the instance details and continues with the parameters for the experiments. Furthermore, results are presented in this section.

5.1 Instances

The vehicle travels at a constant speed of 25 km/h in a service area of 20km x 20km, the time limit is 360 minutes. The tour starts and ends at a depot located in the middle of the service area. The vehicle is uncapacitated. 100 customers are expected to request service, 25 of them are requests known in advance. The remaining customers request service during the day and the request times are assumed to be distributed uniformly over time. The request locations are distributed either uniformly (U) or in two customer clusters (2C). For 2C, the customers are distributed normally around two cluster centers at (5km, 5km) and (15km, 15km) of the service area. For this customer distribution, the vehicle has to change customer clusters at some point of the tour. The different segments of the resulting tour require different levels of detail for the value approximation.

5.2 Parameters for Experiments

For obtaining and comparing results, three different approaches were used. One approach is myopic and accepts greedily as many requests in every decision point as possible. This heuristic is used in order to analyze the approaches regarding anticipation. The other two approaches apply ATB with two different state space partitionings. The first one uses equidistant representatives which resembles a lookup-table, the second one uses representatives obtained by PSP. For both approaches that apply ATB, 300 representatives are used.

For PSP, states are sampled over 300 simulation runs in the design phase. After the sampling, a k-medoids algorithm is used to find representatives. This clustering algorithm appears to be a good choice as the representatives have to be actual states that can be reached. This may be not relevant for the current combination of problem and state description. It could, however, be important for other problem features that are discrete and where states in between do not have a meaning (e.g., days). The chosen number of representatives is 300, k is therefore set to 300. Since not only the Euclidean distance in the (t, s)-plane is important to determine the similarity of two states S_1 and S_2, the absolute difference of the observed values v_1 and v_2 is also included in the distance function that is used in the clustering. This distance function is presented in Equation (2). ATB with equidistant representatives does not require a design phase.

$$d = \sqrt{(t_2 - t_1)^2 + (s_2 - s_1)^2} * |v_2 - v_1| \tag{2}$$

For both partitioning approaches, the values are approximated during 150,000 simulation runs in the approximation phase. Since realized values are not available, the Euclidean distance is used for the approximation process.

The quality of the approximated values is then evaluated by 10,000 simulation runs in the evaluation phase.

5.3 Partitionings

The first result regards the positions of the representatives obtained by the state space partitioning approach and how the positions of the representatives depend on the distribution of the customer requests. In Figure 3, the sets of representatives used for ATB are presented for both customer settings.

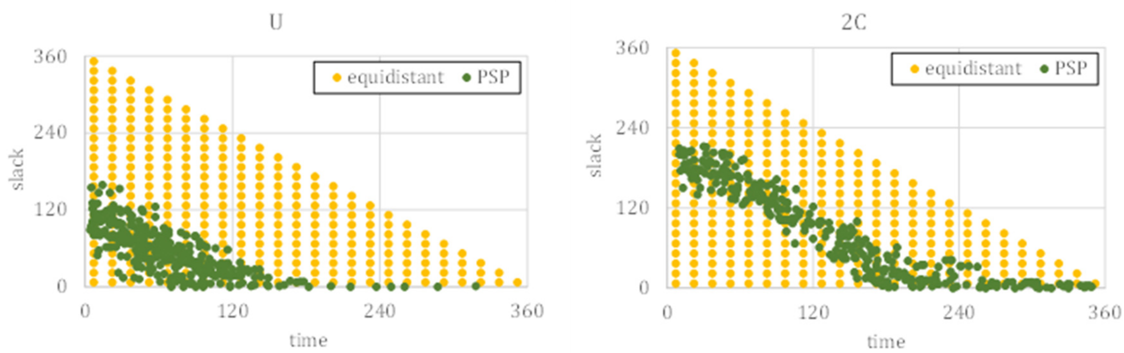

Figure 3: Positions of Representatives in State Space

The left part shows the scenario of uniformly distributed customers. Here, the representatives focus on the lower left area, there is no representative with a slack of more than 200 and only a few representatives are needed for states with a time of more than 200. The representatives for 2C show a different structure. In general, many of the representatives have a higher slack and there are more representatives for those areas with a time of 200 and above. The reasons for this are linked with the explanation for the confirmation rates that are presented in Subsection 5.4.

5.4 Solution Quality

In Figure 4, the approaches using ATB are compared with a myopic confirmation policy.

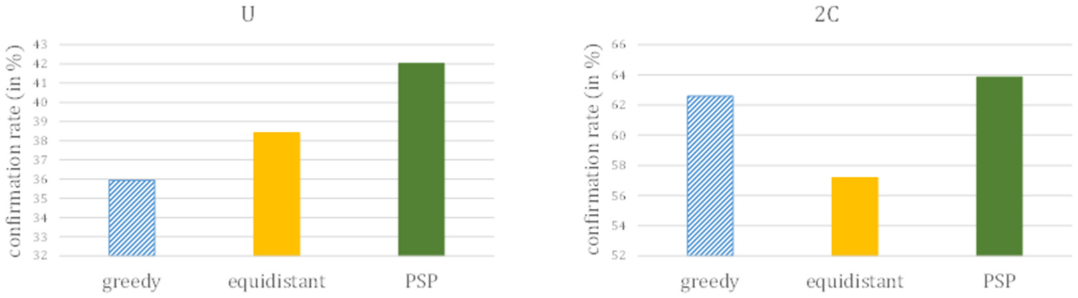

Figure 4: Confirmation Rates

For uniformly distributed customers, early request customers are spread in the whole service area. Hence, the initial tour is already quite long. As a consequence, not many dynamic requests can be confirmed. If the customers are distributed in two customer clusters, the initial tour only concentrates on these areas and is typically shorter. This leads to more slack and facilitates more confirmations of dynamic customer requests.

It can also be seen that ATB with representatives obtained by PSP leads to better results in terms of the confirmation rate in comparison to ATB with equidistant representatives. For U, a greedy confirmation policy confirms customers far off the initial tour, while ATB results in higher confirmation rates as the anticipation leads to more rejections of those customers. Notably, ATB with PSP representatives only performs slightly better than the greedy approach which is more successful than ATB with equidistant representatives for 2C. For this scenario, customers are located in one of the two clusters with the same probability. The early customer requests, which have to be served, are very likely to lead to an initial tour already covering both customer clusters. The greedy confirmation policy accepts as many customer requests as possible. Since the requests are also in one of the two clusters, the additional time to serve the customer is typically not very high for this customer distribution scenario. The approach following a greedy confirmation policy therefore performs well as there are no customers far off a tour. ATB with only a relatively small number of equidistant representatives, however, aggregates states that are not similar. In this case, representatives are 15 time units apart in both dimensions. ATB with representatives obtained by PSP, on the other hand, partitions the state space in a more problem-specific way and is therefore able to approximate values in more detail which leads to higher confirmation rates.

The chosen distance function has a considerable effect on the resulting representatives. This can be seen comparing values and counters of the representatives after the approximation phase. The counter counts the number of observations associated with the partition. Figure 5 presents the counters and values of the representatives of the customer scenario U after the approximation phase.

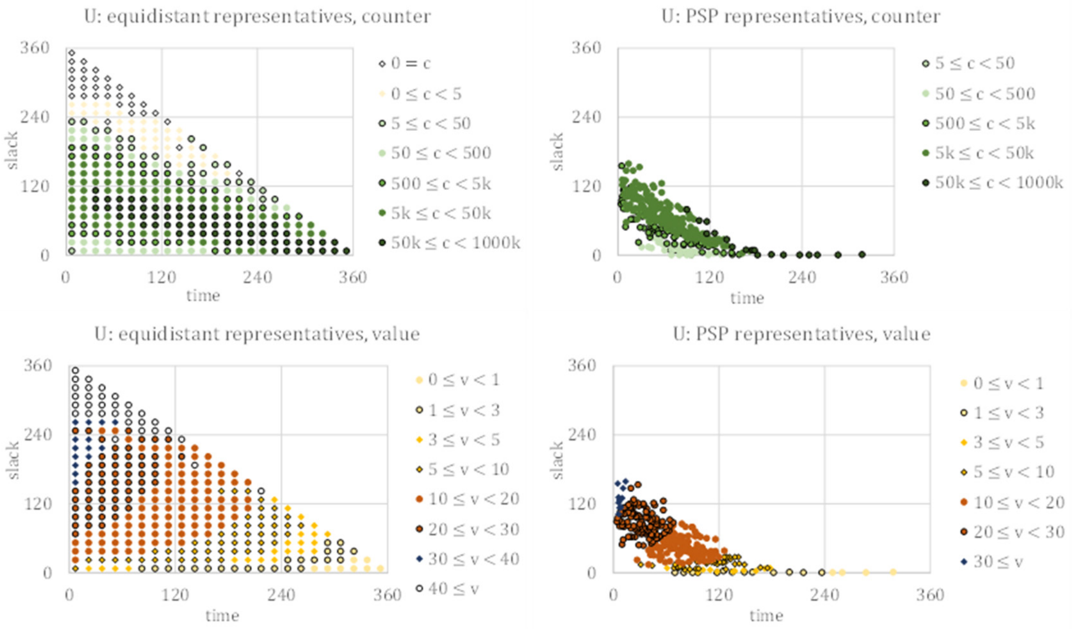

Figure 5: Characteristics of Representatives after Approximation Phase, U

The representatives obtained by PSP are not exactly located in areas with the highest counter because the value differences are also incorporated in the distance function used for the clustering. Due to this, areas are represented where it is important to capture differences in the values. Since the values for states late in the decision horizon are typically small, the absolute value differences are small and only a few representatives are found for this area. The same results for customer scenario 2C are presented in Figure 6.

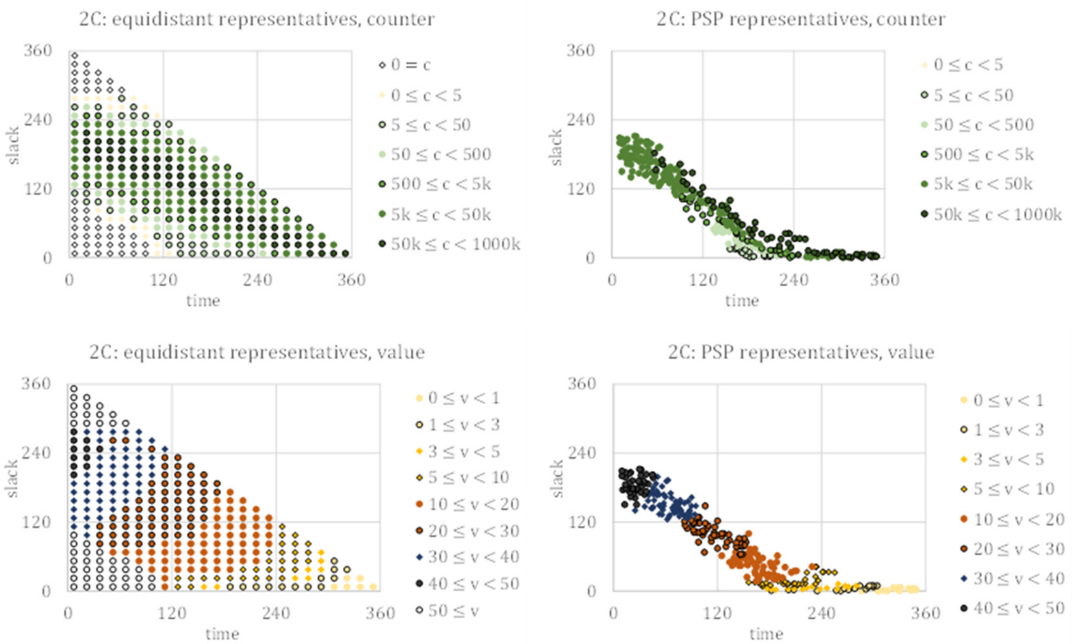

Figure 6: Characteristics of Representatives after Approximation Phase, 2C

Here, the overall values are typically higher as explained above. Differences of observed values can therefore be higher, a differentiation is required. The distance function in the clustering approach is able to provide such a differentiation while also focusing on frequently observed areas. The shape of the representatives obtained by PSP resemble the shape of the most frequently observed equidistant representatives and also focuses on areas with only some slack left. These areas are important for the value approximation because they have a small value due to the slack being close to zero. If these representatives were not present, states in this area would be overestimated.

Figure 7 shows an important area of the representatives obtained by PSP in more detail.

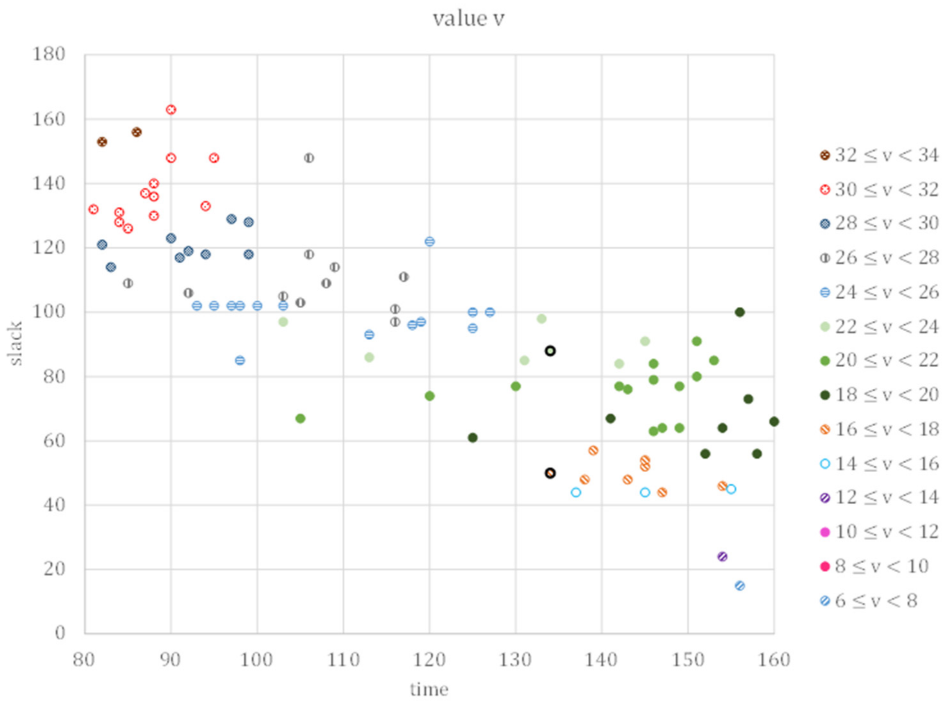

Figure 7: PSP Representatives after Approximation Phase, 2C

In the center of the figure, there is an area with only few representatives and the differences of the representatives' values are rather large. The two representatives surrounded by black circles can be seen as an example for this property. The upper representative (134,88) has a value (an expected number of future confirmations) of 23.53, the lower one (134,50) has a value of 17.47. These differences can be explained by the problem and the customer distribution. Since customers are distributed in two clusters, the vehicle has to switch customer clusters at some point. In this area, a cluster change is likely to happen. Since the cluster change requires some time, many requests can occur in this time. As a result, the number of confirmed requests in the first decision point of the second cluster is typically high and the value of expected confirmed requests after a decision point drops drastically. The upper representative therefore represents a situation in which the vehicle did not drive to the second cluster yet, there are still many expected confirmations and the value is therefore high. In contrast, the lower representative represents a first PDS after the cluster change, the value and the slack dropped because many requests were confirmed. The large area with $100 \leq t \leq 140$ represents the area where only few observations occur due to the cluster change.

This theory can be supported by Figure 8 which shows the arrival of a vehicle in the second cluster over time. It can be seen that the cluster change happens in a very specific area when using equidistant representatives and that the representatives obtained by PSP allow more flexibility for the cluster change.

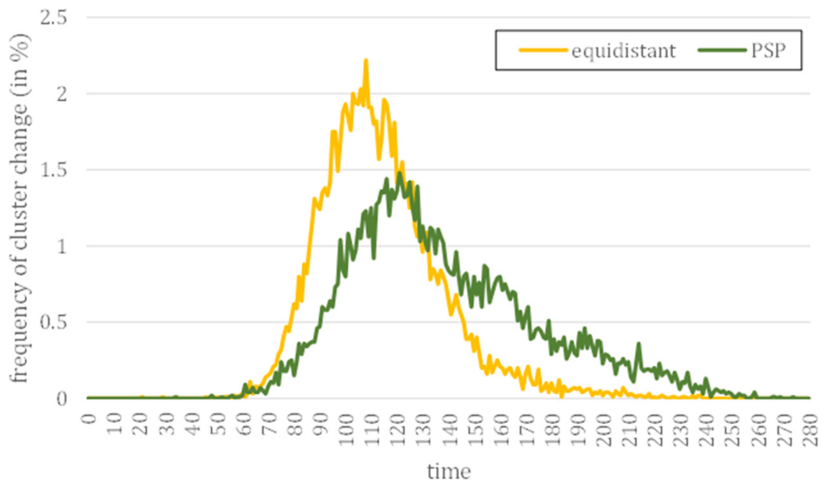

Figure 8: Arrival Times after Cluster Change, 2C

In essence, PSP is able to partition the state space according to the problem and instances which efficiently provides sufficient approximation and an anticipatory policy.

6 Conclusion and Future Research

Decision making for dynamic vehicle routing problems is difficult due to the necessary anticipation of the future. This anticipation is often achieved by methods of approximate dynamic programming. Because of the size of the state space, both an aggregation and a partitioning of the state space are required for DVRPs.

In this paper, a state space partitioning approach is proposed and in combination with the aggregation approach ATB applied to a vehicle routing problem with stochastic customer requests. The combination of ATB and PSP utilizes the approximation of values as a method of approximate dynamic programming and aims on designing the representatives of the state space for the value approximation in a problem-specific way. The locations of the achieved representatives are reasonable considering the proposed distance function. Results show that the solution quality can be improved and anticipation is enabled when using the problem-specific representatives instead of the same number of equidistant representatives. The main purpose of this paper is to show the potential of PSP in the field of DVRPs.

One main advantage of PSP is that various distance functions can be used for the clustering. This may allow adding additional attributes to the aggregated state space. Using other distance functions that are more specific may, however, require some insight into the specific problem. Using additional attributes or different distance functions might be subject of future research. This would also allow, for example, to consider a multi-periodical perspective where customers do not get rejected but have to be served the next day. Further, PSP is able to find the important areas of the state space rather fast and could even be used to create a state space that adapts over time. In the future, multiple clustering might be used for a more effective learning. These modifications might further improve the efficiency of PSP.

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Teilkonferenz
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Die Teilkonferenz 'CSCW & Social Computing' adressiert Herausforderungen bei der Entwicklung, Einführung und Evaluation von Informationssystemen zur Unterstützung der Zusammenarbeit in Teams, Communities und sozialen Netzwerken. Die Unterstützung menschlicher Arbeit durch Informationssysteme setzt ein hinreichendes Verständnis für technologische Entwicklungen einerseits und die Arbeitspraktiken der angestrebten Nutzer andererseits voraus. Aus diesem Grund wird bei Kooperationssystemen von soziotechnischen Systemen gesprochen, die eine integrierte Betrachtung des organisatorischen, psychologischen, soziologischen, betriebswirtschaftlichen und technischen Hintergrundes notwendig machen. Die Teilkonferenz soll Interessierte aus den genannten Disziplinen zusammenzubringen. Es sind sowohl verhaltenswissenschaftliche (Fallstudien/Feldstudien, qualitative und quantitative Analysen, Experimente) oder gestaltungswissenschaftliche, empirische Arbeiten (Prototypen, Aktionsforschung), als auch theoretische, konzeptuelle und technische Arbeiten erwünscht.

Traditionell wird die Teilkonferenz vom Leitungsgremium der gleichnamigen GI-Fachgruppe organisiert. Mit der Hilfe eines 26-köpfigen Programmkomitees konnten auf Basis von 57 Reviews 10 der eingereichten 20 Beiträge angenommen werden. Die Annahmequote von 50% liegt etwas höher als bei den CSCW-Teilkonferenzen der vergangenen MKWIs (2014: 42%).

Alexander Richter, Michael Prilla, Michael Koch

(Teilkonferenzleitung)

Widerstand beim Einsatz von Kollaborationssystemen in Unternehmen: Eine Untersuchung zu Entstehung, Ursachen und Maßnahmen

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Abstract

Kollaborationssysteme (KS) sind heute in der Unternehmenswelt unverzichtbar, jedoch scheitern viele KS-Einführungsprojekte an dem Widerstand der Nutzer. Häufig wird Widerstand der Inflexibilität der Nutzer oder schlechten Schulungsmaßnahmen zugeschrieben; er kann aber auch auf andere Missstände hindeuten. Widerstand ist somit nicht notwendigerweise eine irrationale Antwort oder eine eigennützige Reaktion. Vielmehr dient er als Diagnosewerkzeug für die Analyse von gescheiterten KS-Projekten oder der Evaluation der Erfolgschancen solcher Projekte. Ziel dieses Beitrags ist es, zu untersuchen, warum Mitarbeiter KS nicht oder nur widerwillig benutzen und wie dem begegnet werden kann. Dazu wird auf Basis einer systematischen Literaturanalyse ein Forschungsmodell mit 13 Hypothesen entwickelt, das Ursachen von und Maßnahmen gegen KS-Widerstand analysiert. Die Analyse zeigt, dass noch deutlicher Forschungsbedarf in Bezug auf die Auswirkungen verschiedener Ursachen auf die Intensität und Arten von KS-Widerstand besteht. Die Forschungslücke im Bereich der Maßnahmen ist sogar noch größer – zwar werden in der Literatur Maßnahmen erwähnt, doch sind diese oft sehr generisch und die Übertragbarkeit auf KS fraglich.

1 Einleitung

Kollaborationssysteme (KS) dienen der Unterstützung bzw. Ermöglichung der Kommunikation, Koordination und Kollaboration von Menschen in verteilten Projekten, Prozessen und Teams in und zwischen Organisationen mittels Informations- und Kommunikationstechnik (Riemer 2009). KS sind heute in der Unternehmenswelt unverzichtbar, denn sie fördern die Transparenz und Zielstrebigkeit in Teams, das Wissensmanagement und damit die Wettbewerbsfähigkeit und Produktivität von Unternehmen (Riempp 2004). Jedoch können KS nur dann Nutzen stiften, wenn die Mitarbeiter sie auch benutzen. Unternehmen müssen folglich ein Interesse daran haben, die kontinuierliche Nutzung von KS zu gewährleisten. Am Beispiel von Oticon wird sichtbar, wie groß die Herausforderungen bei Veränderungen im Unternehmen im Zusammenhang mit neuen KS sein können. Der Hörgerätehersteller unternahm 1991 Maßnahmen zur Erhöhung der Produktivität

(Larsen 1998), indem er sämtliche eingehenden Briefe scannte und umfassende KS etablierte. Obwohl der Kulturwandel „über Nacht weg vom Papier“ scheiterte, war die Umstellung letztlich erfolgreich. Larsen führt dies nicht nur auf die Qualität der KS, sondern auch auf gemeinsam geschaffene und akzeptierte Werte im Unternehmen sowie ein Verständnis der Zusammenarbeit der Mitarbeiter zurück. Das Beispiel zeigt, dass der Grund für den Widerstand gegen KS häufig nicht darin liegt, dass die technischen Lösungen schlecht sind (Jiang et al. 2000). Ohne die Teilhabe der potenziellen Nutzer sind solche Systeme oft zum Scheitern verurteilt. So wurden z.B. fehlende Informationen und fehlendes Vertrauen ins Team als häufige Probleme identifiziert (Bhattacherjee und Hikmet 2007; Klaus und Blanton 2010; Markus 1983). Auch wenn im Idealfall die Mitarbeiter einem KS gegenüber positiv eingestellt sind, kann zudem Widerstand auftreten, wenn die Benutzung zu unhandlich erscheint. Beispielsweise gaben die Ärzte in einem Krankenhaus als Grund für jedes Röntgen eine (an diesem Ort höchst selten vorkommende) Schusswunde in das System für die gemeinsame Bearbeitung der Patientendossiers ein, um Zeit zu sparen (Lapointe und Rivard 2005).

KS-Widerstand muss jedoch nicht negativ sein, sondern kann auch als Werkzeug zur Erkennung von Missständen dienen (Hirschheim und Newman 1988). Zudem kann er Organisationen daran hindern, Systeme zu implementieren, die negative Folgen wie zunehmenden Stress, Fluktuation oder ein abnehmendes Leistungsniveau bewirken (Markus 1983). Wenn dabei jedoch Konflikte entstehen, die zu viel Zeit und Aufmerksamkeit erfordern, ist Widerstand eher dysfunktional. Widerstand ist somit nicht notwendigerweise eine irrationale Antwort oder eine fehlgeleitete und eigennützige Reaktion gegenüber Innovationen (Jiang et al. 2000). Vielmehr dient er als ein wertvolles Diagnosewerkzeug für die Post-mortem-Analyse von gescheiterten Einführungs-projekten von Informationssystemen (IS) oder die Ex-ante-Evaluation der Chancen für den Erfolg einer Implementierung (Bhattacherjee und Hikmet 2007). In den meisten Fällen ist das Ziel daher, den Widerstand zu vermeiden oder ihm konstruktiv zu begegnen, falls das Vermeiden nicht möglich ist. Der Blick in die wissenschaftliche Literatur zeigt, dass trotz der großen Verbreitung und Wichtigkeit von modernen KS nur wenige Forschungsmodelle systematisch Ursachen und Folgen von Widerstand gegen KS gegenüberstellen (Gosain 2004, Bhattacherjee und Hikmet 2007), während es viele Forschungsarbeiten zum Thema IS-Widerstand im Allgemeinen gibt (Kane und Labianca 2009, Klaus und Blanton 2010, Rivard und Lapointe 2012). Die Zielsetzung dieses Beitrags ist, zu untersuchen, warum Mitarbeiter KS manchmal nicht oder nur widerwillig benutzen (Ursachen) und wie dem begegnet werden kann (Maßnahmen). Dazu wird auf Basis einer systematischen Literaturanalyse ein theoretisches Forschungsmodell entwickelt, das Ursachen von und Maßnahmen gegen KS-Widerstand systematisch gegenüberstellt und zeigt, wie diese auf Widerstand einwirken.

2 Widerstand gegen Informationssysteme

Widerstand wird in der Literatur unterschiedlich definiert. So kann Widerstand als die Opposition eines Nutzers gegen wahrgenommene Veränderungen im Zusammenhang mit der Implementation von neuen IS gesehen werden (Markus 1983; Polites und Karahanna 2012), als Sichtbarwerden eines Unbehagens der Nutzer in Bezug auf ein unzulängliches System (Hirschheim und Newman 1988; Marakas und Hornik 1996) oder als Vermeidungsverhalten durch die mit einem IS assoziierten Bedrohungen (Ferneley und Sobreperez 2006; Kane und Labianca 2009; Marakas und Hornik 1996). Diesen Definitionen ist gemein, dass sie auf *eine bestimmte* Verhaltensweise fokussieren und weniger auf die konzeptionelle Natur von Widerstand. Aus Sicht eines allgemeinen

Forschungsmodells für KS-Widerstand sind solche spezifischen Definitionen jedoch ungeeignet. Dieser Beitrag stützt sich daher auf die Definition von Rivard und Lapointe (2012). Diese definieren IS-Widerstand als *eine Reihe von* Verhaltensweisen von Nutzern, die damit ihre Unzufriedenheit gegen ein IS zeigen wollen.

Eine direkte Folge dieser verschiedenen Definitionen von Widerstand ist eine Vielzahl von Klassifizierungen von Widerstand. Autoren differenzieren z.B. zwischen passivem (z.B. Apathie, psychologischer Rückzug, unkooperatives Verhalten, verminderte Produktivität) und aktivem (z.B. inakkurate Dateneingaben, Umgehungsverhalten, Benutzen von Schatten-IT) (Klaus et al. 2010; Kim und Kankanhalli 2009), offenem und verstecktem Widerstand (Kim und Kankanhalli 2009; Laumer und Eckhardt 2010) oder verschiedenen Stufen der Destruktivität von Widerstand (Shang und Su 2004). Laumer und Eckhardt (2010) sprechen von einer Zunahme des Widerstands von einem versteckt-passiven bis zu einem offen-aktiven Verhalten. Ähnlich unterscheiden Lapointe und Rivard (2005) die vier Stufen Apathie, passiver, aktiver und aggressiver Widerstand.

Apathie kann als desinteressiertes Verhalten und Inaktivität einer Person gegenüber einer Situation beschrieben werden (Meissonier und Houze 2010). Dabei handelt es sich um einen Übergangszustand zwischen Widerstand und Akzeptanz. *Passiven Widerstand* leisten Personen, die Änderungen verlangsamen und das bisherige IS behalten wollen. Er ist für das Umfeld des Nutzers kaum wahrnehmbar und schwer als Widerstand erkennbar, wodurch der Umgang damit erschwert wird (Laumer 2011). *Aktiver Widerstand* ist für das Umfeld des Nutzers beobachtbar und äußert sich z.B. in vorkommenden Beschwerden (Bhattacherjee und Hikmet (2007). Während solche Reaktionen dazu dienen könnten, Frustration zu verarbeiten und eher harmlos sind, kann das von Lapointe und Rivard (2005) erwähnte abfällig artikulierende Verhalten die Arbeitskollegen negativ beeinflussen. Klaus et al. (2010) beschreiben Schatten-IT als stärkste Form von aktivem Widerstand, weil der Nutzer seine Arbeit absichtlich als Protest gegen das IS mithilfe eines anderes Systems durchführt. *Aggressiver Widerstand* tritt in der Praxis nur selten auf und kann öffentliche Aktionen wie z.B. Boykott, Machtkämpfe und Streiks (Lapointe und Rivard 2005; Meissonier und Houze 2010) oder physisch-destruktive Aktionen wie z.B. Sabotage (Hirschheim und Newman 1988; Sobreperez et al. 2005) beinhalten.

3 Forschungsmethode

Die Zielsetzung dieses Beitrags ist eine systematische Untersuchung und Synthese des aktuellen Forschungsstands zu KS-Widerstand. Daher wurde eine systematische Literaturanalyse zu Widerstand im Zusammenhang mit der Implementation oder Benutzung von IS und KS durchgeführt, die sich an den etablierten Richtlinien für die Literaturanalyse und -synthese orientiert hat (Fettke 2006; Vom Brocke et al. 2010; Webster und Watson 2002). Die Literatursuche wurde in den folgenden Datenbanken durchgeführt: EBSCO Business Source Complete, Elsevier ScienceDirect, Emerald Management Xtra, Google Scholar, Jstor, Springer Link (Zeitschriftenartikel), WISO Wirtschaftswissenschaften. Die Literatursuche begann mit einer Suche nach Schlüsselwörtern in Titeln, Abstracts und Schlagwörtern, gefolgt von einer Rückwärts- und Vorwärtssuche (Webster und Watson 2002). Die verwendeten Suchmuster lauteten folgendermaßen: „[Begriff] & [Collaboration/Kollaboration] & [Begriff]“, „[Begriff] & [Resistance/Widerstand]“; „[Resistance to/Widerstand gegen] & [Begriff], wobei für „Begriff“ jeweils relevante Wörter wie z.B. „Technology“, „Resistance“, „Tools“ oder „Methods“ eingesetzt wurden. Die Relevanz von Artikeln wurde neben thematischer Passung u.a. auch durch

Zitationshäufigkeit im Rahmen der Rückwärtssuche bestimmt. Zudem wurden ausgewählte Bücher in die Literaturauswahl aufgenommen. Diese Suche resultierte im ersten Schritt in 279 Artikeln, die durch sukzessive Verfeinerung eingegrenzt wurden. Beispielsweise wurden Artikel aus Politik, Psychologie und Management, die nicht originär aus dem Wirtschaftsinformatik- oder IS-Kontext stammen, aber von entsprechenden Quellen zitiert wurden, ausgeschlossen. Weitere verwandte Themen wie z.B. Social Software, Enterprise 2.0, Wissensmanagementsysteme und bekannte Archetypen von Systemen wie Product Data Management (PDM), Customer Relationship Management (CRM) und Enterprise Resource Planning (ERP) wurden ausge-schlossen, um zu fokussieren und im vorgegebenen Rahmen zu bleiben. Damit alle Artikel genügend hohen Qualitätsanforderungen entsprachen, wurden aus der Menge an gefundenen Artikeln in der Regel jene für die Literaturuntersuchung ausgewählt, die aus einer Zeitschrift aus dem AIS Senior Scholars' Basket of Journals[1] stammen oder aus einer Zeitschrift, die im VHB JOURQUAL 3.0[2] mindestens mit C bewertet wurden. Ausnahmen bildeten Artikel, die das Thema aus einer bisher nicht berücksichtigten Perspektive beleuchten. Aus den verbleibenden 43 Artikeln wurde jene in die Analyse aufgenommen, die sich maßgeblich mit dem Phänomen Widerstand gegen IS oder KS befassen. Aus diesem Auswahlprozess resultierten 30 Publikationen. Die inhaltliche Klassifikation der Artikel erfolgte entlang der zwei grund-sätzlichen, im Kontext dieses Beitrags fokussierten Oberkategorien Ursachen und Maßnahmen von Widerstand. Auf Basis der Schlagwörter der Artikel und einer konzeptzentrischen Analyse wurden die in Tabelle 1 gelisteten Kategorien und Dimensionen identifiziert.

	Kategorie	**Dimensionen**
Ursachen von Widerstand	Individuelle Faktoren	Bedrohungen und Verluste; Persönlichkeit und Lernfähigkeit
	Organisatorische Faktoren	Managementverhalten; sozialer Einfluss und Kultur
	Technologische Faktoren	Funktionale Eigenschaften; nicht-funktionale Eigenschaften
Maßnahmen	Partizipative Maßnahmen	Unterstützung der Nutzer; Kommunikation
	Direktive Maßnahmen	Proaktiver Implementierungsplan; Jobprofile/-konditionen

Tabelle 1: Resultierende Kategorien und Dimensionen der konzeptzentrischen Analyse

4 Analyse der Ergebnisse

Um die Ursachen von KS-Widerstand und mögliche Gegenmaßnahmen zu identifizieren, wurden die Quellen in den Kategorien aus Tabelle 2 systematisch bzgl. ihrer Wirkungszusammenhänge untersucht. Das resultierende Forschungsmodell ist in Bild 1 dargestellt. Die Tabelle 2 enthält eine Übersicht aller Quellen.

[1] Der http://aisnet.org/?SeniorScholarBasket beinhaltet acht international anerkannte Zeitschriften im Bereich Informationssysteme.
[2] http://vhbonline.org/service/jourqual/vhb-jourqual-3/teilrating-wi/

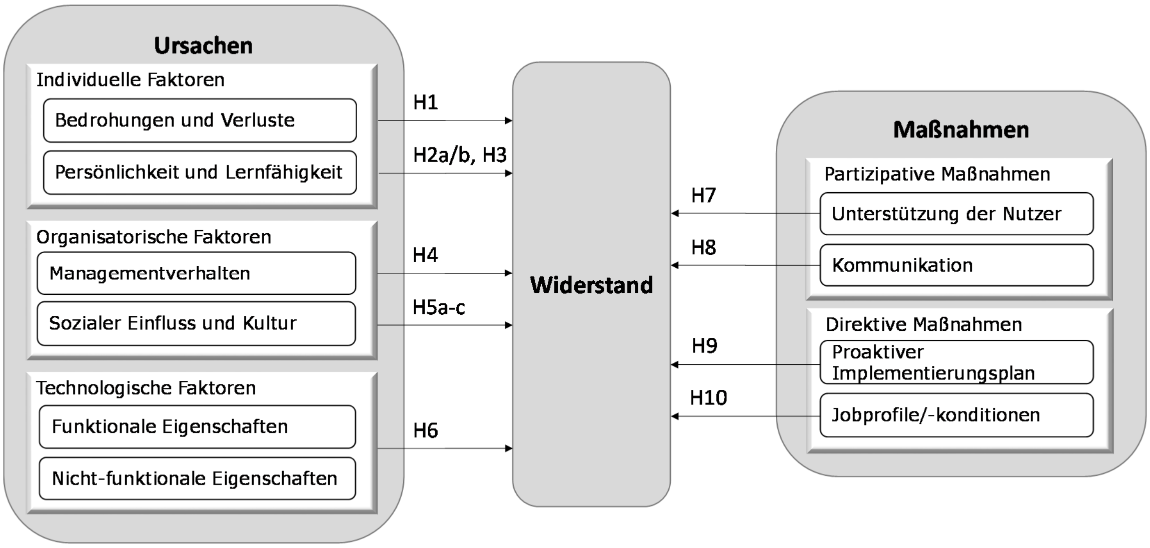

Bild 1: Theoretisches Forschungsmodell

4.1 Ursachen für KS-Widerstand

Die Ursachen für KS-Widerstand lassen sich aufgrund der Befunde der konzeptzentrischen Analyse in individuelle, organisatorische und technologische Faktoren klassifizieren. Individuelle Faktoren umfassen Bedrohungen und Verluste sowie Persönlichkeit und Lernfähigkeit. Organisatorische Faktoren beinhalten Managementverhalten und sozialen Einfluss und Kultur. Zu den technologischen Faktoren gehören funktionale und nicht-funktionale Eigenschaften. Grundsätzlich lässt sich beobachten, dass es nur sehr wenig Literatur im Hinblick auf KS-Widerstand gibt und sich die überwiegende Literatur mit IS-Widerstand im Allgemeinen befasst. Für die Quellen in Tabelle 2 und in der nachfolgenden Diskussion wurden daher nur solche Quellen zu IS-Widerstand für die Hypothesenableitung herangezogen, die sich auf den KS-Kontext übertragen lassen.

4.1.1 Individuelle Faktoren

Bei den individuellen Faktoren sind wahrgenommene Bedrohungen und Verluste in den verschiedenen Ausprägungen die meistgenannten Ursachen für Widerstand. Neue KS verändern potenziell die politische und soziale Situation im Unternehmen, was je nach vorherigen Machtbefugnissen nicht alle Nutzer positiv wahrnehmen (Laumer 2011). KS fördern zudem die Transparenz von Entscheidungen und Arbeitsergebnissen, was dazu führen kann, dass sich Manager in ihrem Entscheidungsstil angegriffen fühlen (Jiang et al. 2000) und Mitarbeiter eine Gefährdung ihres Vertrauensverhältnisses zum Topmanagement oder ihres Status fürchten (Meissonier und Houze 2010). Kim und Kankanhalli (2009) betonen hierbei die Bedeutung der persönlichen Kosten-Nutzen-Analyse. Dabei gibt es zwei Arten von Kosten: Erstens die Umstellungskosten (und der damit einhergehende Arbeitsverlust) bzgl. eines neuen KS und zweitens die psychologischen Kosten der Ungewissheit, weil ein Nutzer nicht sicher sagen kann, welche Risiken und Auswirkungen mit dem neuen KS einhergehen. Je negativer die Kosten-Nutzen-Analyse dabei ausfällt, desto stärker fällt der Widerstand aus. Ähnlich argumentiert Joshi (1991), dass Individuen Veränderungen daraufhin evaluieren, ob ihnen die eigene Situation nach der Veränderung im Vergleich zur Situation anderer gerecht vorkommt. Ist dies nicht so, erhöht sich der Widerstand. Die erste Hypothese lautet deshalb:

H1: Das Ausmaß der im Rahmen einer KS-Implementierung wahrgenommenen Bedrohungen hat einen positiven Einfluss auf die Intensität des Widerstands.

Die zweithäufigste in der Literatur genannte Ursache für KS-Widerstand ist Persönlichkeit und Lernfähigkeit. So nennen z.B. Wen et al. (2011) Stress, Erschöpfung, Sorgen, Depressionen und sogar Herz-Kreislauf-Erkrankungen als Ursachen für Widerstand. Maier et al. (2011) machen Ursachen in den unterschiedlichen Charaktereigenschaften von Individuen aus. Manche Personen ziehen beispielsweise die Routine vor, denken eher kurzfristig oder sind bzgl. Änderungen kognitiv unbeweglich und sind daher nicht gewillt, einen vorübergehend erhöhten Lernaufwand zu betreiben.

	Kategorie	Dimensionen	Publikationen
Ursachen für Widerstand	Individuelle Faktoren	Bedrohungen und Verluste	Bhattacherjee und Hikmet (2007), Doolin (2004), Hirschheim und Newman (1988), Maier et al. (2012), Marakas und Hornik (1996), Markus (1983), Sobreperez et al. (2005)
		Persönlichkeit und Lernfähigkeit	Ang und Pavri (1994), Bhattacherjee und Hikmet (2007), Hirschheim und Newman (1988), Joshi (1991), Krovi (1993), Laumer et al. (2010), Maier et al. (2011), Marakas und Hornik (1996), Markus (1983), Martinko et al. (1996), Polites und Karahanna (2012), Sobreperez et al. (2005), Wild et al. (2012)
	Organisatorische Faktoren	Managementverhalten	Ang und Pavri (1994), Hirschheim und Newman (1988), Klaus und Blanton (2010), Krovi (1993), Marakas und Hornik (1996), Martinko et al. (1996)
		Sozialer Einfluss und Kultur	Ferneley und Sobreperez (2006), Kane und Labianca (2009), Markus (1983); Meissonier et al. (2013)
	Technologische Faktoren	Funktionale Eigenschaften	Cenfetelli (2004), Doolin (2004), Ferneley und Sobreperez (2006), Hirschheim und Newman (1988), Jiang et al. (2000), Laumer et al. (2009), Sobreperez et al. (2005)
		Nicht-funktionale Eigenschaften	Cenfetelli (2004), Hirschheim und Newman (1988), Jiang et al. (2000)
Maßnahmen in Bezug auf Widerstand	Partizipative Maßnahmen	Unterstützung der Nutzer	Joshi (1991), Kane und Labianca (2009), Kim und Kankanhalli (2009), Klaus und Blanton (2010), Krovi (1993), Markus (1983), Martinko et al. (1996), Rivard und Lapointe (2012), Shang und Su (2004)
		Kommunikation	Bhattacherjee und Hikmet (2007), Joshi (1991), Klaus und Blanton (2010), Krovi (1993), Laumer et al. (2010), Lapointe und Rivard (2005), Markus (1983), Martinko et al. (1996), Meissonier und Houze (2010), Rivard und Lapointe (2012), Shang und Su (2004), Wen et al. (2011)
	Direktive Maßnahmen	Proaktiver Implementierungsplan	Ang und Pavri (1994), Bhattacherjee und Hikmet (2007), Gosain (2004), Jiang et al. (2000), Kane und Labianca (2009), Kim und Kankanhalli (2009), Klaus et al. (2010), Krovi (1993), Lapointe und Rivard (2005), Laumer et al. (2010), Marakas und Hornik (1996), Markus (1983), Martinko et al. (1996), Meissonier et al. (2013), van Offenbeek et al. (2013)
		Jobprofile/ -konditionen	Joshi (1991), Klaus und Blanton (2010), Krovi (1993),Shang und Su (2004)

Tabelle 2: Ursachen und Maßnahmen in Bezug auf Widerstand

Laut Sobreperez et al. (2005) spielt beim Umgang mit einem IS auch die sachverständige Beurteilung des Nutzers eine wichtige Rolle. Falls die Nutzer nicht glauben, dass ein IS ihnen die ihrem Status angemessene Ermessensfreiheit und Autonomie gibt, werden sie Widerstand leisten und, falls möglich, das IS ignorieren oder keinen Aufwand in das Lernen der KS-Funktionen investieren. Polites und Karahanna (2012) beschreiben zudem Trägheit und Gewohnheit als wichtigen Faktor, der Nutzer davon abhält, sich in ein neues IS einzuarbeiten – unabhängig davon, wie benutzerfreundlich oder nützlich es ist. Es folgt daraus die zweite Hypothese:

H2a: Eine träge und änderungsunwillige Persönlichkeit des Nutzers hat einen positiven Einfluss auf die Intensität des Widerstands.

H2b: Eine geringe Bereitschaft des Nutzers zu vorübergehend erhöhtem Aufwand für das Lernen der Nutzung eines KS hat einen positiven Einfluss auf die Intensität des Widerstands.

Martinko et al. (1996) sehen eine mögliche Ursache für Widerstand zudem in den individuellen Erfahrungen der Nutzer mit ähnlichen Technologien. Es kann daher sogar vorkommen, dass die Nutzer mit dem aktuellen KS nicht durchgängig zufrieden sind, aber nicht vom Zusatznutzen eines neuen KS überzeugt werden können und daher lieber weiter mit dem alten KS arbeiten (Hirschheim und Newman 1988). Die nächste Hypothese lautet daher:

H3: Schlechte Erfahrungen mit früheren KS-Implementationen haben einen positiven Einfluss auf die Intensität des Widerstands.

4.1.2 Organisatorische Faktoren

Die am häufigsten genannte Ursache in der Literatur für KS-Widerstand ist fehlendes oder nicht angemessenes Managementverhalten. Hirschheim und Newman (1988) sowie Martinko et al. (1996) sprechen generell von mangelnder Unterstützung seitens des Managements als Ursache für Widerstand. Rivard und Lapointe (2012) sehen in der Inaktivität der Verantwortlichen das den Widerstand am meisten fördernde Verhalten. Derartige Versäumnisse im Managementverhalten können allerdings zum Bruch des psychologischen Vertrags[3] zwischen dem Management und den Nutzern und zu zunehmendem Widerstand führen (Klaus und Blanton 2010). Die KS-Implementierung sollte daher nicht als rein technischer, sondern vor allem als sozialer Prozess betrachtet werden (Ang und Pavri (1994). Es folgt daraus:

H4: Eine mangelnde Unterstützung der Nutzer durch das Management vor, während und nach einer KS-Implementation hat einen positiven Einfluss auf die Intensität des Widerstands.

Ferneley und Sobreperez (2006) diskutieren die Beeinflussung der IS-Benutzung (z.B. unsachgemäße oder nur teilweise Nutzung) durch negative Meinungen und Spott von Arbeitskollegen. Sozialer Einfluss und Kultur ist daher die zweite wesentliche Ursache für KS-Widerstand. So können kulturelle Unstimmigkeiten zwischen einem KS und der vorherrschenden Denkweise (z.B. bei sehr stark hierarchisch geprägter Unternehmenskultur) zu Widerstand führen (Meissonier et al. 2013). Weiterhin beschreiben Kane und Labianca (2009) und Markus (1983), dass auch der soziale Benutzungskontext eines IS, respektive die intraorganisatorischen Machtverteilung, ein wesentlicher Grund für Widerstand sein kann – besonders, wenn zentrale und gut vernetzte Personen im Unternehmen gegen das KS arbeiten. Es folgt daraus die fünfte Hypothese:

H5a: Je mehr zentrale und gut vernetzte Personen das KS negativ sehen, desto wahrscheinlicher ist Widerstand.

H5b: Je stärker die Vorbehalte von zentralen und gut vernetzten Personen gegen das KS sind, desto höher ist die Intensität des Widerstands.

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[3] Klaus und Blanton (2010) definieren den psychologischen Vertrag als Überzeugungen von Individuen bzgl. akzeptierten Versprechungen, auf die sie sich verlassen.

H5c: Je mehr die Unternehmenskultur und die durch das KS geprägte Kultur voneinander abweichen, desto höher ist die Intensität des Widerstands.

4.1.3 Technologische Faktoren

Die funktionalen und nicht-funktionalen Eigenschaften eines IS werden bei vielen Autorinnen und Autoren als eine Ursache von KS-Widerstand aufgeführt (Cenfetelli 2004; Hirschheim und Newman 1988). Zu den relevanten Faktoren zählen z.B. mangelhaftes Systemdesign, schlechter Zugang zu Arbeitsstationen und unangemessen lange Antwortzeiten (Martinko et al. 1996) sowie Funktionen, deren Nutzen unklar oder nicht intuitiv ist (Cenfetelli 2004), oder Dateneingabeprozeduren, die durch Umgehungsmaßnahmen („Workarounds") wesentlich abgekürzt werden können (Ferneley und Sobreperez 2006). Folgende Hypothese wird daraus abgeleitet:

H6: Je weniger die funktionalen und nicht-funktionalen Eigenschaften eines KS an die Bedürfnisse der Nutzer angepasst sind, desto höher ist die Intensität des Widerstands.

4.2 Maßnahmen gegen KS-Widerstand

Basierend auf der Einteilung von Jiang et al. (2000) werden nachfolgend partizipative und direktive Maßnahmen unterschieden.

4.2.1 Partizipative Maßnahmen

Unter den partizipativen Maßnahmen erfährt Unterstützung in der untersuchten Literatur am meisten Erwähnung. Dazu gehören bessere Schulungsunterlagen, persönliche Unterstützung und Hilfe auf Nachfrage beim Diagnostizieren und Lösen von Problemen (Joshi 1991). Kane und Labianca (2009) empfehlen zudem auf bestimmte Nutzer zugeschnittene und breit angesetzte Schulungen. Entsprechend lässt sich formulieren:

H7: Je besser die Unterstützung der Nutzer im Rahmen von Schulungen, Beratungen und Support ist, desto niedriger ist die Intensität des KS-Widerstands.

Es empfehlen sich verschiedene Kommunikationsmaßnahmen zur Förderung der gegenseitigen, bidirektionalen Kommunikation (Riempp 2004). Dazu können anonyme Umfragen verwendet werden (Bhattacherjee und Hikmet 2007) oder es kann ein Feedbacksystem für die Nutzer eingerichtet werden (Krovi 1993). Rivard und Lapointe (2012) empfehlen die Diskussion von Problemen, Umfragen und die Organisation von Gesprächsrunden, Arbeits- oder Fokusgruppen. Zudem sollten die Nutzer beim Entscheidungs- und Designprozess einbezogen werden, um so eine gute Balance zwischen der Befriedigung der individuellen Bedürfnisse und den Zielen des Implementationsprojekts zu schaffen (Krovi 1993; Markus 1983; Martinko et al. 1996; Wen et al. 2011; Jiang et al. 2000). Die achte Hypothese lautet entsprechend:

H8: Je mehr vertrauensfördernde Kommunikations- und Beteiligungsmaßnahmen im Zuge eines KS-Implementationsprojekts ergriffen werden, desto niedriger ist die Intensität des KS-Widerstands.

4.2.2 Direktive Maßnahmen

Die in der Literatur am meisten genannte Maßnahme gegen KS-Widerstand ist das Vorhandensein und Nachhalten eines klaren Implementierungsplans (Klaus et al. 2010), der nicht nur die technische Perspektive, sondern auch die wahrgenommenen Bedrohungen und Verluste der Nutzer abbildet und hilft, diese zu adressieren (Ang und Pavri 1994; Lapointe und Rivard 2005). In einem solchem

Plan sollte zudem die Wahrnehmung von Widerstand thematisiert werden, denn einige Arten von Widerstand treten erst über einen längeren Zeitraum auf oder fallen kaum auf. Verantwortliche, die Widerstand nicht bemerken, können auch nicht darauf reagieren (Markus 1983). Schließlich sollten die Maßnahmen gegen Widerstand an das KS und die Organisation angepasst werden (Jiang et al. 2000). Beispielsweise sollten Maßnahmen eingeplant werden für die Analyse der Netzstruktur von Teams, um so Schlüsselpersonen hinsichtlich KS-Widerstand zu identifizieren (Kane und Labianca 2009). Empfehlenswert ist zudem das Erstellen von Nutzerrichtlinien (Markus 1983; Krovi 1993) mit klaren Definitionen von Rollen und Verantwortlichkeiten (Krovi 1993) sowie die proaktive Lösung von organisatorischen Problemen vor der Einführung eines neuen KS (Markus 1983). Es folgt daraus Hypothese 9:

H9: Umso proaktiver und umfassender der KS-Implementierungsplan mögliche Widerstands-szenarien adressiert, desto niedriger ist die Intensität des KS-Widerstands.

Auf Ebene der individuellen Jobprofile/-konditionen spricht Krovi (1993) von der Bedeutung, den Nutzern im Rahmen der KS-Nutzung Verantwortlichkeiten zuzuweisen, die diese motivieren und zur Nutzung des KS anregen. Joshi (1991) sieht zudem angemessenen Lohn und eine Verbesserung des Jobstatus als wirksame Maßnahmen gegen Widerstand an. Die letzte Hypothese lautet daher:

H10: Umso eher der neue Verantwortungsbereich eines Nutzers durch Anreize honoriert wird, desto niedriger ist die Intensität des KS-Widerstands.

5 Diskussion

Obwohl die Forschungsliteratur zum Thema Ursachen von KS-Widerstand noch nicht sehr umfassend ist, scheint die Lücke im Bereich der Maßnahmen noch größer zu sein. In der bisherigen Forschung werden zwar Maßnahmen erwähnt, doch sind viele dieser Maßnahmen sehr generisch und die Übertragbarkeit auf KS ist fraglich. Ähnlich haben auch Rivard und Lapointe (2012), die in ihrem Artikel detailliert die Reaktionen und Maßnahmen des Managements auf Widerstand untersuchen, nur wenige Artikel gefunden, die sich auf die Reaktion des Managements auf Widerstand beziehen. Zudem listen Krovi (1993) und Jiang et al. (2000) zwar verschiedene Maßnahmen auf, führen diese aber nicht weiter aus. Die zukünftige Forschung sollte daher aufbauend auf den oben genannten Artikeln eine vertiefte Betrachtung dieser Maßnahmen durchführen. Dabei wäre auch eine differenziertere Betrachtung der Maßnahmen sinnvoll, welche die Auswirkungen von vermindernden und vorbeugenden Maßnahmen im Detail untersucht. Ebenfalls relevant ist die Untersuchung, ob einige Maßnahmen personenabhängig sind (beispielsweise offene und ehrliche Kommunikation) oder ob sich dafür organisatorische Empfehlungen oder Vorgaben definieren lassen.

Viele Autorinnen und Autoren haben die individuellen Faktoren und insbesondere die Angst vor Bedrohung und Verlusten als wichtigste Ursachen von IS-Widerstandes identifiziert. Es ist jedoch auch hier festzustellen, dass nur wenig Forschung zu den Beziehungen zwischen Ursachen und Widerstand vorhanden ist, insbesondere ob bestimmte Ursachen bestimmte Arten von Widerstand erzeugen. In ihrer Recherche haben auch Bhattacherjee und Hikmet (2007) kaum Aussagen gefunden, die Ursachen und Ergebnisse von Widerstand in einem nomologischen Netz verbinden. Es gibt allerdings wenige Ausnahmen. So leisten z.B. gut ausgebildete, lernfähige Angestellte mit hohem Status eher aktiven Widerstand (Lapointe und Rivard 2005). Trotz dieses Beispiels besteht noch deutlich Forschungsbedarf in Bezug auf die Rolle und Auswirkungen verschiedener Ursachen auf die Intensität und Arten von KS-Widerstand.

Die technologischen Faktoren werden in Abschnitt 4.1.3 im Vergleich zu den nicht-technologischen Faktoren nur relativ kurz behandelt, da technologische Faktoren zwar in der Literatur häufig aufgelistet, aber selten in der Tiefe behandelt und ihnen häufig im Vergleich zu den individuellen und organisatorischen Ursachen weniger Bedeutung zugewiesen wird. Wenig thematisiert wurde bis heute die Rolle von Kultur und sozialem Einfluss auf Widerstand in Unternehmen und die Frage, ob eine gute soziale Vernetzung zu weniger oder mehr Widerstand führt. Insbesondere im Hinblick auf KS ist diese Fragestellung jedoch von besonderer Relevanz, da die soziale Vernetzung auch als ein wesentlicher Erfolgsfaktor derartiger IS gilt.

6 Zusammenfassung

Im Rahmen dieses Beitrags wurde der bisherige Forschungsstand zu KS-Widerstand analysiert und synthetisiert. Dazu wurde mithilfe einer systematischen Literaturanalyse anhand 30 wissenschaftlicher Publikationen ein theoretisches Forschungsmodell entwickelt, das Ursachen von KS-Widerstand und entsprechende Gegenmaßnahmen klassifiziert und deren Effekte beschreibt. Es konnte aufgezeigt werden, wo Forschungslücken vorherrschen. So ist die Anzahl der bestehenden wissenschaftlichen Publikationen zum Thema Widerstand im Hinblick auf KS immer noch gering, auch wenn die Zahl der Publikationen in den letzten Jahren leicht gestiegen ist. Weiteres Forschungspotenzial besteht hinsichtlich der Maßnahmen und der detaillierten Auswirkungen verschiedener Ursachen.

Mit der Synthese und der Analyse des Wissenstands in der bisherigen Forschung kann der vorliegende Beitrag zu einem besseren Verständnis und Umgang mit KS-Widerstand in Theorie und Praxis beitragen. Forscher profitieren von der systematischen Klassifikation und Gegenüberstellung verschiedener Faktoren im Forschungsmodell und dem Aufzeigen der oben genannten Forschungslücken. Praktiker erhalten eine kompakte Übersicht bzgl. der Aufdeckung und der Ursachen von KS-Widerstand und erste Anhaltspunkte, mit welchen Maßnahmen sie auf möglichen KS-Widerstand im Unternehmen reagieren können. Anhand der synthetisierten Konzepte und der dargestellten Beziehungen können Verantwortliche Schlussfolgerungen ziehen, die vor, während oder nach einer KS-Implementation von Nutzen sein können. Durch die gewonnenen Erkenntnisse wird es im Berufsalltag leichter fallen, kritische Aussagen der Nutzer zu neuen KS zu interpretieren, Beobachtungen einzuordnen und ggf. die Verantwortlichen in Bezug auf KS-Widerstand zu beraten.

Dieser Beitrag hat allerdings auch Einschränkungen, die berücksichtigt werden sollten. Erstens beschränkte sich die systematische Literaturuntersuchung aufgrund des gegebenen Rahmens auf 30 Artikel, deren Auswahl auch durch subjektive Eindrücke geprägt ist. Zweitens fokussierte die Auswahl, Klassifikation und Analyse der Literatur ausschließlich auf Ursachen und Maßnahmen von Widerstand. Es ist möglich, dass durch diese Fokussierung weitere relevante Aspekte zum Thema nicht beachtet wurden. Drittens wurden aufgrund geringer Forschungsdichte viele Erkenntnisse aus der allgemeinen Literatur zu IS-Widerstand auf KS übertragen. Es ist daher Aufgabe zukünftiger Forschung empirisch zu prüfen, inwieweit die hier abgeleiteten Hypothesen sich tatsächlich auf KS anwenden lassen und inwiefern Anpassungen oder Ergänzungen des theoretischen Forschungsmodells vorzunehmen sind.

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What Do We Know About Task Characteristics of Crowdsourcing?

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Abstract

Digitalization and the Internet changed our life. Many phenomena are responsible for this change. A relatively new one is crowdsourcing. Companies such as Amazon or Procter and Gambles use crowdsourcing successfully. The change will continue and we need to fully understand this subject to use the potential offered by this new phenomenon. This literature review summarizes and structures the crowdsourcing literature with focusing on the crowdsourcability of tasks. We analyzed the outsourcing literature to build a framework and adopted 7 perspectives, which were used to describe the outsourcability of tasks. The framework helps us to structure and analyze the crowdsourcing literature with focusing on the crowdsourcability of tasks. We found relevant literature regarding every perspective, but great research gaps were shown concerning these perspectives, leading to the assumption that the task characteristics of crowdsourcing are not sufficiently explored by the state-of-the-art literature. More research is needed to fully understand and use the potential of crowdsourcing.

1 Introduction

We live in a world of constant change. Since its invention, the Internet is a driving factor for changes in our life. In our professional life, digitalization and the Internet unfolded their potential in many different ways. Jeff Howe identified a new change in his Wired Magazine article in 2006 and called it "crowdsourcing". The fundamental idea of crowdsourcing is that a crowdsourcer (which could be a company, an institution, or a non-profit organization) proposes the voluntary undertaking of a task presented in an open call to an undefined group of contributors (individuals, formal or informal teams, other companies) (Blohm et al. 2012).

Ever since, many organizations changed their tasks through crowdsourcing (Geiger et al. 2011). Numerous examples of success stories can be found with companies using crowdsourcing in their business tasks or them being based on it (Stol and Fitzgerald 2014). Amazons marketplace for workforce "Mechanical Turk" or Procter and Gambles innovation platform "Connect + Develop" are just two examples of the diverse possibilities crowdsourcing offers. Among the success factors of crowdsourcing are for instance (1) a high number of people who are easy accessible and who can execute tasks (2) anytime (3) at low costs (Malone et al. 2011). These factors lead to competitive advantages for the crowdsourcing companies (Prpic et al. 2015). As a result of this development, a new management decision occurred, dealing with the question “What tasks can we crowdsource?”. But to crowdsource intelligently, we have to fully understand the potential of crowdsourcing. It is important to understand which characteristics of tasks influence the “crowdsourcability” of a certain task. Crowdsourcing is a relatively new field of research, a limited amount of literature in the task context is available, and therefore, researchers suggest to further analyze the fit between task and crowdsourcing (Chiu et al. 2014, Afuah and Tucci 2012, Zhao and Zhu 2014).

In order to address this research gap, the present paper summarizes and structures the current research of crowdsourcing through a literature review with focusing on the characteristics of tasks’ crowdsourcability. It is conducted according to vom Brocke et al. (2009) and Webster and Watson (2002). On the basis of the outsourcing literature, we will develop a framework with 7 different perspectives with which the outsourcability of tasks was analyzed, and we will apply them on crowdsourcing. Extensive literature is dedicated to the question of what task an organization could outsource (Gerbl et al. 2015). Frameworks were created to understand which characteristics of a task have to be considered for the decision whether to “make or buy”. Now, with the third dimension “crowd” in play, a similar question arises for management and science.

This paper proceeds as follows: Chapter 2 describes the structure of the literature review, which uses the framework according to vom Brocke et al (2009). In addition to that, we explain the conceptualization of the topic and how we will categorize the literature in 7 perspectives. Chapter 3 focuses on the findings and offers insights on the literature found concerning every perspective. Chapter 4 discusses these results and offers a research agenda. In chapter 5, we reflect on our present paper critically by concentrating on possible limitations. Finally, we conclude our literature review in Chapter 6.

2 Literature Review

The literature review follows the five steps of the framework of vom Brocke et al. (2009): 1) Definition of the Review Scope, 2) Conceptualization of the Topic, 3) Literature Search, 4) Literature Analysis and Synthesis, and 5) Derivation of a Research Agenda.

Characteristic		Categories			
1	focus	research outcomes	research methods	theories	applications
2	goal	integration	criticism	central issue	
3	organization	historical	conceptual	methodological	
4	perspective	neutral representation	espousal of position		
5	audience	specialized scholars	general scholars	practitioners	general public
6	coverage	exhaustive	exhaustive & selective	representative	central/pivotal

Table 1: Review Scope

2.1 Definition of Review Scope

To define the review scope, we followed the taxonomy by Cooper (1988). This literature review focuses on research outcomes and theories related to the crowdsourcability of tasks. The paper aims to integrate the present state of the art in crowdsourcability of tasks into a conceptual overview. The existing body of knowledge will address general and specialized scholars.

2.2 Conceptualization of the Topic

Crowdsourcing is closely related to outsourcing. “Many of the problems identified in this crowdsourcing initiative are very similar to the problems reported in the early days of outsourcing” (Nevo et al. 2012, 15). On the one hand, Gossman and Helpman (2002) define outsourcing as subcontracting a set of internal activities in a bilateral relationship to an external organization, for example another company. On the other hand, Leimeister and Zogaj (2015) regard crowdsourcing as proposing work to an undefined mass, the crowd. In crowdsourcing, we observe three different models: (1) internal crowdsourcing, which organizes an internal crowd through an internal platform, (2) external crowdsourcing without mediation, which organizes an external crowd through an internal platform, and (3) crowdsourcing with an intermediary, where an external crowd is organized by an external platform (Leimeister and Zogaj 2013). In this paper, we focus on the third model, crowdsourcing with an intermediary, considering that we use a conceptual outsourcing framework to analyze the literature and crowdsourcing with an intermediary, which among all crowdsourcing models is the closest to outsourcing. Both sourcing types give an internal task to a single player outside. The task will equally be sourced externally, but in the context of outsourcing, the task will often be executed by a single employee; in the context of crowdsourcing, the task will often be executed by an undefined group of individuals. Since outsourcing is a mature field of science compared to the field of crowdsourcing, it seems advantageous to use the experience of outsourcing and to apply it to a certain extent in the field of crowdsourcing.

We develop our conceptional framework based on the contributions of Gerbl et al. (2015), Graf and Mudambi (2005), and Vining and Globerman (1999); each of them created a framework explaining the outsourcability of tasks. According to Nevo et al. (2012), the outsourcing client perspective was mostly used to analyze the outsource capabilities. All papers share this perspective, as for instance Gerbl et al. (2015). They drew a conceptual framework from the transaction cost and resource-based view theories, combining firm-level and process-level factors with location attractiveness. The transaction cost theory seems especially suitable due to the fact that its main objective is to analyze the circumstances under which market governance is more cost-efficient within the boundaries of a firm or outside of them (Dibbern 2008), and because it is the most used theory in the context of outsourcing (Perunović 2007). Furthermore, the combination of firm-level, process-level, and location by Gerbl et al. (2015) seems beneficial because, besides internal aspects, it also takes into account that locations inherit diverse circumstances linked to their different distances and combines this with internal aspects. In addition to that, we also consider Gerbl et al. (2015) with including the paper of Graf and Mudambi (2005), whose objective it is to improve the understanding of the location decision. At the same time, we add the paper of Vining and Globerman (1999), who focus on the internal aspects, such as the decision to source. With these two papers extending the work of Gerbl et al. (2015), we want to develop a comprehensive framework. Finally, we will use this framework to analyze the crowdsourcing literature. The literature has to be synthesized into appropriate categories, which have to be developed. Following, we describe these categories:

- Complexity Perspective: This category refers to the complex interdependencies mentioned in the paper by Gerbl et al. (2015). It summarizes papers that deal with the general question of what task is crowdsourcable. The modulation of tasks, the coordination and communication outside the modulated tasks, and the understanding related to it are examples that are of interest. If the complex interdependencies are high, the need for coordination will increase the transaction costs, and they are therefore important for the crowdsourcability.

- Uncertainty Perspective: This category refers to the uncertainty that can occur as a result of changing requirements for the intermediary's customer. Changing circumstances due to quick cycles may frequently lead to changing task requirements. This would result in lower crowdsourcing ability because the specification prior to crowdsourcing a task would change too fast.
- Control Perspective: This category refers to the performance measurement difficulties related to the contribution and performance by the intermediary's crowd. Precisely defining measurable outcomes is the focus of this category. In addition to that, people of the crowd cheating concerning the measurements are of interest. If measurement categories are not defined properly, the quality of the results delivered by the crowd cannot be assed, making crowdsourcing impossible.
- Knowledge Security Perspective: This category refers to intellectual protection issues. Legal mechanisms, such as patents, NDAs, or trusted crowds can be crucial for a company prior to crowdsourcing a task to protect itself against data loss or other issues.
- Strategic Perspective: This category refers to the strategic level of crowdsourcing with regards to the competitive advantage. It also covers issues concerning the availability of internal resources and crowdsourcing capabilities, skills, and experiences concerning crowdsourcing, such as language or crowdsourcing management skills.
- Cost Perspective: This category refers to costs involved in crowdsourcing a task. It covers aspects such as preparing the crowdsourcing process internally, or external costs such as paying the intermediary.
- Quality Perspective: This category is related to the outcome quality of the crowdsourced task delivered by the intermediary. This includes all possible outcomes, for instance ideas, investments, or software. If the crowd cannot deliver results with acceptable quality concerning a specific task, this task will not be crowdsourcable.

Besides the conceptual framework, the literature review is based on a definition of the key variables (Webster and Watson 2002). The paper focuses on structuring the characteristics of task crowdsourcability. We will adapt the search of key words to the framework we develop in this paper.

2.3 Literature Search

Relevant articles are identified by a systematic literature review to guarantee comprehensibility and traceability of the process. A journal search on diverse databases and a key word search was conducted. In addition to that, a forward and backwards search was executed.

The journal search was conducted on the following databases: EBSCO (Business Source Complete), Web of Science, ProQuest, Emerald, and ScienceDirect. Concerning the key variables, we used the following: 1. "crowdsourcing" AND "complexity", 2. "crowdsourcing" AND "Uncertainty", 3. "crowdsourcing" AND "Control", 4. "crowdsourcing" AND "Cost", 5. "crowdsourcing" AND "Knowledge", 6. "crowdsourcing" AND "Strategy", and 7. "crowdsourcing" AND "Quality".

The literature review identified 46 papers, of which 27 were considered relevant. A paper was considered relevant, if it had contributed to explaining the crowdsourcability of a task according to one or more of the seven perspectives developed in this paper. Eleven of them were found through forward and backwards search. Nineteen papers were considered irrelevant due to their lack of contribution to any perspective developed in this paper.

3 Findings

Overall, the existing research on the crowdsourcability of tasks contributes to every perspective we developed in this paper.

- Complexity Perspective: A company can crowdsource simple, complex, and creative tasks (Schenk and Guittard 2011). A simple task includes rather poor cognitive requirements, and crowdsourcees receive mostly micropayments. Crowdsourcing a simple task seems interesting in a case where many simple tasks are crowdsourced. That means, the bigger the amount of simple tasks of an organization, the more likely it is that this organization decides to crowdsource them. On a small scale, it is cheap to deal with it internally, but on a big scale, it becomes cheaper to crowdsource. Crowdsourcing complex tasks is defined as knowledge-intensive problem solving. Crowdsourcing complex tasks appeared to be more crowdsourcable, the more frequently the problem had already been solved outside the company. Contrary to Afuah and Tucci (2012), Schenk and Guittard (2011) believe that if the problem needs very rare and specific skills or expertise, it is less likely to be successfully crowdsourced. For instance, if crowdsourced software development projects require rare technical skills and these are not available, then the projects will hardly receive any submissions (Nevo et al. 2012). This means, the more the required knowledge for a task is available by the crowd, the higher is the crowdsourcability of a task. On the other side, every task is crowdsourcable as long as the task is simple to describe, to communicate, and to modularize (Afuah and Tucci 2012).
- There is an alternative way of looking at task complexity (Nakatsu et al. 2014). Crowdsourcing can also be described as a threefold phenomenon. It includes 1) task structure, which describes how well a task is defined or specified. The second aspect 2) covers task interdependence, describing how well a task can be solved by an individual or group. Finally, there is 3) the task commitment, describing which level of commitment is expected. Nevo et al. (2012) focused on software development tasks, which are well suited for crowdsourcing. They addressed the first aspect 1) of Nakatsu by pointing out that tasks with a clear specification, low priority, and no need for domain knowledge are particularly appropriate for crowdsourcing. In terms of task type, they identified new developments, which are not closely linked to existing functionality, labor-intensive tasks with low skill requirements, or idea generation, and which are regarded as suitable for crowdsourcing. Existing applications may be difficult to decompose due to internal dependencies or licensing agreements.
- Uncertainty Perspective: Software development tasks in an agile life cycle can be problematic due to specification issues. It is difficult to define the stories in advance (Nevo et al. 2012). This means, the better a process can be anticipated for a timeframe wide enough leading to a high predictability and stable specifications, the higher is the chance to decide to crowdsource. Therefore, it seems that the degree of task repetition may influence crowdsourcability. The higher the repetition rate, the lower is the uncertainty of a possible change in the crowdsourcing

process, and the more likely it is to crowdsource. In general, the lower the uncertainty, the higher is the chance to decide to crowdsource.

- Control Perspective: It is critical to the success of a crowdsourcing project to establish specific measurements to evaluate the outcomes. If a task is crowdsourced, it is important to be able to control the result. The easier the outcome of a crowdsourced task can be controlled, the higher is the crowdsourcablity of a task (Ford et al. 2015). Some measures were described in the literature. Similar to rating scales, they were identified as performance measurements in terms of evaluating decision quality in an idea generation context (Riedl et al. 2013). The literature indicated that a multi-criteria scale outperforms a single-criteria scale, leading to higher decision quality. In addition to that, multiple criteria scales can complement or replace expert panels in their assessment of customer-based idea generation (Blohm et al. 2011). Another alternative could be automated control mechanisms. They were successfully used to control the output of the crowd (Lee et al. 2011). All these measurements are useful to counter cheaters. In addition to that, cheaters are less frequently found with novel tasks that require abstract thinking or creativity. Also, tasks with less reusable outcomes are less frequently approached by cheaters (Eickhoff and Vries 2013). To summarize, tasks with higher control through specific measurements and other means may be more likely to be crowdsourced.

- Knowledge Security Perspective: Several knowledge security problems arise if crowdsourcing is used as a tool. One matter is that companies have to open up to internal problems. This new management philosophy is sometimes difficult to implement. Another one is the IP ownership and the concern about how the company can ensure its intellectual property if a new idea is generated outside (Bonabeau 2009). As a solution, intellectual property and trade secrets can be protected through contractual constrains. As alternative solution, the possibility to decompose a task in a manner that leads to the original problem not being understandable for a single crowdworker could be considered (Ford et al. 2015). Therefore, it seems that the better the internal IP is protected and the clearer the IP situation is, the higher is the crowdsourcability of a task.

- Strategic Perspective: Crowdsourcing can significantly influence a company's ability by leveraging previously unattained resources to build competitive advantages. The strategic value could only be gained by aligning the purpose of engaging with crowdsourcing with the goals of the company, and therefore, the type of knowledge or expertise needed from the crowd in order to access the proper crowd directly needs to be defined in advance. Finally, the outcomes of the crowd need to be aligned with existing internal processes (Prpic et al. 2015). This means, the better the purpose of engaging with crowdsourcing is aligned with the outcome, the more likely it is that a task is crowdsourcable.

- Apart from the alignment, employees and the company's capabilities also influence the strategic perspective. A company that does not have the necessary internal capabilities should consider crowdsourcing. This lets us assume that the lesser necessary internal expertise a company has, the more likely a task could be considered to be crowdsourced. The motivation of employees is important, leading to the suggestion that high routine tasks should be considered for crowdsourcing due to the effect of demotivating employees internally also resulting in lower quality (Ford et al. 2015). It also seems more likely to decide to crowdsource in the strategic perspective, the higher the routine characteristic of a task is. But crowdsourcing should only be considered if enough experience or/and time is available. If not, the company will not receive a suitable solution from the crowd or will not be able to use the solution. The literature provides recommendations to build an effective absorption capacity, such as creating high acceptance for crowdsourcing among the internal employees of a company or focus on tasks that are precisely explainable and easy to understand (Blohm et al. 2012). Therefore, the more experience in crowdsourcing and the more time a company has for the crowdsourcing project, the higher is the crowdsourcability of a task.

- In addition to that, crowdsourcing a task to an intermediary is also connected to a strategic risk if a platform changes its business model or processes. Following that string of argumentation, a task is more crowdsourcable, the better intermediaries can signal a potentially long-lasting business relationship. Furthermore, companies should start with little and simple projects with low risk involved. Through first positive experiences, companies collect valuable crowdsourcing experience and decrease internal doubts that make the project management more complicated (Schenk and Guittard 2009).
- Cost Perspective: The costs involved in projects vary according to the nature of crowdsourcing, ranging from micropayments to several thousands of Dollars (Schenk and Guittard 2011). For instance, due to crowdsourcing, complex infrastructure for software development may be needed, such as having two development and test environments (Nova et al. 2012). Some cost categories are related to crowdsourcing, such as costs of planning and organizing a crowdsourcing project, the costs of employing the crowd and/or the intermediary, and finally the costs related to manage the changes required to implement the crowdsourced solutions. In addition to that, crowdsourcing costs should be looked at as outsourcing costs and cost savings potential. This means the literature relates certain cost saving potential with outsourcing, and the same potential is seen in crowdsourcing. As examples, availability on a flexible demand basis, increased time to market, or the filter function of intermediaries resulting in presenting only the most promising crowd solutions to the customer, and avoiding time spent with contributions by underperforming employees are mentioned. To summarize, costs have to be smaller than the benefits (Ford et al. 2015). This would mean that the bigger the positive delta between benefits and costs, the higher is the potential to be crowdsourcable.
- Quality Perspective: The quality of the outcome, as a benefit of crowdsourced tasks, has an influence on the crowdsourcability of tasks. If the crowd delivers an unacceptable level of quality concerning a certain task type, consequently, this type of task cannot be considered for crowdsourcing. Therefore, we will look at different quality outcomes of crowdsourcing. There are different definitions for the quality of a crowdsourcing outcome. For instance, the quality of simple tasks could be defined as the amount of tasks achieved, and complex tasks could be defined as the characteristics of the problem's solution or originality (Schenk and Guittard 2011). In the field of software development, the quality of crowdsourced submissions was in certain projects marginally acceptable (Nevo et al. 2012). This may be related to the crowdsourcees' capabilities, because the quality of outcome is related to the crowdsourcees' abilities and qualities (Allahbakhsh et al. 2013). Another possibility may be a low motivation or a high complexity of the task, because motivation is positively and task complexity is negatively related to quality (Lee et al. 2015). By contrast, Zaidan et al. (2011) demonstrated that non-professionals can deliver translations on a professional level at much lower costs than professional translators. In addition, it was also shown that certain training improves the outcome of tasks (Lee et al. 2010). But quality can also be improved by selecting the right criteria for crowdsourcees as orientation for their work. Giving crowdsourcees the right criteria for their annotations increases the quality (Hsueh et al. 2009). Certain tasks can be even more suitable

for crowdwork than for experts, such as applications where many varied data points are collected. In this case, a heterogeneous crowd is better for delivering a higher quality than a homogenous group of experts (Kitter et al. 2008). Moreover, an automated aspect in allocating information through crowdsourcees increased the quality (Oleson et al. 2011). If it comes to novelty and costumer fit, Poetz et al. (2012) claim that user-generated ideas outperform professionals, but do so a little less concerning feasibility. We saw examples with marginally acceptable outcomes and some with acceptable outcomes. This means, the higher the quality as a form of benefit, the higher is the crowdsourcability. Finally, it depends on the delta described before. The bigger the delta between benefit and costs, the more likely a task can be crowdsourced.

4 Discussion and Research Agenda

Prior to the literature review, we looked at the outsourcing literature. We examined concerning which perspectives the outsourcability of tasks was analyzed. Furthermore, we identified seven perspectives and examined the state of the art of the crowdsourcability of tasks according to our perspectives. This paper reveals that the research of crowdsourcing in the perspective of outsourcability is in certain areas at an early stage. There are no sufficient research results to fully understand all task characteristics of crowdsourcing. Although a few papers cover all perspectives, the depth of the research is not yet sufficient.

First, the complexity perspective distinguished between simple, complex and creative tasks in a synthetic and analytical perspective (Schenk and Guittard 2011). It would be very useful to back this perspective with a broader empirical basis of practical examples to verify the perspective and better understand the impact of complexity on crowdsourcability of tasks. Furthermore, every task is crowdsourcable as long as it can be easily described, communicated, and modularized (Afuah and Tucci 2012). Therefore, future research could focus on how a task could effectively be described, communicated, and modularized in regards to crowdsourcing a task, this means developing a systematic modularization method for crowdsourcing.

Second, an agile life cycle can be problematic due to specification issues (Nevo et al. 2012). If a task is to be crowdsourced, the aspect of a stable task specification should be addressed. Future research could focus on further verifying whether our suggestion that the lower the uncertainty, the more likely a company decides to crowdsource, is correct. A way of addressing this perspective could be looking for possibilities that could reduce uncertainty of crowdsourcing tasks, to increase the crowdsourcability.

Third, it seems that the control perspective could be more profoundly explored by developing a more generic translation of a basic measurement system, which could be used for adaption concerning a novel task. A certain elementary framework could further explain the depth of the control perspective. Therefore, future research could focus on measurement possibilities in different project settings. A framework might be developed to standardize the measurement process for certain types of tasks. With this in mind, the success of crowdsourcing projects could become more comparable. This comparability could be a good indicator for the crowdsourcability potential of projects. Another limitation of control approaches is derived from the subjective nature of quality; developing a more objective definition would be necessary (Allahbakhsh et al. 2013). Considering the importance of the control perspective, not many papers were published. The better the crowdsourcing task can be controlled, the higher is the crowdsourcability of a task.

Fourth, our results suggest that a clear and well-protected IP may be important for the decision to crowdsource. To expand the set of possible crowdsourcing tasks and to further use its potential, it is important to find actual solutions. If the IP issues were further explored, the crowdsourcers would have more security possibilities for their tasks, thus an increased crowdsourcability. Some important questions in this field were addressed (Bonabeau 2009, Ford et al. 2015), but it lacks for example an empiric study with a meaningful amount of cases and a useful diversity of possible solutions as outcomes. If such a study is not conducted in the future, the field of crowdsourcing will limit itself unnecessarily to a smaller field than it actually could be, and it will leaves certain tasks with a decreased crowdsourcability.

Fifth, crowdsourcing is mostly regarded as a complementary tool to the old business model to create additional competitive advantage. By contrast, it should also be considered as a way to change business models in order to adapt to changes in the environment of a company. In some strategic situations, crowdsourcing might not just be a tool but a game changer, changing the organizational structure of organizations. If the strategic potentials of crowdsourcing are further explored, the general crowdsourcability of tasks can increase.

Sixth, it lacks a clear assessment of different crowdsourcing costs. If the cost perspective is not clearly analyzed, research will not be able to assess the real benefits crowdsourcing is potentially delivering. Beginnings of categorizing costs were found (Ford at al. 2015), but it needs further development and validation. It could be beneficial to pursue this path and to profit from the extensive research in the field of outsourcing costs. In addition to that, it might be useful to localize certain cost elements along the crowdsourcing process, from the planning phase to the result review via the actual execution of the crowdsourcing task. This could enhance the IT management ability to forecast the cost structure of crowdsourcing projects and to quantify the costs more properly. If costs are precisely predictable, the tasks will have an increased crowdsourcability.

Seventh, the field of crowdsourcing has not sufficiently looked into possible parallels of outsourcing and crowdsourcing characteristics. This comparison could be beneficial for crowdsourcing if findings in the field of outsourcing could be used in the crowdsourcing field. New findings could be generated faster with a good scientific foundation. An outcome could be a framework, which could be used as help to analyze the crowdsourcing potential of projects to increasingly visualize the crowdsourcability of a task.

Eighth, some perspectives are linked to each other. It seems important to analyze these links to better understand the matter of crowdsourcability. For instance, the quality perspective seems to be linked to the cost perspective. It still seems difficult to exactly quantify the delta between costs and quality or benefits, such as time to market, flexibility, or other benefits. In the future, it may be interesting to connect the cost and benefit dimensions more closely by offering a broader empirical basis of diverse practical examples to better explore the value generation of crowdsourcing. In the end, the benefits and quality of crowdsourcing might be described, but if they include higher costs, they seem to vanish; benefits must outweigh costs (Ford et al. 2015). If this equation is properly explored and it is possible to generate reliable predictions, the crowdsourced task will have an increased crowdsourcability. In addition to that, it also seems also reasonable to connect the control perspective to the quality perspective. These two perspectives were often mentioned together in papers and seem to influence each other directly. The more precisely and efficiently the control mechanisms work, the better the quality can be ensured. For instance, it would be more difficult for crowdsourcees to cheat and the crowdsourcing process would deliver more reliable results.

5 Limitations

With this paper, we conducted an extensive literature review to summarize and categorize the research in the field of crowdsourcing with regards to the task crowdsourcability characteristics. Critically reflecting on this paper, two aspects are worth to be mentioned. First, it is possible that there are further research papers not considered in this framework that might be relevant for this or a similar subject. Also, one should take into account that the papers addressed in this work were solely non-technical. Even though the technical background might play a role in the crowdsourcability of tasks, this aspect is outside the scope of this paper. Second, the core focus of this literature review was crowd-related. It is possible that non-crowd-related papers address further key issues.

6 Conclusion

The present paper categorized and summarized literature from the field of crowdsourcing and linked the findings to task characteristics of crowdsourcing. The categorization was structured according to outsourcing frameworks due to the extensive research experience in this field and the relation to crowdsourcing. On the one hand, the findings showed that every perspective was covered with research. On the other hand, the limitations showed great research gaps concerning these perspectives, leading to the assumption that the task characteristics of crowdsourcing are not sufficiently explored by the state-of-the-art literature. More research is needed in this field to fully understand and use the potential of crowdsourcing. Finally, we found that the relation between the research fields of outsourcing and crowdsourcing is quite new to the domain while it may offer substantial insights.

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Der Einfluss von Technologieeigenschaften von Group Decision Support Systemen auf Gruppenentscheidungen im Hidden Profile

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Abstract

Die beiden Übersichtsarbeiten von Wittenbaum et al. (2004) und Lu et al. (2012) zum Einfluss von Computer-Mediated Communication (CMC) auf die Entscheidungsqualität und den Anteil an geteilten Informationen im Hidden Profile Paradigma kamen jeweils zu inkonsistenten Ergebnissen. Als eine mögliche Erklärung gaben Lu et al. die unterschiedlichen Technologieeigenschaften der in den Studien verwendeten Group Decision Support Systems (GDSS) an. Um dieser Annahme nachzugehen wurden im Rahmen einer Übersichtsarbeit, mit dem Fokus auf die Technologieeigenschaften, relevante Artikel zusammengestellt und auf die Einflussfaktoren Erscheinungsjahr, Gruppengröße, Mediensynchronität, Anonymität und Support-Stufe untersucht. Neuere Studien liefern dabei einen höheren Anteil an positiven Ergebnissen als ältere Studien. Ebenso zeigen größere Gruppen tendenziell häufiger einen positiven Effekt als kleinere Gruppen. Bei den betrachteten Technologieeigenschaften ist zu erkennen, dass eine höhere Support-Stufe des GDSS, sowie die Möglichkeit zur asynchronen Kommunikation tendenziell eher zu positiven Ergebnissen führen. Anonymität hingegen führte zu gemischten Ergebnissen.

1 Einleitung und Motivation

Der zunehmende globale Wettbewerb sowie die damit einhergehende Nachfrage nach Arbeitskräften mit vielfältigen Fähigkeiten, Erfahrungen und Expertise (Kozlowski und Bell 2001) führten in den letzten Jahrzehnten zu einer wesentlichen Entwicklung in den Unternehmensstrukturen, dem Wandel von individuellen Jobs zu kooperativen und teambasierten Arbeitsstrukturen (Lawler et al. 1992). *„A collection of three or more individuals who interact intensively to provide an organizational product, plan, decision or service“,* so definierten Devine et al. (1999) die Aufgaben einer Gruppe bzw. eines Teams. Entscheidungen gewinnen dabei in der heutigen Arbeitswelt zunehmend an Komplexität (Hargadon 1998; Devine et al. 1999). Gruppen haben das Potenzial bessere Entscheidungen zu treffen als der individuelle Entscheidungsträger, da Wissen und Expertise mehrerer Personen in Gruppendiskussionen gebündelt werden kann (Davis and Toseland 1987).

Dabei stellt sich jedoch die Frage, wie effizient Gruppen in solchen Arbeitsstrukturen agieren. In der Literatur wird die Effizienz von Gruppenprozessen beschrieben als die Differenz von positiven und negativen Effekten der Gruppenarbeit (Davis und Toseland 1987). Die positiven Effekte auf das Ergebnis (Bspw. Qualität, Quantität oder Prozessdauer) durch die Gruppenarbeit im Vergleich zur Summe der Einzelarbeit von allen beteiligten werden dabei als Group Process Gain bezeichnet. Als positive Effekte der Gruppenarbeit gelten dabei zum einen Lerneffekte der Gruppenmitglieder untereinander und Synergieeffekte durch zum Beispiel unterschiedliche Fachrichtungen der Gruppenmitglieder. (Hackman und Morris 1975) Gruppenarbeit bietet wiederum auch die Möglichkeit sich Unterstützung und Bestätigung (Social Support) bei Gruppenmitgliedern für eigene Ideen oder Vorschläge zu holen (Carson et al. 2007). Group Process Losses wiederum beschreiben einen negativen Effekt auf das Ergebnis beim Vergleich von Gruppenarbeit zur Summe der Einzelarbeiten (Steiner 1972). Diese negativen Effekte entstehen zum Beispiel durch Konformitätsdruck (Conformity Pressure), durch den die Gruppenmitglieder bestrebt sind zu einer einheitlichen Meinung zu finden und daher eher zu einer Gruppenkonformen Meinung tendieren, als zu einer widerstrebenden (Bspw. Hackman and Morris 1975). Einen weiteren negativen Effekt beschreibt Evaluation Apprehension, bei dem eine verzerrte Bewertung von eigenen Beiträgen zu einer Gruppenarbeit stattfindet. Dabei werden die eigenen Beiträge als wichtiger wahrgenommen, als die von anderen Gruppenmitgliedern und auch Informationen als wichtiger wahrgenommen, die die eigene Meinung unterstützen, als die Beiträge, die mit der eignen Meinung im Konflikt stehen (Bspw. Diehl and Stroebe 1987). Ein struktureller Nachteil von Gruppenarbeit ist, dass die Effektivität sinkt, je mehr Personen an der Gruppenarbeit beteiligt sind. Denn in den meisten Situationen kann immer nur eine Person aktiv sein, während die anderen Teilnehmer zuhören und für diese Zeit geblockt sind und nicht an eigenen Beiträgen arbeiten können (Production Blocking) (Bspw. Diehl und Stroebe 1987). Um die Effizienz von Gruppenprozessen zu steigern gilt es demnach die positiven Effekte der Group Process Gains zu maximieren, während gleichzeitig versucht wird den negativen Einfluss der Group Process Losses zu minimieren.

Informations- und Kommunikationstechnologien bieten in diesem Rahmen neue Möglichkeiten, von der einfachen Unterstützung des Informationsaustausches bis hin zur Überbrückung von zeitlichen und räumlichen Barrieren in virtuellen Teams (Davis und Toseland 1987; Kozlowski und Bell 2001). Demnach ist anzunehmen, dass die Entscheidungsqualität durch den Einsatz von unterstützenden Kommunikationstechnologien gegenüber traditioneller Face-to-Face Kommunikation (FTF) verbessert wird, da diese die insgesamt verfügbare Informationsmenge erhöhen und der Informationsaustausch besser strukturiert werden kann (Bspw. Dennis 1996a; McLeod et al. 1997). Jedoch zeigen Studien einen inkonsistenten Effekt von CMC auf die Qualität von Gruppenentscheidungen. Dabei zeigen einige Studien einen positiven Effekt von CMC im Vergleich zu FTF Gruppen (Bspw. Dennis 1996; Lam und Schaubroeck 2000). Andere Studien wiederum zeigen einen negativen Effekt auf (Bspw. Hightower und Sayeed 1995; Baltes et al. 2002; Li 2007). Wittenbaum et al. stellen in ihrer Übersichtsarbeit die inkonsistenten Ergebnisse in diesem Forschungsbereich zusammen und nennen als einen möglichen Erklärungsansatz das Jahr, in dem die Studien durchgeführt wurden. Bei aktuellen Studien soll demnach ein höherer Anteil an positiven Effekten zu erwarten sein. Begründet wird dies mit dem gesteigerten Stellenwert, den Technologie im Alltag einnimmt und der somit höheren Vertrautheit der Probanden. (Wittenbaum et al. 2004) Aufgrund der steigenden Bedeutung von Technologien als Kommunikationsmedium in Unternehmen (Wittenbaum et al. 2004) verwenden Wissenschaftler GDSS bzw. CMC zunehmend als Standardmedium zur Untersuchung des Informationsaustausches im Rahmen von Gruppenentscheidungen (Bspw. Mennecke 1997; Postmes et al. 2001). Aufbauend auf den

Ergebnissen von Wittenbaum führten Lu et al. (2012) eine Meta-Analyse mit dem Ergebnis durch, dass auch hier kein eindeutiger Effekt von CMC auf das Teilen von einzigartigen Informationen oder das lösen der Hidden Profile Aufgabe nachweisbar war. Die Autoren merken jedoch an, dass ein positiver Effekt von CMC zu erwarten war und begründen dies mit den Möglichkeiten der Anonymität und Strukturierung von Informationen durch GDSS und stützen sich dabei auf die Ergebnisse von Dennis et al. (1996b; 1996c). Als eine mögliche Begründung führen die Autoren an, dass nur wenige der betrachteten Studien vergleichbare Softwarelösungen verwendet haben, sodass sie keine genaue Untersuchung durchführen konnten. Daher sehen Lu et al. weiteren Forschungsbedarf in diesem Bereich, um den Effekt einzelner, verschiedener Technologien besser zu untersuchen und zu beschreiben (Lu et al. 2012). Anknüpfend an diese Ergebnisse wurde im Rahmen einer Übersichtsarbeit untersucht, ob unterschiedliche Technologieeigenschaften als Erklärungsansatz für die inkonsistenten Ergebnisse der Studien im Bereich der Forschung zu GDSS in Frage kommen.

2 Qualität von Gruppenentscheidungen

Das wichtigste Effizienzkriterium von Gruppenentscheidungen ist dabei die Qualität der getroffenen Entscheidungen. Diese sollen nicht nur möglichst schnell getroffen werden können, sondern es muss auch die beste der Entscheidungsoptionen ausgewählt werden. Als wesentlicher Faktor auf die Qualität von Gruppenentscheidungen wurde von Stasser und Titus (1985) das Teilen von einzigartigen, ungeteilten Informationen beschrieben. Laut diesen entsteht ein großer Verlust an Entscheidungsqualität dadurch, dass Gruppenmitglieder, die als einzige eine bestimmte Information besitzen, diese nicht mit ihrer Gruppe teilen. Durch dieses Zurückhalten von Informationen wird die Entscheidung auf Grundlage weniger Informationen gefällt, als eigentlich zur Verfügung stehen würden (Stasser und Titus 1985). Das Messen der Entscheidungsqualität gestaltet sich jedoch als schwierig, da für die meisten Entscheidungssituationen nicht bekannt ist, welche Informationen es insgesamt gibt, wie diese Informationen verteilt sind und welche der Optionen die beste Wahl darstellt. Um dem entgegenzuwirken und um das Entscheidungsproblem konstant für alle Probanden zu halten, hat sich in der Forschung zu Gruppenentscheidungsprozessen das Hidden Profile Paradigma etabliert (Bspw. Dennis 1996; Van Swol et al. 2003). Beim Hidden Profile Paradigma werden die Probanden in Gruppen von meist vier bis sechs Teilnehmern aufgeteilt und vor ein Entscheidungsproblem mit zwei Entscheidungsoptionen gestellt. Zu Beginn des Experiments bekommt jeder Proband einen Einleitungstext, der Informationen zu den Entscheidungsoptionen enthält. Dabei wird zwischen geteilten Informationen, die jedes Gruppenmitglied bekommt, und einzigartigen Informationen, die jeweils nur ein Gruppenmitglied bekommt, unterschieden. Die Informationen sind dabei so verteilt, dass jeder Proband anhand seiner Startverteilung an Informationen eine der Entscheidungsoptionen bevorzugt. Nimmt man jedoch alle verfügbaren Informationen zusammen ist zu erkennen, dass eigentlich die andere Option die bessere Wahl ist. Um dies zu erkennen müssen die Probanden während der Diskussionsphase des Experiments möglichst viele ihrer ungeteilten, einzigartigen Informationen mit den anderen Gruppenmitgliedern teilen.

3 Einflussvariablen

Aufbauend auf den Ergebnissen und Empfehlungen der Studien von Wittenbaum et al. (2004) und Lu et al. (2012) wurden die fünf Variablen (1) Erscheinungsjahr der Studie, (2) Gruppengröße, (3) Anonymität, (4) Synchronität und (5) Support-Level identifiziert, die einen möglichen Einfluss von Technologieeigenschaften auf den Informationsaustausch und die Entscheidungsqualität haben können. (1) Laut Wittenbaum, Hollingshead und Botero (2004) könnten negative Einflüsse durch computervermittelte Kommunikation, welche in Studien der 90er Jahre beobachtet wurden, möglicherweise nicht mehr zu replizieren sein, da Menschen heutzutage zunehmend erfahrener und versierter im Umgang mit Technologien sind. (2) Production Blocking ist ein wesentlicher Nachteil verbaler Kommunikation, der bei steigender Gruppengröße immer mehr an Gewicht zunimmt (Diehl und Stroebe 1987; Dennis und Wixom 2001). Dabei kann CMC, durch Parallelismus, helfen Process Losses, gerade bei größeren Gruppen, zu mindern (Valacich et al. 1992; Lowry et al. 2006). Parallelismus schwächt den Effekt des Production Blocking ab, denn Gruppenmitglieder müssen nicht darauf warten, dass ein anderes Mitglied seinen Informationsbeitrag abgeschlossen hat, sondern können simultan Informationen in eine Diskussion einbringen (Dennis und Wixom 2001). (3) Anonymität ermöglicht es Gruppenmitgliedern Informationen einzubringen, ohne identifiziert zu werden und kann somit die Motivation zum Beitrag von Informationen fördern (Dennis and Wixom 2001). (4) Die Auswirkungen von Media Synchronicity auf Gruppenentscheidungen war der Fokus mehrerer Studien (Bspw. Hassel und Limayem 2011; Murthy und Kerr 2004; Münzer und Holmer 2009). Neben den Variablen des zeitlichen Feedbacks und den eingesetzten Kommunikationsmedien, wurde hierbei zwischen zwei Kommunikationsprozessen unterschieden: Vermittlungsprozesse beinhalten den Austausch großer Mengen von Informationen; Konvergenz führt zu einem gemeinsamen Verständnis von Informationen (Hassel und Limayem 2011). Verschiedene Medien unterstützen diese zwei Prozesse in unterschiedlichem Maße. Hassel und Limayem (2011) zeigten, dass Gruppen, die asynchrone Textkommunikation verwendeten, d. h. Medien niedriger Synchronität, mehr Informationen austauschten und bessere Entscheidungen trafen, als solche, die per Audio-Video-Konferenz, d. h. Medien hoher Synchronität, kommunizierten. Den größten Erfolg beim Lösen einer Hidden-Profile- Aufgabe hatten Gruppen, welche beide Medien verwendeten; das Text-Medium zur Vermittlung von Informationen und den Audio-Video-Kommunikationskanal zur Entscheidungsfindung. (5) Nach der Klassifizierung von DeSanctis und Gallupe (1987) werden Group Decision Support Systeme (GDSS) oder auch Group Support Systeme (GSS) in zwei Stufen unterteilt. Zur ersten Stufe gehören Werkzeuge, welche die Kommunikation von Gruppen ermöglichen und durch Eigenschaften wie etwa Parallelismus und Anonymität verbessern sollen. GDSS bzw. GSS der Stufe 2 bieten neben den genannten Funktionalitäten von Systemen der Stufe 1 weitere Werkzeuge zur Analyse und Organisation von Informationen, wie etwa die Strukturierung, Modellierung, Veränderung und Rangordnung von Informationen. Eine höhere Support-Stufe sollte demnach auch zu einer Steigerung der Entscheidungsqualität bzw. des Informationsaustausches führen.

4 Methodik

Es wurde eine Literatursuche in den sechs folgenden wissenschaftlichen Literaturdatenbanken: ACM Digital Library, IEEE Xplore Digital Library, PsycINFO, SAGE Journals, ScienceDirect und Scopus mithilfe der folgenden Suchbegriffe durchgeführt: *Group Decision, Group Decision Making, Hidden Profile, Hidden Profile Task, Information Pooling, Information Sampling, Information System, Computer-Mediated Communication, Technologically-Mediated Communication, Group Support System, Group Decision Support System, Decision Support System, Electronic Meeting System, Groupware und Virtual Teams*. Die Ergebnisse dieser Suche wurden nach dem PRISMA-Statement von Moher et al. (2009) ausgewertet und aussortiert.

Auswahlkriterien für die Studien waren im wesentlichen (a) es handelt sich um eine Studie, welche den Einfluss von implementierten GDSS oder vergleichbaren Technologien auf Gruppenentscheidungen im Hidden Profile, d.h. Information Sharing und Decision Quality, untersucht; (b) das Hidden-Profile-Paradigma wurde für die Entscheidungsaufgabe in der Studie bzw. im Studiendesign angenommen und eindeutig spezifiziert; (c) der Technologiebegriff beschränkt sich auf die Unterstützung von Gruppenentscheidungen im engeren Sinne, d. h. auf die Unterstützung des Information Sharing.

			Technologieeigenschaften				
Autor	Stichprobe	Gruppengröße	Synchronität	Anonymität	Support-Stufe	Einfluss auf Informationsaustausch[a]	Einfluss auf Entscheidungsqualität[b]
Dennis (1996c)	140	10	asynchron	ja	2	positiv	n.s.
Dennis (1996b)	126	6	asynchron	ja	2	n.s.	n.s.
Dennis et al. (1997)	150	10	asynchron	ja	2	positiv	n.s.
Dennis et al. (1999)	70	2	synchron	nein	1	-	n.s.
Graetz et al. (1998)	148	4	synchron	nein	1	-	negativ
Hightower und Sayeed (1995)	93	3	synchron	nein	1	positiv	-
Hightower und Sayeed (1996)	87	3	synchron	nein	1	positiv	-
Hollingshead (1996a)	159	3	synchron	ja	1	negativ	n.s.
Hollingshead (1996b)	309	3	synchron	ja	1	negativ	n.s.
Kerr und Murthy (2009)	128	4	synchron	nein	1	negativ	negativ
Kinney und Dennis (1994)	168	2	synchron	nein	2	-	n.s.
Lam und Schaubroeck (2000)	216	3	synchron	nein	1	positiv	positiv
McLeod et al. (1997)	236	4	synchron	ja, nein[c]	1	positiv, n.s.	negativ
Mennecke et al. (1995)	256	4	synchron	ja	1	n.s.	-
Mennecke und Valacich (1998)	256	4	synchron	ja	1	n.s.	n.s.
Muhren et al. (2010)	48	3	synchron	nein	1	positiv	n.s.
Murthy und Kerr (2004)	140	4	synchron, asychron[c]	nein	1,2[c]	positiv, n.s.	positiv, n.s.
Robert et al. (2008)	183	3-5	synchron	nein	1	n.s.	-
Shirani (2006)	197	4	synchron	nein	2	positiv	-
Straus (1996)	162	3	synchron	ja	1	negativ	n.s.
Streng et al. (2010)	32	4	synchron	nein	2	positiv	n.s.
Werkhoven et al. (2001) [d]	80	3	synchron	nein	1	positiv	n.s.

[a] Wurde in den Studien ein positiver, negativer oder nicht signifikanter Einfluss von CMC im Vergleich zu FTF Gruppen auf den Informationsaustausch festgestellt

[b] Wurde in den Studien ein positiver, negativer oder nicht signifikanter Einfluss von CMC im Vergleich zu FTF Gruppen auf die Entscheidungsqualität festgestellt

[c] Wurde im Rahmen der Studie variiert

[d] Im Rahmen der Studie wurden isotrope und nicht-isotrope Telekonferenzen im Vergleich zu FTF Gruppen untersucht

Tabelle 1: Übersicht der ausgewählten Studien

Die Übersichtsarbeiten von Lu et al. (2012) und Wittenbaum et al. (2004) dienten als weitere Hilfestellung; u.a. beim Abgleich der Ergebnisse der Literatursuche. Des Weiteren wurde die Schneeball-Methode angewendet, d.h. die referenzierte Literatur der aufgenommenen Artikel wurde auf weitere relevante Artikel und Studien überprüft. Diese wurden ebenfalls mithilfe der oben genannten Einschlusskriterien überprüft und ggf. in die systematische Übersichtsarbeit aufgenommen. Auf Basis der Einschlusskriterien wurden aus den 911 gefunden Studien 22 Studien aufgenommenen, analysiert und kategorisiert. Die Tabelle 1 zeigt die aufgenommenen Studien, sowie die erfassten Einflussvariablen im Überblick.

5 Ergebnisse und Diskussion

Insgesamt spiegeln die Ergebnisse zum Einfluss von GDSS auf Gruppenentscheidungen gegenüber FTF-Kommunikation die Inkonsistenz der Ergebnisse der Übersichtsarbeiten von Lu et al. (2012) und Wittenbaum et al. (2004) im Kontext des Hidden-Profile-Paradigmas wieder. Betrachtet man den zeitlichen Aspekt der Publikation der Studien, so zeigt sich, dass neuere Studien tendenziell einen größeren Anteil an positiven Ergebnissen bezüglich des Einflusses der Verwendung von GDSS gegenüber FTF-Kommunikation aufweisen. Die Ergebnisse geben Anhaltspunkte, dass die Aussage von Wittenbaum et al. (2004) bezüglich des Einflusses der Zeit auf die negativen Einflüsse von GDSS zutrifft und neuere Studien durch einen gesteigerten Umgang mit Technologie im Laufe der letzten Jahre positivere Ergebnisse aufweisen. Von den acht Studien, die ab dem Jahr 2000 veröffentlicht wurden, stellten sechs einen positiven Einfluss von GDSS auf den Informationsaustausch oder die Entscheidungsqualität bei der Lösung einer Hidden-Profile-Aufgabe fest. Lediglich zwei Studien zeigten einen negativen Einfluss auf Gruppenentscheidungen. Betrachtet man die Studien der 90er Jahre, so ist bei diesen ein höherer Anteil an Studien festzustellen, die über negative Auswirkungen von GDSS auf Gruppenentscheidungen berichten. Zwei Studien, die positive Einflüsse von GDSS feststellten, stehen sechs Studien gegenüber, welche negative Einflüsse der Verwendung von GDSS aufzeigten.

Ein weiterer, untersuchter Faktor ist die Gruppengröße. Ein Großteil der Studien verwendete eine Gruppengröße von drei bis fünf Personen. Zwei Studien, in denen der Einfluss von GDSS auf die kollektiven Entscheidungen von Paaren untersucht wurde, zeigten keine signifikanten Auswirkungen computervermittelter Kommunikation. Eine mögliche Ursache ist, dass Production Blocking, eines der wesentlichen Nachteile, die durch parallele Kommunikation über GDSS geschwächt werden, tendenziell nur in größeren Gruppen auftritt (Valacich et al. 1992). Unter den drei Studien mit Gruppen größer als fünf stellten zwei einen positiven Einfluss durch die Verwendung von GDSS fest. Diese kleine Anzahl an Ergebnissen impliziert, dass Technologieunterstützung Gruppenentscheidungen tendenziell bei größeren Gruppen stärker positiv beeinflusst. Dem gegenüber stehen die Ergebnisse von Mennecke (1997), der keinen signifikanten Einfluss der Variation der Gruppengröße auf den Informationsaustausch von computerunterstützten Gruppen feststellen konnte.

Anonymität kann laut Dennis und Wixom (2001) die Motivation von Gruppenmitgliedern zum Beitrag von Informationen fördern, führte jedoch im Rahmen der betrachteten Studien zu sehr inkonsistenten Ergebnissen. Die Eigenschaft der Anonymität ist im Rahmen der Betrachtung der Studien gegeben, wenn diese eindeutig im Studiendesign spezifiziert oder beschrieben wurde, etwa durch die Spezifikation, dass Gruppenmitglieder generische Namen in Chats verwendeten (Bspw. Straus 1996). Dies trifft auf insgesamt neun Studien zu, die im Rahmen der Untersuchung des

Einflusses von GDSS betrachtet wurden. In zwei Studien förderte die Implementierung anonymer Textkommunikation den Informationsaustausch; in drei Studien wurde ein negativer Einfluss auf Gruppenentscheidungen ermittelt; und in drei Studien wurde kein signifikanter Einfluss festgestellt. McLeod et al. (1997) zeigten, dass anonyme Textkommunikation den Austausch von ungeteilten Informationen förderte. Gleichzeitig stellten sie einen negativen Einfluss auf die Entscheidungsqualität durch diese fest.

Im Rahmen einer detaillierteren Betrachtung der Studien bezüglich des Einflusses von GDSS gegenüber FTF-Kommunikation zeigte sich, dass GDSS mit bestimmten Technologieeigenschaften tendenziell einen höheren Anteil positiver Ergebnisse aufweisen. GDSS mit Funktionalitäten zur Informationsstrukturierung zeigten generell einen größeren Anteil positiver Ergebnisse bezüglich des Einflusses von GDSS als solche, die diese Eigenschaften nicht implementierten. Dies ist konsistent mit den Erkenntnissen von Dennis und Wixom (2001), die eine bessere Eignung von Level-2-GDSS für Entscheidungsaufgaben gezeigt haben und dies mit einer besseren Eignung zur Organisation, Strukturierung und Analyse von Informationen begründen.

Generell wurden in den Studien generische und vor allem auf Textkommunikation basierende GDSS, seien es herkömmliche Chat-Tools oder Discussion Boards, implementiert und untersucht. Betrachtet man die Ergebnisse der Studien in den verschiedenen Kontexten, so zeigt sich, dass sich Beziehungen des Einflusses von GDSS mit unterschiedlichen Faktoren abzeichnen. Studien, in denen GDSS Eigenschaften zur asynchronen Textkommunikation oder Funktionalitäten zur Informationsstrukturierung implementierten, zeigten einen höheren Anteil an positiven Ergebnissen bezüglich des Einflusses auf Informationsaustausch oder Entscheidungsqualität gegenüber Studien zur technologieunterstützten synchronen Textkommunikation. Des Weiteren blieben negative Ergebnisse bezüglich deren Einflusses auf Gruppenentscheidungen aus.

6 Zusammenfassung und Ausblick

Konsistent mit den Erwartungen von Wittenbaum et al. (2004) gibt es bei neueren Studien einen höheren Anteil an positiven Ergebnissen als bei älteren Studien. Zu dem zeigen größere Gruppen tendenziell häufiger einen positiven Effekt als kleinere Gruppen. Bei den betrachteten Technologieeigenschaften ist zu erkennen, dass eine höhere Support-Stufe des GDSS, sowie die Möglichkeit zur asynchronen Kommunikation tendenziell eher zu positiven Ergebnissen führen. Anonymität hingegen führte zu gemischten Ergebnissen. Hieraus wird ersichtlich, dass Technologieeigenschaften durchaus einen positiven Effekt auf Gruppenentscheidungen haben können. Dies impliziert jedoch auch, dass die Technologieeigenschaften der in Forschungsprojekten verwendeten GDSS stärker evaluiert und beschrieben werden müssen. Reining und Shin (2002) sehen den Ursprung dieser Problematik in einem zu meist deterministischem Vorgehen in der Forschung zu Informationssystemen. Dabei werden die Endergebnisse über verschiedene Stufen von technologischer Unterstützung miteinander verglichen. Dies macht es schwierig den Einfluss einzelner Bestandteile des Informationssystems zu messen und zu untersuchen. Eine mögliche Lösung wäre daher ein prozedurales Vorgehen (Mejias 2007). Daran anknüpfend beschreiben auch Lukyanenko et al. (2014; 2015) eine Evaluationslücke im Design Science Research Cycle nach Hevner (2007), den sie Instantiation Validity nennen. Hierbei zeigen sie auf, dass jedes Informationssystem, das für eine bestimmte Problemstellung oder Forschungsfrage implementiert wird (Instanz), bisher weitestgehend nur deterministisch evaluiert wird. Ein wichtiger Schritt, die Evaluierung des Informationssystems gegenüber den anfänglich erhobenen

Anforderungen bleibt meist aus. Dies hat weitreichende Folgen für die Validität und Reproduzierbarkeit der Ergebnisse, denn nur bei einer ausreichenden Evaluierung und Beschreibung der Funktionen eines Informationssystems können die Informationssysteme nachgebildet werden und die Ergebnisse durch Reproduktion validiert werden. Das Informationssysteme nicht ohne Auswirkungen auf die Ergebnisse ausgetauscht werden können zeigen die inkonsistenten Ergebnisse der betrachteten Studien.

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Integrated Virtual Cooperation in Product Costing in the Discrete Manufacturing Industry: A Problem Identification

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Abstract

Virtual collaboration in corporations is an important factor for working efficiently without the limitations of time and place. As a business domain, product costing is characterized by a high demand for communication, coordination, and information exchange. Nevertheless, practitioners point out that product costing does not exhibit a modern tool-based collaborative practice. Thus, this paper examines the collaborative process in product costing. An exploratory study shows that, in practice, the way of collaboration is still very traditional, often relying on e-mail and lacking integrated IT support. Contributing to the overall workload with almost 90%, collaboration in product costing has a high potential for improvements in productivity and consistency. As a showcase, the study reveals that virtual cooperation has not been integrated into particular business areas and that there is a need to find ways to enable and support such specific forms of virtual cooperation.

1 Introduction

In the discrete manufacturing industry, where products like automobiles, furniture, and electronic devices are manufactured, product costing is performed to identify the costs that a product will generate. The more complex the composition of a product, the more extensive is the process of assessing the costs in advance.

Practice describes product costing as a collaborative business activity involving a high degree of information exchange and communication between many stakeholders. Nowadays, adequate IT support is essential for efficiently performing corporate work. Enterprise 2.0 has become the symbol for virtual, business related collaboration techniques. The concepts and categories of Web 2.0 have been integrated into the corporate environment. Sharing knowledge, finding contacts, and keeping information transparent have become vital activities for companies and their employees, as well as in the relationships with their customers and partners. In research, the adoption of eCollaboration in enterprises is investigated frequently due to the diverse managerial challenges that have not yet been resolved. It could be the missing user involvement, the lack of management support or the inability to properly use eCollaboration tools (Riemer et al. 2009, Alqahtani et al. 2014, Andriole 2010). Communication is an important aspect in the product costing business domain and we want to find out whether the way it is performed and supported today has room for improvement. We see the necessity to analyze integrative approaches for collaboration support and to investigate whether respective information systems are applied in this business field. In eCollaboration, typical questions are related to knowledge, the knowledge holder and the options to get in touch with this person. Considering the product costing process these kinds of issues seem to be clear and not the center of attention. Here, the main topics are communication and information exchange. Furthermore, it appears that both need to be directly linked to the progress of the product costing process. Exactly when a particular task is finished, the exchange of data needs to be initiated to enable necessary discussions to be started. Therefore, this paper examines whether integrated computer-supported virtual cooperation exists in the domain of product costing.

In order to establish a detailed understanding in this business field, the presented paper investigates the collaborative process in product costing within the discrete manufacturing industry and addresses the following research questions:

- Q1: What are the characteristics of collaboration in product costing and which tools are used for it?
- Q2: What are the current deficits of the technological support regarding the collaborative process in product costing?

To answer these questions, the paper is structured as follows: The next section describes product costing in the discrete manufacturing industry and the eCollaboration research field to provide insight into the background of this paper. Section 3 presents the design of the study conducted in this research. Afterwards, the research questions stated above are answered. Sections 4.1 and 4.2 examine the first research question, while Section 4.3 discusses the findings of the second research question. This is followed by a discussion and the paper terminates with a conclusion regarding the relevant findings.

2 Background

2.1 Product costing in the discrete manufacturing industry

Adequate instruments and methodologies are required for the process of corporate management, which includes leading, administrating, and directing a company. Managerial accounting is a practice used to establish the foundations for decisions with the help of financial and non-financial information (Warren et al. 2014). Product costing is a part of managerial accounting that enables companies to calculate the costs that a product generates. Since 70% of the costs of goods sold are already set during product development, preliminary costing is crucial, revealing a high potential to influence costs (Saaksvuori and Immonen 2004).

If a customer asks for a quote for a product that has never been produced, the costs of the product must be calculated before submitting that quote. The goal is to calculate realistic costs to provide a reliable financial assumption and run a successful business. Especially in the discrete manufacturing industry, product costing is a highly relevant task. The products in this industry consist of many parts, which can be produced in-house, in a different plant of the company, or even purchased from a supplier. Furthermore, every product needs to be assembled, often in complex procedures (Hansen et al. 2009). In today's globalized world, new sources of procurement and sales markets emerge every day. Also, manufacturing processes change constantly due to innovative new technologies. Many diverse factors can influence the costs of a product. Especially when profit margins are low, like for automotive suppliers, cost calculations need to be exact, because even small deviations of the calculated from the future real costs per piece sum up tremendously and can easily lead to a money-losing business (Drury 2008). Hence, accurate cost calculations are essential in the discrete manufacturing industry.

In product costing is it necessary to collaborate internally, but also to work together with external partners. In a typical scenario described from practice, the sales management of a company is in direct contact with the customers. They negotiate a new product, agree on the most important specifications and the amount of the desired product. That information is communicated to the product costing department in order to get a cost quote. Product engineering can then start to design the product and give feedback on the possible composition of the product. If the product requires purchasing parts, information needs to be requested from the procurement department in order to negotiate the purchase price of these parts with various suppliers. This information also needs to be validated with the manufacturing department before the final cost quote can be sent to the customer. Thus, collaboration plays an important role in the entire process, due to the number of participants and the amount of information that must be exchanged. The exact method of collaboration also differs from company to company due to individual factors, like the production type and the length of the product development cycle.

The amount of data in management accounting is extensive, and the usage of information technology is substantial (Fiedler and Gräf 2012). In the area of classic cost accounting, the usage of standard software is very typical. In the product development phase, mainly spreadsheets are created using Microsoft Excel. This often leads to problems like the costly manual data administration, inconsistencies, missing documentation, as well as a low degree of integration (Schicker et al. 2008).

2.2 eCollaboration

Research regarding collaboration dates back to the 1980s, when a research community called "computer-supported cooperative work" started to investigate how technology can be used to support people in their work (Grudin 1994). Due to the ongoing evolution of software technology and the emergence of the Internet, new possibilities of collaboration have arisen. Web 2.0 has enabled to work together via the Internet in virtual social networks, using real-time collaboration, instant communication, and collaborative authoring tools. The trend of Web 2.0 also swept over into the business world. eCollaboration, also referred to as Enterprise 2.0 or Social Enterprise (McAfee 2006), covers collaboration within and between organizations based on information and communication technology and describes practices of communication, coordination, and collaboration between people in distributed contexts like projects, teams, or processes within and between organizations (Riemer et al. 2009).

The categories of application are diverse and their development is ongoing. Weblogs and microblogs, wikis and group authoring tools, social networks, and instant communication are just some of the tools found in the modern business environment (Koch and Riemer 2009). Furthermore, social software suites are emerging, following the trend towards integrated solutions that cover several categories of eCollaboration. The implementation of such tools can improve communication, enable collaboration, and provide more flexibility for employees to work together.

Today's work environments demand collaboration between distributed teams without location or time constraints. Accordingly, eCollaboration can benefit a company's work productivity (Alqahtani et al. 2014). Despite these possible benefits, Andriole (2010) revealed a gap between the expected and actual business impacts. Although numerous software products exploit these collaborative technologies, eCollaboration is a complex, risky, and often-ineffective undertaking in practice. The ongoing and rapid emergence of eCollaboration technologies makes it an insecure, unsteady field, both managerially and technologically (Riemer et al. 2009). Consequently, concerns about security and loss of control often arise. One challenge widely investigated in research is the adoption of eCollaboration. A low user adoption can be the result of several factors, as Alqahtani et al. (2014) discovered. The benefits a company creates by successfully adopting eCollaboration strategies can be affected by a lack of employee awareness or ability, an unsupportive corporate culture, or the length of time necessary to integrate these ideas throughout the business (Alqahtani et al. 2014).

The general adoption of eCollaboration has been investigated in numerous research studies (Riemer et al. 2009, Alqahtani et al. 2014). One new aspect worth examination is the business domain specific adoption. In several business domains, the level of collaboration is very high, but the usage of the typical generic eCollaboration tools is not appropriate. As explained in Section 2.1, product costing is a business domain with collaborative structures. Collaboration and the product costing process itself are highly linked, which means a specific division has to be contacted at an exact point in time, e.g. when the supplier has announced the new price for a purchasing part. Such a direct connection of collaboration and the product costing process seems to be missing. Thus, time and resources are wasted due to the inefficient collaboration process. In turn, the classic eCollaboration tools are inapplicable due to their focus on general adoption. In order to investigate this topic and to determine how the situation in product costing could be improved, an exploratory study was designed.

3 Study design

The goal of this paper is to identify whether there exists a lack of integrated cooperation support in product costing. To get a first understanding about the product costing process and its organizational IT support, we designed an online survey. Such a questionnaire is an appropriate tool to collect data very dynamically since the respondents can participate anytime and anywhere, thereby shortening and simplifying the collection process (Bethlehem and Biffignandi 2012). In order to provide a precise structuring, we divided the questionnaire into three topic areas: the collaborative process, its participants, and the IT support for collaboration. Altogether, these topic areas can form a picture about how the participants collaborate, how complex the process is, and whether the participants face problems due to inefficient IT support.

We selected an international sample of participants for the questionnaire to ensure a more robust understanding about collaboration in product costing. The discrete manufacturing industry consists of several industrial sectors. In order to generate a more complete understanding of the situation, the study included companies from different industries. The automotive industry is a key player when it comes to the production of distinct items. As a finished product, an automobile consists of numerous parts including, for example, the body, wheels and the seats. In turn, the seats are made of several parts, which need to be produced or procured, assembled, and provided to the market. Another interesting sector is the machine building industry. The main capabilities of this sector are the production of industrial, agricultural, or construction machinery and components. This also demonstrates the necessity to compose and assemble different elements. Furthermore, the industrial sectors of consumer goods, like the furniture or high tech industry, is included in the study to ensure an objective, inter-branch picture of the current situation in product costing collaboration.

The relevance of product costing depends on the complexity of the manufacturing process of an enterprise. A high degree of complexity can often be found in big manufacturing companies. So we examined the size of enterprises from this industry to find suitable companies for the study. We only selected international companies with more than 1000 employees. Furthermore, different divisions and business roles were considered. Since numerous participants appear to be involved in the process, the integration of the different perspectives is crucial to provide an overall understanding of the process. This covers managerial accounting, product controlling, marketing, sales and procurement, as well as engineering and information technology.

Based on these requirements, we contacted companies from which we knew (due to our background) that they have a potential interest in research regarding product costing. Here, we could win 26 cooperation partners, which signalized their will to participate in our study: seven companies from Germany and 19 companies from the USA were invited to the study, from which 26 German employees and 55 US employees were contacted. The study was conducted in April 2015. Altogether, 15 companies took part: six from Germany and nine from the USA. From the 81 invitees 28 people participated in the study, evenly split among employees from American and German companies.

4 Findings

4.1 Unsatisfactory collaboration in product costing

The study results underline the importance of product costing in the discrete manufacturing industry. Of the participants, 96.4% see product costing as relevant for running their business successfully, and 25 out of 28 participants stated that it plays an important role for their companies to achieve their strategic goals. For 82.1%, product costing is a topic that is relevant to management. For 28.6%, even the top management is involved in the process.

With regard to the research question Q1, Figure 1 shows which collaboration resources are used during the product costing process. Both internal and external, e-mail was the most frequently used instrument. Every participant mentioned that they used e-mail for internal collaboration. Meetings (96.4%) and telephone usage (89.3%) were also overwhelmingly common methods of collaboration. Behind these predominant methods, in fourth place, was the usage of the calculation software. This means that the tool most central for the accomplishment of product calculation only sometimes serves as a collaboration platform at the same time. Surprisingly, less than half of the companies use workflow support to manage product costing tasks. Looking at the results for external collaboration, it becomes apparent that the support for collaborative work is mostly limited to e-mail (92.9%), telephone calls (82.1%), meetings (53.6%), and telephone conferences (50.0%). A lack of integrated collaboration support both for internal and external cooperation appears to be present.

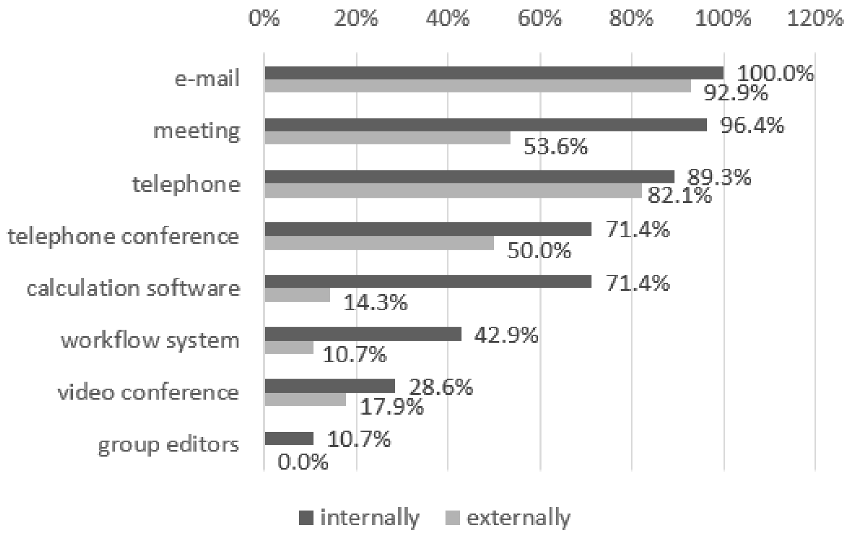

Figure 1: Collaboration tools in use (n=28, multiple answers possible)

Overall satisfaction with IT support in product costing demonstrates the need for action to improve the current situation. As shown in Figure 2, only one in four participants responded that they had satisfying IT support, but every second participant was discontented with it. No correlation between the utilization of a particular IT tool and the satisfaction can be found in the study. Thus the overall traditional way of collaboration could be the reason for the rating, indicating that further investigation is necessary.

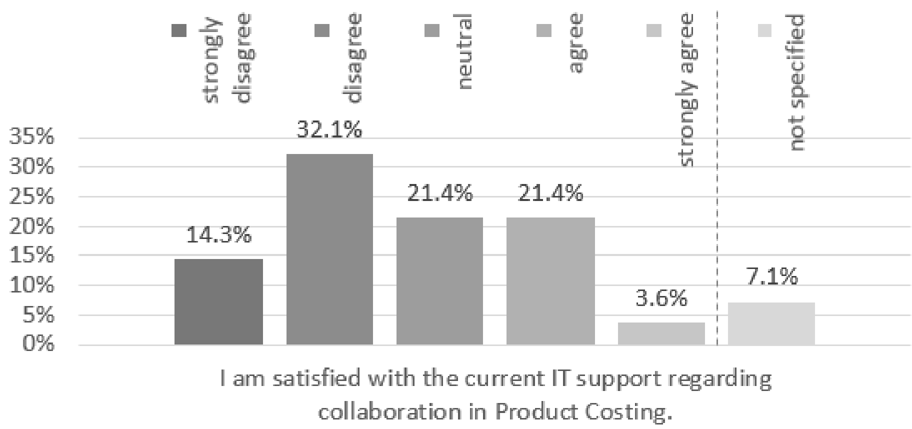

Figure 2: Satisfaction with IT support (n=28)

4.2 High collaboration complexity in product costing

In product costing, working both with stakeholders within the company and with external partners is necessary. Consequently, the study participants were asked about the percentage of time they spend on collaboration compared to their overall workload.

Figure 3 reveals that, on average, 87% of the overall workload in product costing consists of communication and information exchange. More than half of the working time is spent on internal collaboration, indicating room for efficiency improvement. If the IT support enabled to perform the respective tasks faster, half of the workload in product costing could decline significantly. Another

28.5% of the working time is spent collaborating with external partners, so the product costing process also happens to a notable extent externally.

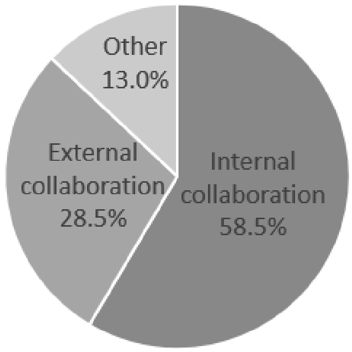

Figure 3: Proportion of workload (n=28)

As described in section 2.1 product costing affects multiple departments of a company. Hence, the roles the study participants hold in their companies were inquired. Seven different roles were included in the study: 12x manager, 9x (product) controller, 8x IT specialist, 5x engineer, 2x sales specialist, 1x marketing specialist and 1x purchaser. Multiple answers were allowed, because an employee can have responsibilities in several divisions. The diversity of roles ensures the reflection of a variety of perspectives in the study.

Furthermore, we investigated who is involved in the collaborative process of product costing (see Table 1). In 85.7% of the companies, a minimum of four employees participates in product costing. For 28.6% of these cases, there are even more than ten participants. In order to understand the interdisciplinary complexity, the number of participating divisions was analyzed. More than half of the study participants stated that up to three divisions were involved in product costing in their company. For 28.6%, four to six divisions need to work together in order to accomplish a cost calculation and 2 participants (7.1%) stated that more than ten divisions are involved. Large companies sometimes have their product development and production distributed over different locations, making face-to-face collaboration impossible which underlines the necessity for technological support. This remote work environment usually does not exceed more than three locations (75.0%).

Number	Colleagues	Divisions	Locations	External companies	People from external companies
01-03	10.7%	53.6%	75.0%	42.9%	32.1%
04-06	46.4%	28.6%	14.3%	17.9%	17.9%
07-09	10.7%	7.1%	0.0%	0.0%	3.6%
10+	28.6%	7.1%	7.1%	14.3%	14.3%
n/a	3.6%	3.6%	3.6%	25.0%	32.1%

Table 1: Product costing participants (n=28)

Beside the internal collaboration, the companies of the participants also work and collaborate with external partners. Mostly, they reported that one to three external companies participate in a product costing process, but four participants (14.3%) specified that their companies cooperate with ten or more external partners. The same applies for the number of external people. In the majority of cases, working together included up to three persons from external organizations. Nevertheless, every seventh participant (14.3%) said that this number was ten or more. It should be considered that a notable amount of the respondents did not provide information about external participation.

The 28 participants stated that they come from the following industrial sectors: 10x automotive, 10x machine building, 6x consumer goods and 2x high-tech. Thus, the study represents a variety of industries with a slight emphasis on the automotive and machine building industries. The described complexity of the collaborative structures can be found in all of these industries, no matter whether the company was situated in Germany or the USA. Referring to the first research question, the high number of people, divisions, and locations involved demonstrates how interdependent and sophisticated the product costing process can be. Furthermore, this data shows how the topic reaches beyond the boundaries of the individual enterprises.

4.3 Strong need for improved IT support for the collaborative process in product costing

Product costing represents a clear process structure (see Figure 4). Of the 28 participants, 18 specified that the process steps are executed in a predefined order (often: 53.6%, always: 10.7%). None of the respondents reported that the process was operated in a completely unstructured way, without a fixed sequence of tasks. This indicates that product costing is suitable for IT support to automate and accelerate the entire process. Furthermore, the respondents reported that it was common to complete the necessary steps simultaneously. More than half of the participants specified that they often (42.9%) or always (17.9%) execute the required tasks in parallel. At least occasionally, this is done by another 28.6% of participants, which underlines the potential to speed up the process. In addition, 85.7% of the participants stated that they often (57.1%) or always (28.6%) have to repeat tasks in order to finalize a cost calculation. Agreements with colleagues and external partners can lead to changed costing goals that need to be reflected in the product cost assessment. Such repetitive work could be reduced or simplified. As described by 25 of 28 participants, the product costing process is characterized by central coordination (often: 46.4%, always: 42.9%). Thus, a particular person usually manages the entire process and takes responsibility for the coordination.

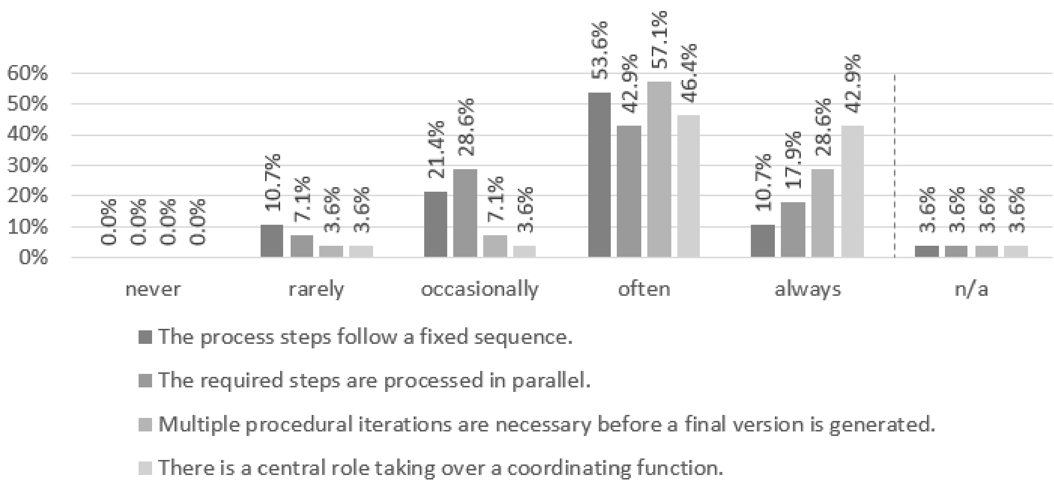

Figure 4: Process structure (n=28)

The present study also analyzed the extent to which the current use of IT supports the collaborative process, shown in Figure 5. This addresses the second research question. An important factor is employee awareness of their tasks and the status of the process. While eleven participants confirmed such an awareness (agree: 35.7%, strongly agree: 3.6%), the same number disagreed to this fact (disagree: 28.6%, strongly disagree: 10.7%). Interestingly, this evaluation does not depend on whether workflow support is used in the product costing process. Another key factor in product costing is understanding the data to be used in the process. Using obsolete prices or estimates can generate incorrect calculations, which can impede the success of a new product if the product cannot cover its own costs. Half of the study participants felt well informed about the data they need to use for a calculation (agree: 39.3%, strongly agree: 10.7%), whereas 28.6% do not get such understanding via system support (disagree: 25.0%, strongly disagree: 3.6%). Hence, the ability of IT support to integrate data effectively for this process should be compared in detail to identify the factors leading to these results. Ideally, the necessary collaboration support is directly integrated into the system used for the product cost assessment. The study results demonstrate that 46.4% of participants work with calculation tools that do not have such integrated support. For 35.7%, the integrated collaboration support is sufficient. Another IT goal is to ensure good results by supporting the prevention of misunderstandings and other miscommunication among colleagues who work together. 13 of 28 participants could not confirm that the IT support for product costing provides an adequate support to help prevent miscommunication and ensure consistency in their company process (disagree: 28.6%, strongly disagree: 17.9%). This indicates a potential to help avoiding costly errors and mistakes.

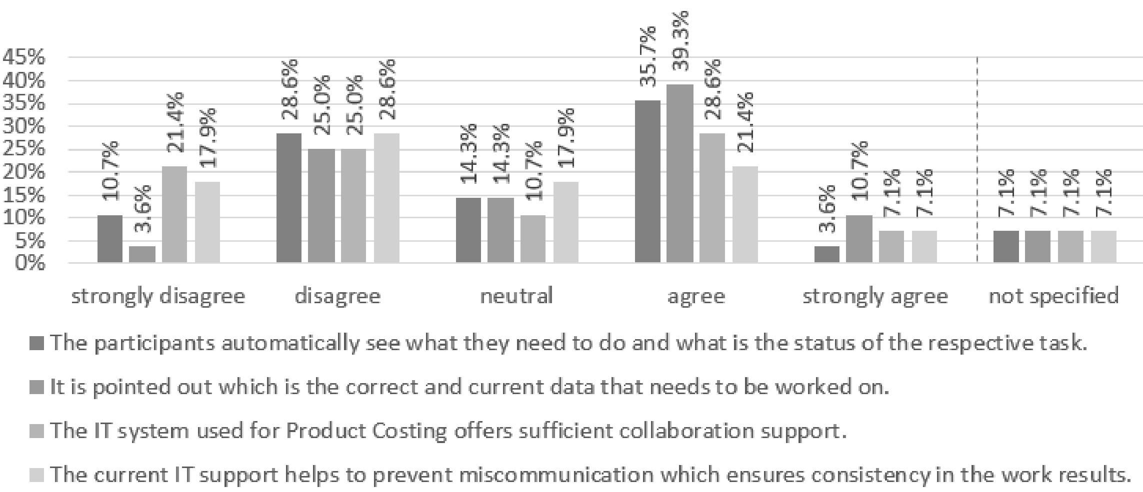

Figure 5: IT support (n=28)

5 Discussion

The study results demonstrate room for improvement in the collaborative process of product costing in the discrete manufacturing industry. Almost 90% of the overall product costing workload consists of collaborative work. The support of collaborative activities is essential to ensure efficiency throughout the entire process. In several companies, more than ten employees participate in product costing, working in up to six different divisions and usually spreading out over up to three locations. Such a separation makes face-to-face teamwork impossible, which underlines the necessity for virtual cooperation. In addition, the need for cooperation with numerous external companies contributes to the complexity of the collaboration process. Since the ratio of collaborative work in product costing is that high, these core capabilities need to be supported efficiently and necessary prerequisites have to be established. Here, all eCollaboration categories are matters of interest in product costing: Communication, coordination as well as collaboration. Consequently, integrated collaboration platforms, also identified as unified communications (Riemer et al. 2009), seem to be suitable, since they offer bundled features from these three categories. Nevertheless, the concrete combination of the business activities, the workflow and the collaborative functions appear to be missing. Eikemeyer and Lechner created a tool to enable domain specific ad-hoc collaboration, but concentrated on the challenge of the high effort to establish the necessary infrastructure (Eikemeier and Lechner 2003). They enabled virtual ad-hoc collaboration in an easy manner instead of focusing on how business domain specificity can be accomplished through process integration. An integrated IT support system could contribute to the clarification who the participants in the process are, their tasks and the progress by representing these structures of the product costing process and enabling virtual collaboration on this basis. Hence, creating more transparency could reduce the complexity.

Half of the study participants stated that they are unsatisfied with the current IT support of their company's product costing process. E-mail programs are still the most common communication tool when it comes to collaborative work support in product costing. With meetings and telephone calls following, the results clearly show that the classic communication tools are still in wide use, but do not offer sufficient support. The integration of workflows and collaboration in the calculation systems is not common and the current IT support does not consistently establish awareness about the process status and the necessary tasks for participants. Another issue is the missing data and system integration. Spreadsheets programs like Microsoft Excel are widely used, resulting in data inconsistencies and errors. By preventing media breaks, time can be saved, errors can be avoided, and more transparency can be provided regarding the collaborative process. Such an integrated system could also ensure data consistency. Furthermore, when the participants understand the benefits such a tool provides, it is likely that the classic, traditional ways of communication and collaboration will be abandoned. Additionally, improved quality of the collaboration support could also result in enhanced user satisfaction, which would be another positive effect. Therefore, further investigation is recommended.

Moreover, the study showed that product costing is a structured process. Due to the high number of iterations, adequate IT support could significantly reduce the repetition of tasks and the resulting workload in this business domain, but it is not available yet. Since parallel execution is very common, proper IT support also has the potential to speed up the entire process. The findings regarding the product costing process lead to the conclusion that the focus of future research needs to be the fusion of virtual collaboration and the specific business process with its activities, tasks and workflows. Generic eCollaboration is not specifically designed to integrate the collaboration support into the work process. A few research projects have been undertaken regarding the idea of bringing business processes and eCollaboration together, but always with a different goal. Working more collaboratively in business process management systems (Kemsley 2010) or creating cross-domain collaborative business processes (Capodieci et al. 2014) were approaches investigating eCollaboration and the process topic, but focusing on completely different issues. Hence, we see a strong need for the investigation of Business Domain Specific eCollaboration.

eCollaboration support that is specifically designed for the adoption in business domains has the potential to support the involved employees exactly where and when a particular support is needed in the collaborative product costing process. Consequently, using resources more efficiently, increasing productivity, and saving time and money are potentials of Business Domain Specific eCollaboration that require further investigation.

Another issue in product costing is the central coordination of the process. When a particular person coordinates all process steps and verifies the respective results, a dependency is generated. Thus, the central coordination of the product costing process can create a workload bottleneck, which is a risky undertaking. From a technological point of view, the coordination of manual steps like informing other employees about tasks or including the necessary data should be supported or possibly automated by means of IT. In addition, the organizational optimization of the process is an interesting field for further investigation. Letting the group take responsibility for the necessary tasks with less restrictions and supervision can lead to quality improvements and a lower error rate. For example, this was shown by Raymond (2001) describing how the bottom up approach noticeably increased the efficiency in the open source development process. Bottom up designs can also be found in the organizational and managerial environment. Consequently, sociotechnical factors should be reflected in further investigation of Business Domain Specific eCollaboration.

6 Conclusion

Enabled by the Web 2.0 evolution, virtual collaboration has become an inherent part for teamwork within and between companies. Nevertheless, research as well as practitioners describe numerous managerial challenges related to the use of collaboration tools in business. We conducted an exploratory study to investigate collaboration in product costing and its current state of integrated virtual cooperation. Participants from different industrial sectors and with varying business roles took part in the present study, creating an objective picture of the characteristics of the product costing process.

The findings of our study demonstrate the current situation regarding collaboration in product costing. The structured process exhibits complex collaboration requirements with a direct dependency on the process steps and its progress. Despite the progress of eCollaboration technology, the IT support of the collaborative product costing process has significant room for improvement. The results of the study show that current IT support is unsatisfactory and that the usage of common eCollaboration tools is insufficient. The missing connection between the concrete product costing process and the collaboration support raises the idea of Business Domain Specific eCollaboration to improve the entire workflow, the transparency of responsibilities, and the productivity of workers involved in this process. Some research work has already been done, but the focus has never been to specifically break down eCollaboration into business domains and its processes.

Future analysis should specify how Business Domain Specific eCollaboration could improve the product costing process and draft a corresponding concept with regard to the investigated issues. Another aspect of further research could be the investigation whether the potential of Business Domain Specific eCollaboration is only a particular need in the product costing process or whether it can also be identified as an issue in other business fields.

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Towards Shared Understanding: Suggesting Principles for Boundary Objects' Use in Innovation Communities

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Abstract

In this paper we suggest principles for boundary objects' use in innovation communities. The goal of these principles is to effectively conduce a shared understanding. For that reason knowledge boundaries must be overcome. We link the theoretical concepts of (1) the boundary objects classification (Carlile, 2004) and (2) the community learning model of van den Bossche (2011) to set a foundation for these principles. Afterwards we empirically develop principles in a field study. Findings suggest that syntactic boundary objects contribute to construct meaning, semantic boundary objects to co-construction, and pragmatic boundary objects to constructive conflict. We can thus suggest principles for use of boundary objects at the three levels of community learning to effectively establish shared understanding in innovation communities.

1 Introduction

Shared understanding is of utterly importance for effective knowledge sharing in innovation communities. Open source software projects, like Linux, heavily benefit from new ideas and concepts of their peers. The individuals involved frame innovation communities which are characterized by their shared interest while voluntarily collaborating (Brown and Duguid 1991). Hence, community members aim at maximizing the effectiveness of knowledge sharing for joint task fulfillment. Thereby, boundaries on manifold levels impede effective knowledge sharing and the creation of shared understanding (Carlile 2004). To remedy boundaries, innovation communities rely, among others, on boundary objects to work on new ideas, collaborate and discuss in a natural manner (Alin et al. 2013). These boundary objects can conduce to shared understanding which means that two community members purposefully working together share a common basis, agree on a mutual mental model and are willing to transform their existing knowledge stock to a shared understanding (Rosenkranz et al. 2014; Bittner and Leimeister 2014). Van den Bossche et al. (2011) introduced a framework for constructing shared understanding, which serves as main theoretical concept. Therein, community learning is established through (1) *construction*, (2) *co-construction*, and (3) *constructive conflict* within communities. Each phenomenon contributes to establishing a shared understanding and subsequently community effectiveness. *Construction* means to share information within the community. Interaction increases with *co-construction,* a mutual process of sharing ideas. Construction and co-construction both result in new meanings in the community. Finally discussing and transforming each other's opinions is framed *constructive conflict*. This means opinions are converged into a new shared mental model which is in this paper regarded equally to a shared understanding.

Li and Robertson (2011) showed how boundary objects in the form of information spaces (e.g. a mixed use of PowerPoint slides, video-, and audioconferencing) positively affected information sharing when developing a new medical treatment. Boundary objects are means that facilitate the mutual process of establishing shared understanding (Bechky 2003). They enable the sharing of knowledge between differing knowledge domains by negotiating meaning and establishing a shared understanding. For this reason, and as second theoretical concept for this paper, Carlile (2004) introduced the characteristics of boundary objects as to (i) *transfer*, (ii) *translate*, and (iii) *transform* knowledge that builds upon the boundary objects criteria of being tangible and up-to-date (Carlile and Rebentisch 2003) as well as concrete (Bechky 2003; Henderson 1991).

In this paper we aim to suggest principles for the use of boundary objects with the goal to create shared understanding in innovation communities. For this reason the Design Science Research (DSR) paradigm is followed. The DSR artifact takes the form of principles for boundary objects' use. It is first theorized, then built on empirically data and finally suggested (Hevner et al. 2004). The DSR artifact aims to solve the problem of effectively creating shared understanding in communities. We draw from the knowledge stock of the theoretical model of Van den Bossche et al. (2011) that explains how community learning behavior on three distinct levels effects shared understanding and the 3-T framework of Carlile (2004). Based on both, principles will be suggested that show how syntactic -, semantic -, and pragmatic boundary objects conduce to each level of community learning behavior and ultimately establish shared understanding.

The subsequent study addresses the research goal on:

How do boundary objects affect the establishment of shared understanding in innovation communities?

The remainder of the paper is organized as follows. First, we provide an overview on the theoretical concepts of shared understanding, the model to create shared understanding as well as boundary objects literature. Second, we depict the conducted field study on the creation of shared understanding in an innovation community. In the findings section we suggest principles based on the empirical results. We conclude in a managerial and academic outlook.

2 Theoretical Background

In the following we introduce the main theoretical concepts (1) on how to establish shared understanding, (2) in innovation communities, and (3) with the use of boundary objects. Based on this (4) the community learning model for the creation of shared understanding will be described.

2.1 Establishing shared understanding

When members of a community collaborate, they strive to achieve shared understanding. However, different perspectives, particularly in innovation communities make the establishment of understandings additionally complex. Sense-making in innovation communities also requires aligning mutual mental models and group cognition. These constructs are common substitutes for shared understanding. However, innovation communities must build upon a "common ground" (Clark 1996) which is here referred to as "shared" to allay misunderstandings. It is established when actors for example use a joint language. Moreover, through constant interactions in the community, e.g. with the use of boundary objects, shared ground becomes shared understanding. Thus it appears that shared understanding is also a specific form of self-awareness in communities (Clark 1996). This means members of a community know (implicitly) they agree upon a set of beliefs. By this we follow the suggested definition of shared understanding that *"[is] the degree to which members of a community concur on the value of properties, the interpretation of concepts, and the mental models of cause and effect with respect to an object of understanding"* (Bittner and Leimeister 2014). Only when shared understanding of a concept or model is established two or more actors can accumulate new knowledge (Holten and Rosenkranz 2011). The phenomenon of shared understanding is hence about knowing how other members of the community interpret a situation. It is of importance to understand how a shared ground is created and how boundary objects influence the process of establishing it.

In communities, however, different norms, value, and beliefs exist that compromise knowledge sharing. Shared understanding is in this article, however, about the alignment of mental models and how boundary objects contributed to it. Henceforth, innovation activities are regarded which requires knowledge transformation of the members of the community and thus goes beyond mere consensus building.

2.2 Collaboration in innovation communities

Members of an innovation community regularly engage in collaboration. They are defined as groups of people voluntarily sharing innovation related knowledge and to collaboratively pursue innovation activities (Franke and Shah 2003). Within the community evolving and alternating innovation tasks result in a creation and re-creation of shared understanding. In accordance to Wood and Gray (1991) collaboration occurs when communities *"engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain"* (p.146). This process is shaped by the goal of the members of the community to achieve shared understanding. However, the creation of shared understanding faces considerable effort. Moreover, boundaries impede collaboration in the community on different levels, e.g., the cognitive level. Nonetheless, collaboration is only effective, when relationships between members of the community are constantly (re-)negotiated. For this purpose the community must rely on tools that facilitate the process of collaboration. Moreover, the social behavior of the members of the community is of importance. This locus of communication and interaction is interesting because mental models and beliefs are shared in the community and thus influence the final shared understanding.

Moreover, the social behavior of the members of the community is of importance. This locus of communication and interaction is interesting because mental models and beliefs are shared in the community and thus influence the final shared understanding. Boundary objects mediate this process from the beginning. In particular this holds true when innovation activities are pursed and knowledge transformation, e.g. in the form of learning, takes place.

2.3 Boundary objects and knowledge management

Boundary objects are artifacts that cross knowledge boundaries, and do so by conveying meaning. In the relationship between two collaborators boundary objects transfer and create knowledge between differing (social) domains. The transfer takes places by using an object to negotiate meaning and to establish shared understanding between the two formerly dispersed domains (cf. Star and Griesemer 1989; Henderson 1991). Building on this definition boundary objects are an integral part for the creation of shared understanding. They can be distinguished in three classes of boundary objects.

Syntactic boundary objects are coined by its focus on establishing a shared infrastructure between two collaborators. Syntactic boundary objects mostly provide the according technology to transfer information between actors (cf. Carlile, 2004, p. 558). These boundary objects are relevant to establish a connection. A syntactic boundary objects can be an email client.

Semantic boundary objects are coined by its focus on task fulfillment. In particular this means, semantic boundary objects provide graphical representation, e.g. in form of process maps, that facilitate knowledge translation between two collaborators. Most importantly semantic boundary objects enhance "back-and-forth" negotiations. This process enables a translation of knowledge (cf. Carlile, 2004, p. 559) and contributes to the building of shared mental models.

Pragmatic boundary objects are coined by their deeply anchoring in social ties (see e.g. Barley et al. 2012). At this level knowledge is transformed which is most complex (cf. Carlile, 2004, p. 559). Pragmatic boundary objects thus must have the capacity to negotiate meaning and support an alignment of initially differing meanings. Finally, individual meanings are co-constructed to a shared understanding. This process is hence dependent on a variety of facilitators mainly impacting social ties. Rich collaboration tools, for instance, provide the means to fulfill the requirements for a pragmatic boundary object.

2.4 The community learning behavior model for shared understanding

To develop and finally suggest principles for boundary objects' use we rely on the community learning model for building shared understanding (Van den Bossche et al. 2011). Studies have shown, that this model is applicable to develop principles for the establishment of shared understanding in groups (see e.g. Bittner and Leimeister 2013). Moreover, the model focuses on learning, a process that is understood as most complex and dependent on new knowledge. Knowledge creation in innovation communities is a locus of mutual working, learning, and innovating for the benefit of the organization (Brown and Duguid 1991). Also learning is a complex process of knowledge transformation that incorporates building new individual mental models which depends on others knowledge (Carlile 2004).

In this study the focus is on the mediating role of boundary objects and how they affect community learning behavior (cf. figure 1 dashed construct).

Studies on mental models (see e.g. Mathieu et al. 2000) showed the positive impact of common agreement on task fulfillment. The studies imply that communities are effectively collaborating, when they share a common ground a prerequisite for shared understanding (see also Rau et al. 2012). To achieve shared understanding a constructive process within the community must take place. In this study the model of Van den Bossche et al. (2011) and Carlile's (2004) three classes of bo1undary objects are of main interest. Moreover, both particularly address knowledge sharing happening within a (innovation) community.

In addition Van den Bossche et al. (2011) explains collaboration as creating meaning and acting upon collectively developed cognition. The model explains how community effectiveness evolves subsequently to shared understanding, based on the three constructs *construction*, *co-construction*, and *constructive conflict*. Boundary objects are particularly interesting for building shared understanding because they pursue the goal of overcoming knowledge boundaries. However, to the best of our knowledge they have not yet been investigated in this context. The research goal is to suggest principles on boundary objects' use to create shared understanding. Therefore the moderator boundary objects (dashed construct in figure 1) is introduced to the model of Van den Bossche et al. (2011).

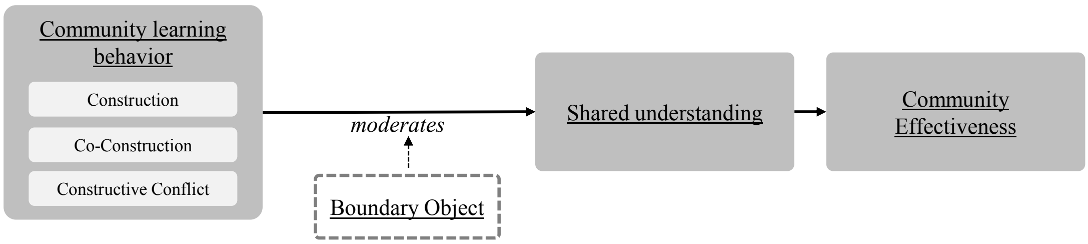

Figure 1: The community learning behavior model adapted from Van den Bossche, Piet et al. (2011)

The concept *construction* is based in learning theory and on linguistic research on conversations. In this sense, meaning is a process that is (co-)constructed. Initially, personal intention is expressed which is the case when the problem is described by a member of the community to others. The correspondent is processing this information to make sense of the situation. This process can become collaborative through "back and forth", thus *co-constructed*. The result is new meaning that sources from collaboration activities (Van den Bossche et al. 2011).

Consensus building also refers to agree to a formerly differing opinion. However, shared understanding is conceived to go beyond consensus and result in mutual mental models. In this building process *constructive conflict* is framed by negotiations. The "new" meaning becomes accepted by both collaborators and hence results in a new common ground. Diverging meanings lead to scrutinize individual interpretations. *Constructive conflict* is an open discussion and reflection of the prevalent problem. The convergence process is part of creating shared understanding and finally shared mental models (Van den Bossche et al. 2011).

3 Research Design

Based on the above theoretical background this section informs on how the principles (DSR artifact) are empirically developed. A qualitative research approach was select to explore the unknown effect of boundary objects to finally suggest principles for boundary objects' use.

3.1 Research strategy

This study examines how innovation community members rely on boundary objects to build a shared understanding. To explore this effect, interaction between community members and the used boundary object were observed. First, the community learning behavior model (Van den Bossche et al. 2011) and the three classes of boundary objects (Carlile 2004) are linked to theorize principles for boundary objects' use in innovation communities. Second, the principles are developed in an exploratory field study setting (Flick 1995). For this reason, two researchers independently took field notes of prevalent boundary object interactions to assess the introduced moderator (cf. figure 1). The notes contributed to solicit requirements and perspectives of community members. The researchers logged all actions of the community members and the objects used while interaction took place. Then semi-structured interviews were conducted ex-post to collect data on the dependent variable *shared understanding.* These interviews took place, because it is accepted that a focus on observational data is limited in its explanatory power of existing knowledge (Flick 1995). Shared understanding is the result of the community learning behavior in the model of Van den Bossche et al. (2011). Hence, in each ex-post interview the constructs, *construction*, *co-construction*, and *constructive conflict* (independent variables) as well as the *boundary objects* used (independent moderator) are collected and coded. The semi-structured interviews focus on exploring the dimensions of the artifacts used and how these contributed to establish shared understanding in the community. Finally, based on the theoretical as well as empirical underpinning principles for boundary objects' use can be suggested.

3.2 Data collection

The field study took place during the spring term 2015 of an undergraduate program of a German private university. The course is part of the Master Program in General Management and is obligatory. In this course students learn how to create, develop and realize innovative business concepts. The students were informed upfront on the study and motivated to participate. The task of all students was to develop an innovative business idea. From the start on, the students already developed first craft ideas and formed communities; nonetheless they did not discuss ideas in detail. Therefore, the course was conducted in such a manner, that the communities were guided through an innovation process from idea searching to idea implementation (cf. Tidd and Bessant 2011). In this process the researchers provided the communities with according means to further build the business idea. Each means is hereafter referred to as a *boundary object.*

Four communities had the task to develop and create the content for a (potentially) successful business idea. Members of each community vary between three to five persons. In the first phase a *business model canvas* (boundary object one) was primarily used. The canvas is a paper-based template that extends the nine key components from Osterwalder et al. (2010) to structure a business idea. Key components are, among others, the target group, value proposition, and value streams. Subsequently, the communities followed the innovation process of selecting their best ideas. They built upon the initially selected content and created *ecosystems* (boundary object two) and *hypotheses* (boundary object three) for their business ideas. The ecosystem is a paper-based template that needs to be filled with symbols to depict the business environment such as key partners and customers. Boundary object three is a paper-based template that requires noting down key hypotheses (antilogs and analogs) of the business idea. Antilogs are hypotheses that are contrary to existing business models whereas analogs copy existing business models. For each section of the template the community has to agree on the most important statements. In the last idea-implementation phase, the four communities created *3D models* of their potential business (boundary object four). These models were created using the concept of Lego serious play (www.seriousplay.com). All respective objects were used to factually realize the developed idea and to create shared understanding within the community.

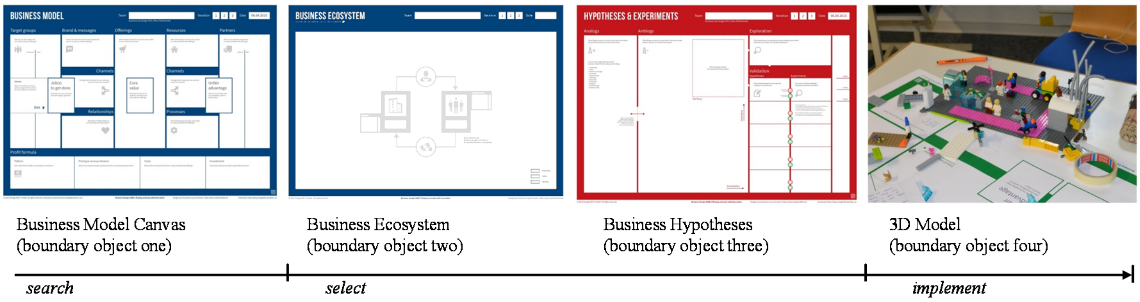

Figure 2: The four boundary objects used within the development of the business idea

The seminar concluded with a discussion and presentation of the developed ideas. Each idea was then qualitatively assessed by both researchers to additionally derive the community effectiveness. Ex-post interviews with all four communities were conducted to assess the construction of shared understanding in the community and the effect of each boundary object used. Interviews were semi-structured and followed the exploration of the moderating effect of boundary objects' use. The setting allowed for collecting the data on the independent variables of *community learning behavior*, *boundary objects' use* and the dependent variable *shared understanding* and *effectiveness* (cf. figure 1). We conducted 12 interviews which lasted between 30 mins and 60 mins (m= 42 mins, sd= 10 mins). Not all members of each community could be interviewed due to time restrictions of the students. All interviews were audio-taped, fully transcribed and analyzed (554 codes, 797 quotes) using qualitative data analysis software (atlas.ti 7). The total interviewing time was 8 hours and 34 minutes. The overarching interest of the interview was phrased as: *"What were the obstacles and drivers when you were collaboratively working on your business idea? And how did the provided tools in each phase support your community to advance the business idea as a whole?*". In all, questions were semi-structured along, among others, the categories: (1) key tasks the object is used for, (2) contribution to discussion, (3) contribution to consensus building, and (4) type of work conducted with the object. They aimed at collecting the individual perception on each of the used boundary object. Interviewees reflected upon the effect of the boundary objects used on their community, to the innovation phase, and in general.

4 Findings

In the following principles for boundary objects' use to create shared understanding in communities are suggested. The suggested design principle are prescriptive knowledge and obey the three claims of Chandra et al. (2015) namely, provide information about (1) the action, (2) the materiality to make the action possible, and (3) the boundary condition. The principles describe the moderating role of each of the three classes of boundary objects (syntactic, semantic, pragmatic, cf. 2.3) to establish a shared understanding.

4.1 Syntactic boundary objects for construction of meaning and knowledge transfer

Construction of shared understanding is defined as carefully listening to the other members of the community. For this task the boundary objects *business model canvas* provided strong support to convey information to others. This is because its perceived characteristics are information transmission. Ideas are just "sent" to the other members of the community and the canvas provides the necessary infrastructure in order to do so. Secondly, construction is conducted through asking questions. The boundary object *business model canvas* with its perceived characteristic of establishing a first common ground in the community supports reducing ambiguity through active discussions. The community initially creates a solution space on which all members have to agree upon.

The data collected indicates a correlation between constructing meaning *(boundary condition)* and syntactic boundary objects *(materiality)*. Interviewees stated that the syntactic capacity of the boundary object *business model canvas* contributed to *listen carefully* to each other and stimulate *asking questions*.

"Some provided ideas like […], useful for the customer section; and other reacted upon this idea and said, well no we actually offer […].

So the discussion started with each section we listened to each other and went through each argument individually." (ID 2: 2:56)

Further on, knowledge transfer is realized within the community with the support of a syntactic boundary object. The boundary object thus moderates the first stage of building shared understanding. It provides an *infrastructure* and initial *common ground*. This common ground is required to then establish the next level of shared understanding in the community.

Construction / Boundary condition	Principle for Boundary Objects' Use
Community members are listening carefully to each other.	P1.1: Use syntactic boundary objects to establish an infrastructure.
If something is unclear, we ask each other questions.	P1.2: Use syntactic boundary objects to establish a common ground in the community.

Table 1: Principles for construction of shared understanding

4.2 Semantic boundary objects for co-construction of meaning and knowledge translation

Co-Construction of shared understanding is coined by the elaboration of ideas within the community. The boundary object *business ecosystem* and *hypotheses* contributed to focus and stimulate discussions in the community. Moreover, the visual characteristics of the boundary object ecosystem contributed to the discussion. In addition, information is translated by other members of the community in the form of complementing ideas. This can be achieved with the support of boundary objects focusing on visuals to discuss ideas. In this process community members start translating information in the form of drawing conclusions from others information. The use of semantic boundary objects can thus facilitate negotiations, enrich discussions, and contribute to create new ideas.

For the semantic boundary object *(materiality)* the data indicates a moderating effect on the co-construction of meaning *(boundary condition)*. Statements from interviewees show that boundary objects with a semantic capacity such as the *business ecosystem* or *hypotheses* lead to *elaboration on each other's* ideas and a *complementation of ideas.* Interviewee 7 states:

"What was very important [for our business idea], was the correct money flow […]. But at that point the others haven't thought about it. They just drew a flow. But then we discussed the sketch again. […] And that was a decisive milestone [for our business idea] and an important contribution of mine." (ID 7: 7:67)

The presented quote stresses the positive effect of visuals to translate meaning when shared understanding is established. This is done with its properties of *facilitating negotiations (action)* within the community. As the interviewee stated, the boundary objects provided a visualization to *discuss information,* and also *develop new ideas.* The boundary object contributes to translate information between two actors with a co-constructive approach.

Co-Construction / Boundary condition	Principle for Boundary Objects‘ Use
Community members elaborate on each other's information and ideas.	P2.1: Use semantic boundary objects to facilitate negotiations.
Information from community members is complemented with information from other community members.	P2.2: Use semantic boundary objects to discuss information.
Community members draw conclusions from the ideas that are discussed in the community.	P2.3: Use semantic boundary objects to develop new ideas.

Table 2: Principles for co-construction of shared understanding

4.3 Pragmatic boundary objects for constructive conflict and knowledge transformation

Constructive conflict is an intensive learning process in the community to build shared understanding. The members of the community ask each other critical and reflective questions that may challenge others. The community is characterized by a process of knowledge transformation which means members of the community are adding up to their existing knowledge in the form of changing and acquainting existing knowledge and thus are learning. Pragmatic boundary objects occupy the capacity that members of the community interact with each other. In this process the boundary object *3D model* further supported the convergence on meaning in the community and established sense-making. Besides that, the *3D model* is a boundary objects that reaches most of the members of the community.

Data indicates that the pragmatic capacity of boundary objects *(materiality)* such as the *3D model* moderates constructive conflict *(boundary condition)* for knowledge transformation within the community. Pragmatic boundary objects provide means to *act upon others comments* and in this vein *ask critical questions*. The *3D model* enhanced the conflict about a still not fully shared opinion on the business offerings. Moreover, members of the community from differing educational backgrounds (marketing versus controlling) had hard to align mental models. This was particular prevalent when the 3D model was constructed. It was used to *share information* and then to *address this differences*.

"And then [when we build the 3D model] the big discussion started. Do we do full service yes or no? Anyway, the model needed to be refined, because it had an unrealistic design. We started again a full discussion on formerly neglected pain points." (ID 26 26:3)

It is found that the rich mix of *interaction* and the *reach of all actors* enhanced *sense-making.* This process was only possible because it built upon the previous efforts to create shared mental models. Finally a knowledge transformation was taking place when the initially differing knowledge backgrounds (marketing versus controlling) were aligned with constructive conflict.

Constructive Conflict / Boundary condition	Principle for Boundary Objects‘ Use
Comments on ideas are acted upon.	P3.1: Use pragmatic boundary objects to interact with.
Opinions and ideas of members of the community are verified by asking each other critical questions.	P3.2: Use pragmatic boundary objects to start sense-making.
In this community, I share all relevant information and ideas I have.	P3.3: Use pragmatic boundary objects to reach all actors.
This community tends to handle differences of opinions by addressing them directly.	P3.4: Use pragmatic boundary objects to start sense-making.

Table 3: Principles for constructive conflict for shared understanding

5 Discussion and Conclusion

In this paper we empirically develop and then suggest principles for boundary objects' use in innovation communities. The community learning framework, boundary objects' capacity to overcome knowledge boundaries and the acquainted knowledge management framework build the theoretical foundation for the development of principles for boundary objects' use.

The community learning framework (Van den Bossche et al. 2011) provides an understanding on how shared understanding in communities is established. Although, the framework acknowledges learning and construction of meaning within the community, it is yet lacking a concrete view on artifacts that moderate knowledge sharing. For this reason the notion of boundary objects (Carlile 2004, 2002) is introduced to the framework. Moreover, the capacity of boundary objects to cross knowledge boundaries is moderating the construction of meaning. We find boundary objects with their three distinct capacities (syntactic, semantic, and pragmatic) to relate to construction, co-construction, and constructive conflict. Hence, we suggest using syntactic boundary objects for construction of meaning (P1), semantic boundary objects for co-construction (P2), and pragmatic boundary objects for constructive conflict (P3).

Syntactic boundary objects provide the means to establish a common ground and infrastructure in a community. They are a necessity to initially align existing ideas of all members of a community. The syntactic boundary objects thus contribute to construct meaning by asking others questions and hence informing the whole community. The result is knowledge transfer in the community. Semantic boundary objects are richer in provoking and spurring discussions in the community. Their capacity is to evoke action upon others ideas. Often times initiated through visuals. With this, semantic boundary objects are best moderating the co-construction of meaning within a community. When applied, knowledge translation is facilitated.

Pragmatic boundary objects provide the means to engage in constructive and contrary discussions. The capacity of pragmatic boundary objects is to reach all collaborating members of the community and then to evoke interaction for final sense-making. This capacity is moderating the constructive conflict necessary to construct shared understanding. Moreover, the goal of pragmatic boundary objects is to finally transform knowledge in the community. This means widely differing mindsets (e.g. because of varying objectives) must be transformed and individually adjusted, to a common and agreed opinion. Knowledge transformation is also the most complex part such it is with constructive conflict to finally establish shared understanding in the community.

We acknowledge limitations of this study with regards to the empirical foundation. The generalization of the constructed principles is limited because they are based on a single in-depth study. We propose to conduct further studies with differing boundary objects to measure their impact on the creation of shared understanding. In addition, the perceived capacities of boundary objects may vary in communities. In our data we found few varying meanings on the efficacy of the used boundary object. A future study could quantify existing knowledge boundaries and their prevalence. Then, based on a capability assessment, boundary objects could more precisely resolve barriers and further reveal proficiency for the found results.

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Einfluss von Demographie und Führungsverantwortung auf die Adaption von Technologien zur Unterstützung organisationaler Ad-hoc-Kommunikation

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Abstract

Weltweit werden nicht nur im privaten sondern auch zunehmend im beruflichen Umfeld Applikationen eingesetzt, die Ad-hoc-Kommunikation zwischen Individuen unterstützen. Neben der Unterstützung ungeplanter Ad-hoc-Prozesse können darüber hinaus im Vergleich zu E-Mails digitale, synchrone Konversationen stärker unterstützt werden. Die Adaption solcher Ad-hoc-Technologien kann jedoch stark variieren. Im vorliegenden Beitrag sollen Theorie-basierte Annahmen hinsichtlich des Einflusses von Demographie und Führungsverantwortung auf die Adaption von Technologien wie Instant Messengern (IM) empirisch getestet werden. Hierzu wird in einem deutschen Großunternehmen analysiert, welcher Zusammenhang zwischen Alter, Geschlecht und Führungsverantwortung zu der Nutzung eines Unified-Communication-Tools, vergleichbar mit dem Dienst Skype, besteht. Auf Basis eines Datensatzes mit über 9 Mio. Nachrichten und 23.000 Accounts konnte über einem Zeitraum von sechs Monaten gezeigt werden, dass im Durchschnitt weibliche Angestellte häufiger Ad-hoc-Nachrichten schreiben als männliche Angestellte und mit zunehmendem Alter sowie Führungsverantwortung die Nutzungsaktivität abnimmt.

1 Einleitung

Im Kontext einer digitalisierten Arbeitswelt und zunehmend verteilten Arbeitsstrukturen spielt die IT-basierte Ad-hoc-Kommunikation eine wichtige Rolle, um eine effiziente und effektive Zusammenarbeit in Organisationen zu ermöglichen. Hierzu erhalten Mitarbeiter z. B. Zugriff auf Instant Messenger, über die unternehmensweit kurze Textnachrichten ausgetauscht werden können. Beispielprogramme sind Skype bzw. Lync (Skype for Business) oder Messenger-Funktionen innerhalb von Social Software (z. B. IBM Connections). Solche Programme bieten zusätzlich eine Awareness-Funktion an, über die erkannt werden kann, ob die gewünschte Ansprechperson verfügbar ist. Trotz eines potenziell hohen Mehrwertes, z. B. für die Team-basierte Kommunikation und Kollaboration, kann die Akzeptanz und Nutzung solcher Technologien unterschiedlich ausgeprägt sein.

Die Literatur zur Technologieadaption hält hierfür unterschiedliche Erklärungsmodelle bereit: das Technology Acceptance Model (TAM) oder die Unified Theory of Acceptance and Use of Technology (UTAUT) nennen u.a. den IT-bezogenen, wahrgenommenen Nutzen und Nutzungsaufwand als Einflussfaktoren, während z. B. im Rahmen der Diffusion of Innovation Theory auf die Innovationsfreudigkeit fokussiert wird. Viele dieser Theorien folgen der gemeinsamen Annahme, dass demographische Variablen einen mittelbaren oder unmittelbaren Einfluss auf die Adaption von Technologien haben. Diese Annahme soll in der vorliegenden Studie auf Basis empirischer Daten im Kontext der Adaption von Instant Messangern getestet werden.

Hierzu wurde ein Datensatz eines deutschen Großunternehmens analysiert, das weltweit ca. 100.000 Mitarbeiter beschäftigt. Dieser Industriekonzern bietet allen Mitarbeitern ein Unified-Communication-Tool (ähnlich zu Skype) als Kommunikationsinstrument an. Im Rahmen der Analyse der Nutzungsdaten wird der Frage nachgegangen, welchen Einfluss das Alter, das Geschlecht und eine eventuelle Personalverantwortung auf die Nutzung dieses Tools haben. Hierzu wird auf Basis von 9,68 Millionen Nachrichten, die im im Zeitraum von Dezember 2014 bis Juni 2015 durch 11.611 Nutzer in Deutschland entstanden sind, analysiert, ob Einflüsse auf die Anzahl der Konversationen über das Tool, der darin enthalten Nachrichtenanzahl und Konversationsdauer identifizierbar sind.

Der Artikel ist wie folgt aufgebaut. Zunächst wird in Abschnitt 2 auf Literatur zu Instant Messaging und potenziellen Einflüsse von Demographie und Führungsverantwortung auf die IT-Adaption eingegangen, um hieraus Hypothesen abzuleiten. In Abschnitt 3 werden das Fallunternehmen und der existierende Datensatz charakterisiert. Die Ergebnisse der Datenanalyse werden in Abschnitt 4 dargestellt, um sie in Abschnitt 5 im Kontext der aufgestellten Hypothesen zu diskutieren. Im letzten Abschnitt 6 werden die Ergebnisse der Studie zusammengefasst, Limitationen genannt und ein Ausblick auf die zukünftige Forschung gegeben.

2 Literaturübersicht und Hypothesen

Instant Messaging (IM) ist eine Kommunikationsform, die extensiv in der wissenschaftlichen Literatur hinsichtlich unterschiedlicher Aspekte und Kriterien untersucht wurde. Studien weisen auf vorteilhafte Einflüsse im Rahmen koordinativer Prozesse oder der Bewältigung von Aufgaben durch die Verwendung von IM und anderer sozialer Medien hin (z. B. Meske und Stieglitz 2013, Riemer et al. 2015, Stieglitz et al. 2014b). Laureano et al. (2014) weisen in ihrer Untersuchung beispielsweise eine Verbesserung der Kommunikation zwischen den Abteilungen, sowie eine erhöhte Effizienz, Produktivität und Zufriedenheit im Kontext von Teamarbeiten hin. Ou et al. (2011) postulieren, dass durch IM eine schnelle und einfache Kommunikation ermöglicht wird, die die Nutzer zu Konversationen ermutigt. Diese erhöhte Interaktion hat hierbei einen positiven Einfluss auf die Arbeitsleistung. Mahatanankoon (2010) zeigt, dass die IM-Nutzung zu einer Steigerung der Kreativität führt, diese sich aber gleichzeitig negativ auf die Jobzufriedenheit auswirken kann. Cameron und Webster (2005) zeigen, dass IM als weniger reichhaltig wahrgenommen wird, als die klassische Face-to-Face-Kommunikation. Darüber hinaus ordnen sie IM einen störenden bzw. arbeitsunterbrechenden Charakter zu. Letzteres wird auch von Gupta et al. (2013) genannt, die auf eine reduzierte Aufgabenqualität und einen erhöht wahrgenommenen allgemeinen Workload hinweisen. Insgesamt sehen Ou et al. (2011) jedoch mehr potenzielle Vorteile als Nachteile in der Nutzung von IM. Neben solchen beispielhaften Vor- und Nachteilen durch die Nutzung von IM wurden Erfolgsfaktoren für die Einführung und Adaption von

Anwendungen identifiziert, die ebenfalls durch Aspekte der Demographie und Managementstruktur tangiert werden (Stieglitz et al. 2013, Stieglitz und Meske 2012, Stieglitz et al. 2014a).

In den genannten Bereichen zeigen sich ambivalente Forschungsbefunde, die unterschiedliche Aussagen zur Varianzaufklärung durch persönliche Variablen treffen. Während mehrere Autoren einen Zusammenhang zwischen demografischen Charakteristiken und der Adaption technologischer Innovationen verneinen (z. B. Baldridge und Burnham 1975, Damanpour und Schneider 2006, Glass und Li 2010, Arts et al. 2011), fanden andere Forscher signifikante Zusammenhänge verschiedener individueller Ausprägungen und dem Adaptionsverhalten. In diesem Kontext stechen insbesondere die Faktoren Geschlecht und Alter heraus, deren Ausprägungen einen hohen Einfluss auf die individuelle Wahrnehmung, Einstellung und Leistung haben (Nosek et al. 2002).

Fallows (2005) und Weiser (2000) zeigen den Unterschied im Kontext der Social Role Theory, dass die Technologienutzung durch Frauen als stärker auf soziale Verbundenheit fokussiert als solche durch Männer. In ihren Arbeiten zeigen sie, dass Internettechnologien durch Frauen stärker zum Zwecke der sozialen Interaktion und Pflege von Beziehungen genutzt wird, während Männer entsprechende Technologien eher aufgabenfokussiert nutzen. Damanpour und Schneider (2006) geben in ihrer Arbeit an, dass männliche Topmanager eher technologische Innovationen initiieren als weibliche, weil diese eher bereit dazu sind, den Status quo zu verändern und Entscheidungen zu treffen, die die Adaption der Innovation begünstigen (z. B. Bereitstellung von Ressourcen). Gleichwohl weisen Eagly und Johnson (1990) sowie Hooijberg und Ditomaso (1996) darauf hin, dass weibliche Topmanager die Implementierung stärker als ihre männlichen Kollegen vorantreiben könnten, da sie eher zu einem partizipativem Führungsstil neigen, in welchem Ad-hoc-Kommunikation durch IM unterstützt wird. Kimbrough et al. (2013) zeigen darüber hinaus in einer Onlinestudie, dass Frauen im Vergleich zu Männern häufiger Kommunikationstechnologien nutzen, wobei Text Messaging (IM), Social Media und Online Video Calls präferiert werden.

Im Rahmen der Theory of Planned Behavior zeigt die Studie von Venkatesh et al. (2000), dass Adaptionsentscheidung bei Männern stärker durch ihre Einstellung gegenüber der expliziten Technologie beeinflusst sind, während bei Frauen eher subjektive Normen und die erlebte Verhaltenskontrolle (perceived behavioural control) von Bedeutung sind. Venkatesh et al. (2000) verweisen auf den nachhaltigen Einfluss der geschlechterspezifische Erstevaluation der Technologie und auf ihre langfristige Nutzung. Brancheau und Wetherbe (1990) analysierten im Kontext der Diffusion of Innovation Theory die Adaption von End-User-Computing, in diesem Fall der Spreadsheet Software. Die Resultate wiesen darauf hin, dass Early Adopters häufig jüngere Personen mit einem hohem Bildungsniveau und Interesse an interpersonelle Kommunikation sind. Nach Rogers und Shoemaker (1971) tendieren jüngere Menschen eher dazu, Innovation zu adaptieren, begründet in einer offeneren Haltung gegenüber Neuerungen. Organisationen mit einem hohen Prozentsatz solcher Individuen adaptieren mit höherer Wahrscheinlichkeit Innovationen. In ihrer Studie zeigen Lerouge et al. (2005), dass Personen ab 50 Jahren Innovationen signifikant weniger nutzen als Menschen zwischen 20 und 29 sowie 40 und 49.

Basierend auf Bantel und Jackson (1989) sowie Hambrick und Mason (1984), gehen Damanpour und Schneider (2006) davon aus, dass jüngere Manager Innovationen eher initiieren als ältere Manager, da sie (1) bessere kognitive Ressourcen für das decision-making aufbringen, (2) sie eher offen für neue Ideen sowie den damit verbundene Risiken sind und (3) sie im Umgang mit neuen Technologien trainierter sind und über aktuelleres Wissen verfügen. Nach Huber et al. (1993) kann ein höheres Alter die Implementierung neuer Technologien ebenfalls einschränken, da ältere Manager sozialisiert seien, die vorherrschenden organisationellen Konditionen und Routinen zu akzeptieren und eine höhere psychologische Verbindlichkeit zu ihnen aufweisen. Dieses Verhalten wird auch von Baldridge und Burnham (1975) erwartet, wobei sie dies in den jeweiligen administrative Positionen und Rollen, wie die der Top-Manager, begründet sehen, die einen Einfluss auf das Involvement eines Individuums im Innovationsprozess ausüben.

Abgeleitet aus der Literatur werden daher folgende Hypothesen aufgestellt, die im Rahmen dieser empirischen Studie getestet werden sollen:

Hypothese
H1: Weibliche Nutzer schreiben im Durchschnitt mehr Nachrichten als männliche Nutzer.
H2: Personen ohne Führungsverantwortung nutzen IM häufiger als Personen mit Führungsverantwortung.
H3: Mit zunehmenden Alter nimmt die IM-Aktivität ab.
H4: Power-User sind am häufigsten jüngere weibliche Personen ohne Führungsverantwortung.

Tabelle 1: Aufgestellte Hypothesen

3 Ergebnisse

3.1 Fallunternehmen und Methode

Betrachtet wird ein großes deutsches Industrieunternehmen mit weltweit ca. 100.000 Mitarbeitern. Der Konzern ist in allen Kontinenten der Welt vertreten, wobei die Mehrzahl der Beschäftigten in Deutschland tätig sind, wo sich auch der Hauptsitz befindet. Das Unternehmen hat sich dazu entschlossen, eine Unified Communication Software einzuführen. Diese deckt dort seit 2010 die Instant Messaging und Präsenz-Funktionalitäten ab, welche seit 2014 um die Funktionen Sprache, Video und Konferenzen erweitert wurde. Aktuell können ca. 50.000 Benutzer davon profitieren, wobei 54% des weltweiten Kommunikationsaufkommens in Deutschland stattfindet; begründet durch die starke Konzentration der Verwaltung und Büroarbeitsplätzen in diesem Land. Aus diesem Kontext wurde der vorliegende Datensatz extrahiert und aufbereitet. Zur eigentlichen Analyse und Weiterverarbeitung der Daten wurde zur Berücksichtigung des Datenschutzes eine Anonymisierung und Aggregation der Daten vorgenommen.

Im weiteren Verlauf wird die Grundgesamtheit der vorliegenden Daten charakterisiert und basierend darauf eine quantitative Datenanalyse durchgeführt. Dabei wird zuerst auf die Gesamtmenge eingegangen, welche sich aus der Präsenz des Unternehmens weltweit zusammensetzt. Entsprechend repräsentiert der Datensatz eine Vielschichtigkeit sowohl im interkulturellen Bereich als auch im Benutzerverhalten. Um eine möglichst große Vergleichbarkeit herzustellen, wurde nach verschiedenen Variablen gefiltert. Weiter sind interkulturelle Diskrepanzen bewusst gemindert worden, indem die Fokussierung der Datenmenge auf Länderebene (Deutschland) erfolgte. Insgesamt floss aufgrund der Filterung (siehe auch folgendes Kapitel 3.2) ein Datensatz mit 9,68 Millionen Nachrichten von 23.677 Nutzern in Deutschland (davon 11.611 aktiv) in die quantitative Analyse ein. Die Analyse zeigt zunächst die Summe der geschriebenen Nachrichten pro Benutzer im evaluierten Zeitraum. Basierend darauf können 5 Nutzerkategorien festgelegt werden, die im weiteren Verlauf näher charakterisiert werden. Im Verlaufe der Analyse wird auf Methoden der deskriptiven Statistik zurückgegriffen.

3.2 Darstellung der Grundgesamtheit

Im betrachteten Großunternehmen zählt die eingesetzte Kommunikationssoftware weltweit insgesamt ca. 50.000 Nutzer, wovon 21.527 im Beobachtungszeitraum von sechs Monaten aktiv waren. Als Aktivität zählt in diesem Zusammenhang die Involvierung in mindestens eine Art der Kommunikation, was ein Sprach- bzw. Videoanruf, eine Chat-Konversation oder eine Konferenz mit gemischten Medien sein kann. Werden allein die IM-Unterhaltungen betrachtet, waren international 21.261 Nutzer aktiv. Im Umkehrschluss charakterisiert sich die Menge der nicht aktiven Nutzer durch keine Interaktion in diesem Zeitraum aus, sondern lediglich durch das Anmelden innerhalb der Software.

Dies ergab eine Gesamtmenge von 4,54 Millionen Konversationen mit 35,5 Millionen Chat-Nachrichten. Eine Unterhaltung besteht aus mindestens einer Nachricht. Die Dauer aller Konversationen summiert sich auf 22.119 Tage. Gezählt wird hierbei jeweils die Zeit vom Start (Zeitpunkt der ersten Nachricht in der Konversation) bis zum Ende (Zeitpunkt der letzten Nachricht in der Konversation). Wird die Dauer einer einzelnen Konversation betrachtet, so beläuft sich der globale Mittelwert hierfür auf 7 Minuten. Werden die Variablen „Führung“ und „Geschlecht“ über die ungefilterte Gesamtmenge betrachtet, so sind 12% (5.635) der gesamten Nutzer in einer disziplinarisch leitenden Funktion tätig. Weiter sind 9.573 Frauen und 31.530 Männer vertreten, wobei 6.775 Datensätze ohne Spezifikation des Geschlechts extrahiert wurden. Insgesamt repräsentieren die Datensätze nach Einschränkung des Zeitraumes und der Filterung der Aktivität 50 Länder mit einer Altersstruktur von 12 bis 72 Jahren. Das Durchschnittsalter beträgt hierbei 40 Jahre.

Wie im Vorfeld erläutert, wurde die Datenmenge gefiltert und die Variable „Land“ auf den Wert „Deutschland“ fixiert. Für die Analysen werden somit ausschließlich Nutzer aus Deutschland betrachtet, welche bezogen auf die Chat-Aktivität 54,6% der globalen Gesamtnutzermenge ausmachen. Dabei wird nicht nur die Kommunikation der Beschäftigten in Deutschland untereinander berücksichtigt, sondern auch das Verhalten eines Nutzers über die Grenzen Deutschlands hinaus. Letzteres spielt eine eher untergeordnete Rolle, was sich in einem stark globalisierten Unternehmen ein unerwartetes Ergebnis war. Die Stichprobe beläuft sich insgesamt auf 23.677 Nutzer in Deutschland. Der gefilterte Datensatz enthält 9,68 Millionen Chat-Nachrichten, welche in 1,31 Millionen Konversationen geschrieben wurden. Im weiteren Verlauf wird zwischen den gesamten Nutzern (23.677) und den aktiven Nutzern (11.611) unterschieden, um eine Charakterisierung der Gruppen zu erlauben.

3.3 Allgemeine Nutzung in Deutschland

Insgesamt verbrachten die Beschäftigten in Deutschland 7.272 Tage in Chat-Konversationen, wobei eine einzelne Konversation im Durchschnitt ca. 8 Minuten dauerte. Nutzer in Deutschland verbringen somit im internationalen Vergleich eine Minute länger in Unterhaltungen als der globale Durchschnitt. Die aktiven Benutzer von Instant Messaging haben in Deutschland ein Durchschnittsalter von 38 Jahren (Nicht-Nutzer: 44 Jahre), wobei vorwiegend Männer ohne Führungsfunktion vertreten sind. Wird das Alter genauer betrachtet, so variieren die aktiven Nutzer in Deutschland von 17 bis 67, wobei ein klarer Schwerpunkt zwischen 25 und 35 Jahren erkennbar ist (siehe Abbildung 1). 11,2% (1.301) der insgesamt 11.611 aktiven Nutzer haben disziplinarische Führungsverantwortung (Nicht-Nutzer: 10,5%). Bzgl. der Variable „Geschlecht“ sind 2.955 Frauen (25%) und 8.656 Männer (75%) vertreten.

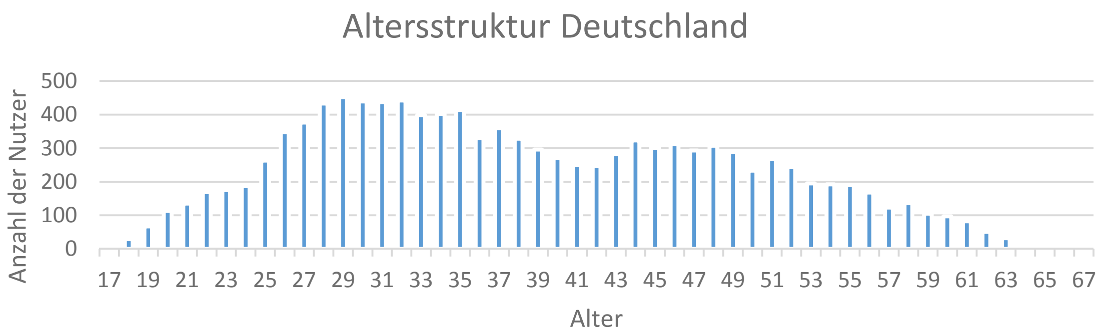

Abbildung 1: Altersstruktur aktiver Nutzer in Deutschland

Ein weiterer Aspekt, der analysiert wurde, ist der internationale Nachrichtenfluss. So werden im Beobachtungszeitraum ca. 665.000 entsprechende Nachrichten verzeichnet, welche in Deutschland beschäftigte Mitarbeiter mit KollegInnen im Ausland austauschten. Dies entspricht 6,9% des gesamten Nachrichtenaufkommens. Mit der Tatsache, dass 60% der Office-Mitarbeiter des Unternehmens im Ausland tätig sind und ein stark globalisierter Handel stattfindet, ist dieser Wert unerwartet gering.

3.4 Aktivitätsanalyse

Die Anzahl der geschriebenen Nachrichten wurde über den Beobachtungszeitraum pro Benutzer summiert und anschließend absteigend sortiert. Daraus ergibt sich für die 11.611 aktiven Benutzer in Deutschland der folgende Verlauf (siehe Abbildung 2).

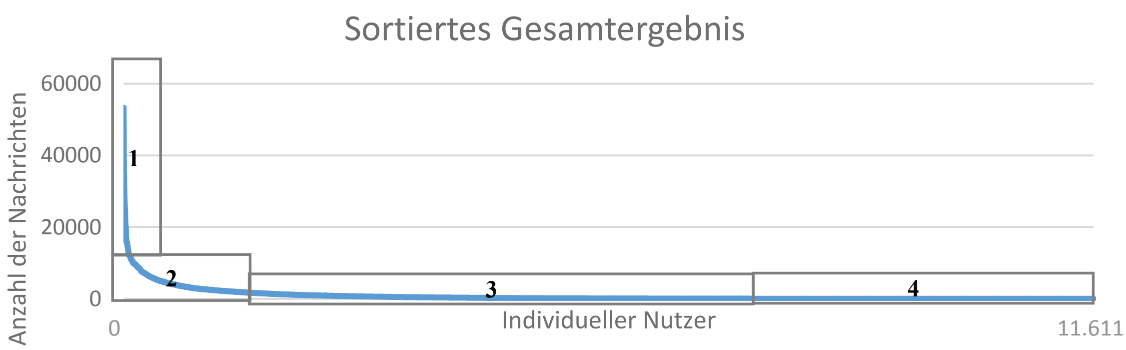

Abbildung 2: Mengenmäßige Verteilung der Chat-Nachrichten

Es lässt sich die Aufteilung in die folgenden fünf Kategorien vornehmen, wobei Kategorie 1-4 die aktiven Nutzer in Abbildung 2 widerspiegeln und Kategorie alle inaktiven Nutzer umfasst:

1. Top 50 (>15.000 Nachrichten im Betrachtungszeitraum)
2. Krümmung der Kurve zwischen 2.500 < Kat 2 < 15.000
3. Lineare Abflachung unter der Schwelle von 2.500 Nachrichten bis 375 Nachrichten
4. Passivnutzer unter 375 Nachrichten im Beobachtungszeitraum
5. Inaktive Nutzer ohne Nachrichtenverkehr

Die Aufteilung wurde in Abbildung 2 kenntlich gemacht. Dabei ist der Abschnitt der Exponentialfunktion, der in die jeweilige Kategorie fällt, durch ein Rechteck gekennzeichnet. Die jeweiligen X-Werte, die innerhalb der Markierung liegen, fallen entsprechend auch in die jeweilige Kategorie. Als erste Kategorie wurden die 50 aktivsten Nutzer gewählt. Hier wurde zwischen den einzelnen Werten je Nutzer die größte Differenz festgestellt. Nicht nur die reine Anzahl der Nachrichten verdeutlicht die Aktivität, sondern auch die Zeit, die die Nutzer sich jeweils in einer Konversation im Schnitt aufgehalten haben. Mit 702 Sekunden ist dies für die Kategorie 1 am höchsten. Als zweiten Bereich konnte die Krümmung der Kurve identifiziert werden, die durch eine zunehmend stärker steigende Nutzeranzahl zustande kommt und sich somit durch immer geringere Abstände bei der Nachrichtenanzahl charakterisiert. In dieser Kategorie haben sich die Nutzer im Mittel 600 Sekunden in einer Unterhaltung aufgehalten. Die Kategorien 1 und 2 stellen somit die aktivste Nutzermenge dar. Die Kategorien 3 und 4 repräsentieren zwar die größte Anzahl an Usern, definieren sich aber zugleich als passive Gruppierungen. Die Splittung der passiven Nutzer in zwei Kategorien erlaubt es, die Charakterisierung der User deutlicher zu differenzieren und einen Trend erkennbar zu machen.

3.5 Demographische Analyse

Basierend auf der Menge von 11.611 Benutzern wurde nach drei Kriterien analysiert: Alter, Geschlecht und Führungsebene. Das Alter wurde hierbei wiederum aufgeteilt in fünf Klassen. Je Merkmal sind in Tabelle 2 die Dauer und die jeweilige Anzahl an Nachrichten pro Konversation herausgestellt.

Merkmal		Dauer pro Konversation (in Sekunden)	Anzahl der Nachrichten pro Konversation (Durchschnitt)
Alter	Alter Klasse: 1 (< 25)	601	9
	Alter Klasse: 2 (25-35)	461	7
	Alter Klasse: 3 (36-45)	447	6
	Alter Klasse: 4 (46-55)	442	5
	Alter Klasse: 5 (> 55)	394	4
Ge-schl.	Geschlecht: Mann	460	6
	Geschlecht: Frau	501	8
Füh-rung	Führungskraft: Ja	426	5
	Führungskraft: Nein	480	8

Tabelle 2: Demographische Analysewerte

Auffallend ist hierbei die Bestätigung der Erkenntnisse aus der Aktivitätsanalyse. So schreiben jüngere Benutzer tendenziell mehr und länger als ältere. Frauen verbringen mehr Zeit in Unterhaltungen, schreiben dabei aber gleich viele Nachrichten wie Männer. Weiter sind Personen ohne Führungsbefugnisse deutlich aktiver als Benutzer mit disziplinarischer Verantwortung.

Kategorie (Anzahl)	Anteil Frauen	Anteil Männer	ØAlter gesamt	ØAlter Frauen	ØAlter Männer	Anteil Vorgesetzte (Anzahl)
Kategorie 1 (50)	67%	33%	27,3	25,9	30,0	0% (0)
Kategorie 2 (959)	48%	52%	30,2	29,0	31,3	2,1% (21)
Kategorie 3 (3071)	33%	67%	34,8	34,1	35,2	4,9% (151)
Kategorie 4 (7501)	19%	81%	41,2	41,6	41,0	15,1% (1129)
Kategorie 5 (12310)	14%	86%	43,5	41,5	43,8	10,5% (1288)

Tabelle 3: Kategorisierung der Nutzer mit zugehörigen Werten

Tabelle 3 stellt die Ergebnisse der Auswertung dar. Hierbei wurden die drei Variablen Geschlecht, Alter und Führung betrachtet. Werden die Prozentsätze im Vergleich zum Anteil der Frauen (25%) und Männer (75%) an der Grundgesamtheit betrachtet, so lässt sich eine überdurchschnittlich hohe Frauenquote in den Kategorien 1-3 identifizieren. Erst in Kategorie 4 und 5 überwiegt der Männeranteil deutlich. Bezogen auf das Alter ist ein ähnlicher Verlauf erkennbar. Hier liegt das Durchschnittsalter für aktive Nutzer bei 30,2 oder darunter, wohingegen die Kategorien 3 bis 5 einen deutlich höheren Mittelwert vorweisen. Hinsichtlich der Nutzer mit disziplinarischer Führungsverantwortung ist niemand aus dieser Gruppe in Kategorie 1 vertreten. Der zunehmend steigende Anteil der Vorgesetzten bei Abnahme der Chat-Aktivität spiegelt sich auch in eine größeren Repräsentanz der Vorgesetzten in der Kategorie 4 und 5 wider. Zusammenfassend ist somit ein aktiver Nutzer eher eine weibliche Person ohne Führungsverantwortung im Alter von durchschnittlich 27 Jahren.

4 Diskussion

Abgeleitet aus der Literaturanalyse wurden vier Hypothesen aufgestellt (vgl. Tabelle 1). Die in der Literatur genannten Ergebnisse basierten überwiegend auf theoretischen Annahmen oder wurden auf Basis kleinerer empirischer Stichproben identifiziert. Die genannte Literatur wies darauf hin, dass sich das IT-Adaptionsverhalten von Beschäftigten nicht nach der fachlichen Ausrichtung bzw. Jobprofil in einem Unternehmen richtet, sondern eine Vorhersage der Adaption und Nutzung der zur Verfügung gestellten Kommunikationsinstrumente auch nach demografischen Merkmalen möglich ist. Durch die in Kapitel 3 durchgeführten Analysen wurden die diesbezüglich in Kapitel 2 aufgestellten Hypothesen getestet. Aus verschiedenen Quellen wurden Tendenzen hinsichtlich des Einflusses dreier Merkmale auf die IT-Adaption abgeleitet: Geschlecht, Alter und Personalverantwortung. Das Gesamtergebnis zeigt einen relativ hohen Anteil passiver Nutzer (91% der Gesamtmasse, vgl. Tabelle 3), welche sich nur selten und kurz in IM-Konversationen aufhalten (vgl. Tabelle 2). Die Aktivität der Nutzer konnte in vier Kategorien unterteilt werden, wobei die Aktivität bei Kategorie 1 am höchsten ist und sich absteigend verhält bis zur Kategorie 4, die die meisten passiven Nutzer umfasst. Weitere Einflussfaktoren wie etwa Dauer und Intensität einer Konversation wurden aus der Literatur aufgegriffen und initial für den Hypothesentest aufbereitet (vgl. Tabelle 2).

Hieraus ergab sich die erste Hypothese H1, dass die Anzahl der Frauen in den aktiven Kategorien höher sein wird als die Anzahl der Männer. Weiter würde nach H1 eine durchschnittliche Konversation bei Frauen mehr Nachrichten umfassen als die von männlichen Usern. Werden die Werte aus der demografischen Analyse verglichen (vgl. Tabelle 2), so schreiben männliche Nutzer lediglich 6 Nachrichten im Schnitt, bei Frauen sind es 8. Weiter findet sich bei der Unterteilung der Nutzer in Kategorie 1, 2 bzw. 3 ein Frauenanteil von 67%, 48% bzw. 33%. Dies ist im Vergleich zum Gesamtanteil der Frauen im Datensatz (25%) vergleichsweise hoch. Hypothese 1 kann somit bestätigt werden.

In Hypothese 2 wurde angenommen, dass die Häufigkeit der Verwendung von IM bei Führungskräften sich von dem Gebrauch bei Angestellten ohne Personalverantwortung unterscheidet. Bestätigt wird dies durch die Charakterisierung von 4,9% der Gesamtnutzer als Führungskräfte in Kategorie 3 und 15,1% in Kategorie 4. Weiter ist der Großteil der Vorgesetzten in der Kategorie 5 (inaktive Nutzer) zu finden, hier sind es 1.288. Es findet sich insgesamt eine hohe Anzahl an Passivnutzern bei den Usern mit Personalverantwortung. Führungspersonal schreibt im Schnitt 5 Nachrichten, gegenüber 8 Nachrichten von Personen ohne Führungsverantwortung. 426 Sekunden verbringen Vorgesetzte in einer Konversation und somit 44 Sekunden weniger als die oppositive Gruppe. Insgesamt ist Hypothese 2 somit bestätigt.

Gemäß Hypothese 3 beeinflusst das Alter ebenfalls die Chat-Aktivität. Demnach würden sich ältere Personen überwiegend in den passiven Kategorien 3 und 4 wiederfinden und darüber hinaus einen geringeren Nachrichtendurchschnitt sowie eine niedrigere Konversationsdauer vorweisen. Wie die Analyse zeigt, sind die Alterssprünge von Kategorie 1 bis 5 signifikant, so liegt das Durchschnittsalter bei Kategorie 1 bei 27,3 Jahren, erhöht sich bei Kategorie 2 um 3 Jahre, um letztlich in den beiden passiven Kategorien 3 und 4 stark anzusteigen (Erhöhung um 4,8 bzw. weitere 6,4 Jahre). Weiter ist erkennbar, dass ab einem bestimmten Durchschnittsalter die Tendenz zur Ablehnung der Technologie steigt, was sich in den inaktiven Nutzern in Kategorie 5 widerspiegelt. Das höchste Durchschnittsalter ist in der Kategorie der inaktiven Nutzer zu finden. Tabelle 2 klassifiziert das Alter in Schritten von 10 Jahren. Dabei ist zu erkennen, dass jüngere Altersgruppen (Klasse 1-3) zwischen 601 und 447 Sekunden in den Konversationen verbringen. Mit steigendem Alter verringert sich also die Dauer, welche ein User in einer Konversation verbringt – im vorliegenden Beispiel bis hin zu 394 Sekunden. Auch die Anzahl der Nachrichten fällt von Klasse 1 mit 9 Nachrichten auf 4 Nachrichten in Klasse 5 (älteste Klasse). Diese Ergebnisse bestätigen Hypothese 3.

Die letzte Hypothese 4 charakterisiert die Gruppe der Power-User und somit Benutzer, die die höchste Aktivitätsrate aufweisen. Folgerungen aus verschiedenen Quellen und die Kombination der hier aufgestellten Hypothesen 1-3 führen zu der Annahme, dass vergleichsweise junge Frauen ohne Führungsverantwortung überdurchschnittlich oft als aktive bzw. Power-User identifiziert werden können. Bestätigt wurde dies durch die aktivsten Kategorien 1 und 2. Nach Tabelle 3 dominiert in beiden Kategorien der Frauenanteil. Weiter liegt das Durchschnittsalter der Frauen in Kategorie 1 bzw. 2 deutlich unter dem der Männer (25,9 zu 30,0, bzw. 29 zu 31,3). Diese Werte liegen im Durchschnitt wesentlich unter dem Durchschnittalter der aktiven Nutzer von 38 Jahren. Insgesamt konnte somit Hypothese H4 bestätigt werden.

Hypothese	Ergebnis
H1: Weibliche Nutzer schreiben im Durchschnitt mehr Nachrichten als männliche Nutzer.	Bestätigt
H2: Personen ohne Führungsverantwortung nutzen IM häufiger als Personen mit Führungsverantwortung.	Bestätigt
H3: Mit zunehmenden Alter nimmt die IM-Aktivität ab.	Bestätigt
H4: Power-User sind am häufigsten jüngere weibliche Personen ohne Führungsverantwortung.	Bestätigt

Tabelle 4: Ergebnisse der Hypothesentests

5 Zusammenfassung, Limitation und Ausblick

Insgesamt hat diese Arbeit gezeigt, dass sowohl die Demographie als auch eine eventuelle Führungsverantwortung einen Einfluss auf die Adaption und Nutzungsintensität von IM in Organisationen haben kann. Weibliche Beschäftigte adaptieren IM tendenziell häufiger als männliche Beschäftigte und sowohl mit zunehmenden Alter als auch Führungsverantwortung nimmt die IM-Aktivität ab. In der Konsequenz wurden insbesondere unter den Powerusern jüngere, weibliche Beschäftigte ohne Personalverantwortung identifiziert. Diese in der Literatur häufig hypothetisierten Annahmen entsprechender Einflüsse konnten in der vorliegenden Studie auf Basis eines umfangreichen Datensatz mit über 9 Mio. Nachrichten von 11.000 Usern bestätigt werden.

Die Arbeit unterliegt jedoch auch Limitationen. So wurden z. B. Konversationen von in Deutschland beschäftigten Personen mit Kommunikationspartnern im Ausland ebenfalls berücksichtigt. Dieser interkulturelle Aspekt kann im Gegensatz zur Geschlechterverteilung nicht eindeutig bestimmt und daher auch nicht vollständig als Variable aus der Grundgesamtheit eliminiert werden. Die Daten zeigen jedoch, dass lediglich 6,4% der Konversationen hiervon betroffen sind und entsprechend nicht von einer signifikanten Änderung des Gesamtergebnisses auszugehen ist. Darüber hinaus gibt die vorliegende quantitative Studie keine erklärenden Hinweise auf die individuellen Kontexte und Entscheidungen zur Nutzung oder Nicht-Nutzung von IM. Auch eine Generalisierung der Ergebnisse ist nur schwer möglich, da aufgrund fehlender Kontextinformationen der Einfluss z. B. der Unternehmenskultur nicht analysiert werden konnte und sich diese in anderen Organisationen stark unterscheiden kann.

Aus der vorliegenden Arbeit können weitere Fragen für die zukünftige Forschung abgeleitet werden. Neben der Eignung spezifischer Tools als Instrument zur Kommunikation und Zusammenarbeit zwischen Beschäftigten stellt sich die Frage der grundsätzlichen Bedeutung von Ad-hoc-Kommunikation in unterschiedlichen Jobprofilen und Hierarchiestufen. Eine variierende, Arbeits-bezogene Notwendigkeit zur Ad-hoc-Kommunikation könnte somit auch die identifizierten demographischen Einflüsse auf die IM-Adaption mindern. Zusätzlich könnte analysiert werden, ob ähnliche Einflüsse von Demographie und Hierarchie in anderen Kulturkreisen gleichermaßen existieren.

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Geodaten in Social Media als Informationsquelle in Krisensituationen

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Abstract

Diese Arbeit untersucht, in wie weit Geodaten aus sozialen Medien vor, während und nach Naturkatastrophen gesammelt und ausgewertet werden können, um das Lagebewusstsein für Hilfsorganisationen und Betroffene zu erhöhen. Im Vordergrund steht dabei die Sammlung und Auswertung von Daten aus dem Kurznachrichtendienst Twitter. Die weit verbreitetsten Methoden zur Sammlung und Analyse werden auf einen Twitter Datensatz zum Zyklon Pam, der im März 2015 den Inselstaat Vanuatu verwüstete, angewandt. Die Beantwortung der Forschungsfragen liefert einen Überblick des Status quo zur Verwendung von Geodaten aus sozialen Medien in Krisensituationen. Zum anderen liefert die Auswertung des Twitter Datensatzes Aufschluss darüber, welche grundlegenden Methoden der Auswertung im Falle des gewählten Beispiels das Lagebewusstsein hätten steigern können.

1 Einleitung

In den vergangenen Jahren haben auf der Welt einige verheerende Naturkatastrophen stattgefunden, die tausende von Menschen das Leben gekostet und dabei erhebliche wirtschaftliche Schäden angerichtet haben. Zu diesen Naturkatastrophen zählen etwa der Hurrikan Katrina in New Orleans im Jahr 2005 sowie die Erdbeben in Haiti (2010), in Sendai, Japan (2011) und in Nepal (2015). Die Art der Katastrophen ist aber nicht auf Naturkatastrophen beschränkt. Auch durch Menschen verursachte Katastrophen, wie etwa Öl-Lecks oder Terroranschläge, können von großem Ausmaß und mit verheerenden Auswirkungen verbunden sein. In diesen Krisensituationen ist es besonders wichtig, Regierungen und Hilfsorganisationen zeitnah mit relevanten Informationen zu versorgen, um sie bei Entscheidungen effizient zu unterstützen (Brown 2001; Lin et al. 2004). Die Betroffenen sind dabei eine wichtige Quelle für Kriseninformationen und können als „First Responder“ dazu beitragen, dass schnell ein umfassendes Bild der Lage erstellt werden kann. Die Betroffenen selbst sollten daher unbedingt in die Informationsinfrastruktur mit einbezogen werden (Reuter et al. 2011). Hilfsorganisationen stehen laufend vor neuen Herausforderungen (Ahmed 2011a), wie etwa der Entwicklung von Standardplänen in Katastrophenfällen (Alexander 2005) oder der Verbesserung des Informationsaustausches in Krisensituationen durch fortgeschrittene Technologien (Bowman et al. 2007). Zu diesen Technologien zählt auch die Auswertung von Geodaten aus Social Media.

Über die letzten Jahre haben Social Media in allen Bereichen des Lebens eine immer größere Bedeutung gewonnen, vor allem als Ergänzung zu den klassischen Medien, wie Radio, TV oder Zeitungen und Zeitschriften (Stieglitz et al. 2014, Meske & Stieglitz 2013). Der große Unterschied zu herkömmlichen Medien liegt in der bidirektionalen Kommunikation, die Social Media ermöglichen (Kaplan and Haenlein 2010). Facebook, das größte der sozialen Netzwerke, hat nach eigenen Angaben 1,49 Milliarden aktive Nutzer im Monat[1]. Twitter-Nutzer versenden täglich 500 Millionen Kurznachrichten[2] und auf YouTube werden pro Minute über 300 Stunden Videomaterial hochgeladen[3]. Auf diese Weise entstehen gewaltige komplexe Datenmengen, deren Auswertung die Forschung Praxis vor Herausforderungen stellt (Bruns und Stieglitz 2014a, Bruns und Stieglitz 2014b). Eine Teilmenge der Daten, die über Social-Media-Plattformen gesammelt werden, bilden dabei Geodaten, d.h. Daten die bestimmten geographischen Koordinaten oder einer Region zugeordnet werden können. Dies geschieht beispielsweise durch die Verwendung der Social-Media-Plattformen über Smartphones mit integrierten GPS-Modulen (Carley et al. 2013; Kim et al. 2013). Zwar befindet sich die Forschung noch am Anfang, doch ein aufkommendes Interesse an diesem Forschungsfeld ist derzeit bemerkbar (MacEachren et al. 2010).

Folgende Forschungsfragen bilden den Kern dieser Arbeit:

(1) Wie können Geodaten aus Social Media genutzt werden, um das Lagebewusstsein während Krisensituationen zu steigern?

(2) Wie hätte eine Auswertung der Geodaten im Falle des Zyklons Pam das Lagebewusstsein schärfen und zu einer erfolgreichen Bewältigung der Krise beitragen können?

2 Social Media in Krisensituationen

Aufgrund der weitreichenden Adaption von Social Media, spielen diese eine immer größere Rolle während Krisensituationen (Sakaki et al. 2013; Slavkovikj et al. 2014). Einzelpersonen nutzen Social Media vor allem, um nahestehende Personen über ihre aktuelle Krisenlage zu unterrichten oder um generelle und lokale Informationen zur Situation zu erhalten (Bruns et al. 2011; Gao et al. 2011; Chen et al. 2012; Landwehr and Carley 2014). Des weiteren passiert es, dass von einzelnen Benutzern Falschinformationen gestreut werden, die aber oftmals durch eine große Anzahl an richtigstellenden Beiträgen anderer Benutzer korrigiert werden (Reuter et al. 2011; Sakaki et al. 2013). Darüber hinaus haben einige Forscher bereits versucht, Ansätze zu finden, um Nachrichten als mehr oder minder vertrauenswürdig einzustufen (Castillo et al. 2011). Während Krisensituationen werden zahlreiche Dienste von Einzelpersonen genutzt, jedoch haben sich Kurznachrichtendienste, wie etwa Twitter, aus Gründen der Einfachheit und Unmittelbarkeit als ein häufig verwendetes Medium etabliert (Reuter et al. 2011; Yin et al. 2012). So untersuchen Fuchs et al. (2013) in ihrer Arbeit, wie geoannotierte Tweets aus Deutschland während der Überflutungen 2013 eingesetzt werden können, um relevante Ereignisse zu identifizieren. Organisationen stehen in den meisten Fällen bessere Daten, Analysetools und Ressourcen zur Verfügung als Individuen. Sie nutzen diese zusätzlichen Möglichkeiten in Verbindung mit Social Media primär, (1) um

[1] https://newsroom.fb.com/company-info/ zuletzt aufgerufen am 05.09.2015
[2] https://about.twitter.com/company zuletzt aufgerufen am 05.09.2015
[3] https://www.youtube.com/yt/press/de/statistics.html zuletzt aufgerufen am 05.09.2015

potenzielle weitere Katastrophen zu prognostizieren, und (2) Falschinformationen entgegenzuwirken, da sie deutlich mehr Vertrauen als Einzelpersonen genießen. Des Weiteren versorgen sie (3) die Öffentlichkeit mit Informationen und nutzen diese Kanäle, um (4) das Ausmaß der Katastrophe zu erfassen und Aktionen zu identifizieren, die die Betroffenen bestmöglich unterstützen können (Ahmed 2011b; Landwehr und Carley 2014). Landwehr und Carley (2014) schreiben in ihrem Artikel über den erfolgreichen Einsatz der Plattform „Ushahidi Haiti" während des Erdbebens auf Haiti im Jahre 2010. Auf der Plattform „Ushahidi" können Berichte von den freiwilligen Nutzern kategorisiert und geo-codiert werden, sodass sie auf einer Karte angezeigt und von allen anderen Benutzen eingesehen werden können.

3 Forschungsdesign

Für die Beantwortung der **ersten** Forschungsfrage wurde ein systematisches Literaturreview mittels einer Keyword-Suche in elektronischen Datenbanken mit hoher Reputation in der Disziplin der „Information Systems" nach vom Brocke et al. (2009) durchgeführt, um somit den Status quo in der Wissenschaft darzulegen. Das Ziel ist es, Ergebnisse zu aggregieren, die zum einen zeigen, inwiefern Geodaten aus Social Media benutzt werden können, um bei der Bewältigung von Krisen- und Notfallsituationen zu unterstützen sowie das Situationsbewusstsein zu erhöhen, und zum anderen Rückschlüsse darauf zulassen, wie die Aggregation und Auswertung von Geodaten aus Social Media verbessert werden können. Hierzu wurde ein Suchstring definiert, um die relevanten Arbeiten zu identifizieren: („Social Media") AND (geo-data OR geo-spatial OR location-data OR geodata OR geospatial OR locationdata OR gps OR „geographic data" OR geovisualization OR „geographical information system"). Dieser String wurde auf die jeweiligen Besonderheiten der einzelnen elektronischen Datenbanken angepasst. Er wurde gewählt, um den Suchbereich größtmöglich zu halten und ihn nicht zu stark durch das Einfügen von krisenverwandten Themen einzuschränken. Auf jeder Plattform wurde innerhalb von Abstract, Titel und Keywords gesucht. In einem ersten Schritt wurden alle Ergebnisse auf den jeweiligen Plattformen in Bezug auf das gegebene Ziel untersucht. Relevante Ergebnisse, die ein Potential zur Beantwortung der Forschungsfrage aufgewiesen haben, wurden in einem zweiten Schritt näher betrachtet und der Volltext kritisch evaluiert. Zuletzt wurden die relevantesten Studien kategorisiert und in eine zuvor definierte Tabelle übertragen.

Für die Beantwortung der **zweiten** Forschungsfrage wurden Daten aus der Social-Media-Plattform Twitter extrahiert und ausgewertet. Dabei wurde eine Vorher-Nachher-Evaluation mittels SART (Situational Awareness Rating Technique) vorgenommen (Taylor 1990; Taylor and Selcon 1994). SART basiert auf einer 7-Punkte Likert Skala, welche 10 Dimensionen umfasst, auf Basis derer ein Situation Awareness Wert berechnet werden kann. Die Dimensionen umfassen „Instabilität", „Variabilität" und „Komplexität" der Situation, „Wachheit", „Freie mentale Kapazität", „Konzentration", „Aufteilung der Aufmerksamkeit", „Informationsqualität und –quantität" und „Vertrautheit". Der vorgeschlagene Fragenkatalog wurde vor und nach der Auswertung des Datensatzes von den Autoren ausgefüllt. Die Ergebnisse wurden daraufhin verglichen, um eine Aussage über die Wirksamkeit der durchgeführten Methoden im Bezug auf eine Steigerung des Lagebewusstseins zu treffen. Die Datensammlung und -aggregation aller Tweets hat mithilfe eines selbst entwickelten Java Tools stattgefunden. Dabei wurden über die offizielle Twitter REST API (https://dev.twitter.com/rest/public/search, abgerufen am 10.12.2015) bestimmte Keywords abgefragt. Alle gesammelten Tweets inklusive der Metadaten, wurden daraufhin in einer Datenbank gespeichert.

In einem nächsten Schritt wurden die gefundenen Tweets aus der Datenbank exportiert und geocodiert. Dies erfolgte mithilfe der Geonames[4] API. Dieser Dienst wurde bereits in anderen Arbeiten (Intagorn und Lerman 2010; Gelernter und Mushegian 2011) erfolgreich zur Geocodierung genutzt. So können große Mengen an georeferenzierten Daten gewonnen werden. So konnten zusätzlich zu den den GPS-Koordinaten, die in den Metadaten enthalten waren, auch die Herkunftsorte geocodiert werden. Zuletzt wurde eine dritte Möglichkeit herangezogen. Dabei handelt es sich um das „*Named Entity Recognition*" (NER), eine Methode aus dem Bereich des „*Natural Language Processing*" (NLP). Hierbei wird der Inhalt der Tweets zuerst in verschiedene Token unterteilt, wie etwa „Personen", „Orte" und „Organisationen" (Ritter et al. 2011). Dann werden die Orte extrahiert und mittels Geocodierung über den Geonames-Dienst in GPS-Koordinaten umgewandelt. Im untersuchten Datensatz wurde die openNLP-Bibliothek[5] zur Erkennung der einzelnen Entität „Ort" in jedem einzelnen Tweet benutzt. Falls mehrere Entitäten erkannt wurden, wurde die letzte als die Entität von Interesse betrachtet. Die Auswertung der Tweets wurde mithilfe von Clustering- und Visualisierungsverfahren durchgeführt. Es wurden zwei interaktive Web-Visualisierungen auf Basis der Leaflet Javascript[6] Library und Kartenmaterial von OpenStreetmap.org[7] erstellt. Die erste der beiden Visualisierungen ist eine interaktive Heatmap zur visuellen Erkundung größerer Ansammlungen von Tweets an bestimmten Orten. Die zweite Visualisierung stellt eine interaktive Karte, auf der die Markierungen zur besseren Übersichtlichkeit gruppiert worden sind. Zuletzt wurde mithilfe des Geoinformationssystem ArcGIS[8], eine statistisch relevante Hotspot-Clusteranalyse erstellt. Diese Analyse arbeitet mit der ArcGIS eigenen „Getis-Ord Gi*", auch Fishnet-Clustering, Methode. Dabei wird die Karte in einzelne quadratische Bereiche eingeteilt und untersucht, wie viele Objekte in den einzelnen Bereichen der Unterteilung sowie den umliegenden Bereichen zu finden sind. Danach werden lokale Anhäufungen mit globalen verglichen und dadurch die statistische Relevanz von einzelnen Clustern bestimmt. Diese Verfahren wurden zum einen gewählt, da ähnliche Verfahren von vielen der in der Literaturanalyse gefundenen Studien, verwendet wurden. Zum anderen waren aufgrund von begrenzten Ressourcen tiefergehende Analysen nicht möglich.

4 Ergebnisse

Die Ergebnisse der systematischen Literaturreche dienen der Beantwortung der ersten Forschungsfrage. Es wurden im ersten Schritt insgesamt 1.964 Einträge mit den angegebenen Keywords auf allen elektronischen Datenbanken gefunden (Tabelle 1 - Ergebnisse aus der Suche in elektronischen Datenbanken) wovon 46 als relevant eingeordnet wurden. Die Auswertung hat zahlreiche Möglichkeiten aufgezeigt, in denen Geodaten in Krisensituationen verwendet werden können, um das Situationsbewusstsein zu steigern. Ein großer Teil der Forschung beschäftigt sich damit, möglichst komplette Systeme mit einer Vielzahl an Funktionen zur Sammlung und Auswertung von Geodaten zu liefern, die meist in Form einer interaktiven Weboberfläche bestehen. Beispiele für derartige Systeme sind etwa „SensePlace2" (MacEachren et al. 2011), „Scatterblogs2" (Bosch et al. 2013) oder die Social-Media-Krisen-Kartierungsplattform von Middleton et al. (2014).

[4] http://www.geonames.org/, abgerufen am 10.12.2015
[5] https://opennlp.apache.org/, abgerufen am 10.12.2015
[6] http://leafletjs.com/, abgerufen am 10.12.2015
[7] http://www.openstreetmap.org/, abgerufen am 10.12.2015
[8] http://www.esri.com/software/arcgis, abgerufen am 10.12.2015

	Möglichkeiten zur Aggregation von Geodaten aus Sozialen Medien					Möglichkeiten zur Analyse von Geodaten aus Sozialen Netzwerken						
Autor(en)	Metadaten	User Location	Text Extraktion	Volunteered Geographic Information	Geofencing	Karten	Foto/Video Sammlungen	Zeitgraphen / Animationen	Keyword/Tag Cloud	Soziale Netzwerk Graphen	Clustering –Methoden	Statistische / Mathematische
(Adam et al. 2012)	X		X								X	
(Bahir and Peled 2015)			X									
(Beltran et al. 2013)	X				X	X	X					
(Ben Kalifa et al. 2014)	X					X					X	
(Bendler et al. 2014a)	X					X						
(Bendler et al. 2014b)	X											X
(Chae et al. 2014)	X					X		X	X			
(Chen et al. 2015)	X		X									
(Cheong and Lee 2010)	X					X					X	
(Compton et al. 2014)	X	X				X		X				
(Erskine and Gregg 2012)				X		X	X		X			
(Feng et al. 2014)	X		X					X			X	
(Fujisaka et al. 2010)					X						X	
(Cao et al. 2015a)					X	X	X					X
(Guy et al. 2010)	X	X				X	X					
(Iizuka et al. 2011)				X		X						
(Li et al. 2013a)	X											
(JI et al. 2012)		X				X		X				
(Kondor et al. 2013)	X	X	X									
(Kumar et al. 2012)	X	X	X								X	X
(Cao et al. 2015b)	X						X					
(Lee et al. 2012)	X										X	X
(Liang et al. 2015)											X	X
(MacEachren et al. 2011)	X		X			X		X			X	X
(Malleson and Andresen 2015)	X										X	
(Middleton et al. 2014)			X	X		X						X
(Núñez-Redó et al. 2011)	X				X	X	X	X				
(Odlum and Yoon 2015)	X					X		X				
(Phillips and Sankar 2013)	X		X									
(Pohl et al. 2013)		X									X	
(Pohl et al. 2015)	X	X	X			X	X	X			X	X
(Reips and Garaizar 2011)	X				X	X		X				
(Ruocco and Ramampiaro 2014)					X						X	
(Sabty et al. 2013)					X	X	X	X			X	
(Sakai and Tamura 2015)	X					X		X			X	
(Shelton et al. 2014)	X					X				X	X	
(Sinnappan et al. 2010)												
(Spinsanti and Ostermann 2013)			X			X					X	
(Streefkerk et al. 2014)				X		X			X			
(Thom et al. 2014)	X				X							
(Valecha et al. 2010)				X		X			X			
(Walther and Kaisser 2013)					X	X	X	X			X	
(Wang et al. 2015)	X	X	X			X						X
(Li et al. 2013b)	X										X	
(Yanagimoto and Isaji 2014)	X	X	X									
(Young et al. 2014)	X					X						X

Tabelle 1 - Einordnung der gefundenen Ergebnisse in Kategorisierungstabelle

Quelle	Ergebnis	Relevante Artikel	% der gesamten Studien	% der relevanten Studien
IEEE Explore	50	9	0,46%	19%
AIS Electronic Library	556	5	0,25%	11%
ScienceDirect	588	9	0,46%	20%
SpringerLink	770	23	1,17%	50%
Gesamt	**1964**	**46**	**2,34%**	**100%**

Tabelle 2 - Ergebnisse zur Keyword-Suche

Die Systeme bieten die Möglichkeit zur Aggregation von Social-Media-Daten über eine Keyword Suche auf verschiedenen Plattformen über deren APIs. Aus den gefundenen Daten werden, sofern möglich, die GPS-Koordinaten aus den Metadaten extrahiert oder die Ortsangaben in den Profilen der Benutzer identifiziert und geocodiert. Die Methode, Geodaten mittels Named Entitiy Recognition zu ermitteln, ist eine weitere Möglichkeit, die die oben genannten Systeme anbieten. Dabei ist es vorteilhaft, dass diese Angaben häufig eine höhere Präzision aufweisen als die Angaben aus den Profilen der Benutzer, teilweise sogar bis hin zu Straßennamen. Diese Angaben werden häufig von Personen vor Ort hinterlegt, da diese detailliert über Vorfälle in Krisengebieten berichten können. Bei dieser Methode handelt es sich um ein vollautomatisiertes Verfahren, das keine perfekten Ergebnisse liefert, aber durch angepasste Software eine Genauigkeit von 70% oder mehr erreichen kann (Ritter et al. 2011; Gelernter and Mushegian 2011). Ein weiterer Ansatz umfasst beispielsweise das Sammeln von Daten auf dem umgekehrten Weg. Dabei werden Daten in einem definierten Radius um gegebene Koordinaten gesammelt, sofern die APIs der Anbieter diese Art der Anfrage zulassen. So haben Lee et al. (2011) solche Daten benutzt, um ungewöhnliche regionale Ereignisse in Japan zu aufzudecken.

Die ausgereiftesten Arbeiten setzen auf Systeme zur Analyse und Visualisierung der Daten. Die Möglichkeit der Visualisierung durch das Plotten der Daten auf einer Karte bieten fast alle Systeme. Darüber hinaus wird auch ein temporaler Aspekt von zahlreichen Systemen unterstützt. Mit weitergehenden räumlichen Clusteranalysen, die von zahlreichen Systemen zur Verfügung gestellt werden, lassen sich Orte mit einem besonders hohen Personenaufkommen identifizieren und gegebenenfalls „Untereeignisse" aufdecken (Walther and Kaisser 2013; Bendler et al. 2014a; Bendler et al. 2014b). Meist werden Daten mit inhaltlichen Auswertungen kombiniert, so dass auch eine thematische Gruppierung der Beiträge erfolgen kann. Das inhaltliche Clusterverfahren kann in Kombination mit Geodaten auch verwendet werden, um „Untereeignisse" innerhalb größerer Krisen zu identifizieren und zu verorten, die ansonsten möglicherweise erst im Nachhinein erkannt worden wären (Chae et al. 2012). Nicht zuletzt sind auch multimediale Daten, wie etwa geoannotierte Bilder, von vielen Systemen auf einer Karte darstellbar und können den Mitarbeitern in Kontrollzentren ein besseres Bild der aktuellen Lage vermitteln.

Zur Beantwortung der **zweiten** Forschungsfrage wurde eine Auswertung von Twitterdaten vorgenommen. Die erste Auswertung visualisiert die Daten durch eine Heatmap (Abbildung 1). Es zeigen sich vor allem durch Profilinformationen und NER Auswertung explizite Cluster. Vor allem die NER Auswertung zeigt aber Cluster in den besonders betroffenen Regionen, wie es Vanuatu ist. Die Geocodierung brachte keine Cluster hervor.

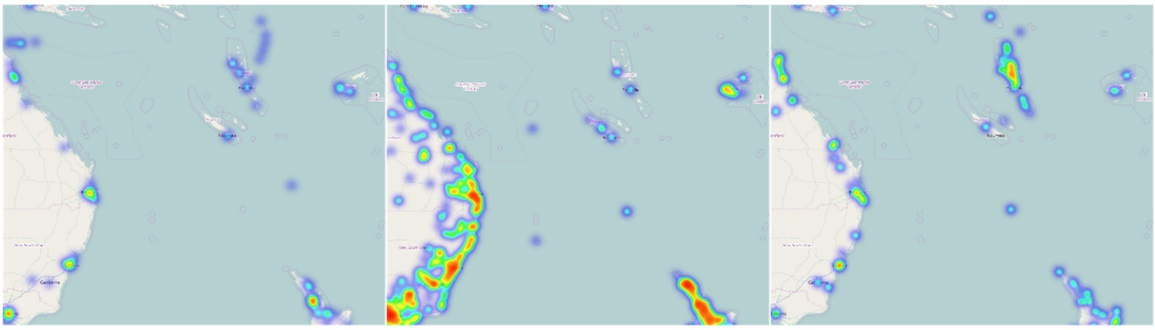

Abbildung 1 – Heatmap der geocodierten Tweets. Metadaten (Links), Profilinformationen (Mitte), NER (Rechts)

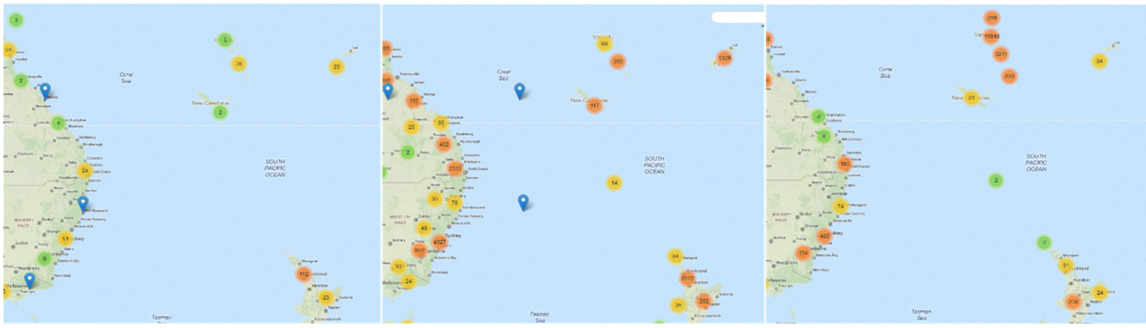

Abbildung 2 – Markerclustering der geocodierten Tweets. Metadaten (links), Profilinformationen (Mitte), NER (rechts)

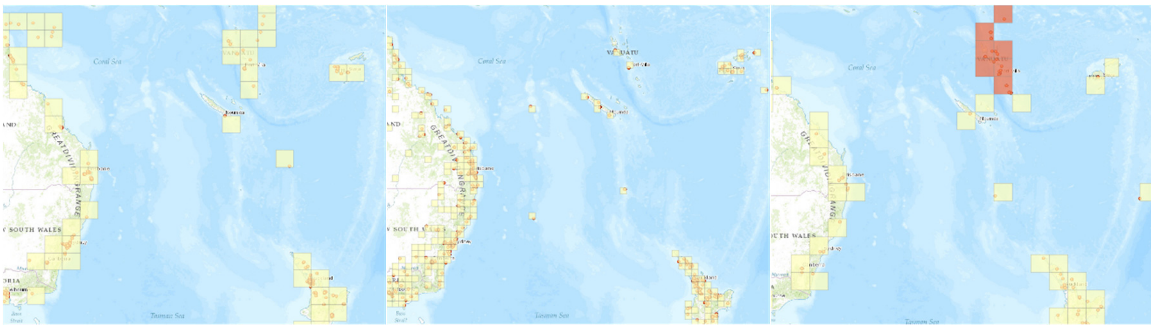

Abbildung 3 – Fishnetclustering der geocodierten Tweets. Metadaten (links), Profilinformationen (Mitte), NER (rechts)

Durch das Markerclustering (Abbildung 2) ließen sich die Daten besonders effizient interaktiv erkunden. Dabei konnten auch hier vor allem mittels der NER Methode Cluster erkannt werden. Die Hotspot-Analyse (Abbildung 3) zeigt nur bei der Auswertung der NER Orte, ein statistisch relevantes Aufkommen an Tweets auf Vanuatu an. Durch die Reduzierung der Komplexität mittels Visualisierung und der Möglichkeit der Untersuchung von im Krisengebiet auf Vanuatu verorteten Tweets, ließen sich Beiträge identifizieren, die zur Steigerung des Lagebewusstseins hätten beitragen können (Tabelle 3). Zum einen könnten sie für Helfer nützlich sein, wie etwa Tweet 3, der über lokale Unzugänglichkeiten informierte und zum anderen könnten sie Betroffenen helfen, sich ein Bild der Lage zu machen (Tweet 2,4) oder über den Status einzelner Personen zu informieren (Tweet 1). Dennoch finden sich immer noch viele irrelevante Tweets. Die Evaluation mittels der 10 Dimensionen umfassenden SART-Methode ergab eine Steigerung des Situationsbewusstseins von durchschnittlich drei auf sechs Punkte. Es konnten vor allem die Dimensionen

„Informationsmenge“ und „Informationsqualität“, sowie die Dimension der „Komplexität“ um 2-3 Punkte verbessert werden. Die Dimension der „Einteilung der Aufmerksamkeit“ hat sich um einen Punkt verschlechtert. Die übrigen Dimensionen zeigten im Durchschnitt keine signifikante Veränderung.

ID	Benutzername	Tweet	Datum
1	Akorikalo	I survived! #CyclonePam #vanuatu http://t.co/3jg59lorHH	2015/03/16
2	Deanprocter	Super tropical #cyclone #PAM 40km from Shefa Island, #Vanuatu heading for Port Vila at 20kmh with wind 270-320kmh 13m waves #Category5	2015/03/13
3	Sijoroma	.@28storms: Part of Devil's Point Road washed away outside of Port Vila, #Vanuatu (via Michael Thompson) #CyclonePAM http://t.co/sglb8QvBg6	2015/03/15
4	amyvchristian	Families belongings at an evacuation centre in Port Vila. #Vanuatu #TCPam #Oxfam @OxfamAustralia http://t.co/6OPpV0XcyA	2015/03/20

Tabelle 3 - Ausgewählte Tweets

5 Diskussion

Die Ergebnisse zur Beantwortung der ersten Forschungsfrage haben den Status quo der Forschung zu den Themen der Sammlung und Auswertung von Geodaten aus Social Media dargelegt. Zur Sammlung von Geodaten über die eingebetteten GPS-Koordinaten bestehen jedoch einige Limitationen. Tweets enthalten nur etwa 1-5% der Nachrichten Geoinformationen (Gelernter and Mushegian 2011; Thom et al. 2014; Bahir and Peled 2015). Dies hat zur Folge, dass große Datenmengen gebraucht werden, um qualifizierte Informationen daraus abzuleiten. Es sei zudem erwähnt, dass die durch die hier verwendete SART-Methode quantifizierte Veränderung des Lagebewusstseins, einer Messung einer sehr kleinen Stichprobe entspricht. Dies erschwert eine starke Verallgemeinerung der Aussagen und sollte im Hinblick auf weitere Forschung betrachtet werden. Die eingebetteten Geodaten sind darüber hinaus meist von der größten Relevanz, da sie voraussetzen, dass sich der jeweilige Benutzer zu einem bestimmten Zeitpunkt an einem bestimmten Ort aufgehalten hat und so Informationen zur aktuellen Lage vermittelte. Die geringe Anzahl geokodierter Nachrichten kann teilweise durch das Geokodieren der Nutzerprofile kompensiert werden. Hier ist es meist ein hoher Anteil an Profilen, die einen Ort angegeben haben, jedoch beziehen sich die Angaben nur in wenigen Fällen auf einzelne Städte. Bei Katastrophen mit großem geografischem Ausmaß sind diese Daten hilfreicher, als bei Katastrophen, die etwa nur auf einen einzelnen Ort begrenzt sind. Auch kann das zugrundeliegende Kartenmaterial mit weiteren Informationen angereichert werden, wie es im Falle der Arbeit von Mittelst et al. (2015) mit Karten zur Energieinfrastruktur geschieht. Diese Infrastrukturdaten müssen jedoch abrufbar sein, was in vielen Regionen der Welt nicht gegeben ist. Im Bereich der Auswertung von Geodaten zur Steigerung des Lagebewusstsein haben sich zahlreiche verschiedene Ansätze gezeigt. In nahezu allen Auswertungen wurde Gebrauch von Karten zur Visualisierung der geografischen Daten gemacht. Dies erscheint jedoch nur dann sinnvoll, wenn eine Art von visueller Gruppierung benutzt wird, da sonst bei größeren Datenmengen leicht die Übersicht verloren wird. Eine derartige Auswertung erscheint auch im Hinblick auf den vorliegenden Datensatz sinnvoll und sollte in folgende Arbeiten mit einfließen. Mithilfe von statistischen Verfahren wurden darüber hinaus Aussagen über zukünftige Ereignisse, bzw. die zukünftige Situation in Krisensituationen, getroffen.

Dadurch könnten Helfer schneller an Orte geschickt werden, an denen sie in naher Zukunft gebraucht werden. Dies geschieht zumeist über Bewegungsprofile und einen großen Datenbestand. Häufig kann jedoch kein ausreichend großer Datenbestand sichergestellt werden bzw. die Bewegungsprofile werden aufgrund von Bruchstückhaften Daten erstellt und sind somit ungenau. Die am häufigsten verwendete Methodik zum Untersuchen der Geodaten ist das Clustering. Dabei werden geografische/temporale wie auch thematische Clusteringverfahren benutzt. Nur durch das Gruppieren der Daten ist es überhaupt möglich, die großen Datenmengen zu verstehen. Die geo-temporalen Verfahren gruppieren die Daten meist auf einer Karte nach ihren räumlichen und zeitlichen Attributen. Die thematischen Clusteringverfahren hingegen erlauben eine automatische Einordnung der Daten in bestimmte Themen. So werden die Inhalte beispielsweise durch „Latent Dirichlet Allocation" klassifiziert. Dabei werden Sätze mittels eines Algorithmus auf ein übergeordnetes Thema hin untersucht und anhand der gefundenen Themen kategorisiert. Diese Funktionalität wird zum Beispiel genutzt, um Themenwolken für ausgewählte Regionen zu erstellen. Bei dieser Methodik bestimmen jedoch die Quantität und die Güte der Daten, ob eine erfolgreiche Einsortierung in verschiedene Kategorien möglich ist.

6 Zusammenfassung und Ausblick

Die generelle Frage nach der Verwendbarkeit von Geodaten aus Social Media zur Steigerung des Lagebewusstseins während Krisensituationen konnte durch eine tiefgehende beantwortet werden. Der verwendete Suchstring beinhaltet eine starke Variation bezüglich Geodaten, beschränkt sich jedoch auf den Begriff „Social Media". Zukünftige Arbeiten könnten eine noch größere Variation an Suchbegriffen untersuchen. Es hat sich gezeigt, dass zahlreiche interessante und innovative Ansätze bestehen, die auf unterschiedliche Weise versuchen, aus den vorhandenen, begrenzten geografischen Informationen in Social Media weitere verwendbare Daten zu extrahieren. Des Weiteren gibt es vielfältige Forschungsprojekte, die Geodaten im Kontext unterschiedlicher Krisen auswerten und anhand dieser Auswertung eine Schärfung des Lagebewusstseins anstreben. Einige dieser Projekte sind etwa „SensePlace2", „GeoVista" und „Scatterblogs2". Die Möglichkeiten reichen von verschiedenen Arten der Visualisierung auf Karten, über räumlich-temporale Auswertungen, bis hin zu vielfältigen Arten von Clusteranalysen. Darüber hinaus konnte die spezifische Frage nach der Möglichkeit, Geodaten aus Social Media zur Steigerung des Lagebewusstseins während des Zyklons Pam zu nutzen, adressiert werden. Es wurden GPS-Daten, geokodierte Profilinformationen sowie geocodierte, mittels NER extrahierte Orte, als Datenbasis für eine Auswertung verwendet. Die Auswertung umfasst verschiedene Visualisierungen, sowie eine Clusteranalyse. Eine Auswertung der Analysen hat gezeigt, dass beispielweise ein Anwender in einem Krisenmanagement-Kontrollzentrum durch die Heatmap- und Markerclustering-Methoden und deren interaktive Karten deutlich schneller einen Überblick über die räumliche Dimension der Katastrophe gewinnen kann. Darüber hinaus konnte durch die Clusteranalyse aufgezeigt werden, in welchen Regionen sich Hotspots mit einer statistisch relevanten Häufung von Datenpunkten befinden, wodurch ein möglicher Indikator für Gebiete mit besonderen Bedürfnissen identifiziert werden konnte. Da die Nutzung von Social Media in Zukunft weiter ansteigen wird und auch der durch Naturkatastrophen verursachte Schaden weiter wachsen wird, werden auch die zuständigen Organisationen in Krisensituationen weiterhin auf Social Media als wichtigen Bestandteil zur Steigerung des Situationsbewusstseins setzen.

Zusammenfassend ist festzuhalten, dass es sich bei der durchgeführten Auswertung um eine weniger ausgereifte Analyse handelt, als es beispielsweise bei „SensePlace2" der Fall ist. Dadurch ist es durchaus möglich, dass mit ausgereifteren Auswertungsmethoden ein noch höherer Grad an Situationsbewusstsein hätte erreicht werden können. Weiterhin ist die durchgeführte Auswertung auf die englische Sprache begrenzt, welche nicht die Amtssprache in Vanuatu ist. Dies lässt vermuten, dass eine zusätzliche Sammlung und Auswertung von Tweets in der Amtssprache betroffener Regionen auch mehr Daten liefern würde, die bessere Ergebnisse bei einer darauffolgenden Auswertung liefern würden.

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The Case of UniConnect – The Shaping of an Academic Collaboration Platform

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Abstract

In this paper we present a study of socio-technical change and the adoption of an enterprise collaboration system (ECS). Through the use of a longitudinal interpretive case study, we examine the context and dynamics at play in the implementation of an academic collaboration platform. The collaboration platform was envisaged as an information infrastructure for teaching and research collaboration with the objective of supporting Boyer's four scholarships. Using theories of socio-technical change as both a theoretical and analytical lens and concepts drawn from actor-network theory (ANT) we focus on the shaping of the platform, the translations that occur and the inscriptions that emerge from the aligning and re-aligning of heterogeneous networks of actors and interests. In the study findings we present the different constellations and concerns that emerged as the project passed through several phases. In its current state the information infrastructure has achieved a degree of durability; the various interests in the actor-network are aligned and, to a large extent, the platform could be described as having achieved irreversibility.

1 Introduction

The emergence of new forms of enterprise collaboration systems that incorporate social software functionality (e.g. social profiles, blogs, wikis, activity streams, collaborative tagging etc.) has generated much interest for both researchers and practitioners in recent years (Riemer et al. 2015). A new form of information infrastructure (Star and Ruhleder 1996; Bowker 1996), enterprise collaboration systems (ECS) are based on enterprise social software (ESS) to support social networking, collaboration and content sharing within organisations and across institutional settings. In this paper we use theories of socio-technical change, specifically actor-network theory (ANT) to explore the complex and dynamic processes of adoption and appropriation of an ECS as an academic collaboration platform. Actor-network theory originated in the 1980s in the field of Science and Technology Studies (STS) (Callon 1986; Latour 1987; Akrich and Latour 1992; Law 1992) and has subsequently been used as an analytical and theoretical lens in many studies of IT and information systems including: ERP (Elbanna 2007); HRIS (Dery et al. 2013); eProcurement

(Hardy and Williams 2008); IOIS (Rodon et al. 2007). However, to date, there are no in-depth, longitudinal studies of the introduction and shaping of an ECS. One obvious reason is that in comparison to most standard business software it is still early days. ESS as a viable software platform for enterprise social networking, collaboration and content sharing has only been available since around 2006/7. For example, recent Social Business studies find most companies are still in an early stage of ECS adoption (Williams and Schubert 2015). For a period of seven years, through a wider programme of research in the area of enterprise information management and collaboration technologies, we have been tracking a large-scale, industry strength ECS being implemented as an academic collaboration platform. In this paper we report on the first findings from this longitudinal study.

ECS present an interesting contrast to standard business software such as ERP, HRIS and e-procurement systems where processes are more clearly defined in advance and highly controlled. ECS are more open to interpretive flexibility; the users of ECS have many degrees of freedom as to how they appropriate and use the system (Doherty et al. 2006). Thus, making the shaping of an ECS more complex as different groups within an organisation may adopt and use the same ECS functionality in diverse ways to serve different interests and outcomes. ANT provides a powerful lens through which to investigate this socio-technical change and examine the shaping of the academic collaboration platform. The paper is organised as follows. In Section 2 we provide a brief overview and background to the aims for the academic collaboration platform. These are organised using Boyer's four scholarships (Boyer 1990). In Section 3 we introduce the theoretical and methodological background to the study through a discussion of the insights that ANT offers with regard to the study of socio-technical change. In Sections 4 and 5 we present the interpretive case study and illustrate how these key concepts were used to make sense of the adoption and shaping of the academic collaboration platform. The final section provides a discussion of the implications of our findings for both research and practice.

2 Research Setting: the aims of the academic collaboration platform

In this study we examine the implementation and shaping of an academic collaboration platform, an initiative of the University Competence Center for Collaboration Technologies (UCT) powered by IBM. Originally conceived as a technical infrastructure with processes, materials, places and communities to support the academic work of teaching, research and scholarly network building, the objectives of the project are to support multiple forms of scholarship and encompass all of Boyer's four scholarships (Boyer 1990). In his influential report "Scholarship Reconsidered: Priorities of the Professoriate" Boyer advocated a more inclusive view of what it means to be a scholar; presenting four interrelated and integrated views of scholarship. These have shaped the original conception of the UCT and are summarised below.

Scholarship of Discovery "comes closest to what is meant when academics speak of 'research'". It "contributes to the stock of human knowledge" (Boyer 1990:17), that is inquiry that advances knowledge and is often described as "basic research", focusing on investigation and theorisation. In the context of the UCT this means conducting basic research on ECS that explores key themes in CSCW and information systems. For example through studies of the ways that Social Business and enterprise collaboration systems shape workforce collaboration and the development of frameworks, tools and methods that assist in theorising about the adoption, appropriation and use of enterprise collaboration systems.

Scholarship of Integration gives “meaning to isolated facts” and “…seeks to interpret, draw together, and bring new insight to bear on original research” (Boyer 1990:17-18). It is concerned with interpreting and placing research into a wider context that is “interdisciplinary, interpretive, integrative” (Boyer 1990:21), focusing on synthesis. In the context of the UCT this is expressed through the development of the joint collaboration platform itself, providing the opportunities for universities to work together and with industry partners on joint projects, to provide an e-research infrastructure.

Scholarship of Application is concerned with the relevance of academic scholarship in the wider social context and ensuring that scholarly research is applied to “consequential problems”. (Boyer 1990:21). Boyer makes it very clear he is not suggesting “knowledge is first ‘discovered’ and then ‘applied.’ The process we have in mind is far more dynamic.” (Boyer 1990:23), the focus is on relevance. In the context of the UCT this means using the university-industry collaboration to address real-world phenomena and issues of relevance to business and society. An example is the research being conducted by the UCT on social analytics. Measuring what happens on the platform, extracting knowledge on how we can learn from that to conduct successful ECS implementation projects and addressing the social questions associated with analytics and the individual.

Scholarship of Teaching embraces those scholarly activities related to teaching and learning. Boyer argues that those “who teach must, above all, be well informed and steeped in the knowledge of their fields.” (Boyer 1990:23). Teaching itself is not merely transmission of knowledge but “transforming it and extending it as well”. He views engagement with the subject matter and the questions asked by students and the professors themselves as a catalyst for “creative new directions” and understandings (Boyer 1990:24). The focus is on enhancing understanding. In the context of the UCT this means providing an exclusive collaboration platform for Universities to enable transfer of knowledge. To develop and deliver high quality teaching material that draws from the latest research and provides students with experiential learning opportunities. For example, through the development of the exercise “Enterprise 2.0 – The Game” which provides a simulation game including work packages and a learning environment

3 Research approach and design

In the following sections we describe the research design, our data sources, collection and analysis methods. We begin with a discussion of Actor-Network Theory (ANT); our aim is not to provide a comprehensive overview of ANT (cf. Callon 1986; Latour 1987; Law 1992; Walsham 1997; Monteiro 2000) but to explain how key ANT concepts have assisted in organising both the analysis of the project data, insights and interpretations. The study follows an interpretive case research approach (cf. Walsham 1995a, Walsham 1995b). Our aim is to investigate the adoption of an information infrastructure (the academic collaboration platform) and to examine and understand the interplay between the various actors, events, artefacts and strategies that shape the platform. To ask questions about how and why the project evolved in the way it did, to identify key moments, trajectories and unintended or unanticipated consequences. Our goal is not to provide prescriptive solutions or statistical generalizations but to provide analytical and theoretical insights that deepen our understanding of the complex situated nature of ECS that may provide guidance in future cases.

3.1 ANT as an analytical lens

We follow the view of (Monteiro 2000) that “the development, introduction and use of an information infrastructure are an involved socio-technical process of *negotiation*” that requires an “analytic vehicle that helps tease out interesting and relevant issues related to the ‘management’ of such processes”. ANT provides us with such a lens, giving visibility to the interplay between diverse, heterogeneous arrangements of actors such as humans, technological artefacts, practices and institutions and examines how their interests are translated and aligned to form actor-networks (Walsham 1997). For the purposes of this paper we draw on the parts of our analysis that focus on the analytical concepts of translation and inscription. *Translation* is concerned with the continually negotiated process of aligning the interests of the different actors and the strategies, processes and outcomes of assembling actor-networks to create temporary social order. Callon (1986) identifies four “moments” of translation: problematisation, interessement, enrolment & mobilisation of allies. Actors are enrolled by persuasion and negotiation building a *network of allies*, shaping the nature of, in this case, the academic collaboration platform. *Inscription* refers to “the types of transformation through which any entity becomes materialized in to a sign, an archive, a document, a trace” (Latour 1999). Inscriptions are malleable and may change or become more fixed over time as interests are re-aligned. *Irreversibility* is seen as a process of institutionalisation (Monteiro 2000). A socio-technical system is described as being irreversible when it is no longer possible to go back to a point where alternative translations existed.

3.2 Data collection methods and sources

Multiple data collection methods were used including research diaries and field notes (kept by the project initiator and project team), documentary evidence (meeting notes, official meeting minutes, project reports, official planning documents, project documentation, training materials, videos and presentations), semi-structured interviews with project team members, sponsors and ‘users’ and content and data from the academic collaboration platform itself (e.g. system logs, activities, tasks, discussions in the project blogs, wiki content). This latter data source is especially rich as it is both time stamped and linked, showing the development of discussions/ideas, the arrival of new actors and artefacts etc. For example, the discussion around the change of name for the platform was conducted in the project blog. In terms of platform usage, the system data allows us to analyse (both temporally and spatially) the components that are used, the ways the network grows and is reshaped and the type of content that is being added.

3.3 Data analysis and data presentation methods

As described above we use analytical concepts commonly used in ANT to organise, analyse and interpret the study’s data sources. We began by identifying the actors and capturing this information in an actor table. We then traced their place, interests and relations (or not) in the heterogeneous network by developing a series of diagrams showing the evolving actor-networks and, by tracing backwards and forwards, deepened our understanding of how the project proceeded, the translations that took place and became inscribed. These are captured in an in-depth case study. Key aspects of the case and our analysis and findings are presented below.

4 The Case: University Competence Center for Collaboration Technologies powered by IBM (UCT)

The UCT project was initiated by The *Business Software Research Group (FG BAS)* at the University of Koblenz-Landau. In June 2007, the product “IBM Connections” (the flagship component of IBM’s Collaboration Suite) was released to the market. The FG BAS had been working with IBM Notes/Domino since the group’s inception. IBM Connections was the logical successor for collaboration support. This next generation of collaboration software incorporated “social features” and seemed the ideal application for research and teaching. In 2009, the FG BAS developed their first ideas for a joint project with IBM and approached key managers in the company. IBM showed a general interest in the idea and agreed to provide free software licences to the research group. The concept for a formal cooperation project was jointly developed over a period of more than a year. The partners agreed to draw up a two-year contract that included a partial sponsoring. The project, with the name “University Competence Center for Collaboration Technologies powered by IBM” had been started.

The expected benefits that were associated with the UCT project are the ones typically found in a University-Industry Collaboration (Schubert et al. 2015): On the *University side* (FG BAS) it was the financing of a Ph.D. position, a positive reputation, interesting research and the establishment of a leading technology platform for teaching and research. The ultimate goal of the joint initiative from the point of view of the University was the strengthening and enlarging of the research group and the provision of high quality teaching and research. The objectives on the side of the *industry partner* IBM can be derived from the aims defined in the collaboration contract: a major goal was making students familiar with IBM technology. Today’s graduates are tomorrow’s decision makers and technology vendors have a vested interest in this target group. Other aims were associated with positive communication towards existing and potential clients. IBM Connections was a new software product at this time and a positive vetting by the University was assumed to have a positive impact on customer opinion in general. Since IBM is a company that depends on profits and shareholder value, the ultimate goal was to sell more IBM Connections licences to customers.

Figure 1 shows the timeline of the UCT project. The upper part of the diagram contains the project history with the main artefacts, people and events. The bottom part of the timeline contains selected network metrics including the number of members, users and communities over time. The most important *artefacts* that had an influence on the development of the project are the different versions of the actual collaboration platform (IBM Connections), the promotional website (of the UCT project), which changed substantially over time, the teaching material (most prominently the 8C Model and The Game), experimental software add-ons e.g. for gamification and the promotional UCT video. The most influential *people* are the representatives from the two core organisations, University of Koblenz-Landau and IBM. As can be seen from the diagram, some roles were subject to frequent change of personnel (e.g. IBM Sponsor), which provided a challenge for the continuity of the project. The most important *events* were the meetings for the negotiation and extension of the formal collaboration contract (which defines the roles and responsibilities of the partners) and, later in the project, the appearances of the UCT at academic conferences. The metrics part of the diagram shows the development in the number of *members*, registered *users* and *communities* (= established workspaces) on the IBM Connections platform over time. The first four years show a *linear growth* in all three sections. Starting from year five an *exponential growth* can be observed, which at this point in time appears likely to continue. The ways these elements shape the evolution and unfolding of the project is discussed below.

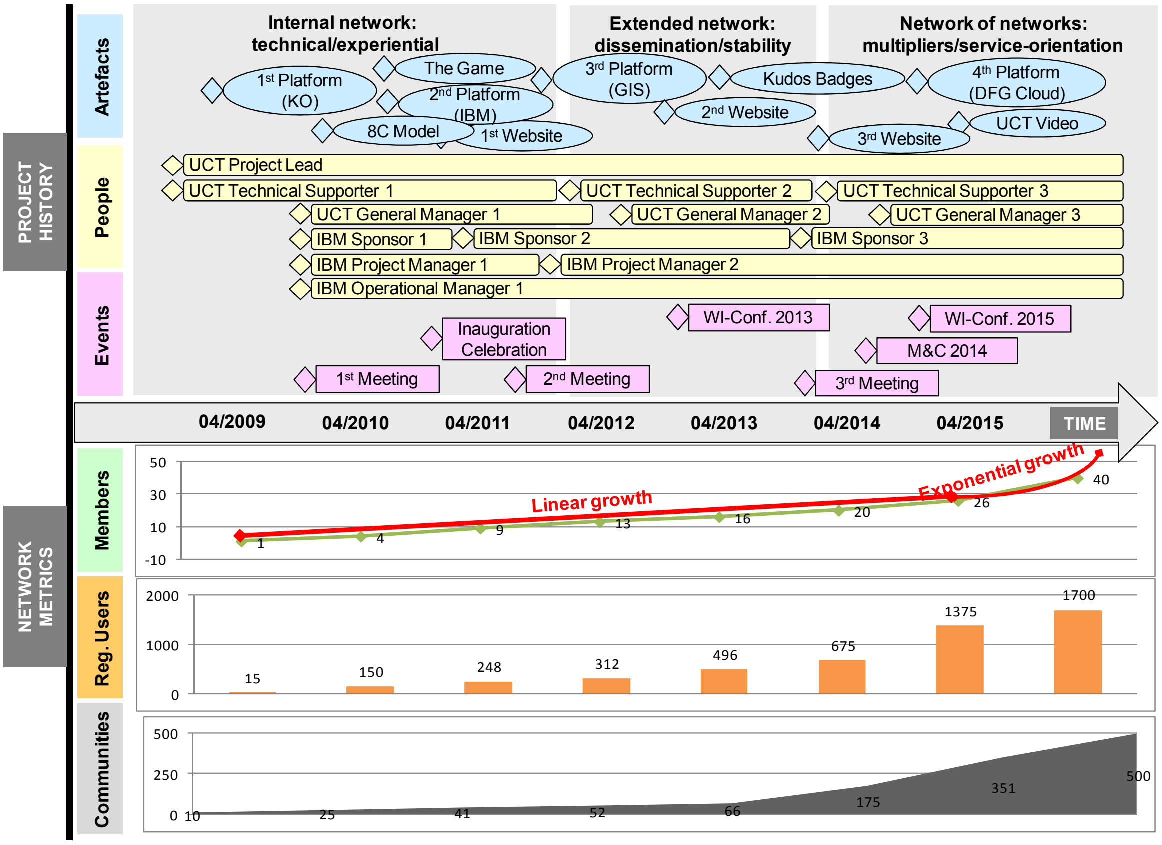

Figure 1: Time line of the UCT project (as of Sept. 2015)

5 Analysis: Aligning the Interests, Emerging Actor-Networks and Inscriptions

The analysis reveals three development phases for the UCT project: 1) the forming and shaping of the internal network (core project group), 2) the extended network (core group plus pilot members) and 3) the network of networks (emergence of sub networks). The setup of these three networks and their development will be discussed in the following sections.

5.1 Phase 1: Building the foundations: technical/experiential

The first phase of the UCT project was characterised by the building up of technical knowledge and experiential learning. The main focus was on forming the core group and defining a joint understanding of the subject area. The platform was mainly used for teaching. During this time the main parties behind the UCT project were the University of Koblenz-Landau, IBM, the TU Ilmenau and two other pilot Universities (Figure 2). The focus of this phase was largely experiential and investigative and on understanding technology requirements and capabilities. In terms of scholarship the emphasis was primarily on Boyer's *Scholarship of Teaching*.

The *problematization stage* was characterised by the need to master technical challenges. IBM Connections was a fairly new product and it was technologically complex due to its innate architectural design. The target group of the UCT consisted of a professor who wanted to make this commercial software available to their students and who were interested in the use of high quality teaching material in the area of CSCW. In this first phase, the UCT core group put the main focus on the platform's *potential for teaching* and did not fully realise the large potential of the platform as a digital workplace, a feature that became important in a later phase of the development.

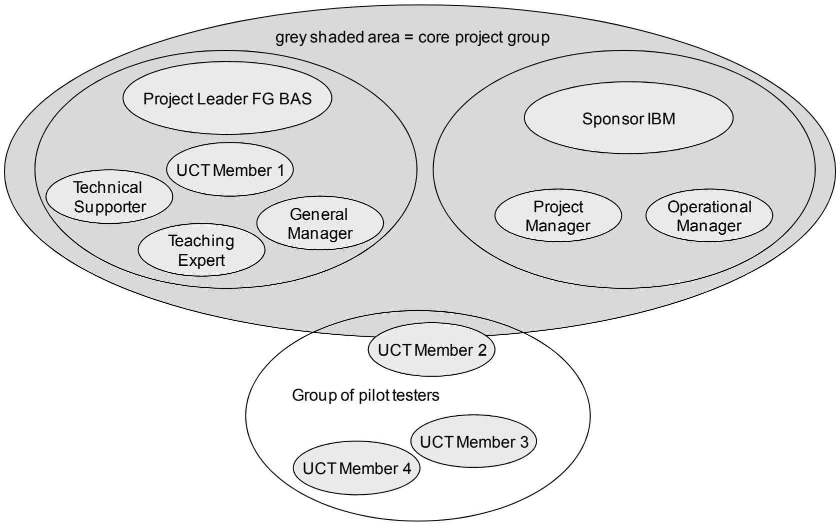

Figure 2: First phase: the UCT core project group and pilot members

In the first phase the UCT project group, consisting of FG BAS and their IBM contacts, struggled with technology. The first technical supporter built up a test installation on the hardware in Koblenz that was used for teaching the CSCW course (1^{st} platform). The IBM Connections application is not multi-tenant capable which means that the project team needed to build up a second platform for other Universities that wanted to use IBM Connections. As a consequence, an intensive search for hardware began because the hardware resources of the FG BAS were not sufficient for a second platform implementation. IBM offered a preliminary solution but only for a limited period of 12 months, so the search for a viable operations model continued.

The first phase of the UCT project was characterised by a constant struggle with the stability/availability of the platform. The people behind the UCT project were the most crucial aspect of its eventual success. There was a need for three different skill profiles: technical, managerial and leadership. Interestingly, each of the project partners provided a contact person representing these skills. These roles are referred to as technical supporter, general manager and project leader/sponsor. The professor in charge of the UCT project, *the focal actor*, had been a CSCW expert for more than 15 years. She had been an IBM Lotus Notes developer at previous organisations and brought valuable technology know-how into the project. Her prior experiences in the field of IBM technology provided the grounds for IBM's trust in the research collaboration. She provided stability and an organisational memory for the constantly changing staff.

During this phase of the project, the first four University members used the platform mainly for teaching purposes. Their *main interest* was to make a leading collaboration solution available to their students in order to provide graduates with the necessary competitive skills for the job markets. They acted as *pilot testers* for both the technical platform and the teaching material. The student activity during this time was largely experiential and feedback indicates that the software was not yet fully mature.

One of the most influential people of the UCT project was the IBM operational manager. His teaching engagement at the TU Ilmenau required the provision of IBM Connections so it was in his interest to establish a project that would provide the necessary technology to his students. He was an *influential actor* who brought TU Ilmenau into the UCT project at a very early stage. The other two Universities were *enrolled* by the focal actor. Successful collaboration projects had been conducted with both institutions and a positive relationship had already been established. Since the two professors were also in charge of teaching and research in the area of CSCW at their institutions they had a *natural interest* in the platform and were easily convinced to join the network.

One of the main objectives of the UCT project was the development of high quality teaching material to be made available to the member Universities. As a first step the professor in charge of the CSCW course at the University of Koblenz-Landau, developed a classification model that provided an ideal structure for the assortment of teaching material (the "theoretical" knowledge for the lectures) and also provided the students with a lens for their experiential examination of collaboration technology. The *8C Model* (Williams 2011) was refined over a period of 12 months and accepted by all core parties. The model itself became a *key inscription* and turned out to be a major ingredient of success for the project. It secured agreement about structure, terms and definitions in the focus area of "Enterprise Collaboration Systems" among the project members. Over the years, the model was successfully adapted for teaching in other Universities, used for customer projects by IBM consultants and used as an analytical lens in a plethora of qualification theses and student projects. The model and the underlying terminology created the foundation for a joint understanding of the subject area and a structured approach to the teaching of the subject of ECS. The business simulation game *"Enterprise 2.0 – The Game"* was created to complement the theory. It is based on the 8C model providing students with Work Packages that support experiential learning. The simulation game is technology agnostic and requires the students to test and experience a range of different collaboration technologies from different vendors including open source software.

5.2 Phase 2: Securing long-term stability: service-orientation

The second phase of the UCT project was characterised by securing the long-term stability of the platform and by the increasing *enrolment* of new members. The entrance of the new core player, Gesellschaft für Informationssysteme GmbH (GIS), changed the dynamics of the core group which now consisted of two industry partners and the University of Koblenz-Landau (Figure 3). GIS is an IBM Business Partner specialising in the implementation of business solutions in user companies. GIS had the belief that University education has to be supported and that there would be positive effects on customer projects and the improved possibility of hiring well-trained graduates. The new partner contributed its product "GIS Collaboration Center", an IBM Connections implementation which is enriched by administrative features e.g. for self-registration. TU Ilmenau remained in their role as *important ally*. The other University members were no longer pilot testers but now *regular users* of the platform. With the growing number of members, the focus shifted to a *higher degree of service-orientation* (member support). The platform was still mainly used for teaching but the establishment of the first research communities could be observed. While the first phase had been largely shaped by Boyer's Scholarship of Teaching this was now complemented by the *Scholarship of Discovery*, which also attracted a new type of member with different interests. In this phase, the IBM Connections platform was updated to a new version that provided a content library (IBM Filenet). IBM Quickr as a file container was removed from the technology portfolio. This led to a considerable simplification of the necessary technology portfolio. IBM Connections (now provided by GIS) became much more stable and reliable, which led to a continuous improvement of the student feedback. The attention of the Koblenz staff members could now shift from technical issues to the improvement of the service for members (e.g. showing them how the platform works). It was now feasible to offer the platform to an increasing number of Universities. In this second phase the number of connected Universities gradually increased to 13. This required more help with the onboarding and the focus turned to the support of new teaching staff at member Universities.

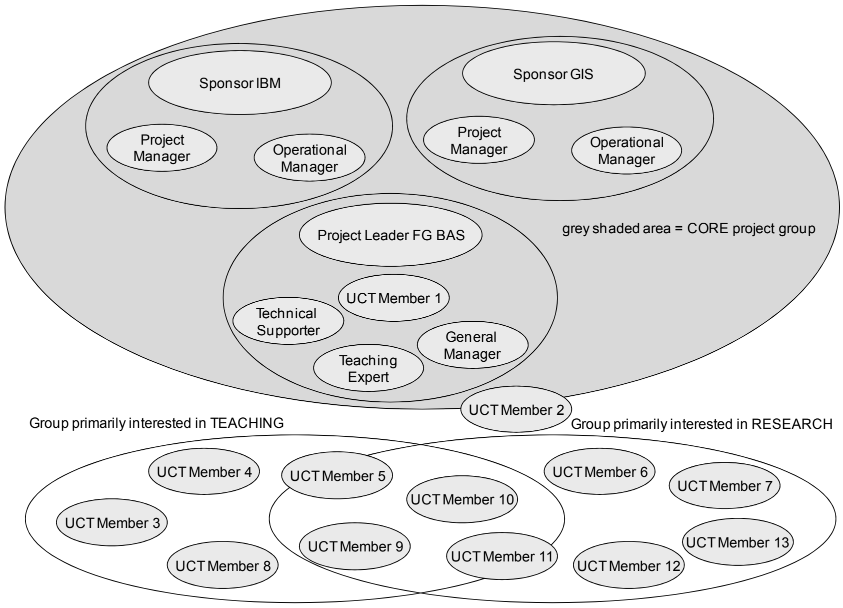

Figure 3: Second phase: the extended network of the UCT

The platform was named "Academic Collaboration Platform (ACP)" and provided a reliable solution for all UCT members (University of Koblenz-Landau as well as the growing number of other Universities). Up to this moment, the instances of IBM Connections had been installed on dedicated servers. GIS virtualised the environment and deployed it in a rented Cloud service center (IaaS). The renting of the hardware meant a "cash-out" for the project partner GIS, a problem that had to be addressed in the long run. The project group had to search for ways of either covering the cost or finding a cheaper hardware solution. This phase was also characterised by communication activities to make the possibilities for UCT members better known to the target group (academics at German speaking Universities).

After the fact it became clear that IBM, FG BAS and GIS had differing ideas about what the potential target members wanted and needed at the start of the project. IBM was convinced that IBM Connections was a great tool for teaching institutions and would be highly appreciated by University professors. There was a general assumption that users would be willing to pay for the service. FG BAS on the other hand assumed that the financing of the project had to be provided by the industry partners. It became increasingly obvious that the members were not willing to pay for the service. The fees displayed on the UCT website had a hindering effect on the acquisition of new members. Over a period of more than a year the payment model was discussed among the three partners. In the end, the University partner suggested a "pay-what-you-want" approach, thus giving the members the possibility to pay – but only if they felt they had used the service and were able to raise the money. An "invitation to pay" was sent in an e-mail and the actual invoice could be configured; choosing zero as an amount was a viable option. After the introduction of this new payment model, the income from member fees stayed meagre and presented a lingering problem. The new payment scheme made it easier to acquire new members and the number of members and with it the number of registered users started to rise remarkably. The *service-oriented inscription* witnessed through the presentations and publicity materials demonstrated the availability of a stable platform that now attracted professors who were not familiar with either the core actors or the IBM technology.

5.3 Phase 3: Emerging network of networks: exponential growth

The third phase of the UCT project (Figure 4) was characterised by an exponential growth in the number of members spurred by the emergence of a variety of sub-networks. Satisfied UCT members started using the platform for their collaboration projects and encouraging more members to join the network.

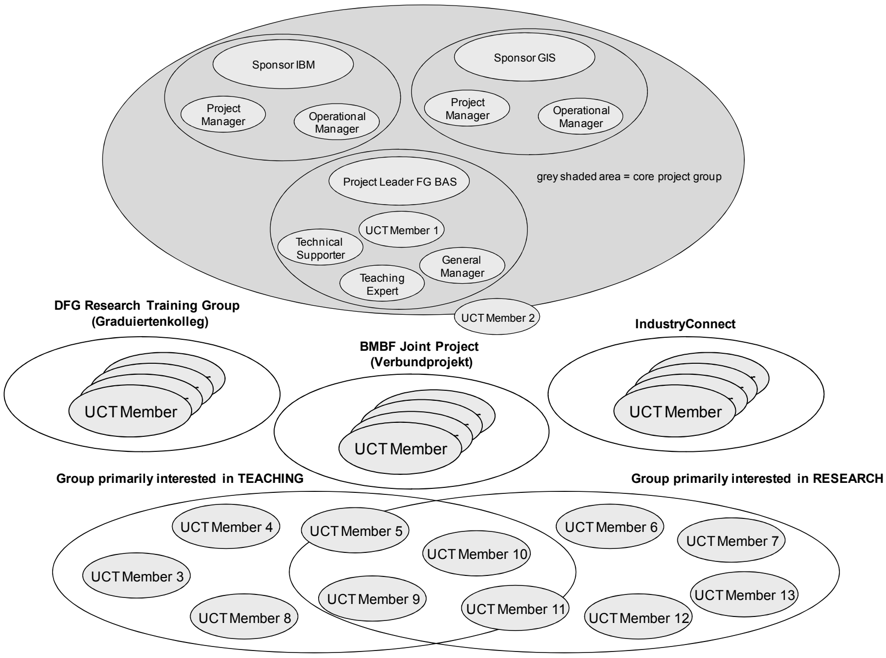

Figure 4: Third phase: the network of networks

The main parties behind the UCT project were still the University of Koblenz-Landau, IBM and GIS, who guaranteed the long-term stability of the network. This phase, in a way, marked the point of no return for the UCT and its renamed product "UniConnect" when members started to rely on the availability of the platform and were putting a lot of effort into developing their own communities and managing their content. Only in this phase did the project started to fulfil its initial objectives in all of Boyer's scholarships (Boyer 1990). The platform became home to communities with researchers from different Universities and different academic backgrounds that were conducting joint research with the help of a UniConnect community (*Scholarship of Integration*). The platform also provided a forum bringing together University and industry partners, e.g. in collaboration projects such as IndustryConnect (*Scholarship of Application*).

In the third phase the UniConnect platform underwent another major migration. FG BAS had successfully won a DFG project grant together with two other research groups in Koblenz and had received substantial funding for a cloud service infrastructure on the Koblenz premises (DFG Cloud). This cloud center presented the ideal solution for the hosting of UniConnect. The platform was moved to the DFG Cloud in September 2014 (4^{th} platform). This version of the platform has been very stable since then. The move was a major step in the project because it removed the monthly cost for the hardware for the industry partner GIS.

In May 2014, the platform was renamed *"UniConnect"*. The renaming turned out to be another important step in the project. The new name is more intuitive than the previous name "Academic Collaboration Platform (ACP)" and has made the communication of the purpose of the platform much easier. In this phase, UCT members started to use the platform increasingly as a collaboration platform for their research projects. Sub-networks emerged on the platform. Members recruited members and thus became *allies* to the focal actor. In this phase the *inscription* changed to become a *network of networks* which was reflected in the growing number of communities used by two or more of the member institutions. Examples of such projects are a DFG-Graduiertenkolleg, a BMBF-Verbundprojekt and the IndustryConnect initiative (a collaboration between University and industry partners). UniConnect now provided a platform for the different interests of the members (teaching, material, digital workplace) and thus represented the *obligatory passage point (OPP)* in the UCT project. In this phase the project reached a state of near *irreversibility*. More than 30 institutions were now enrolled with 1500 users that are active in 350 communities. The registration numbers of new members were now *increasing exponentially*.

6 Concluding Remarks

Using the concepts of translation and inscription we have identified different phases through which the project passed and made visible different interests and shapers of the project. From an initial technical and teaching inscription to a more service-oriented inscription and finally, when the technology platform had been stabilised, the payment problem had been minimised (for the moment), the growth in the network of members and a transition to a network of networks. The point where members bring their own partners to the platform has created a degree of irreversibility of inscribed interests and institutionalisation of the collaboration platform. Aligning the interests was not unproblematic, differing interests of the key partners, unknown interests of the target group, differing assumptions about expectations and interest in platform by potential members and willingness to pay for the service all marked potential problems. The adjustment of the payment scheme reduced the reluctance of new members to join the platform. However, it is the constant investment of time and belief of the core group into strategies to stabilise the technology (platform migration), promote the vision (videos, one to one support, teaching materials) and sustain the project that carried it forward. Serendipitous events played an important role, for example, a significant enabler came in the arrival of a new player (GIS) who provided the necessary stability at a time when resources were running low. An unanticipated consequence is witnessed in the change of the platform name to UniConnect. This act had the unexpected outcome of providing a clearer identity for the platform and a powerful means of aligning interests. All parties immediately adopted the new name and UniConnect became an obligatory passage point. This study has provided a deeper understanding of the events, strategies and actions that have shaped the use of UniConnect. Space limitations prevent a fuller discussion of these strategies and learning, however we hope that our analysis serves to stimulate further discussion and research about the situated nature of socio-technical change in the area of ECS.

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Nutzenpotenziale von Enterprise Social Software im Innovationsprozess

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Abstract

Die erfolgreiche Generierung von Innovationen kann für Unternehmen einen entscheidenden Wettbewerbsvorteil darstellen. Von Relevanz ist es daher herauszufinden, wie Organisationen den Innovationsprozess gestalten können, um Vorteile daraus zu realisieren. Einen möglichen Gestaltungsparameter stellen dabei die Art der zur Verfügung gestellten Informationssysteme (IS) sowie der Umgang mit diesen dar. Da sich der Einsatz von Enterprise Social Software (ESS) in zahlreichen Unternehmen und vielfältigen Bereichen in den letzten Jahren etabliert hat, bietet es sich an zu prüfen, inwieweit diese Art von IS geeignet ist, auch im Innovationsprozess angewandt zu werden und welche Potenziale sich daraus für Unternehmen ergeben. Daher werden in diesem Beitrag Ergebnisse einer Fallstudie präsentiert, die auf der Auswertung von Daten aus 21 qualitativen Interviews basieren. Es zeigt sich, dass ESS (1) die Vernetzung, (2) die Partizipation sowie (3) die Zusammenarbeit während der Ideengenerierung, -akzeptierung und -umsetzung unterstützen kann und dabei Nutzenpotenziale, wie die Steigerung der Serendipität, entstehen.

1 Einleitung

Bereits vor über einem halben Jahrhundert konnte Solow (1957) zeigen, dass Innovationen und technischer Fortschritt die Haupttreiber für wirtschaftliches Wachstum und Wohlstand einer Gesellschaft sind. Für den Erfolg durch Erhaltung und Steigerung der Wettbewerbsfähigkeit von Unternehmen sind Innovationen daher unverzichtbar (Kim und Mauborgne 1999) und somit stellt sich weniger die Frage nach dem „ob", sondern vielmehr danach „wie" Innovationen von Unternehmen optimal generiert werden. Zwei grundsätzliche Sichtweisen dominieren dabei die Diskussion darüber, wie dies geschehen kann: Vertreter der marktorientierten Sichtweise (z.B. Porter 1980) argumentieren, dass die Innovationsleistung einer Unternehmung maßgeblich durch die Konditionen des Marktes bestimmt werden. Eine größere Priorität der Betrachtung des eigenen Unternehmens erfolgt im ressourcenbasierten Ansatz (z.B. Wernerfelt 1984), demgemäß vor allem firmeninterne Ressourcen einen Kontext entstehen lassen, in dem sich Innovationsaktivitäten entwickeln können.

Der Innovationsprozess wird oftmals als interaktiv, unvorhersehbar, unstetig und geradezu chaotisch beschrieben (Quinn 1985), woraus im Extremfall schlussgefolgert werden könnte, dass Planung, Management und Design von Innovationsprozessen fast unmöglich sind. In Anlehnung an den ressourcenbasierten Ansatz, lässt eine moderatere Betrachtungsweise es jedoch zu, dass organisatorische Rahmenbedingungen, also Strukturen und Prozesse, Innovationen aktiv stimulieren und produzieren können, solange diese die unvorhersehbare Seite von Innovationen berücksichtigen (Kanter 2000). Von Interesse ist es demnach, welche Voraussetzungen in Unternehmen geschaffen werden müssen, um ein effizientes Innovationsmanagement zu ermöglichen und zu realisieren. Einer von vielen Gestaltungsparametern ist dabei die Art der Informationssysteme (IS), die Unternehmen zur Verfügung stellen, um die Zusammenarbeit der Mitarbeiter zu fördern. Eine Möglichkeit dies umzusetzen bietet der Einsatz von Enterprise Social Software (ESS), welche sich in den letzten Jahren in zahlreichen Unternehmen zur Unterstützung der Kommunikation und Kollaboration in vielfältigen Bereichen etabliert hat (Williams und Schubert 2015).

In diesem Zusammenhang leitet sich das diesem Beitrag zugrundeliegende Forschungsziel ab. Es soll herausgefunden werden, welche Nutzungsszenarien für ESS im Innovationsprozess existieren und welche Potenziale sich daraus für Unternehmen ergeben. Dabei wird Innovation im Rahmen dieser Arbeit als unternehmerischer Prozess aufgefasst, der in den drei Phasen der Ideengenerierung, -akzeptierung und -realisierung abläuft. Um dieses Ziel zu erreichen, wurde eine explorative Fallstudie in einem Unternehmen der Unternehmenskommunikations-Branche durchgeführt, wobei 21 qualitative Interviews als primäres Datenmaterial dienen. Kapitel 2 liefert zunächst einen kurzen Überblick über das dieser Arbeit zugrundeliegende Verständnis von Innovationen sowie der Rolle von IS im Innovationsprozess im Allgemeinen und ESS im Besonderen. Kapitel 3 umfasst die Beschreibung der Fallstudie, der Planung der Datenerhebung sowie der anschließenden Analyse. In Kapitel 4 werden die Ergebnisse präsentiert und darauf folgend in Kapitel 5 diskutiert. Ein Fazit und ein Ausblick auf weitere Forschungsarbeiten schließen den Beitrag ab.

2 Grundlagen

2.1 Innovation als unternehmerischer Prozess

Grundsätzlich lassen sich Innovationen als Neuerungen definieren, die mit einem technischen, sozialen und/oder wirtschaftlichen Wandel einhergehen (Gabler Wirtschaftslexikon 2015). Eine Innovation kann dabei als ein Objekt betrachtet werden, das eine subjektiv neue Idee, z.B. eine Verfahrensweise (Prozess-Innovation) oder ein Produkt (Produkt-Innovation) darstellt (z.B. Rogers 2003). Eine differenzierte Betrachtungsweise beschreibt Innovation als unternehmerischen Prozess, der alte und gewohnte Strukturen aufbricht und so einen Weg für Neues ebnet, was in Anlehnung an Schumpeter (2003) auch als Prozess der schöpferischen Zerstörung bezeichnet wird. Eine Vielzahl an Prozessmodellen wurde entwickelt, die sich u.a. durch ihren Fokus und den Betrachtungsumfang unterscheiden. Je nach Modell werden drei bis sechs oder auch mehr Phasen im Innovationsprozess dargestellt (Bircher 2005). Dieser Prozess kann sich von der Exploration und Analyse eines Problems, der Ideensuche und -bewertung bis zur Markteinführung und Diffusion in mehreren Phasen innerhalb und außerhalb einer Organisation abspielen (Kanter, 2000). Im Rahmen dieser Studie soll der Betrachtungsumfang auf die organisationsinternen Phasen eingeschränkt werden, da diese durch eine intern genutzte ESS beeinflusst werden können.

Vermarktung, Diffusion und retrospektive Analyse einer Innovation werden somit nicht betrachtet. Ein Ansatz, der diese interne Perspektive vertritt, ist das Dreiphasenmodell des Innovationsprozesses von Thom (1980), das im deutschsprachigen Raum viel Anerkennung gefunden hat (Verworn und Herstatt, 2000). Es stellt die Idee in den Mittelpunkt und untergliedert den Innovationsprozess in folgende drei Hauptphasen:

1. Ideengenerierung: Zu Beginn des Innovationsprozesses steht die Ideengenerierung, deren Zielsetzung es ist, möglichst zahlreich qualitativ hochwertige Ideen zu erhalten. Diese Phase umfasst Tätigkeiten der Suchfeldbestimmung, der Ideenfindung sowie des Vorschlagens von Ideen.
2. Ideenakzeptierung: In dieser Phase werden die zuvor generierten Ideen geprüft und Entscheidungen für oder gegen einen zu realisierenden Plan getroffen. Ziel ist es, für neue Ideen nicht nur die Unterstützung des Managements zu gewinnen, sondern darüber hinaus auch eine Akzeptanz im gesamten Unternehmen zu schaffen.
3. Ideenrealisierung: Bei einer als erfolgversprechend bewerteten Innovation folgt der Ideengenerierung und -akzeptierung die Ideenrealisierung. Hier geht es um die konkrete Verwirklichung von Ideen, wozu detaillierte Ausarbeitungen, die Anfertigung von Piloten sowie die Vorbereitung des Absatzes einer Innovation gehören.

2.2 IS und Innovationen

IS spielen als Innovationsobjekte seit Jahrzehnten eine wichtige Rolle in Organisationen. Immer kürzere Entwicklungszyklen führen zu einer wachsenden Anzahl (informations-) technologischer Produktinnovationen (Fichman 2000), wie Smartphones oder e-Book-Reader. Mindestens von ebenso großer Bedeutung für Unternehmen sind Prozessinnovationen, die durch den Einsatz von IS realisiert werden (Davenport 2013), wie automatisierte Lager- oder Einkaufsprozesse. In Anlehnung an den Forschungsgegenstand dieser Arbeit, wonach Innovation als Prozess verstanden wird, der möglichweise durch den Einsatz eines neuen IS unterstützt, bzw. verändert wird, geht es somit um eine Prozessinnovation im Innovationsprozess.

Allgemein betrachtet bieten IS viel Potenzial, den Innovationsprozess zu beeinflussen. So können beispielsweise Ideen zentral an einem Ort gespeichert, verwaltet und gemeinschaftlich von Nutzern bewertet oder weiterentwickelt werden (Blohm et al. 2011), ohne dabei Reibungsverluste an Schnittstellen zu generieren (Reichwald und Piller 2006). Bei spezieller Betrachtung der ESS-Anwendung im Innovationsprozess, zeigt sich, dass vor allem die Nutzbarmachung externer Quellen unter den Schlagworten Open Innovation oder Customer Co-Creation in den letzten Jahren Beachtung gefunden hat (z. B. Chesbrough 2003, Füller et al. 2009, Gassmann 2006, von Hippel 2005).

Obwohl Umfragen interessante Zusammenhänge der organisationsinternen ESS Nutzung im Innovationsprozess wie z.B. mehr und bessere Ideen oder niedrigere Produktionskosten vermuten lassen (z.B. Kenly 2012), hat dieser Bereich in der Forschung bisher nur wenig Beachtung gefunden. Da Nutzer mithilfe einer ESS digital interagieren, sich vernetzen und Inhalte gemeinsam erstellen, bewerten, strukturieren und bearbeiten können (Koch und Richter 2007), bietet eine derartige Lösung die Möglichkeit, die gefühlte Distanz der Akteure im Innovationsprozess zu verringern (Gassmann 2006) und so nicht nur das Suchen und Finden relevanter Ideen und Gesprächspartner zu erleichtern, sondern auch die Kommunikation und Zusammenarbeit zu erleichtern. Erste wissenschaftliche Studien zeigen, dass Wikis und Blogs nicht nur die kreativen

Prozesse (Quiggin 2006), sondern auch die Wissensgenerierung, -verteilung und -speicherung im Innovationsprozess unterstützen und dadurch die kollektive Intelligenz der Mitarbeiter eines Unternehmens fördern können (Standing und Kiniti 2011). Leonardi (2014) fand heraus, dass die Sichtbarmachung von Wissen und Kommunikation (Awareness) über eine ESS sowie daraus resultierende neue Arbeitsweisen die individuelle Innovationsfähigkeit steigern. Gray et al. (2011) konnten belegen, dass Mitarbeiter, die innerhalb eines Social Bookmarking Systems stärker vernetzt sind, auch gleichzeitig innovativer sind. Ciriello und Richter (2015) zeigen, dass die Nutzung von ESS Mitarbeiter untereinander verbinden und dadurch die gemeinsame Arbeit an Innovationen beeinflussen kann. Keine der Untersuchungen geht dabei explizit auf die ESS Nutzung in den unterschiedlichen Phasen des Innovationsprozesses ein. Mit dieser Arbeit möchten wir daher einen Beitrag dazu leisten.

3 Die Fallstudie

3.1 Beschreibung der EQS Group AG

Die EQS Group AG (im Folgenden zur Vereinfachung „EQS“ genannt) mit Hauptsitz in München, ist ein internationaler Anbieter für digitale Unternehmenskommunikation. Mit insgesamt über 175 Mitarbeitern an weltweit 9 Standorten bietet das Unternehmen seinen mehr als 7.000 Kunden unterschiedliche Leistungen an. Hierzu gehören unter anderem die Verbreitung von Finanz- und Unternehmensmitteilungen, die Entwicklung von Konzernwebseiten, Online-Finanz- und Nachhaltigkeitsberichten, Apps sowie weiterer Website-Tools oder auch die Umsetzung von Audio- und Video-Übertragungen (EQS Group AG 2015). Die Vision des Unternehmens ist es, bis zum Jahr 2020 zu einem der fünf weltweit größten Anbieter für Digital Investor Relations zu gehören (EQS Group AG 2015). Um dieses Ziel zu erreichen, spielen Innovationen eine entscheidende Rolle. Sie helfen dem Unternehmen nicht nur bei der Umsetzung neuer Produkte und Lösungen sowie deren stetiger Weiterentwicklung, sondern tragen ebenfalls dazu bei, Arbeitsvorgänge zu optimieren und neue Absatzmärkte zu erschließen.

2013 führte das Unternehmen die ESS Lösung Confluence von Atlassian unter dem Namen „EQS Insight“ ein. Insight unterstützt die globale Zusammenarbeit als zentrale Wissens- und Kommunikationsplattform durch Wiki-, Blog-, Mircoblog- und Social Networking- Funktionalitäten (Atlassian 2015). Die unternehmensinterne Plattform ist seitdem ein integraler Bestandteil der täglichen Arbeit, um Informationen zu kommunizieren oder zu teilen und das implizierte Wissen der EQS zu aggregieren. EQS Insight wird von allen Standorten weltweit genutzt und bietet jedem Mitarbeiter die Möglichkeit neue Ideen zu publizieren und somit potenzielle Innovationen voranzutreiben.

Bisher gibt es bei der EQS kein etabliertes Vorschlagwesen, wodurch Ideen bislang auf unterschiedliche Art und Weise vorangetrieben werden. Die Idee nimmt somit ihren „natürlichen Lauf“ im Unternehmen, unbeeinflusst von unternehmerischen Prozessvorgaben. Diese Umstände machen die EQS zu einem geeigneten Fall für unsere Interview-Studie, die den Einfluss von ESS in den einzelnen Phasen des Innovationsprozesses untersuchen soll.

3.2 Methodisches Vorgehen

Der bisher wenig untersuchte Forschungsbereich legte eine explorative Herangehensweise nahe (Walsham 2006), die wir in dieser Untersuchung in Form einer Fallstudie umgesetzt haben. Die

Daten wurden, wie von Yin (2003) vorgeschlagen, anhand unterschiedlicher Techniken erhoben und in die Analyse einbezogen. Die Datenquellen waren semi-strukturierte Interviews, Dokumente, interne Präsentationen, Internetseiten sowie Nutzungsstatistiken. Dabei haben wir uns an dem von Eisenhardt (1989) vorgeschlagenen Vorgehen zur Erhebung und Auswertung von Fallstudien orientiert. 21 semi-strukturierte Interviews (Schultze und Avital 2011) stellen die primäre Datenbasis unserer Fallstudie dar. Die ausgewählten Interviewpartner verfügen über umfangreiche Erfahrungen mit der ESS in ihrer täglichen Arbeit und aufgrund ihrer unterschiedlichen Positionen, Standorte und Kulturen ermöglichen sie einen breiten Einblick in die Fragestellung.

Um das Gespräch mit den Teilnehmern zu unterstützen wurde ein Interviewleitfaden mit insgesamt 29 Fragen aus verschiedenen Kategorien zusammengestellt (Bryman und Bell 2007). Dieser beinhaltet Fragen zum Innovationsmanagement, insbesondere zu den Phasen des Innovationsprozesses, sowie der Innovationskultur im Unternehmen. Um relevante Aussagen eindeutig den Phasen des Innovationsprozesses zuordnen zu können, haben wir uns dabei an dem oben beschriebenen Phasenmodell (Thom 1980) orientiert und entsprechend Fragen zur ESS Nutzung hinsichtlich der Ideengenerierung, -akzeptierung und -realisierung gestellt. Ein Auszug aus dem Interviewleitfaden ist in Abbildung 1 dargestellt.

- Allgemeine Information zur Person, Position und Erfahrungen mit Insight.
- Wie hoch schätzen Sie das Innovationspotenzial der EQS ein? Wird es genutzt?
- Gibt es einen definierten Innovationsprozess bei der EQS?
- Wie werden Sie über neue Ideen und Innovationen informiert?
- Wem und wie werden Ideen kommuniziert?
- Welchen Einfluss hat die ESS auf die…
    - Ideengenerierung
    - Ideenakzeptierung
    - Ideenrealisierung
- Welche Probleme entstehen in den jeweiligen Phasen?
- Welchen Nachteil hat die ESS?
- Welche Barrieren gibt es in den verschiedenen Phasen?

Abbildung 1: Auszug aus dem Interviewleitfaden

Die Interviews wurden zwischen Juli und September 2015 über Telefon, Skype und von Angesicht zu Angesicht mit einer Durchschnittslänge von 77 Minuten geführt. Anschließend wurden sie transkribiert und die Textdokumente kodiert. Ein Kodierleitfaden half dabei, die Aussagen auf ihre Kerninhalte zu reduzieren und diese Kernaussagen anschließend den Phasen des Innovationsprozesses zuzuordnen sowie Potenziale der ESS zu identifizieren. Beispiele der Kodierung sind in der nachfolgenden Tabelle 1 dargestellt.

Vollständig transkribierter Satz	Kernaussage	Phase	Potenzial
„*Vielleicht hat mal ein Kollege eine Idee, wo man daraus eine andere Idee spinnen kann, die er dann zufällig auch gepostet hat und das sieht man dann ganz zufällig im Portal und hat dann da vielleicht was*.“	Ideen entstehen zufällig durch das Lesen von Beiträgen.	Ideen-generierung	Serendipität
„*Da denke ich ist die Möglichkeit am größten, weil du konkret die Ideen zusammenfassen kannst, weil du sie promoten kannst, weil du sie als Package nochmal vorstellen kannst.*“	Umsetzungspläne für Ideen werden zentral gespeichert und sichtbar gemacht.	Ideen-realisierung	Zentrale Wissens-speicherung

Tabelle 1: Beispiele der Kodierung

Die Analyse der kodierten Texte brachte schließlich die im nächsten Kapitel dargestellten Ergebnisse hervor.

4 Ergebnisse

4.1 Allgemein

Die Auswertung der Daten aus der Fallstudie zeigte, dass sich Insight in der EQS seit der Einführung 2013 als zentraler Informations- und Wissensspeicher etabliert hat. Alle Mitarbeiter weltweit sind mit einem Profil vertreten. Die 21 Befragten nutzen Insight mehrmals wöchentlich, wovon sich 8 Teilnehmer mehrmals täglich und 7 mehrmals wöchentlich auch aktiv beteiligen. Das bedeutet, sie konsumieren nicht nur Informationen, sondern geben Daten aktiv in das System ein indem sie z.B. Seiten oder Blogs editieren, anlegen oder kommentieren. Somit verfügen alle 21 Interviewpartner über umfangreiche Erfahrung hinsichtlich der ESS Nutzung.

Diverse, unternehmensspezifische Use Cases haben sich seit der Einführung gebildet. Beispiele hierfür sind neben der Organisation von Meetings, der Verwaltung von Urlaubsanträgen oder der Abwicklung von Projektaufträgen auch die gemeinsame Arbeit an Produktweiterentwicklungen. Vor allem die Wiki-Funktionalität wird von den Mitarbeitern geschätzt, um Informationen zu Produkten, Abteilungen, Mitarbeitern, der Organisation oder Prozessabläufen zu dokumentieren sowie Teile des Projektmanagements abzubilden.

Das Innovationspotenzial der EQS schätzen die Befragten als generell hoch ein, wobei dies ihrer Meinung nach derzeit noch nicht vollständig genutzt wird. Einen fest definierten Innovationsprozess bzw. ein betriebliches Vorschlagswesen gibt es bei der EQS nicht, wodurch sich Ideen unbeeinflusst von bürokratischen Vorgaben im Unternehmen entwickeln. Die Befragten unterschieden hinsichtlich der Ideengenerierung in ihrem Unternehmen zwischen einer Top-down und einer Bottom-up Initiierung. D. h. der Innovationsprozess wird entweder durch die Geschäftsleitung angestoßen, indem sie Ideen zu bestimmten Themenfeldern einfordert, oder eine Idee wird von der Belegschaft vorangetrieben. Die undefinierte Vorgehensweise führt bei den Befragten teilweise zu Unsicherheiten im Umgang mit Innovationen, die sich darin äußern, dass innovative Ideen nicht immer mit genügend Nachdruck verfolgt werden.

4.2 ESS in den Phasen des Innovationsprozesses

Die Auswertung der Aussagen, die sich auf die Nutzung der ESS im Innovationsprozess beziehen, ergab, dass Insight bisher zwar keine dominante Rolle spielt, aber durchaus in den Phasen der

Generierung, Akzeptierung und Realisierung von Ideen genutzt wird und relevante Vorteile sowie Potenziale dieser Nutzung gesehen werden. So gaben 15 Teilnehmer (71%) an, Insight ist in der Lage, die Phase der Ideengenerierung sinnvoll zu unterstützen, 17 (81%) sagten dies hinsichtlich der Ideenakzeptierung, und ebenfalls 15 der 21 Befragten (71%) sahen Potentiale der ESS Nutzung während der Ideenrealisierung. Die übrigen gaben an, entweder kein Potenzial zu sehen bzw. dies nicht beurteilen zu können.

Die Analyse der Interviews ergab, dass Insight (1) die Vernetzung, (2) die Partizipation sowie (3) die Zusammenarbeit und zentrale Wissensspeicherung funktional unterstützen und somit zu einer Verbesserung des Innovationsprozesses beitragen kann. Abbildung 2 liefert einen Überblick über die aus der Studie generierten Ergebnisse, die im Folgenden je Phase im Detail erläutert und zur besseren Nachvollziehbarkeit mit Aussagen aus den Interviews belegt werden.

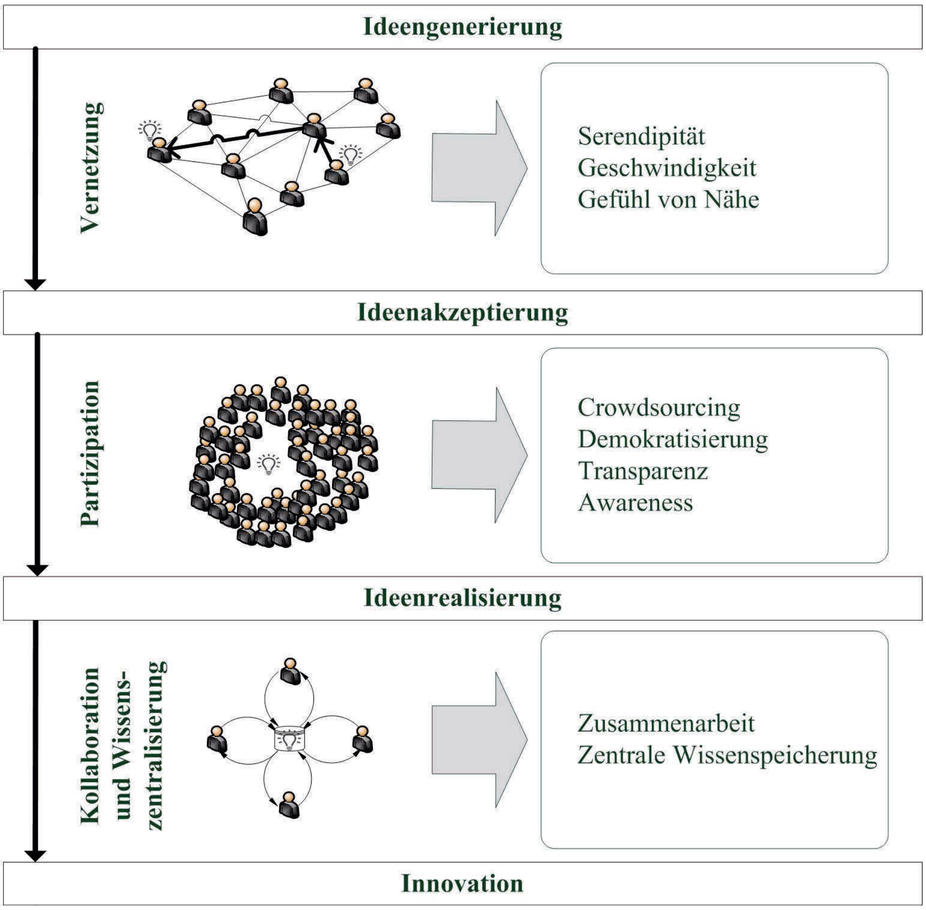

Abbildung 2: Nutzenpotenziale und Unterstützung im Innovationsprozesses durch ESS

Ideengenerierung durch Vernetzung:

Die Ideengenerierung ist eine kreative Leistung, die kontext- und personenabhängig unterschiedlich erbracht wird. Bei der EQS spielt vor allem das direkte, persönliche Gespräch eine wichtige Rolle - Face-to-Face, am Telefon oder auch per E-Mail. Die Datenauswertung ergab, dass sich die Vorteile von Insight in dieser Phase vor allem aus der Unterstützung der globalen Vernetzung der Mitarbeiter ergeben.

Durch die Möglichkeit, Kontakte über die ESS zu knüpfen und Kollegen oder Inhalten zu folgen, vermittelt die ESS den weltweit verteilten Beschäftigten ein Gefühl von Nähe (Interview 08 (i08):

„*[…] dadurch, dass man eben auch mal kurz mit Hongkong oder mit Kochi kommunizieren kann. Das bringt die Firma ein bisschen näher zusammen und fördert die Kommunikation […]. Dadurch ist es einfacher Ideen weiterzuleiten, wodurch diese prinzipiell gefördert werden*“). Darüber hinaus gestaltet sich die Kommunikation über die Plattform sehr persönlich und findet unabhängig von Position und Hierarchieebene statt, so dass Ideen einfach und schnell verbreitet werden können (i08: „*Das [Insight] fördert, glaube ich, dass man auf einer persönlicheren Ebene ist. […] Ich glaube dadurch, dass man halt relativ einfach kommunizieren kann, z.B. mit Kollegen in Indien, merke ich, dass man sich sehr schnell auch mal Ideen zuwerfen kann.*“) Diese Vernetzung führt dazu, dass neue Inhalte allen Beschäftigten schnell zur Verfügung stehen, was wiederum einen positiven Effekt auf mögliche unerwartete Entdeckungen (Serendipität) hat, aus denen sich Ideen entwickeln können (i05: „*Es kann ja auch mal passieren, dass jemand, der nicht am Projekt mitarbeitet, zufällig reinschaut und deswegen eine Idee hat, die total gut wäre, auf die niemand im Team gekommen ist.*“)

Ideenakzeptierung durch Partizipation:

Die Phase der Ideenakzeptierung ist gekennzeichnet durch die Prüfung entstandener Ideen sowie einer anschließenden Auswahl. Die Partizipationsmöglichkeiten von Insight an einer sich entwickelnden Idee - unabhängig von Standort und Position des Mitarbeiters - ermöglichen es, hierarchieübergreifend und schnell viele Menschen zu erreichen sowie ein differenziertes Meinungsbild zu erhalten.

Dadurch, dass Ideen über die ESS öffentlich nicht nur einsehbar, sondern auch editierbar sind, unterstützt Insight die Ideenakzeptierung innerhalb der Mitarbeiterschaft. Den Gedanken der Demokratisierung ebenfalls unterstützend, dient der Like-Button von Insight dazu, eine mögliche Zustimmung zu einer Idee öffentlich kund zu tun (i21: „*Eigentlich fühlt sich damit jeder Beteiligte auch gleichberechtigt irgendwie. Das finde ich schon ganz nett und es ist ein super Tool, um einfach zu Monitoren, wie das allgemeine Stimmungsbild dazu ist. Und halt auch ein Ergebnis zu finden.*“) Zusätzlich unterstützen die Funktionalitäten der ESS dabei, Transparenz und Awareness für Ideen zu schaffen, die zum Feedback einladen und dadurch wiederum Ideen verbessern können (i06: „*Alleine dadurch, dass es eben nicht nur gesprochen irgendwo ist, hat man mal irgendwas gehört, du kannst es lesen, es ist da [im Insight]. Und dadurch musst du dich damit auseinandersetzen und tust es auch. Ob es dann akzeptiert wird ist eine andere Geschichte, aber es ist einfach wichtig, dass sie da ist die Information.*“) Die ESS birgt damit nicht nur das Potenzial, den gesamten Innovationsprozess zu beschleunigen, sondern dem Unternehmen die kollektive Intelligenz der Belegschaft (Crowdsourcing) nutzbar zu machen (i11: „*Of course it's a good influence between people to share the idea. So, maybe this group of people starts to share more on the idea, so they will affect or influence other people to contribute more.*“)

Ideenrealisierung durch Kommunikation und zentrale Wissensspeicherung:

In der letzten Phase geht es schließlich um die konkrete Verwirklichung von Ideen, von Grob- über Feinkonzepte bis hin zur Fertigstellung des Innovationsobjektes. Hier wird die Zusammenarbeit zwischen den Projektmitarbeitern sehr viel intensiver. Detaillierte Ausarbeitungen müssen angefertigt, die Implementierung vorbereitet werden. Insight unterstützt diese Phase indem es seinen Nutzern Werkzeuge zur zentralen Ablage und gemeinsamen Bearbeitung von Dokumenten zur Verfügung stellt und darüber hinaus die Kommunikation der verteilt arbeitenden Mitarbeiter der EQS z. B. in der Form von Projektwikis fördert.

Die Unterstützung der ESS in dieser Phase geschieht vor allem durch das zur Verfügung stellen einer Kommunikations- und Kollaborationsplattform sowie eines zentralen Datenspeichers, der allen Mitarbeitern eine identische Wissensbasis ermöglicht (i19: „*In dem Moment, in dem so ein Projekt dann tatsächlich gestartet wird, ist natürlich Insight als Plattform schon extrem wichtig. Dort werden die ganzen Informationen recht transparent geteilt und es kann auch darauf hingewiesen werden „wir starten jetzt den Relaunch vom Mailing-Tool, hier ist auch das Pflichten- und Lastenheft usw." Da ist es dann sicherlich sehr relevant.*") Über Insight wird darüber hinaus gemeinsam an konkreten Konzepten oder Plänen der Innovation gearbeitet (i16: „*In der Umsetzung einer Idee ist Insight das Tool, in dem wir alle zusammenarbeiten. Insight ist das Tool, wo alle Mitarbeiter Zugriff haben. Das heißt, es bietet einfach dadurch eine Plattform für die Zusammenarbeit.*") Gleichzeitig können die Informationen nachvollziehbar editiert und dadurch einzelne Arbeitsschritte exakt dokumentiert und zurückverfolgt werden. Durch diese Transparenz wird eine intensive Zusammenarbeit z.B. an einer Produktidee unterstützt.

5 Diskussion

Wie die Auswertung der Daten zeigt, bietet eine ESS durch die Verstärkung der Vernetzung von Mitarbeitern das Potenzial, den Innovationsprozess zu unterstützen. Dabei sind es vor allem in der Phase der Ideengenerierung oft die schwachen Beziehungen eines Netzwerks, die relevante Funktionen erfüllen (s. „strengh of the weak ties", Granovetter 1973), und dadurch zu Serendipität führen können (Siemens 2014). Es macht daher Sinn, innerhalb von Organisationen spontane Verbindungen zu fördern, die Wissen schnell und unerwartet übertragen und so Ideen entstehen lassen (Kanter 2000). Gleichzeitig ist jedoch zu beachten, dass Ideen vor allem durch individuelles Talent und Kreativität entstehen. Eine ESS kann dabei nur eine von vielen möglichen Ideenquellen sein. Aber ob und wie diese individuellen Fähigkeiten unterstützt und aktiviert werden und schließlich in erfolgreichen Innnovationen münden, können Unternehmen durch die Rahmenbedingungen beeinflussen (Kanter 2000), z.B. durch das zur Verfügung stellen einer ESS.

Die Nutzbarmachung der „Weisheit der Vielen" (Crowdsourcing) kann für Organisationen viele Vorteile mit sich bringen. Unter bestimmten Voraussetzungen ist davon auszugehen, dass die Qualität einer Innovation sich verbessert, je mehr Mitarbeiter an deren Beurteilung und Entwicklung beteiligt sind (Surowiecki 2004). Dies muss von Unternehmen jedoch nicht nur ermöglicht, sondern aktiv unterstützt werden. Starre, formale Strukturen, die hierarchieübergreifende Bottom-up Kommunikation hemmen, können nicht von der Weisheit der Vielen profitieren und innovatives Verhalten sogar blockieren (Kanter 2000). Gleichzeitig ist es bedeutend, Expertenwissen und Minderheitenmeinungen nicht ungeprüft von „der Masse" überstimmen zu lassen und stattdessen sorgfältig zu prüfen, ob bspw. Gruppendruck eine Rolle spielt oder organisatorische Rahmenbedingungen herrschen, die die Meinungsvielfalt einschränken und dadurch innovatives Verhalten hindern (Surowiecki 2004). In der Phase der Ideenakzeptierung stellt dies eine große Herausforderung für Organisationen dar.

Grundsätzlich gibt es hinsichtlich der funktionalen Unterstützung in der Phase der Ideenrealisierung als zentraler Wissensspeicher und Kollaborationstool auch Alternativen zu einer ESS. Beispielhaft seien hier Dokumentenmanagementsysteme genannt, die ebenso wie eine ESS in der Lage sind, Dokumente an einem zentralen Ort abzulegen und allen Mitarbeitern einen Zugriff sowie die Bearbeitung ermöglichen. Gleichzeitig ist es aber eine Eigenschaft von ESS, diese Funktionalitäten mit denen der vorangegangenen Phasen in einem System zu vereinen und dadurch Schnittstellen inklusive der damit verbundenen Problematiken zu vermeiden (Reichwald und Piller 2006). Zudem unterstützt der Netzwerkcharakter der ESS auch in dieser Phase die Zusammenarbeit, indem z.B. relevante Gesprächspartner und Unterstützer einer Ideenrealisierung identifiziert werden können (Kanter 2000).

6 Fazit

Obwohl die Daten, die dieser Studie zugrunde liegen, nicht repräsentativ sind, so haben sie aufgrund ihres explorativen Charakters und der hohen Anzahl ausgewerteter Interviews dennoch einige interessante Ergebnisse hervorgebracht. Diese liefern wichtige Hinweise über mögliche Einsatzszenarien einer ESS zur Unterstützung des Innovationsmanagements. Die Betrachtung von Innovation in der Form eines unternehmerischen Prozesses zeigte, dass Nutzenpotenziale in allen Phasen existieren. Diese bieten Unternehmen die Möglichkeit, Innovationen effektiver und / oder effizienter zu gestalten, indem z.B. die Schnelligkeit bis zur Ideenrealisierung gesteigert oder die Qualität einer Innovation verbessert wird.

Dabei ist jedoch, wie einleitend beschrieben, zu beachten, dass erfolgreiche Innovationen ein gewisses Maß an Unstrukturiertheit erfordern. Einen Prozess „der schöpferischen Zerstörung“ im Detail zu definieren, und dabei vorzugeben, wie ein IS anzuwenden ist, würde sich daher wahrscheinlich negativ auswirken. ESS überlässt die Art der Nutzung sowie die Strukturierung der Inhalte grundsätzlich seinen Nutzern. Somit liegt es in der Hand der Unternehmen, den Mitarbeitern die Rahmenbedingungen zu liefern, die Innovationen zulassen und fördern.

Abschließend ist festzuhalten, dass wir mit dieser Arbeit einen ersten Schritt hin zu einem tieferen Verständnis über mögliche Zusammenhänge zwischen einer ESS Nutzung und der Innovationsleistung bzw. -fähigkeit eines Unternehmens gegangen sind. Um signifikante Aussagen über kausale Zusammenhänge treffen zu können, ist eine quantitative Studie mit großer Stichprobe und Probanden aus weiteren Unternehmen nötig. Zusätzlich liefern die umfangreichen Datensätze der vorliegenden Fallstudie weitere Möglichkeiten der Exploration, z. B. hinsichtlich der Gestaltungsmöglichkeiten eines ESS im Innovationsprozess, möglicher Barrieren sowie kultureller Einflussfaktoren und konkreter Handlungsempfehlungen, was die Autoren in den nächsten Schritten angehen werden.

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Information Systems Research on Enterprise Social Networks – A State-of-the-Art Analysis

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Abstract

Along with the increasing adoption rates of Enterprise Social Networks (ESN) in companies, the study of these corporate online social networks has become an important topic in information systems (IS) research. In this regard, IS research on ESN has addressed topics such as ESN success factors and barriers to use, use practices, and the relevance of ESN in the context of knowledge management.

To date, however, an overview of the topics investigated in ESN research is missing. Addressing this gap, we conducted a systematic review of publications dealing with ESN. Our review focuses on studies published in major IS journals and conferences. In this paper, we illustrate the development of IS research on ESN over time and identify six ESN metatopics: *Implementation*, *Motivation to Adopt and Use*, *Usage and Behavior, Impact on the Organization*, *Success Measurement*, and *Data and Data Analytics*. We discuss core findings within these research streams and develop directions for future research which are hoped to stimulate and guide further research in this field.

1 Introduction

More and more companies introduce Enterprise Social Networks (ESN) to foster collaboration and knowledge sharing amongst their employees. Along with the increasing adoption rates of ESN, researchers in the field of information systems (IS) have shown growing interest in investigating ESN in the organizational practice. In this regard, early publications still studied ESN under the umbrella term of Enterprise 2.0 (Richter and Bullinger 2010). Nowadays, however, a large number of publications addressing various aspects of ESN, such as success factors and barriers to use, use practices, and the relevance of ESN in the context of knowledge management, can be identified.

Existing literature reviews in related areas published in recent years, e.g. dealing with Enterprise 2.0 in general (Richter and Bullinger 2010), external social networking sites (SNS) (Richter et al. 2011b), and IS research on online social networks (Berger et al. 2014a), cover ESN as one amongst other topics. Given the increasing number of publications focusing solely on ESN, a systematic literature review of the questions investigated in ESN research is required. A comprehensive overview of the addressed topics is essential in order to identify gaps and develop directions for future work as well as to inform theory building in ESN research (vom Brocke et al. 2015). To this end, we conducted a literature review of major IS publication outlets spanning the period of time from 2005 to 2015. As a result of our analysis, we identify six metatopics of ESN research and present core findings within these metatopics. We analyze the relationships among the metatopics and develop recommendations for future research. Prior to discussing the results of our analysis, the next sections provide background information on ESN and describe the literature review process.

2 The Use of Social Software in Corporate Settings

The use of social software in companies is referred to as Enterprise 2.0 by McAfee (2006). As such, social software places emphasis on the principles inherent to the Web 2.0 (Osimo et al. 2010). The focus is on user interaction, self-organization, usability and the collective creation of content by all users instead of individuals.

Social software includes applications such as weblogs and microblogs, wikis and group editors, social tagging and social bookmarking services, SNS and instant messaging services (Koch and Richter 2009, 11). As to internally used SNS, yellow pages applications, as e.g. “Blue Pages” in the case of IBM, can be regarded as a very early form of corporate social networking (Koch and Richter 2009, 60). In the following, some of the earlier versions of corporate SNS, e.g. Yammer, focused on the aspect of microblogging by allowing users to post short messages into a message stream and to follow other users’ updates (e.g. Riemer et al. 2011b). Subsequently, providers of corporate SNS integrated more and more Web 2.0 and collaboration features and started to market their platforms under the term of enterprise social networking (Richter and Riemer 2013). Beyond short messaging services, applications such as Yammer, Communote and Jive, nowadays feature wiki-like collaboration capabilities, document management and social networking features, e.g. profile pages, and can be regarded as fully-fledged ESN platforms.

Based on prior work, we define ESN as web-based intranet platforms that rely on Web 2.0 technology and are implemented within organizations (Leonardi et al. 2013; Kügler et al. 2015a). They enable users (1) to communicate with particular other users in private, to contribute to groups or broadcast messages to everyone in the organization (Leonardi et al. 2013), (2) to explicitly connect with other users via features like Following or implicitly connect with them through shared interactions (Leonardi et al. 2013; Behrendt et al. 2014b), (3) to respond to the content posted by other users (Behrendt et al. 2014b), (4) to present information about themselves (Behrendt et al. 2014b) and (5) to traverse the profile information and content created by others (Leonardi et al. 2013). The communicative actions of users on the ESN lead to visible traces that persist over time (Leonardi et al. 2013).

3 Literature Review

Within this literature review, we identify and extract scientific publications covering the topic ESN. The objective is to reveal the state of the art in order to create a foundation for advancing knowledge on the topic as well as to derive implications for future research and practice (Webster and Watson 2002; Torraco 2005).

3.1 Source Selection and Search Strategy

Due to the focus of this literature review on IS (Bandara et al. 2011), we based our selection of relevant outlets for the literature search on the Senior Scholars' Basket of Journals (AIS 2011) provided by the Association for Information Systems (AIS). To ensure a sufficient scope (Webster and Watson 2002), we considered further high quality IS journals as well as the proceedings of the main IS conferences according to the VHB-JOURQUAL3 rating (VHB 2015) for business information systems (Table 1).

Databases	Outlets	Search Terms	Search Option
DBLP	Journals: BISE/WI, CACM, CAIS, EJIS, IJIEM, ISJ, ISR, JAIS, JEIM, JIT, JMIS, JSIS, MISQ Conferences: AMCIS, CSCW, ECIS, HICSS, ICIS, MKWI, PACIS, WI	Enterprise Social Network*, Corporate Social Network*, Enterprise Social Software, Corporate Social Software, Enterprise Knowledge Sharing, Corporate Knowledge Sharing, Enterprise Microblogging, Corporate Microblogging, Enterprise Social Media, Corporate Social Media	/
AIS eLibrary			Fields: Abstract, subject, title
ACM Digital Library			Fields: Abstract, title
IEEE Xplore			Fields: Document title, abstract
EBSCO Host			Fields: Abstract, subject, title
Springer Link			Title contains exact phrase

Table 1: Overview of the search process

Next, we identified relevant keywords for our literature search. Due to the development of ESN platforms, earlier publications often refer to ESN as microblogging services. Other designations include e.g. corporate social network(ing), enterprise social media and social software. For a comprehensive literature research, we considered multiple search terms and combinations of them (vom Brocke et al. 2015) (Table 1). As to the time frame for our review, early adopting companies launched their internal SNS in the years of 2006 and 2007 (Richter and Riemer 2009). For this reason, the time period for this literature review comprises the years 2005 to 2015. Carrying out the search process in major databases, we restricted the search range to the title, abstract and keywords. We furthermore conducted a backwards search by reviewing the citations in previously identified literature (Webster and Watson 2002).

3.2 Overview of the Selected Publications

The search process resulted in 191 publications. As a next step, we had to decide whether a publication was relevant for our analysis. This decision was often difficult to make, since, on the one hand, ESN now integrate other – previously independent – types of social software, e.g. Wikis, and, on the other hand, systems such as knowledge sharing platforms increasingly include "social features". Scanning each publication, we excluded publications not explicitly focusing on ESN as well as publications without original content and publications of less than four pages. This selection process led to a final number of 85 publications.

With regard to the distribution of literature on ESN over time (c.f. Figure 1), the highest number of publications within a year was reached in 2014. The strong increase in conference papers from 2010 to 2011 might be due to the growing proliferation of ESN in the organizational practice in these years. Even though low compared to the number of conference papers, the higher number of journal articles published in the last two years indicates a certain level of maturity in ESN research.

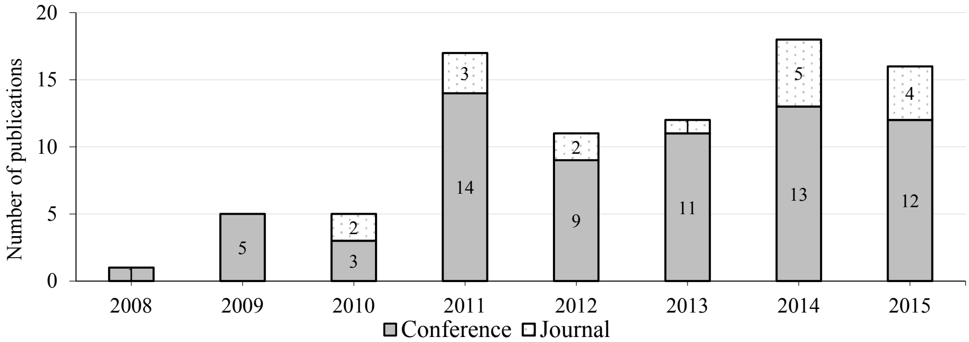

Figure 1: Distribution of publications over time

Likewise notable is the concentration of the reviewed publications on a few conferences and journals. In this regard, the five conferences listed in Table 2 account for 80 % of the identified conference papers. Furthermore, more than 75 % of the selected journal articles were published in five out of twelve searched outlets.

Top 5 Conferences		**Top 5 Journals**	
Europ. Conference on Information Systems	14	Journal of Strategic Information Systems	4
Americas Conference on Information Systems	11	Business & Information Systems Engineering	3
Hawaii Int. Conference on System Sciences	11	Int. Journal of Internet and Enterprise Management	2
Int. Conference on Information Systems	9	Information System Journal	2
Computer Supported Cooperative Work	7	Information System Research	2
# conference papers published on top 5 conferences / # of conference papers	**52/68**	**# journal articles published in top 5 journals / # of journal articles**	**13/17**

Table 2: Conferences and journals with the highest count of publications

4 Metatopics in Enterprise Social Network Research

To identify the main streams in ESN research, we based our initial round of coding on the six Enterprise 2.0 metatopics proposed by Richter and Bullinger (2010): *Goal and Definition*, *(Enterprise 2.0) in the Organization*, *Functionalities*, *Motivation*, *Usage*, and *Data*. We selected this framework since it provides a comprehensive coverage of different aspects in the area of Enterprise 2.0. In the process of analyzing the relevant publications, we added keywords and short sentences to every article, describing its focus area and key contribution. We then reviewed these notes and matched all publications with the predefined six categories. As a result of this procedure, we adapted the framework proposed by Richter and Bullinger (2010) since several publications did not match the predefined categories. Figure 2 illustrates the metatopics identified in the course of our literature review.

The metatopic *Implementation* includes publications dealing with ESN roll out strategies as well as challenges in the implementation phase. *Motivation to Adopt and Use* covers studies investigating determinants of adoption and usage by the platform users. The stream *Usage and Behavior* identifies ESN use practices. Publications assigned to the metatopic *Impact on the Organization* deal with the impact on and effects of ESN in the organizational practice. The stream *Success Measurement* considers the understanding and measurement of success in the context of ESN. Finally, *Data and Data Analytics* focuses on the analysis of data accumulated in the ESN back end.

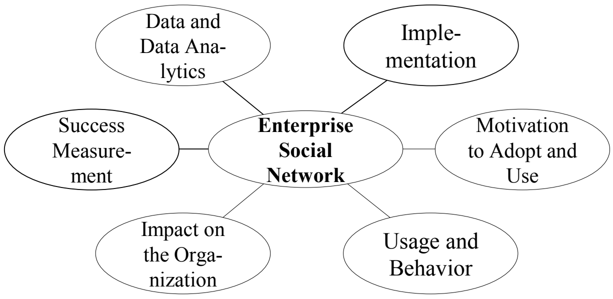

Figure 2: Metatopics in the area of ESN research

While some publications focus on one topic only, others cover multiple (partly overlapping) streams to different extents. Therefore, we estimated the degree to which a publication focuses on a topic using a 3-point-scale, a rating of 3 indicating a strong focus on a metatopic.

4.1 Implementation

Publications assigned to the category *Implementation* cover the pre-implementation phase of ESN, implementation strategies as well as success factors and challenges. As to the preparation and pre-implementation phase, new technologies are often encountered as an “object against existing practice” (Riemer and Johnston 2012, 12). Therefore, the utility of the ESN (Schöndienst et al. 2011) needs to be pointed out from the beginning. Well-established strategies for the implementation itself include bottom-up and top-down approaches. While the bottom-up strategy (Soyland and Herstad 2011) could be considered as a participative exploration by the employees, the top-down strategy implicates an adoption coordinated by the management level – also described as promotion (Richter and Stocker 2011). Irrespective of the pursued strategy, support from the top management has been found to play a critical role in the adoption phase (Günther et al. 2009; Diehl and Schubert 2012; Richter et al. 2013b). Since ESN implementation may be connected to a wide range of different goals (Richter et al. 2011a), the scope of the platform should be aligned with the perceptions of the executives to guarantee a successful implementation (Zealand 2012) and the achieving of a critical mass of users (Günther et al. 2009; Riemer et al. 2012). Challenges during the implementation process, commonly addressed as internal and external issues (Bala et al. 2015), arise particularly due to the collaborative nature of ESN. Therefore, special attention should be paid to the security and privacy of the users when implementing such social software (Kuikka and Akkinen 2011).

4.2 Motivation to Adopt and Use

This stream covers studies that investigate the determinants of the users’ motivation to adopt and engage in ESN. In this context, Kügler et al. (2013) categorize the factors that determine adoption and usage into technological factors, social factors and organizational climate. While technological factors comprise e.g. the ease of using the ESN (Kügler et al. 2013) and the platform and content quality (Chin et al. 2015a), social factors include the perceived critical mass (Kügler et al. 2013;

Chin et al. 2015b) or the enjoyment of helping others (Chin et al. 2015b), for instance. Aspects related to the organizational climate consider e.g. the level of trust and existing collaboration norms in the organization (Kügler et al. 2013). Barriers to adoption and usage are mostly related to privacy concerns of employees (Günther et al. 2009; Buettner 2015). Thus, users need to be aware of and agree to share not only professional but – at times – also personal information with their colleagues (DiMicco et al. 2008).

4.3 Usage and Behavior

The usage of ESN is considered the key research theme with the largest share of publications among all metatopics. Facilitating new possibilities for communication and collaboration (Wagner et al. 2014), ESN enable the creation of context and knowledge (Riemer et al. 2011a; Riemer and Scifleet 2012) and facilitate expert search (Richter and Riemer 2009). Publications assigned to this metatopic explore how employees use ESN in their day-to-day work and aim to identify different use patterns. To this end, most of the publications use case study designs. Examining different forms of usage, Richter and Riemer (2013) present eleven use cases that – amongst others – contain discussions, event notification, informal talk, information storage, and problem solving. Steinfield (2015) further highlights the dominant role of information search. Other researchers cluster multiple use cases, e.g. differentiating between "consumptive" and "contributive" use (Kügler and Smolnik 2014). While consumptive (passive) use indicates the consuming or acquiring of data, contributive (active) use refers to the sharing or contributing of information. Other forms include hedonic use, i.e. use for the purpose of entertainment, and social usage in order to get in touch with colleagues (Kügler and Smolnik 2014). Compared to public SNS that people often use to inform other users about themselves, ESN, however, are mainly employed in a productive way, e.g. by allowing employees to express their opinions and discuss work-related matters (Riemer et al. 2010; Riemer et al. 2011b).

4.4 Impact on the Organization

Publications assigned to this metatopic deal with the impact on and effects of ESN in the organizational practice, such as the influence of ESN on organizational structures, job security, and performance. While Riemer and Richter (2010) find ESN to reproduce existing organizational structures rather than to lead to structural changes, this finding could not be confirmed in a more recent study by Riemer et al. (2015). In this study, Riemer et al. (2015) investigate the role of formal influence, i.e. influence based on a user's role in the organization, and informal influence, i.e. influence derived due to contributions to the ESN, in receiving responses in ESN. They find that, over time, formal hierarchy loses its influence and that the ESN community produces its own, more balanced, communication structures. As to other impacts on the organization, researchers highlight the strong and positive effect of ESN on both job security (Wu 2013) and task/work performance (Suh and Bock 2015; Kügler et al. 2015b). This is primarily due to improved team collaboration (Alexander 2015; Kügler et al. 2015b) and a faster and richer information flow (Wu 2013).

4.5 Success Measurement

Research assigned to this stream aims to understand, define and measure success in an ESN context. This stream is of particular importance for practitioners who are interested in quantifying the impact of a newly introduced platform and justify investments by proving the achieved benefits (Richter et al. 2013a). While Richter and Koch (2009) examine factors and strategies contributing to ESN success, e.g. the integration of the platform in day-to-day activities, Steinhüser et al. (2011) adopt the IS Impact Measurement Model (Gable et al. 2008) to estimate ESN success. Establishing a new success measurement model, Richter et al. (2013a) create a framework that uses collaborative actions, such as the editing, rating or sharing of content, to measure ESN usage and derive implications regarding the achieved business value. ESN success measurement, however, remains difficult since there is, on the one hand, no unique definition of success and, on the other hand, different stakeholders who have different views on success. Hence, success measurement cannot be based on unitarily metrics (Herzog et al. 2013) but will need a set of metrics covering different perspectives.

4.6 Data and Data Analytics

Interacting on ESN, the platform users leave a number of digital traces that are accumulated in the ESN back end. Publications assigned to the stream *Data and Data Analytics* cover the question as to which type of data exists, how it can be extracted from the platform's back end, and how this data could be analyzed. For instance, Behrendt et al. (2014a) explore different ways of conceptualizing relations in ESN, such as relationships based on commenting on another user's activity and sending direct messages. Performing social network analysis, Behrendt et al. (2014a) find that the resulting network graphs vary greatly and suggest that researchers need to be aware of the assumptions that they make when conceptualizing relationships in ESN. Other studies assigned to *Data and Data Analytics* deal with the identification of key users and user roles in ESN. In this regard, Berger et al. (2014b) investigate the structural characteristics of value adding users in ESN and Trier and Richter (2014) identify discourse drivers and information retrievers as ESN actor roles.

4.7 Relationships among the Metatopics

The previous sections provided an overview of the investigated issues and core findings within the six metatopics. However, as stated above (cf. section 4), many publications focus on several metatopics at once to different extents. To discover relationships among the metatopics, we extracted the primarily covered metatopics, i.e. the ones that were covered to a strong and medium degree, for each of the reviewed publications. Using KH Coder (Higuchi 2015), a software for quantitative content analysis, we then created a co-occurrence network of the metatopics considered in ESN research (Figure 3). The size of the circles indicates how often a metatopic occurs in the reviewed publications. While the topics *Usage and Behavior*, *Motivation to Adopt and Use* and *Implementation* are dealt with most frequently, *Success Measurement* and *Data and Data Analytics* can be recognized as emerging fields. The lines between the circles demonstrate a relationship among metatopics. The more often we identified the same combination of topics, the thicker the line between two circles. Moreover, topics in circles of the same color are often investigated together. For instance, the combination of *Impact on the Organization* and *Success Measurement* occurs in many publications.

Each metatopic in Figure 3 is connected to a minimum of three other metatopics, which demonstrates a high interconnectedness of the topics addressed in ESN research. The triad *Usage and Behavior*, *Motivation to Adopt and Use,* and *Data and Data Analytics* indicates, on the one hand, the crucial role of user motivation in fostering platform use. On the other hand, the link to *Data and Data Analytics* shows that studies addressing *Usage and Behavior* and *Motivation to Adopt and Use* frequently use ESN data, e.g. log files, in their analyses. While we identified *Data and Data Analytics* as an independent stream of research in the course of our analysis, its strong connections to several other metatopics indicates its role in providing tools and methods for the collection and analysis of ESN data to support research in these areas. In comparison, studies addressing *Implementation* mostly rely on qualitative data, e.g. interview data, and hence, exhibit a weak connection to *Data and Data Analytics*. The strong relationship between *Impact on the Organization* and *Success Measurement* illustrates that the effects of the ESN within the organization also influence platform success.

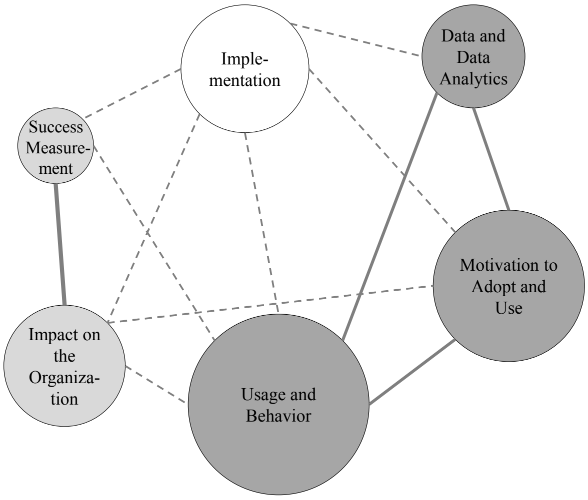

Figure 3: Co-occurrence network of ESN metatopics

5 Directions for Future Research

Having identified six streams of ESN research, we suggest the following recommendations for future research within the metatopics:

- *Implementation*: Even though ESN research has developed recommendations for implementation, organizations still struggle to successfully roll out these platforms. Future research could compare ESN implementations across different organizations in order to identify a more comprehensive set of the related success factors and challenges. As a result, recommendations for implementation depending on a company's size, industry or characteristics related to an organization's culture, could be created.
- *Motivation to Adopt and Use*: Prior research has identified several factors that reinforce or hinder the users' motivation to adopt and engage in the ESN in the early stages of ESN implementation. Based on longitudinal data, future research could analyze how user engagement develops and how user motivation to participate can be reinforced over time.
- *Usage and Behavior*: Existing studies investigating ESN usage mostly employ qualitative research designs to figure out use practices. Future research could identify usage patterns by analyzing ESN data using statistical analyses. That way, platform use could be analyzed and compared across different organizations and industries in a more efficient way.
- *Impact on the Organization:* Some studies suggest that formal hierarchies are less important in ESN and that ESN lead to more balanced and inclusive communication structures. Future research could investigate how ESN usage affects communication practices outside the ESN. It would also be interesting to compare these effects of ESN in different cultural settings.

- *Success Measurement*: More research is needed as to how the objectives of implementation (from different stakeholders) can be translated into dimensions of platform success. ESN data analytics could help operationalize these dimensions by developing and implementing the according metrics. Also, future research could investigate the business value of ESN platforms, e.g. how ESN usage may support meeting organizational business objectives.
- *Data and Data Analytics:* Future research could investigate more deeply the tools and methods that can be used to collect and analyze ESN data. Another open question is to what extent ESN data analytics might be feasible to support organizational decision-making, e.g. in the area of Human Resources Management. Regarding data security and privacy concerns, ESN research could develop recommendations as to how ESN data analytics can be performed in a secure and ethical way.

6 Conclusion

Within recent years, more and more organizations have implemented ESN to foster collaboration and knowledge sharing. Likewise, ESN have become a prominent topic in IS research. Our search for studies on ESN in major IS journals and conferences resulted in 85 publications. We identified six metatopics of ESN research and discussed core findings within the six metatopics. We further analyzed the relationships among the metatopics and provided suggestions for future research.

The results of this paper need to be weighted up against its limitations. Firstly, we restricted our search to major outlets of the IS community and used a limited set of keywords. Secondly, we excluded publications without an explicit focus on ESN, e.g. publications that covered ESN as a side topic. Widening the scope regarding the searched outlets and types of social software might provide further valuable insights.

Addressing these limitations, we will extend our search to other outlets in a follow-up project. Also, we would like to take a closer look at the theories and research designs employed in ESN research and compare these with what has been done in related streams, e.g. research on online social networks. Having provided an initial overview of research on ESN, we hope that the results of this paper motivate and guide future research in the field.

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Teilkonferenz
Cyber-Physische Systeme und digitale Wertschöpfungsnetzwerke

Cyber-physische Systeme (CPS) sind selbstoptimierende und rekonfigurative Systeme, die informationstechnische und physische Subsysteme mittels Kommunikationstechnik verknüpfen. Durch die Einbindung von Sensoren und Aktuatoren in ein digitales Gesamtsystem stellen CPS neuartige Systemfunktionen für die Informations-, Daten-, und Funktionsintegration zur Verfügung und ermöglichen so die Entwicklung vernetzter Wertschöpfungsszenarien wie z. B. Smart Factory und Smart Mobility.

Eine technische Voraussetzung für erfolgreiche CPS sind Dienste und digitale Wertschöpfungsnetzwerke, die den Datenaustausch zwischen den Subsystemen des CPS ermöglichen. An der Schnittstelle zwischen eingebetteten Systemen und Anwendungssystemen müssen insbesondere Event-getriebene Architekturen und Datenschnittstellen konzipiert und implementiert werden. Im Rahmen einer IT-Architektur ist die Gestaltung von CPS als Gesamtsystem festzulegen. Hierbei sind Standardisierungspotenziale zu nutzen, die eine Interoperabilität der Subsysteme ermöglichen. Technische, organisatorische und rechtliche Aspekte sind zu betrachten. Dies wirft auch Fragen der Gestaltbarkeit bzw. Emergenz der Subsysteme und des CPS insgesamt auf.

Die Artikel dieser Teilkonferenz leisten einen Beitrag dazu, CPS besser zu verstehen und nutzen zu können. Andreas Reidt und Helmut Krcmar entwickeln eine Referenzarchitektur für CPS zur Unterstützung der Instandhaltung, um Stillstandzeiten zu verkürzen. Christoph Klima, David Heim und Axel Winkelmann stellen in ihrem Beitrag eine Taxonomie für hybride Leistungsbündel im Internet-of-Things vor. Marcus Mueller, Marvin Hubl, Johannes Merkert, Robin Kuenzel, Sebastian Meyl und Wladislaw Nill zeigen, wie CPS eine intelligente Logistik für den Straßenbau schaffen können.

Daniel Beverungen, Christian Janiesch, Steffen Lamparter, Martin Matzner

(Teilkonferenzleitung)

Intelligent Road Pavement Logistics

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Abstract

Modern road construction sites are highly complex and individualized logistics systems characterized by a plurality of procedural dependencies and dynamically changing environments. Recent studies show that budget overruns and delays are quite common in today's civil engineering projects. Current solutions for monitoring and control of sites often fail in solving these problems since construction projects increase in their complexity. During the last years, construction machines got more and more equipped with sensors and recent work provides improvements in digitalization of building information models as well as the whole construction process. Thus, road construction sites nowadays made their advancements to become cyber physical systems with an increasing demand for automatic control and self-optimization. Multi-agent systems tend to provide a promising technology for this issue. Thus, this paper contributes an agent-based system for road pavement logistics. We conducted a simulation study to show the feasibility of our artifact. The simulation is based on a scenario worked out by a team of domain experts.

1 Introduction

Within Europe, the construction industry holds a market volume of 1,186 billion euro, employs 41.7 million people and generates 9.7% of the EU-27-GDP (European Construction Industry Federation 2011). Recent studies show that nearly 90% of civil engineering projects suffer from budget overruns or delays. On average, the actual costs exceed the estimated costs by 28%, and 40% of the projects were up to three months, 42% up to nine months, and 5% more than 18 months delayed (Flyvbjerg et al. 2003). A main cause is an inadequate site management (Assaf and Al-Hejji 2006).

Contemporary approaches for on-site logistics management (OSLM) rely on global plans which precede execution with planning and scheduling. To achieve a constant flow of material and to prevent stops of the paver, practitioners calculate timing-pulse diagrams and provide them to the truck drivers. Because of environment related reasons (smaller traffic jams, slightly different loading times at the batch plant, etc.), these diagrams are obsolete after the first hour of running the site. In the last years, practitioners and scientists focused their work mainly on improving these planning methods. However, during execution all coordination is still done by the site manager in a traditional manner (Winch and Kelsey 2005). Recently, several techniques have risen to support site management with in-time information about the logistics, construction processes and performance of machines and staff. Most of the research reported in this field concentrates on monitoring construction workers and the fleet of construction machines. The site manager is still the only dispositive authority and centralistic, strictly hierarchical approaches are the predominant organizational model for running logistics systems of construction sites. This hinders needed flexibility of the logistics systems during the execution phase.

A solution to the problem is an automated management that delegates decision and execution authority to local entities. Multi-agent systems (MAS) tend to be a promising means for this purpose (Lin and He 2011). However, systems regarding specific requirements of road construction sites logistics incorporating latest findings and technologies of real-time construction site performance monitoring and fleet management are still scarce in current research. Literature and practice inform only insufficiently about the applicability and usefulness of a combined approach of MAS and real-time monitoring within the road pavement industry. This work aims on closing this gap by proposing and evaluating a MAS that takes into account market available and nearby future solutions for real-time site performance monitoring and fleet management.

The main objective in OSLM is to provide a continuous flow of material with an in sequence delivery of asphalt with certain quality criteria at minimum costs. In contrast to stationary industries, the logistics system of a construction site is characterized by an open-air production that causes unpredictable environmental disturbances. Changing spatial arrangements lead to different destinations and routes in transportation processes. Systems for OSLM need to deal with that specifics and have to provide at least (1) facilities for sensing physical conditions of the site, e.g. machine performances, positions, status (Alur 2015), (2) reasoning mechanism for local decisions, and (3) coordination methods alongside the whole construction supply chain.

To sense, communicate, and store real-time data about physical conditions (e.g. geolocation, material throughputs, loading state), we build up upon market available and nearby future solutions with standard, service-based interfaces. Sensed data is processed by a distributed decision algorithm to reason about local decisions. Scheduled values are retrieved from digital models about geometry, timing and so on. As method for coordination we employ the pull principle as a basic pattern in logistics research. Thus, our cyber physical system acquires and proceed in-time data to achieve a constant flow of material and, subsequently, a higher quality of roads.

Applying the design science method of Hevner et al. (2004), the remainder of this paper is organized as follows. In section 2 we analyze the state of the art in using MAS within the construction industry (knowledge base). The design of our artifact is described in section 3. To show that our approach is feasible to solve problems in OSLM, section 4 proposes an evaluation of the system. Section 5 concludes our work and outlines future research.

2 MAS Application in Construction

Recent studies concerning MAS application in construction focus on agent-based design and agent-based negotiation (Ren and Anumba 2004). However, both streams do not address operational tasks but rather planning and disposition, e.g. negotiation of schedules (Kim et al. 2000), compensatory (Kim & Paulson Jr 2003) or claims and responsibilities (Ren et al. 2003). Simulation experiments show that MAS can reduce the duration of inter-organizational decision-making for construction (Xue et al. 2005; Lin and He 2011). However, in difference to our approach prior research has been concerned with decisions alongside the supply chains but not on an operational level.

As a system for decentralized dynamic resource management in construction companies Oliveira et al. proposed the MACIV system (De Oliveira et al. 1997). When the system receives a task, the agents negotiate with respect to their preference settings and form coalitions in order to fulfill the task. The authors show the feasibility of the system by applying their negotiation method to a real world scenario. Liu and Mohamed applied methods of multi-agent resource allocation (MARA) for scheduling module assembly processes in pipeline construction projects (Liu and Mohamed 2008). They use an auction protocol with a centralized auctioneer allocating material deliveries to the highest bidder. The authors implemented the algorithms and showed that their dynamic programming algorithm slightly outperforms the best-first search.

The MACIV system as well as the MARA approach do not consider real-time data, as we do. The very first work in this field was done by Zhang et al. (2009) resp. Zhang & Hammad (2012). The authors contributed a multi-agent planning algorithm for collaborative actions of mobile hydraulic cranes. The algorithm was implemented in a prototypical system and tested in a laboratory environment with physical models of cranes. However, this preliminary work does not address logistics management comprehensively.

3 A Multi-Agent System for Road Pavement Logistics

3.1 Architectural Overview

Fig. 1 shows the overall architecture of the whole system including third party components for fleet management, asphalt plant management, construction planning and documentation systems, and the component to link the whole system to real time data from the site (e.g. actual paver speed).

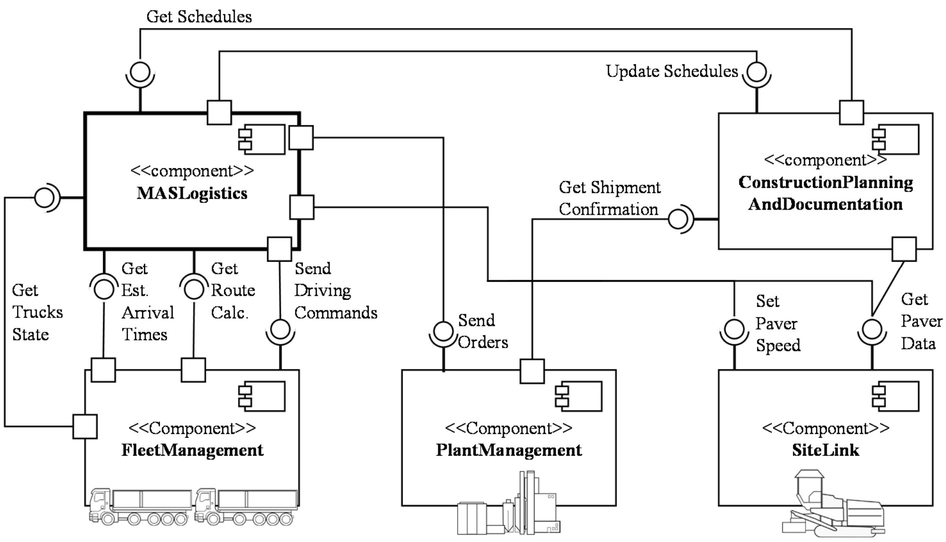
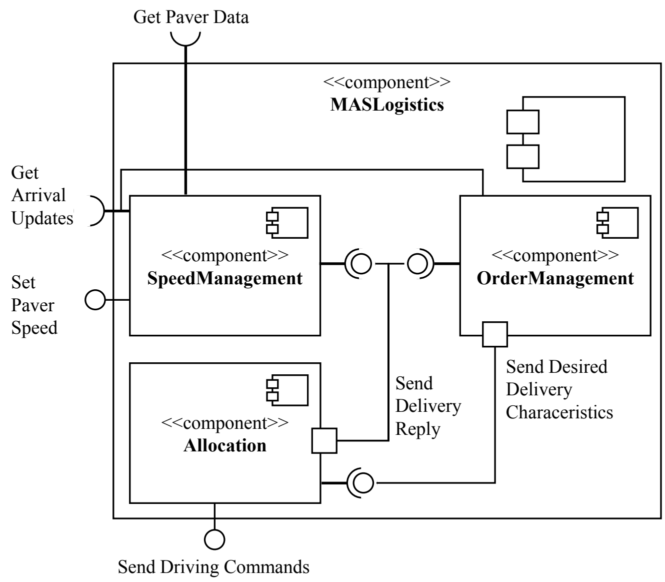


Fig. 1 Architectural Overview

Our artifact mainly consists of two sub-components for on-site logistics management – an allocation algorithm for long-sighted logistics control (“allocation” and “order management” components) and paver speed decision component for short-sighted logistics control (“speed management” component). Both components are combined in the “MASLogistics” component (see Fig. 2).



Description of the components:

SpeedManagement: Determines the production speed of the paver depending on the expected delivery cycle and considering efficacy constraints.

OrderManagement: Determines the order interval. It is effected by the speed management and vice versa.

Allocation: Allocates a delivery order to the best suited delivery truck. It is initiated by the decision component.

Fig. 2 The MASLogistics component

3.2 Interaction Sequences

The order management calculates the characteristics (quantity and time) of an order for asphalt in accordance to the estimated arrival times gathered by from the fleet management. Subsequently, the order management sends an order request to the allocation component and waits for the reply. If the delivery orders were allocated to the trucks, the allocation component sends a reply (Fig. 3).

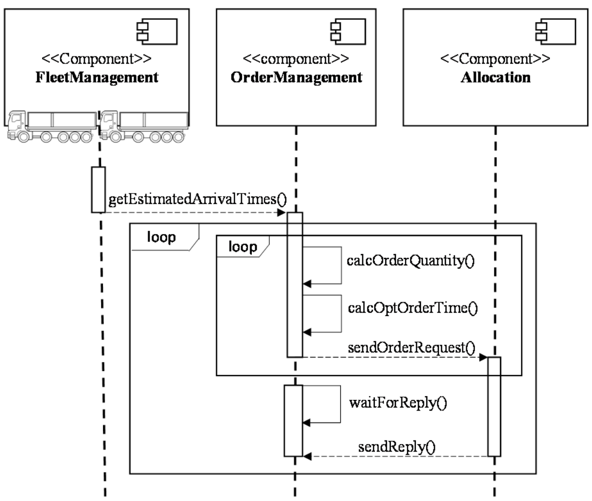


Fig. 3 Interaction between fleet management, order management and allocation

The speed management component calculates the speed in accordance to the estimated arrival times gathered from the fleet management and the actual paver speed gathered from the site link. The calculated optimal speed (low possibility of paver breaks) is transmitted to the paver (see Fig. 4).

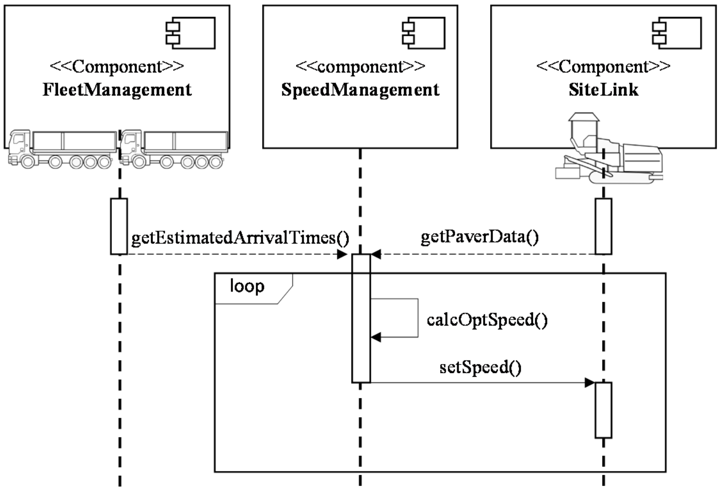


Fig. 4 Interaction between fleet management, speed management and site link

The components for order management and speed management (decision component) and for allocation will be explained in further details in the following subsections.

3.3 Decision Component

The decision component is part of the paver agent's optimization module. Its main goal is to achieve and maintain smooth asphalt laying with as less as possible changes of the production speed. Additional conditions are to maximize the paver's speed and to avoid standstills. In order to achieve this goal, the system has to perform two main tasks: the order management for adapting the orders for the just in time deliveries to the current situation and the speed management for handling short- and middle-time disturbances. It therefore uses the collected and processed data about the transportation and road pavement process, as well as information about the environment.

Order Management The order management component calculates the demand for a new delivery (t_demand) at the paver and the point of time until the delivery has to be ordered (t_order). Ordering to early bears the risk of ordering on base of obsolete information. Ordering too late may lead to a delay in the delivery. Because of the transportation process taking more time than a delivery lasts at the paver, demands in the future have to be estimated and ordered. There is a new demand for asphalt delivery if the latest delivery is completely unloaded at the paver. This is calculated by adding the time needed for unloading ($d\_unloading$) to the estimated arrival time of the order at the paver ($t\_docking$). Latter information is provided by the fleet management system. The duration for unloading is calculated by dividing the capacity of the truck by the throughput of the paver.

$$t\_demand = t\_docking_{latest\ delivery} + d\_unloading_{latest\ delivery}$$

A new order has to be done at last, when the estimated time needed for delivery (*d_delivery*) is higher than the time that remains until the next demand occurs.

$$t\_order = \max(t\_demand - t_0 + d\_delivery, 0)$$

The delivery time is the time needed for performing one delivery and consists of the driving time to the batch plant (*d_journey(Batch Plant)*), the dwelling time at the batch plant (*d_dwelling(Batch Plant)*), driving time from the mixing plant to the paver (*d_journey(Paver)*), and a buffer (*b*).

$$d\_delivery = d\_journey(Batch\ Plant)$$

$$+d\_dwelling(Batch\ Plant)) + d\_journey(Paver) + b$$

When calculating the time of a delivery demand, an order hasn't been sent yet. Thus, the driving time to the batch plant cannot be estimated easily because of the starting point isn't known. The dwelling time of the truck at the batch plant consists of waiting times, loading time and time for other actions as signing the delivery note. The driving time from the batch plant to the paver can be requested from the navigation system or estimated by historical delivery data. A tight schedule is vulnerable to unforeseen events. The use of a buffer reduces the impacts of such events on the process. Is the buffer size chosen too high, the system will become sluggish in case of disturbances.

At the calculated time for ordering, the decision component hands over the ordering details to the allocation algorithm. Algorithm 1 briefly outlines the order management process.

Algorithm 1 Order Management

get logistics data
get paver data
$t\_order := max(t\_demand\ - t_0 + d\_delivery, 0)$
$t\_delivery \coloneqq t\_docking_{latest\ delivery} + d\_unloading_{latest\ delivery}$
if $t_0 <= t\_order$ **then**
    make order
end if

Speed Management The domain experts state, that a smooth paving process without unplanned stops is crucial for a good quality of the built road. The speed management component calculates the optimal speed of the paver on base of the amount of asphalt that is on its way and the points of time the trucks deliver the asphalt. Because of the deliveries were ordered on base of information of the past, the situation may change while a delivery is on its way. In case of disturbances in the transportation process, the speed management component is provided with the new times of arrival by the fleet management system. This and additional information (e.g. current paver speed) is used by the system to determine the optimal speed values for particular time intervals. The need of a speed change is based on the amount of asphalt directly at the paver (buffer). The buffer is defined as a range for any point in time. Our team of domain experts recommend a buffer of two truckloads, based on their experience. The system first determines if and when the buffer constraint is violated. On base of these points in time, intervals are defined within the speed remains constant. Then, the optimal speed for this intervals are calculated. Algorithm 2 briefly depicts this process.

Algorithm 2 Speed Management Component

get logistics data
get paver data
calculate buffer constraint violations
calculate speed intervals
for all *speed intervals* **do**
    calculate optimal interval speed
end for

The optimal interval speeds are calculated by three functions:

$$U \coloneqq \forall v \in U | \min(v) \leq v \leq \max(v) \qquad (1)$$

$$V \coloneqq V \subset U\ s.t. \min(b) \leq b(v) \leq \max(b) \qquad (2)$$

$$opt(v) := max(u(b(v))) \qquad (3)$$

Function (1) defines U which contains all valid values for the paver's speed v. A value is valid if it's greater or equal to minimum speed and smaller or equal to the maximum speed. Function (2) defines V which is a subset of U and only contains these values for speed where the corresponding buffer value b is valid. The buffer value is valid, when it is within the range in that the buffer is defined. Function (3) defines the optimal speed by maximizing the utility of the buffer $u(b)$.

3.4 Allocation Algorithm

Generic Framework We allocate the delivery orders to a delivery agent by means of an auction mechanism. Its generic logic from the auctioneer's point of view is formally given by algorithm 3 and has been introduced in (Mueller et al. 2014). The variables o^*, o_{null} and o are offers, taken from the set of all potential offers O. The variable o^* will eventually contain the offer which wins the delivery order. It is initialized with the void offer, o_{null}.

Algorithm 3 Generic logic for an auction (from the auctioneer's viewpoint)

$o^* := o_{null}$
$O_o := \emptyset$
While ($\xi^*(O_o) = 1$) **do**
  $o := o_{null}$
  $o \leftarrow$waitForOffer
  if ($\xi(o, O_o) = 1$) **then**
    $O_o \leftarrow O_o \cup \{o\}$
    $o^* := o$
  end if
end while
allocate o^*

The variable O_o is a subset of O which is initially empty and is successively filled with the incoming accepted offers. At any point in time O_o contains all previously accepted offers of the particular auction. The incoming offers are collected by the procedure *waitForOffer*. Basically this procedure is a service that waits for invocation by an offer and that delivers this offer as return value, if it is not interrupted by a timeout. Note, that the timeout issue is to be handled within the *waitForOffer* procedure to avoid (infinite) standstill in case no (more) offer is made. Interrupting the *waitForOffer* procedure implies that the placeholder o contains the void offer o_{null}.

The auction algorithm contains two characteristic functions, $\xi^*: \{O_o\} \rightarrow \{0, 1\}$ and $\xi : O \times \{O_o\} \rightarrow \{0, 1\}$. The function ξ^* computes whether the auction is terminated or not. The function ξ computes whether a new offer is accepted or not. Algorithm 3 shows a general framework for auctions where only one offer per auction is allocated in the end and where this offer is the last accepted one. Results are determined by the implementation of the characteristic functions.

The implementation of ξ^* is given by the algorithm 4 and ξ is given by the algorithm 5. The "if"-condition of algorithm 4 implies (in conjunction with algorithm 5) two statements. (1) The auction terminates when every delivery agent has made (at most) one offer. (2) The auction terminates also when the current time given by t exceeds a certain time threshold t_{max}. Note that we leave open where the time threshold is set. It may be even reset after each incoming offer and most probable it is sensible to relate the threshold with the *waitForOffer* procedure.

Algorithm 4 Computation of ξ^*:

Require: O_o The set A of all potential delivery agents (offerers) be known.

```
t ← current time
if |O_o| ≥ |A| ∨ t > t_max then
    return 0
else
    return 1
end if
```

Algorithm 5 Computation of ξ:

Require: o, O_o

```
for all o‘ ∈ O_o do
    if a(o‘) = a(o) ∨ S(o‘) > S(o) then
        return 0
    end if
end for
return 1
```

We formalize that the agent who made an offer o is traceable by the mapping $a : O \rightarrow A$. So the “if”’-statement in algorithm 5 accepts only one offer per agent. But the most important condition for an offer o to be accepted is that the scoring function $S : O \rightarrow \mathbb{R}$ attains a higher value than for any other previously accepted offer o'. That is, finally the implementation of ξ assigns the delivery order to the agent whose offer is the highest scored one.

Instantiation for Road Pavement Logistics The offers that we regard are five-tuples, $O \subseteq \mathbb{R}^5$, incorporating the objectives of logistics, which are reflected by (1) the prize of a delivery order, (2) the quantity of the delivered resource, (3) the condition of the delivered resource, (4) the delivery time, and (5) the place of delivery given as the distance to a reference point.

For the scope of the paper at hand only the time attribute shall be of importance. The values of the other dimensions play only a minor part since they are in most cases of interest constant.

We used the following implementation of the scoring function, where t^* is the aspired delivery time (known to the paver agent [the auctioneer]) and o^{ti} is the offered delivery time by the dumper agent:

$$S(o) = -|t^* - o^{ti}|.$$

Hence, just-in-time deliveries are focused, because the score is highest for the offer with the smallest difference between the aspired delivery time and the offered delivery time. In prior research we designed and evaluated more sophisticated scoring functions with respect to the other dimension (Hubl et al. 2015). The dumper agents calculate with algorithm 6 the expected delivery time which they offer. There, the blocked time slots are determined by the point in time, when the dumper agent arrives at the mixing plant *(slot.start)* and the point in time, when the dumper agent leaves the paver *(slot.end)*. The agent takes into consideration that it must get back to the plant from the previous order as well as that it must get back to the plant for a following order. For this reason the estimated trip time to get from the paver to the plant is added twice to the expected duration of being bound by the delivery order (cf. the line tagged with “(*)”).

Algorithm 6 Calculation of the expected delivery time (by the delivery agents)

t^* is the aspired delivery time (for the paver agent).
slot is a time slot, described by a *start* time and an *end* time.
backlog is a sorted list of blocked time *slots*.
block time is the expected duration the agent has to block for the vacant order.
t(A, B) is the estimated trip time to get from *A* to *B*.
PLANT is the position of the mixing plant.
PAVER is the position of the paver.
for all *blocked slots* in the *backlog* **do**
    $succ.slot :=$ blocked time $slot$ that succeeds the currently focused $slot$
(*) **if** $(succ.slot.start - slot.end) \geq (2 \cdot t(PAVER, PLANT) + block\ time)$ **then**
        $free\ slot.start := slot.end + t(PAVER, PLANT)$
        $free\ slot.end := succ.slot.start - t(PAVER, PLANT)$
        add the *free slot* to the *list of free slots*
    end if
end for
$min.deviation := \infty$
for all *free slots* in the *list of free slots* **do**
    if $free\ slot.start + block\ time \leq t^* \leq free\ slot.end$ **then**
    $min.deviation := 0$
    else if $min\ \{|t^* - free\ slot.start|, |t^* - free\ slot.end|\} < |min.deviation|$ **then**
        $min.deviation := \min\ \{t^* - free\ slot.start, t^* - free\ slot.end\}$
    end if
end for
$offered\ time := t^* + min.deviation$

4 Evaluation

4.1 Simulation Framework, Scenario and Simulation Plan

To show the feasibility of our artifact, we conducted a simulation study based on a scenario worked out by a team of domain experts out of the road construction industry – the parameterization of the simulation (e.g. machine characteristics, times of circulation, loading/unloading times) is based on realistic figures gathered from professional site planning tools and validated by experts. Our simulation framework includes the same data sources (e.g. machine sensors, GPS positions of trucks) that are available in real world, controls all actions (e.g. speed of the paver, loading of a truck at the batch plant) and incorporates traffic jams as a stochastic process affecting the performance of the logistics chain. Thus, it provides a realistic environment for evaluating our artifact, whether it is able to control the whole construction site logistics in accordance to stochastic disturbances (traffic). We measure and analyze the paver speeds calculated by our artifact and the actual arrival times of the trucks. *We suppose our artifact to be feasible if there is a low number of breaks for the paver* (evaluation of decision component) *and if there is a constant flow of material* (evaluation of the allocation algorithm). The first is measured by counting the number of cases, in which our algorithm calculates a paver speed of zero meters per minute. The latter one is measured by analyzing the time differences between two arrivals of trucks at the paver. There are two different scenarios: low traffic and high traffic. Low (high) traffic means that there is a low (high) possibility, that there are delays at all and if there is a delay, that the delay is short (long). A scenario with no traffic matches exactly the pre-planned paver speeds and arrival intervals and was used for calibrating the simulation model. Table 1 summarizes the assumptions of our simulation.

Assumptions	
Plant	One plant without any supply shortfalls; rules of operation: first-come-first-serve; loading times: 2 min. per truck.
Paver	One paver with a planned speed of 1.5 m/min. if trucks arrive as planned.
Trucks	Four trucks with a loading capacity of 2 tons
Cycling times	Loading: 2 min. + driving to paver: 5.3 min. + unloading: 5.6 min. + driving to plant: 5.3 min. = cycling time: 18.2 min.
Traffic	Stochastic process affecting the speed of the trucks in an interval of [0; max. speed]; scenario 1 “low traffic”: it is more possible, that trucks can drive at (nearly) max. speed; scenario 2 “high traffic”: it is getting more likely that truck speed is reduced.

Table 1 Assumptions of the simulation

4.2 Data Analysis

We simulated a road construction site with a working shift of eight hours. Each scenario was run 15 times to smoothen stochastically peak values. Table 2 shows the descriptive statistics of the paver speed for each of the scenarios (1: low traffic, 2: high traffic). The last column shows the mean number of zero speeds per hour calculated in all of the 15 runs.

Scenario	Mean m/min.	Variance (m/min.)²	Standard deviation m/min.	Coeff. of var.	Average number of zero speed per hour
1	1.1009	0.0726	0.2694	0.0659	0.0333
2	1.0545	0.1163	0.3411	0.1103	0.4000

Table 2 Descriptive statistics for paver speed

The team of domain experts (two civil engineers from a leading German construction company and one civil engineer from a leading German construction project management office, all with a practical experience of more than 10 years) states, that paver breaks caused by logistics usually occur about five times per hour according to their experiences. Thus, the simulation shows that, on average, our artifact leads to less paver breaks (less than one per hour) than it is usual on today’s construction sites. The average duration, the paver was set to a speed of zero, is 1.31 minutes (low traffic) and 2.24 minutes (high traffic). The paver speed that was pre-planned by experts for the simulated construction site (assumption: no traffic, homogeneous arrival intervals, and therefore no paver breaks) is 1.5 meters per minute. Thus, simulation shows that our artifact regulates the paver speed in accordance to the expected arrival times of the truck. Since traffic was included in the simulation, the mean speed of the paver is below the pre-planned paver speed in both scenarios. For a high quality of the road and due to the physics of a paver it is crucial to have steady speeds and less speed changes. We care for this by observing the variance of the speed. This variance is kept in acceptable boundaries. The coefficients of variance show that adding more stochastics (traffic) results in a higher dispersion of paver speeds.

Table 3 shows the statistics for truck arrivals in order to evaluate the allocation algorithm. Figures are based on the time differences between two truck arrivals (interval). For instance, the mean time between two truck arrivals is 6.0354 minutes in scenario 1. The arrival intervals calculated by the team of domain experts is 6.00 minutes in a world without traffic. The mean arrival intervals are show, that adding traffic does not have a crucial effect on the average arrival intervals. But the dispersion measurements show that the intervals vary more, the more traffic occurs.

Scenario	Mean minutes	Variance minutes²	Standard deviation minutes	Coeff. of var.
1	6.0354	3.8430	1.9604	0.6367
2	6.3012	6.8938	2.6256	1.0940

Table 3 Descriptive statistics for truck arrivals

Simulation shows that our allocation algorithm reacts to stochastic disturbances (traffic) and leads to mean arrival intervals very close to the calculated ones. Variances in intervals are absorbed by changing the speed of the paver. Of course, higher traffic leads to higher variances of the intervals.

The data at hand provide evidence that the interplay of our two components for on-site logistics management – allocation algorithm for long-sighted logistics control and paver speed decision component for short-sighted logistics control – leads to (a.) less and shorter paver breaks and (b.) to arrival intervals that are similar to the pre-planned optimum.

5 Discussion

Our research makes two specific contributions. At first, we report about a general framework for MAS-based control of logistics in cyber physical systems in which real-time data about physical conditions were automatically retrieved and processed in order to make use of them for short-sighted and long-sighted logistics control. We provide insights into the instantiation of our artifact within the road pavement industry by simulating a pavement projects close to reality. Rigor in simulation was ensured by incorporating a team of domain experts.

Our results reveal that our artifact is a feasible mean for an automatic control of site logistics to handle stochastic external disturbances. Our findings may serve as a guide for practitioners in order to build up an agent-based system for on-site logistics management. Key finding is, that the combination of our components “paver speed management”, “allocation”, and “order management” can act as a purposeful approach to overcome today’s shortcomings in logistics management.

6 Conclusion and Outlook

This paper investigates an agent-based system for on-site logistics management with just in time deliveries. In our design science work, we specifically focused on deriving our artifact from the knowledge base of decision as well as auction theory. As a result, we got a better understanding about the purposefulness of our artifact in the road pavement industry which serves as our domain of application. We suggest that a combination of long-sighted logistics control (“allocation” and “order management”) and short-sighted logistics control (“speed management”) lead to less paver breaks that it is usual on nowadays construction sites. Although our work already provides evidences for the usefulness of MAS in construction, there are many opportunities to extend our research. Future work will also focus on evaluating our artifact in real construction site projects.

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Referenzarchitektur für Cyber-physische Systeme zur Unterstützung der Instandhaltung

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Abstract

Der Einsatz von Cyber-physische Systemen (CPS) in der Instandhaltung von komplexen Produktionsanlagen kann helfen fehler- oder wartungsbedingte Stillstandszeiten zu verkürzen. Fehler können durch CPS frühzeitig erkannt und Wartungszyklen dezentral anhand der Abnutzung der jeweiligen Anlage bestimmt werden, wodurch zentrale Systeme entlastet werden. In der aktuellen Praxis wird die Instandhaltung jedoch nicht effizient durch IT-Systemen unterstützt. Oft muss der Instandhalter benötigte Informationen händisch aus diversen proprietären Systemen oder analogen Quellen beziehen. Eine dezentrale Lösung anhand eines CPS, welches den Instandhalter bei der Fehlerbehebung und Wartung unterstützt, würde den Prozess stark verbessern. Zur Erleichterung der Implementierung eines solchen CPS wird in diesem Beitrag eine Referenzarchitektur (RA) eines solchen Systems präsentiert. Diese skizziert die wiederverwendbaren Komponenten, die Verteilungsmechanismen zwischen beteiligten Systemen und deren Funktionsumfang. Zur Erstellung dieser RA wurden eine Literaturrecherche, Anforderungsanalyse in vier Unternehmen durchgeführt, um die Anforderungen an ein CPS in der Instandhaltung aufzunehmen.

1 Einleitung

Der technologische Fortschritt führt im produzierenden Gewerbe zu immer komplexeren Maschinen, Anlagen und Prozessen. Neue Trends, die oft unter den Begriffen der digitalen Fabrik (Hollstein et al. 2012), Cyber-physische Systeme (CPS) (Geisberger und Broy 2012) und Industrie 4.0 (Lachenmaier et al. 2015) zusammengefasst werden, verstärken die disruptiven Effekte auf das produzierende Gewerbe deutlich. Damit verbunden sind insbesondere Auswirkungen auf unterstützende Prozesse wie der Instandhaltung, welcher sich dadurch entscheidend ändert. Unter Instandhaltung wird die nach DIN als „Kombination aller technischen und administrativen Maßnahmen sowie Maßnahmen des Managements während des Lebenszyklus einer Betrachtungseinheit zur Erhaltung des funktionsfähigen Zustandes oder der Rückführung in diesen, so dass sie die geforderte Funktion erfüllen kann“ (DIN 31051, 6) verstanden. Die Instandhaltung und damit der Anspruch an die handelnden Personen, welche sie durchführen, werden aufgrund der angeführten Entwicklungen fortlaufend herausfordernder. Die Fehleranalyse und -behebung erfordern ein zunehmend tieferes Sachverständnis des Aufbaus von Maschinen und Systemen. Dies trifft insbesondere dann zu, wenn verschiedene Maschinen von unterschiedlichen Herstellern von einzelnen Instandhaltern betreut werden.

Neben den steigenden Anforderungen durch den technologischen Fortschritt ermöglicht ebenjener auch, dass die Instandhaltung durch effiziente IT-Systeme Unterstützung erhält. Der Instandhalter könnte u. a. bei der Fehlersuche durch Augmented Reality (Emmanouilidis et al. 2011) unterstützt werden, Wartungspläne könnten durch Condition-Monitoring Systeme (CMS) in Abhängigkeit von der aktuellen Abnutzung bestimmter Komponenten berechnet werden (Abdennadher et al. 2010) oder unterstützende, mobile Systeme könnten die nötigen Informationen zur Arbeitsbewältigung aggregiert darstellen (Fellmann et al. 2013).

Die Einbindung dieser Systeme in unternehmensspezifischen Produktionsprozesse und die Bündelung von Informationen aus mehreren Quellen und Systemen ist jedoch oft unzureichend (Bienzeisler et al. 2014). Dies führt dazu, dass die Instandhaltung nicht optimal durch IT-Systeme unterstützt wird. Im Rahmen einer Analyse der Instandhaltung bei vier Unternehmen bestätigte sich dort dieser Sachverhalt: in den untersuchten Unternehmen müssen bspw. Daten aus einer Vielzahl an Systemen oder analogen Quellen manuell gesucht und extrahiert werden, was zu hohen Wartezeiten, erhöhter Fehleranfälligkeit und in letzter Konsequenz längeren Stillstandszeiten führt. Die Gründe hierfür sind vielfältig: die Entwicklungskosten für zentrale Systeme zur Unterstützung der Instandhaltung sind zu hoch, da die Integration von Daten aus heterogenen, oft proprietären Systemen mit hohen manuellen Aufwand verbunden ist. CMS sind bspw. oft nur bei einigen Maschinenherstellern in teils einfacher Art und Weise vorhanden und hauptsächlich für die eigenen Maschinen verfügbar. Diese entwickeln die CMS mit jeweils unterschiedlichen Datenprotokollen, Übertragungsmechanismen und zusätzlich meist noch unterschiedlichen informationstechnischen Konzepten (Winter und Wollschlaeger 2015). Daneben ist mangelndes Know-How bei Beurteilung der technologischen Potentiale ein weiteres Hemmnis die verfügbaren Technologien effizient einzusetzen (Bienzeisler et al. 2014).

Ein System, welches konsequent auf die Möglichkeiten von CPS zugeschnitten ist, könnte hier ein wichtiger Schritt zur Lösung dieser Herausforderungen und in die Richtung hin zur Digitalen Fabrik darstellen. CPS umfassen in diesem Beitrag „eingebettete Systeme, Logistik-, Koordinations- und Managementprozesse sowie Internetdienste, die mittels Sensoren unmittelbar physikalische Daten erfassen und mittels Aktoren auf physikalische Vorgänge einwirken, mittels digitaler Netze untereinander verbunden sind, weltweit verfügbare Daten und Dienste nutzen und über multimodale Mensch-Maschine- Schnittstellen verfügen“ (Geisberger und Broy 2012, 244). Insbesondere wird der Teil des CPS untersucht, welcher einer einzelnen Produktionsanlage zuzurechnen ist. Durch Ausnutzung der Möglichkeiten eines CPS können dezentral bestimmte Funktionen bereitgestellt werden, die den Instandhalter und zentrale Instandhaltungssysteme - sofern sie existieren - entlasten. In Kombination mit neuen, sich verbreitenden Standards in der Produktion, wie OPC UA (Enste und Mahnke 2011), ist es möglich, dezentral Informationen von Maschinen mit deutlich weniger Aufwand zu extrahieren. Dies ermöglicht Funktionen leichter über verschiedene Systeme zu verteilen und diese ohne größeren Aufwand in bestehende Systeme der Produktion einzubinden.

Um die zukünftige Entwicklung von solchen Systemen zu erleichtern wird in diesem Beitrag eine Referenzarchitektur (RA) für CPS zur Unterstützung der Instandhaltung präsentiert. Eine RA ist eine spezielle, abstrakte Architektur, welche die allgemeinen Richtlinien zur Spezifikation von konkreten Architekturen setzt (Angelov et al. 2009). Diese stellt in abstrakter Weise dar welche Funktionen und damit welche Intelligenzverteilung zwischen verschiedenen Systemen durch effiziente Ausnutzung der Fähigkeiten eines CPS abgebildet werden können. Demzufolge wird die

RA Domänenwissen im Bereich der Instandhaltung bereitstellen und den Entwurf einer Softwarearchitektur zur Einbettung eines CPS in ein übergeordnetes System erleichtern, welches dem Menschen zur Bewältigung der Aufgaben der Instandhaltung dienen soll.

Der Beitrag gliedert sich dabei wie folgt: in Kapitel 2 werden die Grundlagen der Instandhaltung, die beteiligten Systeme und diesbezüglich der aktuelle Stand der Forschung dargelegt. Daneben wird ein Überblick über aktuelle RAs gegeben, die im Kontext der Industrie 4.0 und der Instandhaltung von Bedeutung sind. In Kapitel 3 wird das Vorgehen zur Erstellung der RA vorgestellt, um diese anschließend anhand einzelner Sichten zu erläutern. Anhand dieser Sichten und den Erfahrungen aus dem Erstellen dieser Architektur wird eine Zusammenfassung gegeben, welche in die zukünftige Forschung mündet.

2 Verwandte Arbeiten

2.1 Instandhaltungsarten und -systeme

Es existieren nach Niu et al. (2010) verschiedene Instandhaltungsarten, welche in Abbildung 1 zu erkennen sind. Grundsätzlich kann zwischen der reaktiven und der präventiven Instandhaltung unterschieden werden, wobei die präventive sich weiter in zwei Subkategorien unterteilen lässt: eine periodisch festgelegte, vorbeugende Instandhaltung und eine zustandsabhängige (engl.: Condition Based). Die reaktive Instandhaltung bezeichnet die Fehlerbehebung nach dem Auftreten einer Störung, wohingegen die präventive vor dem Eintreten dieser Störung stattfindet um diese zu verhindern. Entweder richtet sich diese nach dem konkreten Zustand der Anlage bzw. eines Bauteils (Condition Based Maintenance) oder die Instandhaltung ist in einem Plan periodisch festgelegt.

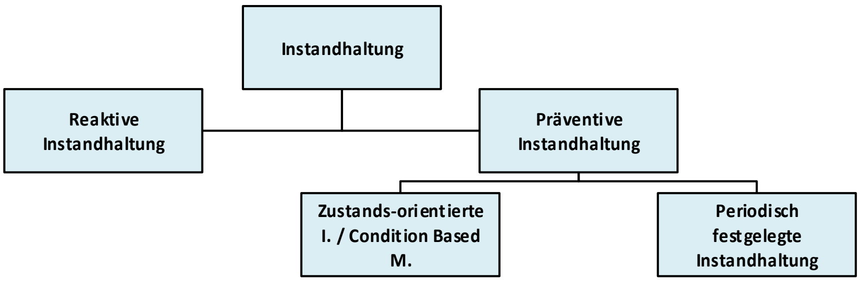

Abbildung 1: Instandhaltungsarten, in Anlehnung an (Niu et al. 2010)

Diese Instandhaltungsarten werden in der Praxis parallel eingesetzt und besitzen jeweils eigene Anforderungen an unterstützende IT-Systeme. Die reaktive Instandhaltung benötigt Systeme, die den Instandhalter bei der Fehleranalyse und -behebung unterstützen, wohingegen die präventive Instandhaltung hauptsächlich durch Systeme unterstützt wird, die einen wirtschaftlich optimalen Wartungsplan erstellen, der sich nach dem möglichst exakten Zustand der Maschinen richtet.

2.2 Beteiligte Systeme in der Instandhaltung

Der Instandhalter benötigt für seine Tätigkeit Daten aus unterschiedlichen Systemen, die sich teilweise auf verschiedenen Ebenen der Automatisierungspyramide (Bauernhansl 2014) befinden. Die folgende, auf Hänsch und Endig (2010) aufbauende Liste enthält einen Auszug der für die

Instandhaltung relevanten Systeme und zeigt auf welche Daten aus diesen für die Instandhaltung eine Rolle spielen:

- CMS - Dienen der Überwachung und der Bewertung des Zustandes von Anlagen.
- Instandhaltungsplanungs- und -steuerungsysteme (IPS) (engl. Computerized Maintenance Management System (CMMS)) - Planen, Steuern und Überwachen Instandhaltungsmaßnahmen.
- ERP - Neben der möglichen Integration von Instandhaltungsmodulen, können Ersatzteile direkt nachbestellt werden oder Abrechnungen mit Verbindung zu Instandhaltungsmaßnahmen veranlasst werden.
- Manufacturing Execution System (MES) - Maschinenbelegung und Maschinendaten werden vom MES benötigt, um den optimalen Wartungszeitpunkt zu bestimmen.
- Dokumenten- und Wissensmanagementsysteme - Dokumente bspw. Handbücher zu Anlagen werden durch das Dokumentenmanagementsystem bereitgestellt und Wissensmanagement-systeme stellen aggregiertes Wissen aus dem Unternehmen dar.
- Systeme des Engineering-Data-Management (EDM) bzw. Produktdatenmanagement (PDM) - Hierdurch werden u. a. Produktdaten zu der Maschine bereitgestellt.
- Mobile Assistenzsysteme – Mobile Assistenzsysteme unterstützen den Instandhalter bei seiner Tätigkeit, meist in Form einer App. Beispiele sind bei Fellmann et al. (2013) im Rahmen des Projektes EMOTEC entwickelt worden oder auch in einer einfachen Form von Campos et al. (2009). Diese Systeme sind hauptsächlich als Datenaggregatoren im Einsatz und konzentrieren sich auf eine einfache Darstellung und damit verbundene Bedienbarkeit.

Aus der Anzahl an Systemen ist ersichtlich, dass eine Vielzahl an Schnittstellen und Daten in unterschiedlichsten Formaten für die Instandhaltung von Nöten sind. Diese sind - wenn im Unternehmen vorhanden - oft proprietär und damit schlecht zu integrieren. Zusätzlich ist das Abrufen aufwändig und kann bei aus Berechtigungsgründen der mit erheblichen Einschränkungen verbunden sein. Daher können dezentrale, offene Lösungen, die einen Teil der benötigten Informationen bereitstellen, eine Möglichkeit sein die Integration in die Prozesse der Instandhaltung deutlich zu verbessern.

2.3 Condition Monitoring Systeme

CMS haben oft dezentrale Komponenten, welche direkt an den Anlagen installiert sind und viele Funktionen dezentral abbilden, diese bilden einen Teil eines CPS für die Instandhaltung ab. Daher sind diese Systeme von besonderer Bedeutung bei der Erstellung der RA.

Die Forschung zu CMS beschäftigt sich vor allem mit bestimmten Messverfahren zur genaueren Zustandsbestimmung von Maschinen (Nandi et al. 2005), Techniken der Fehlerdiagnose (García Márquez et al. 2012) und der Entwicklung von CMS für bestimmte Domänen, wie z. B im Smart Home Kontext (Kelly et al. 2013). Mit Architekturfragen eines solchen Systems setzen sich hingegen Bechhoefer and Morton (2012) auseinander. Sie entwickeln eine technische Architektur von CMS bezüglich der Sensorarchitektur, der verwendeten Maßnahmen und Darstellung. Eine Übersicht der vorhandenen Condition Monitoring (CM) Lösungen geben Crabtree et al. (2014) und erkennen, dass diese oft nicht effizient, aufgrund von proprietären Schnittstellen und Sicherheits-bedenken der jeweiligen CM Systementwickler, in bestehende Systemstrukturen eingebunden werden können. Wollschlaeger et al. (2015) entwerfen zur Lösung dieser Problematik eine RA für

CM, welche einzelne Blöcke an Funktionen definiert, die eine generische CM ermöglichen. Daneben stellen sie eine Struktur vor, durch die Informationen aus verschiedenen Subsystemen nachvollziehbar und aggregiert dargestellt werden können.

2.4 Referenzarchitekturen Industrie 4.0

Für die Entwicklung im Bereich von CPS und damit der Industrie 4.0 ist das Erstellen von RAs eine der großen Herausforderungen, um domänenspezifische und -übergreifende Informationsmodelle zur Anbindung von CPS zur Verfügung zu stellen (Geisberger und Broy 2012). Neben den Bestrebungen RA für CMS zu erstellen, gibt es im Kontext Industrie 4.0 Ansätze grundlegende RAs für den gesamten Bereich zu entwerfen. Zum einen wurde durch die Institutionen des VDI/VDE und ZVEI das Referenzarchitekturmodell RAMI 4.0 (Adolphs et al. 2015) und eine abstrakte Industrie 4.0 Komponente vorgestellt, wodurch die zukünftige Entwicklung von Produkten und Geschäftsmodellen erleichtert werden soll. Zum anderen hat das amerikanisch-dominierte Industrial Internet Consortium (2015) eine Industrial Internet Reference Architecture veröffentlicht, welche sich den zentralen Herausforderungen der Architektur des industriellen Internets bzw. der Industrie 4.0 widmet und sich bei der Darstellung an IT-nahen klassischen Architekturen orientiert. Daneben existieren eine Vielzahl an RAs für bestimmte, sehr spezifische Systeme. Im Kontext der Instandhaltung, der beteiligten Systeme und CPS konnte jedoch keine RA identifiziert werden, welche die Herausforderungen der Instandhaltung im Kontext der Industrie 4.0 behandelt. Daher wird mit dem folgenden beschriebenen Vorgehen zur Erstellung einer RA für ein CPS zur Unterstützung der Instandhaltung ein Beitrag zur Schließung dieser Lücke gegeben.

3 Vorgehen

Zur konkreten Erstellung von RAs existiert in den untersuchten RAs und der Literatur keine einheitliche Methodik. Meist werden bestehende Architekturen miteinander verglichen, um daraus eine abstrahierende RA zu erstellen (Grosskurth und Godfrey 2005; Cloutier et al. 2010). Daneben werden oft Informationen über eine Domäne gesammelt und eine Standardlösung durch ein Konsortium erarbeitet, die als Referenzlösung angesehen wird, wie bspw. bei der durch diverse Autohersteller entwickelten Referenzarchitektur AUTOSAR (2015). Letzteres Vorgehen betrifft besonders den Fall, dass aktuelle Lösungen als unzureichend angesehen werden, keine offenen Lösungen verfügbar sind oder es eines Standards bedarf.

Im vorliegenden Fall der RA für ein CPS im Kontext der Instandhaltung konnten keine offenen Architekturen in Literatur und Praxis identifiziert werden, die miteinander verglichen werden können. Dies liegt zum einen daran, dass bestehende Architekturen bzw. Lösungen nicht öffentlich zugänglich sind, zum anderen sind Lösungen, welche die Potentiale von CPS ausnutzen noch nicht in der Praxis angekommen sind. Aus diesem Grund wurde ein mehrstufiger Ansatz gewählt, um eine valide RA zu erstellen. Das Vorgehen orientiert sich dabei an den Grundkonzepten der gestaltungsorientierten Wirtschaftsinformatik (Hevner 2007). Es wurden die Phasen Analyse, Design und Evaluation durchlaufen.

- Literaturrecherche: Eine Literaturrecherche nach Webster und Watson (2002) zu Industrie 4.0, Instandhaltung, RAs, CPS sowie verwandten Themen wurde durchgeführt. Dadurch wurde der aktuelle Status quo zu diesen Themen in der Wissenschaft ergründet, weitere Komponenten für Instandhaltungssysteme identifiziert und möglichst verwandte RAs identifiziert. Hierunter fiel insbesondere die Erkenntnis, dass keine RAs identifiziert werden konnten, welche die

Möglichkeiten von CPS in der Unterstützung der Instandhaltung aufzeigen. Teile der Ergebnisse werden in Kapitel 2 angesprochen. Ein Fokus der Literaturrecherche bestand darin die Bereiche Maschinenbau, Informatik und Wirtschaftsinformatik thematisch zu verbinden.

- Situation und Anforderungen aus der Praxis: Vier Unternehmen aus unterschiedlichen Branchen wurden bzgl. des Themas der Instandhaltung untersucht. Die Unternehmen waren ein Fahrzeughersteller, ein Windparkbetreiber, ein Automobilzulieferer und ein Maschinenhersteller. Instandhaltung wird bei diesen Unternehmen teils als eigener Service für andere Unternehmen erbracht, teils auch von Dritten getätigt oder von eigenem Personal für eingekaufte Maschinen betrieben. Auch sind die Anforderungen an ein System zur Unterstützung der Instandhaltung in einer eigenen Fabrik andere als bei Windräder, die sich in einem spärlich besiedelten Raum mit großen Distanzen zueinander befinden. Dort stellen u. a. Konnektivität und damit die Verfügbarkeit von Informationen große Herausforderungen dar. Der Ablauf war zweigeteilt: Zuerst wurde der aktuelle Status in der Instandhaltung bei den jeweiligen Unternehmen aufgenommen. Es wurden die Prozesse aus der Instandhaltung untersucht, die beteiligten Systeme beschrieben und geklärt wie diese zur Unterstützung der Instandhaltung herangezogen wurden. Daneben wurden Anforderungen an ein Instandhaltungssystem aus Sicht der Unternehmen aufgenommen, so dass vier unabhängige Lastenhefte für ein solches System entstanden. Durch die unterschiedliche Branchenzugehörigkeit und Ausprägungen der Instandhaltung dieser Unternehmen wurde ein umfangreiches Bild der Instandhaltung und der Bedürfnisse der Unternehmen gezeichnet. Hierdurch wurde es möglich aus den einzelnen spezifischen Architekturen für ein solches System eine umfassende, generische RA zu erstellen.
- Zusätzlich wurden im Kontext der Anforderungsaufnahme und Entwicklung mehrere Feedbackgespräche mit Entwicklern und Stakeholdern bzgl. der RA geführt, um diese nach dem jeweiligen Feedback iterativ zu verbessern.

Durch das Vorgehen konnte sichergestellt werden, dass die erarbeitete Lösung hohe Praxisrelevanz besitzt, da viele Anforderungen an das System aufgenommen werden konnten, welche direkt aus dem Bedarf der befragten Industrieunternehmen stammen. Durch die Literaturrecherche konnten verwandte RAs, Trends und weitere Anforderungen in die RA miteinfließen.

4 Referenzarchitektur CPS für die Instandhaltung

Die Darstellungsarten von RAs sind in der Literatur vielfältig und hängen oft von der jeweiligen Forschungsrichtung, dem Zweck, des Anwenderkreises und der gewählten Abstraktionshöhe der Architektur ab. Der Zweck der hier vorzustellenden konzeptuellen RA ist grundlegendes Domänenwissen zur Entwicklung eines solchen Systems bereit zu stellen. Daneben soll die Kommunikation mit Stakeholdern in einem Entwicklungsprojekt erleichtert werden. Aus diesem Grund wurde eine möglichst einfache, generische Darstellung gewählt, welche auf komplexere Notationen und spezielle Modellierungstechniken verzichtet. Folglich ist kein Expertenwissen für Interpretation und Verständnis nötig und der konzeptuelle, abstrakte Charakter der RA wird betont.

Unterteilt ist die Darstellung in zwei Sichten, die sich im weitesten Sinne an die Sichten von Kruchten (1995) und der RA des Industrial Internet Consortiums (2015) orientieren. Dadurch ist es möglich das zu entwerfende System aus verschiedenen Blickwinkeln zu betrachten. Die RA soll den Rahmen für die Auswahl von Verantwortlichkeiten und deren Verteilung darstellen, daher liegt der Fokus auf den nachfolgend beschriebenen Sichten:

- Die Funktionale Sicht beschreibt die funktionalen, logischen Einheiten (Module) des Systems. Diese können als Softwaremodule im abstrakten Sinne verstanden werden und wurden anhand aufgenommener Anforderungen aus Literatur und Praxis erstellt. Die Module bilden die Basis für die weitere Entwicklung und stellen ein Grundgerüst zur Auswahl der Verantwortlichkeiten dar. Der Aufbau des Systems lässt sich modular erweitern und an den spezifischen Anwendungsfall anpassen lassen.
- Die Verteilungssicht zeigt, wie die Intelligenzverteilung der Module zwischen CPS und anderen Systemen ablaufen sollte. Die Entscheidungen, welche Module auf welchem Gerät implementiert werden hat hier Empfehlungscharakter. Abweichungen können und sollen abhängig von den individuellen Bedürfnissen bzw. verfügbaren Systemen und offenen Schnittstellen in den jeweiligen Unternehmen getätigt werden.

4.1 Funktionale Sicht

Die Funktionale Sicht ist in Abbildung 2 dargestellt. Die grauen Rechtecke stellen die aufsteigend nummerierten Module dar, welche von Funktionsblöcken umrahmt sind. Diese Funktionsblöcke stellen eine thematische Zusammenfassung der einzelnen Module dar. Weiterhin besteht innerhalb eines Blocks bzgl. der verwendeten Daten eine Kopplung zwischen den Modulen. Nachfolgend werden die einzelnen Module und deren möglichen Verbindungen beschrieben.

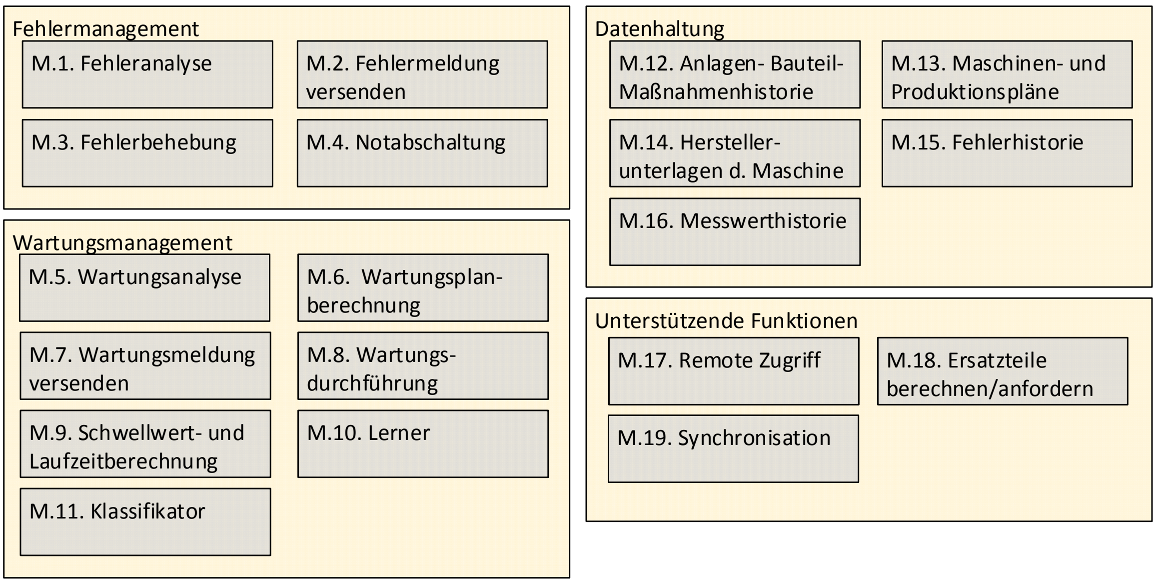

Abbildung 2: Funktionale Sicht

4.1.1 Fehlermanagement

- M.1. Die Fehleranalyse dient der Identifizierung und der Analyse von Fehlern der Anlage, welche mit dem CPS verbunden ist. Anhand von aktuellen Zustandsdaten werden Fehler lokalisiert und möglichst deren Ursachen, z. B. anhand von Fehlerbaumanalysen, ausgegeben. Die wahrscheinlichsten Fehler werden dazu berechnet und mit Kontextinformationen für die Behebung des Fehlers ausgegeben. Die Fehlermeldung durch Modul M.2. und das Stoppen der Maschine durch M.4. werden - wenn nötig - angestoßen.

- M.2. Die Fehlermeldung, welche nach Fehlererkennung versendet wird, sollte in einem offenen Format, z. B XML/JSON, an eine Liste an Empfänger versendet werden können. Die Unterstützung von gängigen Webstandards wie REST oder SOAP ist dazu nötig, um mit anderen Systemen zu kommunizieren. Zusätzlich muss die Möglichkeit gegeben sein Empfänger der Meldungen zu spezifizieren und einen Push/Pull Mechanismus zur Extraktion der Daten festzulegen.
- M.3. Das CPS sollte, wenn möglich, bestimmte Fehler voll- oder semiautomatisch beheben können. Dies kann mechanisch oder – je nach Fehler – digital geschehen.
- M.4. Das CPS sollte je nach Schwere des Fehlers die Maschine stoppen können, um einen weiteren Schaden der Maschine zu vermeiden.

4.1.2 Wartungsblock

- M.5. Unter der Wartungsanalyse subsummieren sich Mechanismen des CM, wie bspw. die Schwingungsdiagnose, die Thermografie, die Stromaufnahmemessung oder die Interpretation von sonstigen Daten aus Sensorik (Ryll und Freund 2010). Der aktuelle Zustand der einzelnen Komponenten wird hier bewertet, indem ein Soll-Ist-Vergleich zwischen ihm und den dazugehörigen Schwellwerten aus M.9. durchgeführt wird. Je nach Ausgang wird M.6. und/oder M.7. angestoßen. Vorlage für dieses Modul sollte die RA von Wollschlaeger et al. (2015) sein.
- M.6. Die Wartungsplanung muss kontinuierlich oder zu fixen Zeitpunkten/Ereignissen den Wartungsplan der Maschine neu bestimmen. Werden z. B. neue Daten in der Wartungsanalyse aufgegriffen, die sich deutlich von Altdaten unterscheiden, muss der Wartungsplan angepasst werden. Verbindungen zu F.9. bestehen in diesem Modul, da der Wartungsplan in Abhängigkeit der Schwellwerte und Prognosen der Komponenten den Wartungszeitpunkt so festlegen muss, dass dieser noch in der Restlaufzeit liegt bzw. dass keine Qualitätseinbußen zu erwarten sind oder der wirtschaftlich sinnvollste Zeitpunkt ausgewählt wird. Zusätzlich muss der Wartungsplan mit einer zentralen Instanz abgeglichen werden, so dass z. B. Personalverfügbarkeit und Wartungsaktivitäten abgeglichen werden können.
- M.7. Wartungsmeldungen sollten ähnlich wie Fehlermeldungen versendet werden, jedoch mit anderer Priorisierung.
- M.8. Das CPS sollte bestimmte Wartungsvorgänge voll- oder semiautomatisch durchführen können. Dies kann mechanisch oder digital – je nach Wartungsaktion – geschehen.
- M.9. In Kombination mit den aktuellen Zustandsdaten und der prognostizierten Abnutzung werden die Schwellwerte für einzelne Komponenten ermittelt. Diese besagen z. B. ab wann Qualitätseinbußen oder ein Ausfall zu erwarten sind, so dass die Wartung wirtschaftlich sinnvoll geplant werden kann. Diese Schwellwerte dienen zur Berechnung des Wartungsplans und der Wartungsanalyse. Die ermittelten Werte können mit ähnlichen Maschinen verglichen und mit einer zentralen Instanz synchronisiert werden, so dass die jeweiligen Ausfallverteilungen jeweils angepasst werden. Des Weiteren müssen Prognosen über die Zustandsentwicklungen berechnet werden, wodurch sich z. B. die Restlaufzeit von den Komponenten anhand der Kennzahl Remaining Useful Life (Si et al. 2011) bestimmen lässt.
- M.10. Der Lerner berechnet anhand von Daten der Anlagen Klassifikatoren zur Fehlererkennung. Anhand von historischen Fehlerdaten werden Muster in Daten der Maschine erkannt, um dadurch die Früherkennung zu verbessern. Der Unterschied zur reinen Wartungsanalyse liegt

hier darin begründet, dass jegliche Daten, die für die Anlage relevant sind mit Hilfe von Data-Mining Techniken analysiert werden.

- M.11. Der Klassifikator erkennt anhand aktueller Daten Fehler und mögliche Fehlerentstehungen. Er stellt eine spezielle vom Lerner trainierte, performante Methode zur Erkennung von Fehler- oder Wartungsmustern dar.

4.1.3 Datenhaltung

Die Module unter Datenhaltung stellen aktuelle sowie historische Daten des CPS bzw. der Anlage bereit, damit diese von anderen Modulen für Berechnungen genutzt werden können oder dem Instandhalter vor Ort oder anderen Systemen zur Synchronisation zur Verfügung stehen. Diese Module werden aufgrund ihrer selbsterklärenden Bezeichnung hier nicht explizit beschrieben.

4.1.4 Unterstützende Funktionen

- M.17. Das CPS, die Anlage und deren Daten sollen von externen Standorten sicher abruf- und steuerbar sein. Eine Freigabe sollte vor externem Zugriff an der Maschine erteilt werden können.
- M.18. Bei Auftreten eines Fehlers oder eines Wartungsvorganges werden dazu passend Ersatzteile bestimmt und ggf. nachbestellt.
- M.19. Die Synchronisation sorgt für den Datenaustausch zwischen M.10 dem Lerner und M.11 Klassifikator. Sie dient dem Informationsaustausch zwischen der Messwerthistorie der Anlagen und der Neuerstellung des Klassifikators. Daneben können Daten, wie bspw. der Wartungsplan, zwischen Backend und CPS oder bestehenden Systemen synchronisiert werden. Des Weiteren können bspw. Maschinenpläne mit dem MES synchronisiert werden. Wichtig ist die Bereitstellung einer Push/Pull Funktionalität zur optimalen Nutzung der verfügbaren Bandbreiten.

4.2 Verteilungssicht

In Abbildung 3 wird die Modulverteilung der RA per Verteilungssicht illustriert. Dargestellt sind zwei Systeme auf denen sich Module befinden

- CPS - Hiermit ist das jeweilige CPS an einer Maschine bzw. Anlage gemeint. Dies kann sich direkt innerhalb der Anlage oder auch an einem direkt der Maschine zugeordnetem maschinennahen System befinden.
- Backend - Dieses System stellt einen zentralen Server dar, auf dem die Informationen zusammenlaufen, welche zentral gespeichert werden müssen.

In der Abbildung ist zu sehen, dass sich einige Module im Zwischenbereich der Systeme befinden. Dies bedeutet, dass diese Module auf beiden Systemen verfügbar sein müssen. So ist es denkbar, dass der Wartungsplan sich auf der Maschine befindet, jedoch gleichzeitig mit einem übergeordneten Instandhaltungssystem abgeglichen werden muss. Ein besonderer Fall stellt M.10. Lerner dar, da dieses Modul nur auf dem Backend verfügbar sein sollte. Dieses sammelt die Sensor-/Fehler-/Verschleißdaten von einer beliebigen Zahl an ähnlichen Maschinen, um mit komplexen, kostenintensiven Berechnungen die Klassifikatoren an den jeweiligen Maschinen anzupassen.

Abbildung 3: Verteilungssicht

Die vorgestellte Verteilung bei dieser Sicht ist keine festgelegte Verteilung, d. h. unterschiedliche Arten der Verteilung können existieren, insbesondere, wenn bestimmte Altsysteme weiter benutzt werden sollen. Genauso ist die Lokation des CPS nicht genau bestimmt, so können bestimmte SPS oder Feldgeräte ebenso Teile des CPS darstellen.

5 Zusammenfassung und Ausblick

Durch die erläuterte RA wurden die wichtigsten Module, Funktionen und Konzepte eines CPS zur Unterstützung der Instandhaltung generisch dargestellt. Anhand des bereitgestellten Domänenwissens und Anforderungen, die sich aus dieser ableiten lassen, wird die weitere Entwicklung in diesem Bereich erleichtert. Mithilfe der RA ist es möglich eine konkrete, an die eigenen Bedürfnisse angepasste, Architektur zu entwickeln.

Ein wichtiger Punkt, der bei der RA besonders auffällig ist, ist das durch die dezentrale Einbindung die Vernetzung und insbesondere die Synchronisation von einzelnen Daten eine entscheidende Rolle bei der weiteren Entwicklung spielen wird. Effiziente Implementierungen, angepasst an verfügbare Bandbreiten und Protokolle, zur dezentralen, wie auch zentralen Synchronisation zwischen einer beliebigen Anzahl an Maschinen werden bei der Umsetzung entscheidend sein.

Zur weiteren Evaluation der vorliegenden RA sollen in Zukunft verschiedene Systeme anhand der RA gebaut werden. Darüber hinaus erscheint eine Einbettung dieser RA in eine umfassendere RA, welche den Menschen grundlegend bei typischen Instandhaltungsaufgaben unterstützt als interessant. In dieser müssten insbesondere die Verbindungen des vorliegenden Systems mit dem Menschen, die Darstellung der Informationen und den jeweiligen individuellen Prozessen untersucht werden.

Darüber hinaus erscheint ein Vergleich zwischen verschiedenen Industrie 4.0 RAs für sinnvoll, da viele uns bisher bekannten Systeme ähnliche Muster enthalten. Die Beschreibung ebenjener und die Analyse hinweg könnten einen wichtigen Beitrag zur Vereinfachung der Entwicklung in diesem Bereich darstellen und wichtiges Domänenwissen bereitstellen.

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Teilkonferenz
Digitalisierung und Privacy

Die zunehmende Digitalisierung und Vernetzung im privaten und im beruflichen Kontext ermöglicht die automatisierte Erhebung, Speicherung und Auswertung von enormen Mengen an Daten. So werden bspw. mittels Smartphones nicht nur Internet-Nutzungsdaten erfasst, sondern gleichzeitig etwa auch Standortdaten des Anwenders erhoben und mit weiteren Daten verknüpft. In gleichem Zuge steigt das Bewusstsein über die Bedeutung von Daten als ein ökonomisches Gut. Dies schafft nicht nur Vorteile, sondern geht insbesondere in Bezug auf Privacy mit großen Herausforderungen einher, die zahlreiche Forschungsfragen aufwerfen.

Ein Aspekt ist dabei die weiterhin festzustellende Diskrepanz zwischen geäußertem und tatsächlichem Verhalten der Nutzer, was auf Schwierigkeiten bei der Messbarkeit verschiedener Privacy-Skalen hindeuten kann. Sabrina Hauff, Manuel Trenz, Virpi Kristiina Tuunainen und Daniel Veit unterscheiden verschiedene Arten von Privacy Risks und beschreiben einen strukturierten Skalenentwicklungsprozess, um diese zielgerichtet erfassen zu können. Tina Morlok, Christian Matt und Thomas Hess beschäftigen sich mit den wahrgenommenen Auswirkungen der eigenen Technologienutzung auf die Privatsphäre Dritter und untersuchen, inwiefern die eigene Nutzungsintention davon beeinträchtigt wird. Christoph Buck, Daniela Kaubisch und Torsten Eymann adressieren in ihrem Beitrag die Vorbildung von Nutzern hinsichtlich potentieller Privatsphäre-Gefahren und untersuchen deren Eignung als möglichen Erklärungsansatz für den vermeintlichen Widerspruch zwischen geäußerten Privatheitsbedenken und der schier ungezügelten Nutzung von werbefinanzierten Smartphone-Apps. Thomas Wagenknecht, Timm Teubner und Christof Weinhardt analysieren, inwieweit die Offenlegung respektive die Anonymität der eigenen Identität bei der Erstellung von nutzergenerierten Inhalten und Meinungen die Rezeption durch andere Nutzer beeinflusst.

Christian Matt, Peter Buxmann, Thomas Hess

(Teilkonferenzleitung)

Wer weiß was? – Digitale Privatsphäre und App-Literacy aus Nutzerperspektive

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Abstract

Der zügellose Konsum mobiler Applikationen wird in der Literatur unter anderem mit theoretischen Konstrukten wie dem Privatsphäre-Paradox erklärt. Da diese theoretische Grundlage die Perspektive der Nutzer und deren spezifische Vorbildung vollkommen außer Acht lässt, adressiert der Artikel die App-Literacy der Nutzer um zu ergründen, ob sich Nutzer im Umgang mit Privatsphäre paradox verhalten. Anhand einer qualitativen empirischen Studie wird die spezifische Bildung der Nutzer bestimmt und anhand einer Inhaltsanalyse gezeigt, dass die Nutzer die durch mobile Applikationen drohenden Privatsphäre-Gefahren aufgrund ihrer zu niedrigen App-Literacy nicht einschätzen können und sich somit nicht paradox verhalten. Der Artikel zeigt, dass Nutzer Angebote mobiler digitaler Ökosysteme zwar ausgiebig in Anspruch nehmen, die daraus entstehenden Gefahren jedoch nicht kennen und somit auch nicht einschätzen und bewerten können.

1 Einleitung

„Privatsphäre sollte nicht nur eine Wahl sein, die wir treffen können, und sie sollte sicherlich nicht der Preis sein, den wir bezahlen müssen, nur um im Internet surfen zu dürfen.“ (Kovacs 2012)

Smartphones sind heutzutage als Alltagsbegleiter von Konsumenten kaum mehr wegzudenken und gehören zu der meist verkauften elektronischen Geräteklasse. Smartphones stellen dabei einen umfassenden Speicherort von Erinnerungen, Inhalten, Interessen und Verhalten dar und versetzen Datenaggregatoren in die Lage ein Abbild des realen Lebens des Konsumenten und des (gewünschten) Selbstbildes des Nutzers zu erstellen. Es existiert folglich ein stetig wachsendes Archiv an verifizierten und personalisierten Informationen mit höchster Datengüte, das auf ein Smartphone eindeutig zurückverfolgt werden kann (Egele et al. 2011). Anders als Computer, Laptops oder Tablets kann ein Smartphone als personalisiertes Endgerät angesehen werden, wodurch das umfassende Datenarchiv über die Geräte-Identifikator (ID) und das Nutzerprofil des Operating System (OS)-Anbieters einem Nutzer eindeutig zugeordnet werden kann. Durch die unzähligen Möglichkeiten der Sammlung, Speicherung und Verarbeitung von persönlichen Informationen ergeben sich für Nutzer massive Gefahrenpotentiale durch Verletzungen ihrer Privatsphäre (Enck 2011).

Insbesondere das Geschäftsmodell von kostenlos verfügbaren mobilen Applikationen (Apps) basiert auf der Sammlung und Auswertung von persönlichen Daten. Obwohl den meisten Nutzern das Bezahlen mit persönlichen Daten bewusst sein müsste, beziehen sie scheinbar bedenkenlos verschiedenste Apps auf ihr Smartphone. Dieses paradoxe Verhalten wird in der Literatur als Privatsphäre-Paradoxon bezeichnet (Norberg et al. 2007), (Jensen et al. 2005). Das Privatsphäre-Paradox unterstellt, dass sich Nutzer paradox in Bezug auf mobile Applikationen (Apps) verhalten: Sie lehnen Anwendungen, welche persönliche Daten (weiter-)verwenden, im Allgemeinen ab, verhalten sich aber im Speziellen entgegengesetzt (Wenninger et al. 2012).

Der vorliegende Artikel versucht die Hintergründe des vermeintlich paradoxen Verhaltens von Nutzern zu ergründen und strebt eine weiterführende Erklärung des Phänomens des ungezügelten App-Konsums an. Die hierbei zugrunde liegende Hypothese besagt, dass Nutzer, welche eine nur eingeschränkte spezifische Bildung (Literacy) hinsichtlich Privatsphäre-Gefahren (Art und Umfang der Datenaufnahme, -aggregation und -verarbeitung) besitzen, sich aufgrund der bestehenden Informationsasymmetrie nicht paradox verhalten. Dementsprechend verfolgt der Artikel die Beantwortung der beiden folgenden Forschungsfragen:

- Verfügen private Nutzer über App-Literacy und reicht diese aus um Privatsphäre-Gefahren im mobilen Ökosystem zu erkennen und einschätzen bzw. bewerten zu können?

Im nachfolgenden Kapitel wird die relevante Literatur zu digitaler Privatsphäre und Privacy-Literacy diskutiert, die Besonderheiten digitaler mobiler Ökosysteme dargestellt und Diskrepanzen zwischen Privatsphäre-Bedenken und Handeln erläutert. In Kapitel 3 wird die qualitative empirische Studie zur Untersuchung der Privacy-Literacy vorgestellt. Der Artikel schließt mit einer Schlussbetrachtung, den Limitationen der Studie und möglichen zukünftigen Forschungsrichtungen.

2 Theoretische Grundlagen

2.1 Relevante Literatur zur Privatsphäre und App-Literacy

Das Konstrukt Privatsphäre ist in mehrdimensionaler Weise komplex und kann aus unterschiedlichen Blickwinkeln betrachtet werden (Hotter 2011).[1] Eine der wohl bekanntesten Definitionen stammt von Warren und Brandeis und definiert Privatsphäre als "the right to be let alone" (Warren und Brandeis 1890). Diese Worterklärung ist jedoch sehr allgemein und unvollständig, da sie in Bezug auf persönliche Daten und deren Preisgabe den überaus wichtigen Bestandteil der Kontrolle außer Acht lässt (Bok 1983). Rössler (2001) bedenkt zudem, dass nicht immer das kontrolliert werden kann, was kontrolliert werden sollte, wie z.B. die Weitergabe von Daten an Dritte. Im Folgenden wird der Begriff nach Hotter (2011, 83) verstanden als ein

„Schutzmechanismus, der dem Individuum durch die Möglichkeit des selektiven Verbergens und Veröffentlichens der eigenen Person individuelle Freiheit garantieren soll“.[2]

[1] So gibt es beispielsweise soziologische, philosophische, psychologische, rechtliche, anthropologische, feministische und politische Ansätze. Zusätzlich hat sich der Begriff bzw. die Annahme darüber, was privat ist, im Zeitverlauf gewandelt [He11].

[2] Welche Bedeutung Privatsphäre für ein Individuum hat, wird oftmals unterschätzt. Rössler (2001) stellt dazu die These auf, dass eine autonome Lebensführung nur möglich unter Bedingungen geschützter Privatsphäre ist. Eingriffe in die Privatsphäre sind deshalb auch immer Verletzungen der Bedingungen von Autonomie. In liberalen Gesellschaften gilt es jedoch zu beachten, dass die Privatsphäre nur ein relativer Wert sein kann, da diese durch die Freiheiten anderer Mitbürger, wie z.B. der Pressefreiheit oder der freien Meinungsäußerung, begrenzt ist und die Intensität der Privatsphäre auch von den eigenen Eigentumsverhältnissen abhängt.

Durch die neuen Medien und Informationstechnologien werden Individuen immer mehr zu gläsernen Konsumenten, wodurch der Schutz der Privatsphäre gefährdet ist.

Personenbezogene Informationen haben demnach zunehmend den Charakter einer Ressource bzw. eines Tauschobjekts. Oftmals ist der Verzicht auf die Kontrolle der persönlichen Daten Bedingung für die Nutzung von digitalen (Öko-)Systemen, wodurch die Verantwortung auf private Vertragspartner übergeht und Nutzer eine unübersichtliche Vielzahl einzelner Verträge mit Privaten Vertragspartnern einzugehen haben. Diese Entwicklung stellt nicht nur eine Gefahr der Privatsphäre dar, sondern auch eine Gefahr für ein selbstbestimmtes, autonomes Leben und individuelle Freiheit, da eine selektive Selbstveröffentlichung und Verschließung innerhalb digitaler Freiheitsspielräume nur bedingt kontrollierbar ist (Hotter 2011).

Ob und inwiefern sich Nutzer über derartige Gefahren und Gefahrenpotentiale bewusst sind, bzw. bewusst sein können ist die Messung deren App-Literacy (Buck et al. 2014). In Analogie zum Begriff Digital Literacy, der nach Park (2014) die Vertrautheit mit den technischen Aspekten des Internets, die Kenntnis über institutionelle Gewohnheiten und gängige Privatsphäre-Praktiken umfasst, wird der Begriff App-Literacy hier im Kontext mobiler Applikationen eingesetzt. In der Literatur bestehen weitere Begriffe wie Privacy Awareness, Computer Literacy oder Privacy Literacy, die jedoch nicht mit dem hier beschriebenen Begriff App Literacy synonym verwendet werden können. Besonders der Begriff Privacy Literacy mag sehr zutreffend klingen, wird jedoch bereits schon von Vegheş et al. (2012) als die Einstellung der Nutzer bezüglich der Sammlung, Nutzung und Verarbeitung ihrer persönlichen Daten beschrieben. Vegheş et al. (2012) lassen somit das technische Know-how der Nutzer außer Acht. Der Begriff App Literacy hingegen beschreibt den Kenntnisstand und die Vertrautheit von Nutzern über die technische Funktionsweise von mobilen Applikationen und die Bildung der Nutzer im Hinblick auf Privatsphäre-Gefahren, was ebenfalls ein Verständnis über die Funktionsweise des App-Marktes einschließt. Ein Nutzer mit geringer App Literacy kann beispielsweise potentielle Privatsphäre-Gefahren nicht adäquat erkennen, da ihm dazu die zugrundeliegenden spezifischen Kenntnisse fehlen. Ein Nutzer mit hohem App Literacy versteht dagegen die zugrundeliegende Funktionsweise und Praxis mobiler Applikationen und kann Gefahren besser erkennen und dementsprechend zielgerichteter handeln.

Innerhalb der Forschungsdomäne des Information Systems Management (IS) können nur wenige Arbeiten identifiziert werden, die Literacy direkt oder indirekt untersuchen. Liao et al. (2011), Furnell und Moore (2014), Kraus et al. (2014) und Malhotra et al. (2004) ziehen die Literacy der Nutzer als erklärende Variable hinzu, allerdings steht Literacy nicht im Zentrum der Untersuchungen. Eine Vielzahl anderer Studien untersuchen zudem die Literacy der Nutzer bezüglich des Mediums Internet (Hargittai 2005), (Yamakami 2012). Eine Übertragbarkeit auf den mobilen Kontext ist aufgrund der Besonderheit des mobilen Ökosystems nur sehr begrenzt möglich. Einzig die Studie von Kraus et al. (2014) untersucht die App-Literacy im mobilen Kontext. Kraus et al. (2014) untersuchen dabei Privatsphäre und Sicherheitskenntnisse (P&S-Kenntnisse) und Privatsphäre-Bedenken als Prädiktor für Nutzung bzw. Nichtnutzung von Schutzmechanismen.

2.2 IT-Sicherheit in mobilen digitalen Ökosystemen

Das mobile Ökosystem weist im Vergleich zur webbasierten Systemarchitektur zwei hauptsächliche Besonderheiten auf, die zum einen den Aspekt der Datensammlung und zum anderen die technischen Beschränkungen des mobilen Ökosystems umfassen. Diese Besonderheiten werden im Folgenden eingehender betrachtet, bevor ein Einblick in die Sicherheitsthematik beim Design der mobilen Applikationen gegeben wird.

Die erste Besonderheit besteht darin, dass bei der Nutzung von Apps validierte und hochgradig personalisierte Datensätze über den Nutzer gewonnen werden können (Buck et al. 2014). Durch die Kumulation der gesammelten spezifischen Informationen einzelner Apps kann eine bisher nicht erreichbare Datenaggregation stattfinden. Anders als bei web-based Services, wie beispielsweise Facebook oder Twitter, sind bei der Autorisierung von Apps über das Betriebssystem zusätzliche, für Manipulationen nicht anfällige, validierte Daten, wie MAC-Adresse, Geräte-ID, Telefonnummer und hinterlegte Kontoinformationen für In-App Bezahlmethoden verfügbar (Buck et al. 2014).

Die zweite Besonderheit besteht beim Smartphone im Vergleich zum PC darin, dass Smartphones viel geringere Rechenleistungen aufweisen und deshalb auch nur abgespeckte Sicherheitssysteme integrieren. So haben Smartphones keine ausgetüftelte Firewall, keine intelligenten Detektions- und Abwehrmechanismen bei Systemangriffen und auch kaum eine effektive physische Zugangskontrolle (Posegga und Schreckling 2011). Zudem kommt, dass bei mobilen Netzwerken im Vergleich zum wired Netzwerk die offene Übertragung drahtloser Signale, die hohe Fehlerrate bei der drahtlosen Übertragung sowie das Sicherheitsmanagement für das Smartphone und die Sicherheitsbedenken beim Aufzeichnen der Aufenthaltsorte problematischer sind. Durch die Möglichkeiten der umfassenden Datenaggregation ist die Anforderung an eine sichere Systemarchitektur im mobilen Umfeld höher, jedoch sind gleichzeitig mehrere technische Restriktionen zu beachten, die einen Aufbau eines sicheren Systems sehr schwierig gestalten. Es sind beispielweise komplexe Codes als Verschlüsselungsverfahren oder manche Sicherheits-Netzwerkprotokolle, wie beispielsweise Webservices, im mobilen Umfeld nicht oder nur schwer einsetzbar, da eine hohe Rechenleistung oder eine stabile Internetverbindung benötigt werden, die in mobilen Systemen nicht immer gegeben ist (Theng und Li 2006).

2.3 Diskrepanz zwischen Privatsphäre-Bedenken und Handeln

Aufgrund der zahlreichen Privatsphäre-Gefahren auf den verschiedenen Infrastrukturebenen, den zahlreichen Akteuren im Datensammlungs- und Verarbeitungsprozess, der Besonderheit der App-Systemarchitektur und den komplizierten und oftmals unzureichenden Datenschutzbestimmungen, sollte ein rationaler Nutzer erhebliche Privatsphäre-Bedenken beim App-Download aufweisen.

Privatsphäre-Bedenken sollen hier nach der Definition von Dinev und Hart (2006) und Xu et al. (2012) als Bedenken um den möglichen zukünftigen Verlust der Privatsphäre als Folge von freiwilliger oder unfreiwilliger Preisgabe von sensiblen Daten bezeichnet werden. Privatsphäre-Bedenken resultieren dabei aus der digitalen Kommunikation und Transaktion mit teilweise anonymen Akteuren, der Intransparenz des zugrunde liegenden App-Marktes und aus der Nutzung und Interaktion mit Apps, was von den Nutzern einen gewissen Kenntnisstand zur Bedienung und Nutzung von Apps abverlangt (Liao et al. 2011).

Es bleibt unklar, ob Nutzer überhaupt in der Lage sind, sicherheitsrelevante Entscheidungen vernünftig treffen zu können und adäquate Sicherheitskontrollen durchzuführen (Mylonas et al. 2013). So sind Nutzer meist recht gut darin, einzelne Risiken aufzuzählen, weil sie etwa in den Medien thematisiert werden (Friestad und Wright 1994), (Campbell und Kirmani 2000). Jedoch fehlt es ihnen an Grundverständnis, um zu erklären, warum und in welchem Kontext bestimmte Risiken ernst genommen werden sollten (Vedder 2011). Dies stellt Nutzer beim App-Downloadprozess und -Nutzungsprozess auf die Probe, da eine gewisse App-Literacy verlangt wird, um beurteilen zu können, welche App-Berechtigungen Privatsphäre-Risiken bergen. Meist werden die Berechtigungen bestätigt, da oftmals weitere Details der Berechtigungen das Know-how des Nutzers übersteigen (Posegga und Schreckling 2011). Aufgrund dieses Wissens- und Informationsdefizits des Nutzers ist der App-Markt durch das Vorliegen asymmetrischer Informationen gekennzeichnet, welche von den App-Nutzern nur durch erhebliche Transaktionskosten, wie beispielsweise durch das Aneignen eines technischen Verständnisses, überwunden werden können. Eine geringe App-Literacy kann Privatsphäre-Bedenken und den Handlungsspielraum der Nutzer beeinflussen, da zur Entscheidungsfindung beim App-Kauf essentielle Informationen vorliegen, aber nicht verstanden werden.

Sollten die Nutzer tatsächlich eine sehr geringe App-Literacy aufweisen, dann beruhen die Risikoabwägungen, wie sie beispielsweise beim Privacy-Calculus-Erklärungsansatz von Dinev und Hart (2006) getätigt werden, auf falschen Annahmen und verzerren die Risiko-Nutzenabwägung im erheblichen Maße. Gleichzeitig ruhen Privatsphäre-Bedenken auf Risiko-Wahrnehmungen und der Faktor Vertrauen könnte je nach App-Literacy variieren. Die Vermutung liegt also nahe, dass eine Korrelation zwischen App-Literacy und den anderen Erklärungsvariablen vorliegt. Eine genaue Untersuchung zur App-Literacy von Nutzern ist daher essentiell, um in der Lage zu sein, ein theoriegestütztes Model zur Erklärung des Privatsphäre-Paradoxes aufstellen zu können.

3 Qualitative Studie zur App-Literacy

3.1 Methodik der qualitativen Studie

Für die vorliegende Studie wurde ein teilstandardisiertes Leitfadeninterview angewendet, da diese Methode zwei positive Ansätze miteinander verbindet. Zum einem helfen offene Fragen beim Eingrenzen des interessierenden Problembereichs und sorgen für einen erzählenden Stimuli (Lamnek 2010), bei denen die Befragten die Möglichkeit haben, den Detaillierungsgrad selbst zu bestimmen. Zum anderen wird dem Interviewer durch die vorgegebenen Themen ein Rahmen geboten, in dem er sich bewegen kann. Das Vorwissen des Forschers dient dabei zur Strukturierung des Interviewleitfadens.

Die Auswertung des Datenmaterials wurde mit Hilfe der qualitativen Inhaltsanalyse vorgenommen (Mayring 2008). Beim diesem Analyseverfahren werden die erhobenen Daten ausgewertet, indem inhaltlich unveränderte Aussagen zu Kategorien zusammengefasst werden und das Datenmaterial auf diesem Wege reduziert wird (Mayring 2008).[3]

Im Rahmen der Auswertung der vorliegenden Studie fand eine Orientierung an der inhaltlich strukturierten qualitativen Inhaltsanalyse nach Kuckartz (2014) statt, da sie ein exploratives Vorgehen ermöglicht und nicht verfrüht zu Bewertungen drängt, wie dies etwa bei evaluativen oder typisierenden Inhaltsanalysen der Fall ist. Die Kategorien werden hierbei in einem mehrstufigen Verfahren gebildet. In der ersten Stufe wird eine Kategorisierung entlang der Hauptkategorien des Leitfadens vorgenommen, anschließend werden weitere Kategorien am Material weiterentwickelt und ausdifferenziert. Die kategorienbasierte Auswertung und Darstellung gewinnt somit an Differenziertheit, Erklärungskraft und Komplexität.

[3] Die Spezifika dieses Verfahren sind durch ein systematisches Verfahren nach expliziten Regeln gegeben, sodass eine intersubjektive Nachprüfbarkeit gewährleistet werden kann. Aus dem theoriegeleiteten Annahmen und dem empirischen Material werden schließlich Kategorien gebildet (Mayring 2008).

3.2 Datenerhebung und Aufbereitung

Relevant für die Studie sind Personen, die Smartphones und Applikationen nutzen, weshalb die Nichtnutzung einer der beiden Services Ausschlusskriterien darstellen. Eine bestimmte Altersgrenze wurde nicht gesetzt, da jeder Smartphone-User mit der Privatsphäre-Problematik gleichermaßen konfrontiert ist. Um eine gezielte Manipulation zu vermeiden, wurden nicht nur Personen zum Interview gebeten, von welchen bekannt ist, dass sie im Umgang mit Applikationen ein bestimmtes Bildungsniveau aufweisen. Die Auswahl der Befragten wurde entsprechend nach leicht erreichbaren, motivierten und verfügbaren Personen getroffen, weshalb die Befragten aus dem sozialen Umfeld der Autoren stammen. Die Autoren haben dabei versucht, die Auswahl nach sozialen und demografischen Faktoren zu glätten.

Insgesamt wurden 23 Personen befragt, welche die definierten Auswahlkriterien erfüllten und zudem ihr Einverständnis zur Aufzeichnung und Auswertung der im Rahmen des Interviews erhobenen Daten in anonymisierter Form erklärten. Unter ihnen sind 13 Teilnehmer weiblich, 10 von ihnen sind männlich. Die Altersgruppe reicht von 13 bis 60 Jahren, wobei das Durchschnittsalter rund 31,52 Jahre und der Median 26 Jahre beträgt. 65% der Befragten haben einen Hochschulabschluss, 17% ein Abitur, 13% einen Realschulabschluss und 4% keinen Schulabschluss. Die größte Gruppe unter den Befragten stellen die Berufstätigen mit ca. 52,2% dar, gefolgt von Studierenden (30,4%), Personen in Ausbildung (8,7%), Schülern und Arbeitslosen (jeweils 4,3%).

Die darauf folgende Inhaltsanalyse wurde mit Hilfe der Computersoftware MAXQDA11 durchgeführt. Die Durchführung der Datenauswertung erfolgte nach der inhaltlich strukturierenden qualitativen Inhaltsanalyse nach Kuckartz (2014).

3.3 Ergebnisse

Auf Basis der systematischen Kodierung des Datenmaterials wurde die in Tabelle 1 bereit gestellte Themenmatrix erarbeitet, die es erlaubt kategorienbasierte und fallbezogene Aussagen zu machen[4].

Bei den beiden Hauptkategorien zu den Kenntnissen über das App-Geschäftsmodell und über die technische Funktionsweise von Apps wurde nach diesem Schema vorgegangen. Bei der Hauptkategorie zur Datensammlung wurde zusätzlich zu den Subkategorien eine Zusammenfassung auf allgemeiner Ebene vorgenommen, da nur diese Ebene aufzeigen konnte, wie viele der Interviewer durch Nachfragen an zusätzlichen Antworten erhalten konnte. Da diese Nachfragen vielen Befragten weitere Anhaltspunkte gaben, konnten von ihnen deutlich mehr Informationen erfragt werden.[5] Erst durch Nachfragen konnten zusätzliche Angaben gesammelt werden. Dadurch ist eine Zusammenfassung auch auf allgemeiner Ebene der Hauptkategorie in diesem Falle sinnvoll, da nur dadurch ein reelles und umfassendes Abbild über die Kenntnisse zur Datensammlung aufgezeigt werden kann.

[4] Jede Textpassage der Matrix kann dabei auf das Originalmaterial der mittels MAXQDA codierten Textpassage zurückverfolgt werden.
[5] Bspw. bei Probanden, welche über Art und Umfang der potentiellen Datensammlung keinerlei Kenntnis besaßen.

Themenmatrix					
	Hauptkategorie 1		Hauptkategorie 2		
	Subkategorie	Subkategorie	Subkategorie	Subkategorie	→Fallzusammenfassung
Interview 1	Textstellen	Textstellen	Textstellen	Textstellen	→Fallzusammenfassung
Interview 2	Textstellen	Textstellen	Textstellen	Textstellen	→Fallzusammenfassung
Interview 3	Textstellen	Textstellen	Textstellen	Textstellen	
	Kategorienbasierte Auswertung ↓	↓	↓	↓	
	Thema 1.1	Thema 1.2	Thema 2.1	Thema 2.2	

Tabelle 1: Themenmatrix, in Anlehnung an Kuckartz (2014)

Das Wissen der Nutzer über die Datensammlung von ortsbasierten Angaben ist sehr hoch. Ganze 20 von 23 Befragten sind sich darüber bewusst, dass Apps ihre Standorte, bis hin zu Aufenthaltsmustern, aufzeichnen können. Des Weiteren sind sich viele Nutzer auch bewusst, welche ihrer gängigen Apps ihre Standorte aufzeichnen.

Die Kenntnisse der Nutzer über die Aufzeichnung personenbezogener Daten können als mittelmäßig eingestuft werden. Fast die Hälfe der Befragten wissen, dass Angaben zur Person, wie beispielsweise dem Alter, Wohnort und Geschlecht, von Apps erhoben werden können. Knapp die Hälfte der Befragten ist sich zudem darüber bewusst, dass auch E-Mail-Adressen von Apps gesammelt werden können. 10 von 23 Befragten überblicken, dass auch ihre Fotos gesammelt werden können. Nur 2 von 23 Befragten sind sich darüber bewusst, dass ebenso ihre Passwörter von Apps gesammelt werden können.

Das Wissen über indirekt ermittelbare Daten ist sehr gering. Nur wenige Nutzer sind sich darüber bewusst, dass Apps Daten über Interessen, Konsummuster, Suchanfragen, Haushaltseinkommen oder das Alltagsverhalten sammeln. 21,7% der Befragten wissen, dass Daten über ihr Shopping-Verhalten oder ihre Shopping-Interessen aufgezeichnet werden. Die meisten Nutzer geben in diesem Zusammenhang an, dass sie dieses anhand der ihnen zugestellten und zugeschnittenen Werbung erkennen. Rund 17,4% der Befragten ist bewusst, dass ihre allgemeinen Suchanfragen über das mobile Internet aufgezeichnet werden. Nur 2 von 23 Befragten wissen, dass auch ihr Haushaltseinkommen, ihr komplettes Konsummuster, ihre Daten über ihr soziales Umfeld und ihre Beziehungen zu Kontakten aus der Kontaktliste aufgezeichnet werden können. Des Weiteren sind sich ebenfalls nur 2 von 23 Befragten darüber im Klaren, dass die Nutzungsaktivität, welche Auskunft über den Alltagsrhythmus geben kann, ebenfalls von Apps gesammelt werden kann.

Die Kenntnisse über das App-Geschäftsmodell sind gering, da die gesetzlichen Regelungen meist unbekannt sind. Nur wenige Probanden wissen über den vollen Umfang des App-Geschäftsmodells Bescheid. Sie gehen davon aus, dass Daten (Suchverläufe) gesammelt werden, um personalisierte Werbung zuzusenden oder anzuzeigen. Dass jedoch Apps aus dem Nutzerverhalten der Anwender weitaus detailliertere Erkenntnisse über diese ziehen können, ist den meisten Befragten nicht bewusst.

Das Wissen über gesetzliche Datenschutzbestimmungen ist sehr unterschiedlich ausgeprägt. 6 von 23 Befragten scheinen komplett ahnungslos zu sein. Sie hoffen, dass ihre Daten sicher aufbewahrt werden und eine Weitergabe an Dritte nicht möglich ist. Mehr als ein Drittel der Befragten (8 von 23) wusste oder vermutete, dass mit dem Download die Nutzungsberechtigungen akzeptiert werden, in welchen stehen könnte, dass die Daten weitergegeben werden können. Mehr als ein Viertel der Befragten (6 von 23) ist jedoch der Meinung, dass in den Nutzungsberechtigungen steht, dass Daten eben nicht weitergegeben werden können. Die wenigsten Nutzer lesen sich die Nutzungsberechtigungen durch, viele wissen aber, dass dort die Datenschutzrichtlinien stehen müssten. Als Grund für das Nichtlesen der Nutzungsberechtigungen geben die Meisten an, dass diese ihnen zu lang und zu unverständlich sind.

Eine geringe Anzahl (3 von 23) vermutet, dass App-Betreiber die Daten illegal weitergeben. Nur ein Sechstel der Befragten gibt an, dass es darüber hinaus entscheidend ist, welches Datenschutzgesetz Anwendung findet und verweist auf nationale Unterschiede. Nur ein Befragter, ein Jurist, konnte sagen, dass das ausländische Recht meist etwas lockerer ist und deshalb die Datenweitergabe einfacher umzusetzen wäre. Auffällig ist jedoch bei allen Befragten, dass sie sich mit diesem Thema zuvor noch nicht auseinandergesetzt haben und deshalb relativ unsicher sind.

Auch die Kenntnisse über die Weitergabe der Daten weichen stark voneinander ab. 40% der Befragten geben an, dass die Daten eigentlich nicht weitergegeben werden, wobei zwei Drittel dieser Befragten (also 6 von 9) angeben, dass sie davon ausgehen, dass die Daten grundsätzlich nicht weitergeben werden. Ein Drittel dieser Befragten (also 3 von 9) gehen davon aus, dass die Daten grundsätzlich nicht weitergegeben werden, es sei denn der App-Betreiber tut dies illegal oder am Rande des Gesetzes.

Viele der Befragten gehen somit fälschlicherweise davon aus, dass ihre Daten nicht weitergeben werden dürfen, da sie sonst hätten zustimmen müssen. Dass sie dieser Weitergabe wahrscheinlich schon oft durch das Akzeptieren der Nutzungsbestimmungen erlaubt haben, ist ihnen nicht bewusst. Auch Hinweise des Interviewers auf die Nutzungsberechtigungen helfen den Befragten nicht.

Nur knapp die Hälfte der Befragten (11 von 23) besitzen Kenntnis über die Weitergabe der Daten an Dritte. Die restlichen Befragten wissen nicht, ob Daten weitergegeben werden.

Die Kenntnis über die Datenaggregation ist sehr gering. Bei der Nutzung von Apps haben nur äußerst wenige App-Nutzer ein aktives Bewusstsein darüber, dass ihre Daten zu Nutzerprofilen aggregiert werden können. Vielen Nutzern fällt auf, dass die Datensammlung dazu dient, dem Nutzer Werbung zuzuschicken. Allerdings berichten die meisten Befragten dies im Zusammenhang mit Suchanfragen z.B. bei Google über das mobile Internet. Dass auch das Verhalten der Nutzer resultierend aus der App-Nutzung für solche Werbe- und Marktforschungszwecke erhoben wird, ist vielen Befragten nicht bewusst. Zudem haben nur zwei Befragte angemerkt, dass datenverarbeitende Unternehmen Daten einzelner Apps aggregieren. Wie dieser Prozess aber konkret ablaufen könnte, scheinen die Befragten nicht zu wissen.

Eine große Anzahl der Befragten nennt aber den Datenaustausch zwischen Apps in Zusammenhang mit dem Login über einen Identity Provider. Einem Großteil der Nutzer ist hierbei bewusst, dass sie dadurch mehr Daten an z.B. Facebook oder der jeweiligen App freigeben. Grund für eine Missempfindung über diese Verschmelzung von Identity Provider und App ist oftmals Unbehagen darüber, dass die App auf der eigenen Chronik Inhalte posten könnte und dass somit Facebook oder die jeweilige App noch mehr Daten sammeln könnte.

Das technische Wissen über die Funktionsweise von Applikationen der Nutzer weicht sehr stark voneinander ab. Während die Kenntnisse über Privatsphäre-Risiken auf Hardware-Ebene zufriedenstellend sind, fehlt es Nutzern oftmals an grundlegenden Kenntnissen über die Privatsphäre-Risiken auf der Software-Ebene. Bei den Privatsphäre-Risiken auf Netzwerk-Ebene zeigt sich, dass die Befragten ein Basisverständnis aufweisen, wobei es ihnen an spezifischen Wissen fehlt, um fallbezogen Risiken eigenständig erkennen zu können. Anzumerken ist hierbei, dass einige Befragte mit geringer App-Literacy sich nicht auf ihr eigenes Wissen berufen, sondern Entscheidungen in Absprache mit Freunden oder Bekannten mit vermeintlich hoher App-Literacy treffen.

Die Befragten zeigen fast alle Kenntnisse über die Privatsphäre-Risiken auf Netzwerk- Ebene, die einem Basis-Level zugeschrieben werden können. Beinahe alle Befragten wissen, dass Privatsphäre-Risiken auf der Netzwerk-Ebene existieren. Den meisten Befragten (19 von 23) ist bewusst, dass ihre Daten auf Netzwerkebene abgefangen werden können. Wird allerdings nachgefragt, wie bspw. Hacker detailliert an die Daten kommen oder in welchen Situationen Nutzer besonders gefährdet sind, sind die Meisten sehr unwissend.

Nur 5 von 23 Personen haben Kenntnisse darüber, dass ihre Daten bei der Nutzung öffentlicher Netzwerke leichter abzufangen sind. Nur 2 Befragte geben an, dass Hacker auch Passwörter abfangen könnten. Über den Datendiebstahl durch Hacker auf Host-Ebene, falls Apps Daten in einer Cloud gespeichert sind, berichten 5 von 23 Befragten. Es gehen rund 74% der Befragten davon aus, dass nicht alle Apps Daten verschlüsselt übertragen. Insgesamt sind die meisten Befragten sich aber bewusst, dass die Übertragung nicht sicher ist und gehen vorsichtiger mit der Preisgabe sensibler Informationen um.

Die Kenntnisse der Nutzer über die Privatsphäre-Risiken auf Hardware Ebene sind recht gut. Die persönlichen Risiken im Falle eines Gerätediebstahls variieren mit den installierten Apps und dem Umgang mit vertraulichen Informationen. Da in der Studie sehr unterschiedliche Nutzertypen vorliegen, ist die Beurteilung über die Kenntnis zu Privatsphäre-Risiken fallbezogen. Dennoch lässt sich festhalten, dass die meisten Nutzer wissen, dass Fremde direkten Zugang auf Apps haben, sollte der Dieb die Sperre umgehen können. Zudem sehen die Meisten Risiken darin, dass der Dieb in deren Namen Inhalte an ihre Facebook-Freunde oder E-Mail-Kontakte schicken könnte.

Nur eine geringe Anzahl der Befragten ist sich darüber im Klaren, dass der Dieb auch herausfinden könnte, wann eine Person im Urlaub ist und somit die Wohnung etc. frei ist. Zudem wissen Einige, dass der Dieb Käufe z.B. über iTunes, App Stores oder In-App-Käufe tätigen könnte und somit einen finanziellen Schaden auslösen könnte. Manchen ist darüber hinaus auch bewusst, dass Daten nicht nur aus Apps genutzt werden können, sondern auch von Browserseiten, auf welchen der Nutzer automatisch eingeloggt ist und Passwörter hinterlegt hat. Hierbei handelt es sich auch teilweise um Shopping-Seiten.

Die Kenntnisse über die Privatsphäre-Risiken auf Software-Ebene sind sehr gering. Rund 70% der Befragten fehlen Kenntnisse darüber, ob App Stores Apps auf Malware überprüfen. 75% von diesen haben keine Ahnung von Prüfprozessen, die übrigen 25% gehen von falschen Annahmen aus und geben an, dass der App Store Apps auf Malware überprüft. Nur ein Nutzer mit einem iOS Betriebssystem gibt an, dass der App Store Apps auf Malware überprüft, was richtig ist, und wurde dementsprechend nicht der beschriebenen Gruppe zugeordnet. Ca. 30% der Befragten (7/23) sind somit in der Lage, eine korrekte Antwort zu geben. Davon geben 6 der 23 befragten Android-Nutzer an, dass Apps nicht auf Malware überprüft werden.

Die Kenntnisse zu den App-Berechtigungen sind ähnlich gering. Werden die Nutzer gefragt, was unter der App-Berechtigung "Geräte-ID und Anrufinformationen" zu verstehen ist, geben die Meisten gleich an, dass sie das nicht wüssten. Erst durch Nachhaken, versuchen sich die Befragten die Antwort zusammenzureimen, sodass letztendlich 15 Android-Nutzer die richtige Antwort wussten oder diese zumindest vermuteten. Unter Anrufinformationen können sich viele Nutzer jedoch nichts vorstellen. Diejenigen, die mit dem Begriff " Geräte-ID" etwas anfangen konnten, wissen nicht, warum App-Betreiber diese Informationen sammeln. 4 von 15 Befragten gehen davon aus, dass App-betreiber diese Herstellerinformationen brauche, um zu überprüfen, ob die App auf ihrer Geräteklasse funktioniert. Nur 2 von 15 Befragten ist bewusst, dass die ID u.a. für die eindeutige Zuordnung zu Nutzerprofilen erhoben wird.

4 Schlussbetrachtung, Limitationen und zukünftige Forschung

Der vorliegende Artikel nähert sich der Thematik der App-Literacy über eine qualitative empirische Studie. Aufgrund ihres explorativen Charakters und ihrer qualitativen Ausrichtung weist die Studie zahlreiche Limitationen auf. Diese sind bspw. in der Möglichkeit sozial erwünschter Antworten, der Repräsentativität der Stichprobe und der Selbstselektion der Teilnehmer zu sehen. Aufgrund ihres explorativen Charakters um sich dem Themenfeld der App-Literacy zu näher ist die Arbeit vorwiegend deskriptiver Natur und zielt auf die Reproduzierung des Wissensstands der App-Nutzer ab. Die Generalisierbarkeit der Studienergebnisse wird durch die Auswahl der Probanden eingeschränkt. Detaillierte Angaben zum Umfang und Art der Nutzung und der genutzten Apps können hinsichtlich der Probanden nicht gemacht werden.

Trotz dem explorativen Charakter erlaubt die Studie einen Rückschluss bezüglich der aufgeworfenen Forschungsfragen. Nutzer von Apps und mobilen digitalen Ökosystemen verfügen zwar über eine geringe (Basis-)App-Literacy, diese reicht jedoch nicht aus um Privatsphäre-Gefahren erkennen und einordnen zu können. Trotz der massiven Nutzung mobiler digitaler Ökosysteme und deren App-Angebote durch Drittanbieter scheinen die Nutzer die hieraus entstehenden mittel- und langfristigen Gefahren nicht einschätzen zu können. Vor diesem Hintergrund scheint es fraglich, ob Nutzer überhaupt in der Lage sind, Privatsphäre-Risiken im beschriebenen Kontext richtig einzuschätzen. Eine niedrige App-Literacy kann eine weitere Erklärungsvariable für das aus der Literatur bekannte Privacy Paradox liefern. So kann ein möglicher Erklärungsmehrwert aus der Argumentation heraus entstehen, dass Nutzer mobiler Applikationen Ihre Selbstverantwortung des Abbaus vorhandener Informationsasymmetrien auf andere Parteien (bspw. App-Provider, App-Store-Betreiber) auslagern. Forschungsarbeiten im Rahmen des Privacy Paradox und der Verhaltensökonomie stützen diese Erkenntnisse, beispielweise durch verschiedene Heuristiken (Acquisti et al. 2015; Brandimarte et al. 2013). Eine niedrige App-Literacy kann somit eine Erklärung für die Argumentation und theoretische Grundlage des Privacy Paradox liefern und verlangt nach massiven Maßnahmen im Hinblick auf Schutz, Prävention und Aufklärung von App-Nutzern.

Zukünftige Forschungsvorhaben sollten somit verstärkt auf die spezifische Bildung von Nutzern digitaler Systeme eingehen um die tatsächlich vorhandenen Kosten-Nutzen-Abwägungen beschreiben zu können. Die qualitativen Ansätze zur Untersuchung der App-Literacy sollten weitergeführt und in ein valides quantitatives Konstrukt zu einer generalisierbaren App- und Privacy-Literacy überführt werden.

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Perceived Threats of Privacy Invasions: Measuring Privacy Risks (Extended Abstract)

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Online services have become an integral part of our everyday lives. We shop online, we spend time in social networks, or use search engines to identify relevant information. In order to benefit from these easy and convenient ways of buying, communicating, and gathering data, we often share personal data. Companies such as Facebook, Google, and Amazon can use the gained knowledge to improve their service offerings and thus to increase their profits. However, even though people willingly trade personal information for such benefits, surveys continuously find that people are concerned about their privacy in today's digital and data-driven economy (BCG 2013). Thus, the question arises how privacy perceptions influence people's behavior.

Previous research has addressed this question by investigating how privacy concerns, defined as the worries that individuals have with respect to a potential loss of privacy due to organizational practices, are associated with individuals' behavioral reactions (Smith et al. 2011). Two established operationalizations for privacy concerns exist: The concern for information privacy (CFIP) scale (Smith et al. 1996) which differentiates between four different dimensions of privacy concerns, namely the concerns that personal data is collected, is used in an unauthorized way, is improperly accessed, and is erroneous, and the scale of internet users' information privacy concerns (IUIPC) which comprises the dimensions of collection, control, and awareness (Malhotra et al. 2004). Overall, these two operationalizations cover how individuals perceive organizations to handle their data without differentiating whether and how exactly these organizational practices actually impact individuals.

We offer a complementary perspective on how to investigate the influence of privacy on individuals' actual online behavior. We argue that individuals only change their behavior when they perceive to be impacted by third party behavior so that noticeable consequences for themselves might result from third party actions (Dowling 1986). Following this argumentation, the well-established and frequently used conceptualizations of privacy concerns (Malhotra et al. 2004; Smith et al. 1996) may not always cover this behaviorally relevant component. To give an example, secondary use of personal data can steeply increase the value of a personalized information service by improving the algorithms of the organization overall. However, only if individuals fear to be negatively affected by this secondary use, they actually adapt their behavior accordingly. This is the case if they face specific risks such as a financial loss, a reputational damage, or being manipulated in their behavior. Thus, risks have direct behavioral consequences while concerns may or may not be attached to risks.

Based on these arguments, our paper has two objectives: First, we develop scales for the different dimensions of privacy risks as predictors of information disclosure behavior. Second, we compare their explanatory power to the well-established construct of privacy concerns.

To develop privacy risk scales, we followed the five steps by MacKenzie et al. (2011) to generate, validate, and refine our items. (1) We developed a conceptual definition of the latent variables. Thereby, we rely on the commonly used two components of risk, namely the severity of adverse consequences and their probability of occurrence, and we draw from existing literature on risks in other contexts (Featherman and Pavlou 2003; Glover and Benbasat 2010) and from the taxonomy of perceived consequences of privacy-invasive practices (Hauff et al. 2015). Thus, we define privacy risks as the extent to which an individual believes that privacy-invasive practices occur and negatively impact a person in a certain situation. This construct refers to a perception as it describes the perceived risk that a person realizes to face in a context. Moreover, we conceptualize privacy risks as multi-dimensional construct that applies to the entity of individuals. We identify the privacy risk dimensions social, psychological, physical, legal, independence-related, and resource-related. (2) We generated items that represent the latent variables. Therefore, we relied on existing scales for risks that were developed for other contexts wherever possible (Featherman and Pavlou 2003; Stone and Grønhaug 1993) and on statements from seven focus groups which we conducted. Then, the content validity of those items had to be assessed to ensure their suitability. Thus, we used an open sorting with four experienced raters based on the guidelines of Moore and Benbasat (1991) and an item rating to assess the items' content adequacy (MacKenzie et al. 2011). We further adjusted and shortened our instrument accordingly. (3) Next, we formally specified the measurement model by modeling privacy risk as a composite latent construct that comprises our six privacy risk dimensions. We measure all first-order risk dimensions reflectively while the dimensions are formative indicators of the second-order construct privacy risk. (4) We evaluated the scales in a small pre-study to test the comprehensibility of the items and of the scenario that we planned to use in the main study, and assessed reliability and validity to refine our items. (5) The last step of our scale development process aimed at validating our measurement model in a large-scale survey. Moreover, we wanted to investigate privacy risks in a nomological network and make a first comparison to the established construct of privacy concerns. Using a privacy calculus perspective, we investigated how privacy risks or respectively privacy concerns and privacy benefits influence online users' actual information disclosure behavior. We conducted our empirical study in the context of e-commerce and social networking, since data collection is particularly critical in this area. In the first step, participants were asked to actually share personal information in a given scenario where individuals were introduced to a start-up that wants to offer a personalized online magazine and asks for personal information to evaluate and better target its service. In a second step, they were questioned about their perceptions of this situation. The questionnaire was distributed among participants of an undergraduate business lecture at a German university in February 2015. We received 141 completed questionnaires. While we used our newly developed scales to assess privacy risks, we relied on existing scales for measuring privacy concerns (Smith et al. 1996; van Slyke et al. 2006) and perceived benefits (Krasnova et al. 2010). Lastly, we calculated the values of our dependent variable information disclosure behavior by counting the number of information pieces that a person disclosed in the survey (Joinson et al. 2010). We assessed the measurement models and had sufficient values for construct reliability and validity as well as discriminant validity. We also assessed our second-order formative constructs privacy risks, privacy concerns, and benefits using the guidelines of Cenfetelli and Bassellier (2009). We used partial least squares structural equation modelling (PLS-SEM using SmartPLS; Ringle et al. 2015) to examine our models. The results of our analysis showed that in a model with both privacy risks and benefits as predictors of information disclosure, privacy risks ($\beta = -0.400$, $p<0.001$) and benefits ($\beta = 0.358$, $p<0.001$) significantly influence information disclosure behavior as hypothesized. Adjusted R^2 is 0.231. This also confirms the nomological validity of our privacy risk construct. In a second model, we investigated privacy concerns and benefits as predictors of information disclosure behavior. In this case, benefits significantly impact behavior ($\beta = 0.279$, $p<0.001$) while privacy concerns do not ($\beta = -0.352$, $p>0.5$). Adjusted R^2 is 0.199. In a third model, we included both privacy concerns and privacy risks in addition to benefits. Privacy risks ($\beta = -0.314$, $p<0.001$) and benefits ($\beta = 0.334$, $p<0.001$) significantly impact behavior, while privacy concerns do not ($\beta = -0.205$, $p>0.5$). Adjusted R^2 is 0.261.

Our results show that we developed valid measurement scales for privacy risks which offer promising avenues for a further exploration of how privacy perceptions influence individuals' behavior and thus provide several interesting contributions for theory and practice.

We contribute to theory by advancing the understanding of privacy risks as multi-dimensional concept that has the dimensions of social, legal, physical, resource-related, independence-related, and psychological risks. All those dimensions describe the extent to which individuals perceive to be affected by a privacy invasion through third parties. Thus, we offer a novel perspective on how to measure information privacy as previous conceptualizations neglected to capture the perceived impact of negative consequences that can arise from sharing information online.

Our study has also practical implications. Many business models such as those of social network site providers or e-commerce platforms depend on the collection and analysis of user data. Therefore, they are very interested in better understanding the circumstances of individual information disclosure, reasons that might prevent disclosure, and how to mitigate problematic influences. Our conceptualization of privacy risks can help organizations to recognize why consumers hesitate to share information and which risks may have to be mitigated by the service design to prevent discouraged users.

We see several promising avenues for future research. In particular, more heterogeneous samples should be used and the influence of privacy risks in other contexts such as financial or health scenarios should be explored to see which risk dimensions are prevalent there. Investigating how third parties can actively mitigate privacy risks is another promising research direction.

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Teilkonferenz
e-Commerce und e-Business

Die Fachgruppe Electronic Commerce (WI-EC) der Gesellschaft für Informatik veranstaltet im Rahmen der MKWI 2016 den Track e-Commerce und e-Business. Die Themen dieses Tracks zielen auf die Unterstützung des elektronischen Geschäftsverkehrs und die Durchführung von Transaktionen über globale Netze über unterschiedliche Endgeräte in einem weltweit wachsenden Markt ab. Beiträge können ökonomische, technische, rechtliche und benutzerorientierte Aspekte des e-Commerce und e-Business beleuchten. Dabei können sie sowohl methodische Grundlagen, technische Lösungen, analytische empirische Evaluierungen als auch konkrete Fallstudien vorstellen.

Die Teilkonferenz e-Commerce und e-Business umfasst neun Beiträge, die aus 18 Einreichungen ausgewählt wurden. Eingereicht und angenommen wurden empirische und gestaltungsorientierte Forschungsbeiträge zu Online Plattformen im e-Commerce und e-Business, der Nutzung mobiler Apps, Shared Economy und Analysen von Wertschöpfungsketten.

Christian Huemer, Ulrike Lechner, Jan Marco Leimeister, Philipp Melzer, Mareike Schoop

(Teilkonferenzleitung)

Was hält Schweizer KMU davon ab, Social Media zu nutzen?

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Abstract

Obwohl die Nutzung von Social Media Anwendungen durch kleine und mittlere Unternehmen (KMU) in den letzten Jahren angestiegen ist, ist bisher noch relativ wenig darüber bekannt, weshalb genau KMU Social Media nutzen bzw. nicht nutzen. Mithilfe einer Befragung von 278 Schweizer KMU identifiziert die vorliegende Studie Einflussfaktoren auf deren Nutzung von Social Media. Die deskriptiven Ergebnisse zeigen, dass generell lediglich 35% der KMU Social Media für ihre Zwecke einsetzen. Eine explorative Faktorenanalyse identifiziert in Anlehnung an das Technologie-Akzeptanz-Modell (TAM) zwei relevante Faktoren als Treiber für die Einführung von Social Media: das wahrgenommene Risiko und die wahrgenommene Einfachheit der Anwendung. In einer logistischen Regressionsanalyse zeigt sich ein heterogenes Bild bei den Einflüssen, die sich aus den identifizierten Faktoren auf die Social Media Nutzung in KMU ergeben. Während das wahrgenommene Risiko der Hauptgrund ist, weshalb KMU Social Media nicht nutzen, hat die wahrgenommene Einfachheit der Anwendung dagegen keinen Einfluss.

1 Einleitung

Im vergangenen Jahrzehnt hat sich die Nutzung von Social Media Plattformen insgesamt schnell verbreitet. Social Media Plattformen sind kostengünstig, einfach zu bedienen und werden ausgiebig von einer großen Anzahl privater Personen genutzt. Demgegenüber verhalten sich Unternehmen bei der Nutzung und Einbindung von Social Media deutlich zurückhaltender. Zudem sind es im Wesentlichen Großunternehmen, die ihre Präsenz auf Social Media Plattformen ausdehnen, vor allem um Zugriff auf die dortige Masse an privaten Nutzern zu erhalten (Barnes und Jacobsen 2013).

Auch in der Forschung findet der Einsatz von Social Media in Unternehmen zunehmend Beachtung. So wurde der Social Media Einsatz beispielsweise bereits in einzelnen Branchen (Bruhn et al. 2012; Hong 2012), auf bestimmten Plattformen (Lee und Cho 2011; Lipsman et al. 2012; Sinclaire und Vogus 2011) und in verschiedenen Kundensegmenten (Michaelidou et al. 2011; Moore et al. 2013) untersucht. Im Wesentlichen werden Social Media Anwendungen für kommunikations- und marketingnahe Unternehmensfunktionen eingesetzt (Lipsman et al. 2012), wie beispielsweise Beziehungsmanagement mit Kunden und Stakeholdern (Brennan und Croft 2012), Marketing und

Vertrieb (Moore et al. 2013; Schlinke und Crain 2013), Branding und Image (Bruhn et al. 2012; De Vries et al. 2012). Gerade bei Großunternehmen wird Social Media vor allem als Instrument der Markenkommunikation betrachtet, indem Nutzer als Markenbotschafter fungieren und Mund-zu-Mund-Propaganda betreiben (Gensler et al. 2013; Henry und Harte 2012).

Im Gegensatz dazu liegen über die Nutzung von Social Media durch KMU noch kaum empirische Befunde vor. Allerdings sind Unterschiede zu Großunternehmen zu erwarten: Kleine Unternehmen bauen im Vergleich zu Großunternehmen tendenziell persönlichere Kundenbeziehungen auf (Harrigan et al. 2012) und tendieren zu einfachen, kostengünstigen und effizienten Ansätzen der Kommunikation, die mit der Strategie und der Unternehmenskultur in Einklang gebracht werden können (O'Dwyer et al. 2009). Entsprechend können KMU Social Media nicht auf dieselbe Art und Weise einsetzen wie Großunternehmen. Ziel der vorliegenden Studie ist es daher, Einflussfaktoren zu identifizieren, die die Nutzung von Social Media Anwendungen in KMU beeinflussen. Dazu werden Daten aus einer Befragung von 278 Schweizer KMU zum Thema ausgewertet. Eine explorative Faktorenanalyse identifiziert korrespondierend zum Technologie-Akzeptanz-Modell (TAM) zwei relevante Faktoren als Treiber für die Nutzung von Social Media: das wahrgenommene Risiko und die wahrgenommene Einfachheit der Anwendung. Eine darauf aufsetzende logistische Regressionsanalyse ergibt ein heterogenes Bild bei den Einflüssen der identifizierten Faktoren auf die Social Media Nutzung. Während das wahrgenommene Risiko der Hauptgrund ist, weshalb KMU Social Media nicht nutzen, hat die wahrgenommene Einfachheit der Anwendung dagegen keinen Einfluss.

2 Theorie und Hypothesen

2.1 Die Rolle von Social Media als neue Kommunikationsform im Unternehmenskontext

Unter Social Media, versteht man mobile und webbasierte Anwendungen im Web 2.0, die es Einzelpersonen und Gruppen ermöglichen, eigens generierte Inhalte auf interaktiven Plattformen zu erstellen, zu teilen und zu verändern (Kaplan und Haenlein 2010; Kietzmann et al. 2011). Mit der Entwicklung hin zum Web 2.0 hat auch ein entscheidender Wechsel in der Unternehmenskommunikation mit ihren Stakeholdern stattgefunden. Einzelne Personen und Communities können nun Inhalte erstellen und teilen, indem sie beispielsweise über Produkte und Dienstleistungen ohne die Zustimmung der Unternehmen diskutieren („Word-of-mouth") (Beier und Wagner 2015). Hinzu kommt, dass Unternehmen nur noch geringen Einfluss auf die technologischen Eigenschaften von Social Media Plattformen haben. Aus diesem Grund ist die Nutzung von Social Media für Unternehmen oft mit einem gewissen Grad an Unsicherheit verbunden, auch weil die Plattformen von Drittparteien betrieben werden (Mergel 2013). Dies führt auf Seiten der Unternehmen tendenziell zu Befürchtungen, dass sie nicht nur über den Inhalt, sondern auch über die technologische Infrastruktur zunehmend die Kontrolle verlieren.

Die Entscheidung, inwieweit Social Media in KMU gezielt für bestimmte Unternehmenszwecke eingesetzt werden soll, wird allgemein auf Basis individueller Wahrnehmungen und Einschätzungen gefällt (Fu et al. 2006). Dabei ist zwischen zwei Ansätzen zu unterscheiden: Beim *bottom-up*-Ansatz ist es jedem Mitarbeiter des Unternehmens gestattet, im Namen des Unternehmens Social Media Anwendungen einzusetzen. Da in der Regel kaum Kosten damit verbunden sind, sind keine formellen Budget-Genehmigungen notwendig und der offizielle Macht- und Kontrollapparat der Organisation kommt weitgehend nicht zur Anwendung (Livingston 1975). Dies hat zur Folge, dass in kleinen Unternehmen dann meist auch keine Regeln für die Nutzung von Social Media für die Mitarbeiter definiert sind, sondern dies in der individuellen Verantwortung der Einzelnen liegt. Dem gegenüber entscheidet beim *top-down*-Ansatz eine Führungskraft, inwieweit bzw. wie Mitarbeiter Social Media im Unternehmen anwenden (Riemenschneider et al. 2003). Bei beiden Ansätzen wird die Entscheidung für die Nutzung auf der Ebene von Einzelpersonen getroffen. Gerade auf der Individualebene ist die operative Schwelle der Nutzung von Social Media für ein Unternehmen sehr niedrig. Jeder Mitarbeiter, der seine Geschäftskontakte über LinkedIn oder XING verwaltet, wendet bereits Social Media für Zwecke seines Unternehmens an. Offen bleiben jedoch Fragen, wie sich die individuellen Einschätzung organisational auswirken und wann eine Nutzung stattfindet bzw. was diese verhindert. Insbesondere der zweiten Frage widmet sich das Technologie-Akzeptanz-Modell.

2.2 Das Technologie-Akzeptanz-Modell (TAM)

Das ursprüngliche Technologie-Akzeptanz-Modell (TAM) zielte darauf ab, eine Erklärung für die individuelle Entscheidung zur Nutzung von Computern am Arbeitsplatz zu geben (Davis 1989). Grundlage des TAM bildet das sozialpsychologische Modell der „Theory of Reasoned Action" (TRA) von Ajzen und Fishbein (1980). Das TAM wurde in vielen Online-Kontexten angewendet, um die Wahrnehmungen der Nutzer hinsichtlich der Systemverwendung und der Wahrscheinlichkeit der Einführung zu beurteilen (Featherman und Pavlou 2003; Gefen und Straub 2000; Moon und Kim 2001; Pavlou 2001). So wurde es beispielsweise bereits zur Erklärung der Anwendung von mobilen Web-Applikationen (Venkatesh et al. 2003), E-Commerce Anwendungen (Daniel und Grimshaw 2002; Grandón et al. 2011), Online Banking (Pikkarainen et al. 2004), der elektronischen Steuererklärung (Fu et al. 2006; Warkentin et al. 2002) und von Webseiten allgemein (Riemenschneider et al. 2003) angewandt. Dabei sind gemäss des Modells die wahrgenommene Einfachheit der Anwendung und die wahrgenommene Nützlichkeit wichtige Faktoren, die die Absicht zur Nutzung bzw. die tatsächliche Nutzung eines Informationssystems beeinflussen (Adams et al. 1992; Venkatesh et al. 2003).

Die wahrgenommene Nützlichkeit ist der Grad, zu dem eine Person denkt, dass die Nutzung einer neuen Technologie ihr einen Leistungsvorteil generieren wird (Venkatesh et al. 2003). Dabei ist die wahrgenommene Nützlichkeit einer Lösung grundsätzlich in Relation zu alternativen Lösungen zu sehen (Rogers 1983). Web 2.0 und Social Media Plattformen ermöglichen es Unternehmen, mit internen und externen Stakeholdern effektiver und effizienter zu kommunizieren und zu interagieren. Social Media Anwendungen können daher ein effektives Werkzeug sein, um die Leistung eines Unternehmens zu verbessern oder Kosten zu senken. Social Media Plattformen können besonders dazu verwendet werden, um den Bekanntheitsgrad einer Marke zu steigern, die Kosten für Marketingtätigkeiten zu reduzieren und die Geschwindigkeit des Prozesses durch direktes Kundenfeedback zu verbessern (De Vries et al. 2012; Gensler et al. 2013; Henry und Harte 2012; Moore et al. 2013; Schlinke und Crain 2013). Daher wird folgende Hypothese aufgestellt:

H1: Die wahrgenommene Nützlichkeit einer möglichen Anwendung von Social Media hat einen positiven Einfluss auf deren tatsächliche Anwendung in KMU.

Wahrgenommene Einfachheit einer Anwendung bezieht sich auf das Ausmaß, inwieweit ein Nutzer das Arbeiten mit dieser als einfach empfindet (Davis 1989; Riemenschneider et al. 2003). Wahrgenommene Einfachheit gilt als wichtiger Einfluss auf die Nutzung eines Informationssystems (Adams et al. 1992; Venkatesh et al. (2003). Ihr Einfluss wurde beispielsweise bereits im Kontext von E-Commerce (Pavlou 2001) und Online Banking (Amin 2007; Lallmahamood 2007) nachgewiesen. Auf den ersten Blick scheinen Social Media leicht verfügbar, kostengünstig und einfach in der Anwendung zu sein, da sie benutzerfreundlich sind und einzelne Nutzer bequem Profile anlegen sowie Inhalte übermitteln können. Bei näherer Betrachtung zeigen sich jedoch in Bezug auf die Implementierung von Social Media Massnahmen in Unternehmen zusätzliche Erfordernisse, damit die operative Nutzung einzelner Personen auch tatsächlich positive und planbare Effekte für das Unternehmen generiert. So begegnen die meisten KMU bei der Einführung von Social Media signifikanten Schwierigkeiten insbesondere bei der Realisierung geschäftsbezogener Potentiale und der Entwicklung entsprechender Strategien. Vor allem erscheint es aufwändig und schwierig, konkrete und nachhaltige Massnahmen für Social Media Anwendungen aus den konkreten Erfodernissen des Geschäftsmodells und der Unternehmens-strategie abzuleiten, deren Abläufe und Ergebnisse zu beobachten und - wenn notwendig - Anpassungen vorzunehmen (Beier et al. 2013; Ramanathan et al. 2012). Wenn aber der notwendige Einsatz, um Social Media effektiv im Unternehmen verwenden zu können, als zu hoch wahrgenommen wird, bevorzugen es potentielle Nutzer stattdessen, weiterhin herkömmliche Marketing- und Kommunikationskanäle zu verwenden. Daher wird folgende Hypothese aufgestellt:

H2: Die wahrgenommene Einfachheit einer möglichen Anwendung von Social Media hat einen positiven Einfluss auf deren tatsächliche Anwendung in KMU.

2.3 Das wahrgenommene Risiko

Neben den grundlegenden Bestandteilen des TAM (wahrgenommene Nützlichkeit und wahrgenommene Einfachheit der Anwendung) wurde das ursprüngliche Modell um das „wahrgenommene Risiko“ als dritten Faktor ergänzt (Featherman und Pavlou 2003; Fu et al. 2006). Wahrgenommene Risiken lassen Nutzer bei der Einführung einer neuen Technologie zögern. Obwohl ein Risiko objektiv schwer zu messen ist, hat die Literatur das wahrgenommene Risiko als „Erwartung eines Verlusts, die mit einem Kauf verbunden ist und sich hemmend auf das Kaufverhalten auswirkt“, definiert (Peter und Ryan 1976, 185). Die Grundidee des wahrgenommenen Risikos ist, dass das Verhalten eines Konsumenten oder eines Nutzers Konsequenzen haben wird, die von ihm antizipiert werden und die unangenehm sein können (Bauer 1967). Das wahrgenommene Risiko kann dementsprechend die Entscheidung eines Nutzers für oder gegen die Anwendung einer neuen Technologie beeinflussen, wenn die Entscheidung ein Gefühl von Unsicherheit, psychologische Beschwerden, Angstgefühle oder Konflikte hervorruft (Dowling und Staelin 1994; Featherman und Pavlou 2003). Im Online-Kontext wurden bereits konkret Datenschutzrisiken untersucht, die mit der Entscheidung, etwas online zu kaufen oder einen Webservice einzuführen, verbunden sind (Featherman und Pavlou 2003). In Bezug auf Social Media können sich weitere Risikoabwägungen ergeben. So können Nutzer befürchten, dass ihre Datenschutzrechte durch Internet-Plattformen verletzt werden (Farzianpour et al. 2014). Nutzer aus dem geschäftlichen Kontext schätzen Social Media Anwendungen zudem als riskanter ein als etablierte Kommunikationskanäle wie E-Mail, Telefon oder persönliche Kommunikation (Steinman und Hawkins 2010). Darüber hinaus werden Social Media Anwendungen mit einem höheren Maß an Unsicherheit in Verbindung gebracht, weil sie von externen Drittparteien betrieben und gestaltet werden (Mergel 2013). Daher haben Unternehmen keine Kontrolle über die technologischen Eigenschaften der Social Media Plattformen, die Art und Weise, wie sich das Benutzerverhalten verändern kann und die Informationen, die auf den Plattformen gespeichert werden (Aula 2010). Daher wird folgende Hypothese aufgestellt:

H3: Die wahrgenommenen Risiken einer möglichen Anwendung von Social Media haben einen negativen Einfluss auf deren tatsächliche Anwendung in KMU.

3 Daten und Methode

3.1 Datensammlung und Stichprobe

Als Basis für die quantitative Befragung wurden 16 qualitative Interviews mit Ostschweizer KMU, die unterschiedliche Verhaltensmuster in Bezug auf Social Media aufweisen, durchgeführt. Ergebnisse daraus sowie Erkenntnisse aus der Literatur flossen in die Konzeption des Fragebogens mit ein, welcher mit drei Geschäftsführern von kleinen Unternehmen in der Ostschweiz getestet wurde. Auf Basis von Adressdaten des Bundesamts für Statistik (BfS) wurde eine postalische Befragung an eine repräsentative Stichprobe von 10% aller unabhängigen KMU in der Ostschweiz (5‘447 Unternehmen) verschickt. Zudem wurde der Fragebogen auch als Online-Fragebogen angeboten, der für die Befragten über eine spezielle Webadresse zugänglich war und online ausgefüllt werden konnte. Die Fragebögen wurden direkt an die Geschäftsführer adressiert. Diese wurden gebeten, den Fragebogen als „Key Informant“ auszufüllen. Insgesamt wurden die Fragebögen von 324 Unternehmen retourniert, was einer Rücklaufquote von 6% entspricht. Nach Ausschluss aller unvollständigen oder unbrauchbaren Fragebögen konnten Fragebögen von 278 KMU verwendet werden. Zudem wurde auf einen möglichen Non-Response-Bias getestet, indem die Daten der KMU aus der Befragung mit der Struktur der repräsentativen Original-Stichprobe verglichen wurden. Hier zeigte sich ein hohes Maß an Übereinstimmung bei den Verteilungen der Unternehmensgröße, Branche und regionalen Eigenschaften zwischen der originalen Strichprobe und den antwortenden KMU.

3.2 Messgrößen und Variablen

Um Einschätzungen der KMU in Bezug auf die Anwendungen von Social Media zu messen, wurden zehn Aussagen hinsichtlich der wahrgenommenen Barrieren für eine Einführung auf Basis des theoretischen Rahmenwerks entwickelt (siehe Tabelle 1).

Variablen der Faktorenanalyse	Mittelwert Nutzer	N	Mittelwert Nicht-Nutzer	N	p
1. Zu hoher Aufwand	2.78	72	2.86	149	0.56
2. Zu geringer Ertrag	2.81	74	3.08	142	0.04
3. Zu geringe Kontrollmöglichkeiten	2.04	73	2.78	144	0.00
4. Risiko öffentlicher Kritik	1.70	74	2.09	143	0.01
5. Ungeeignet für das Unternehmen	1.84	74	2.92	153	0.00
6. Fehlende Strategie	2.58	74	2.81	145	0.16
7. Feh. Kenntnisse für Social Media Umsetzung	2.24	74	2.72	154	0.00
8. Nicht von Interesse für Kunden	2.18	73	2.86	152	0.00
9. Unsichere rechtliche Lage (Datenschutz)	1.86	73	2.69	147	0.00
10. Feh. Notwendigkeit, Trend mitzumachen	1.78	74	2.58	155	0.00

Anmerkungen: p=p-Werte der t-Tests für Variablenpaare. N ist die jeweilige Größe des Samples.

Tabelle 1: Deskriptive Statistik der Variablen (Barrieren)

Die Befragten wurden gebeten, jede Barriere gegen die Verwendung von Social Media auf einer Likert-Skala zu beurteilen. Dabei repräsentiert eine 1 fehlende Übereinstimmung und eine 4 starke Übereinstimmung mit der Aussage. Obwohl das Forschungsdesign sowohl positive (wahrgenommene Nützlichkeit, wahrgenommene Einfachheit der Anwendung) als auch negative

Aussagen (wahrgenommene Risiken) beinhaltet, wurden die Items alle negativ ausgerichtet, um Unklarheiten beim Ausfüllen des Fragebogens zu vermeiden und spätere Berechnungen einfacher zu gestalten. Die Aussagen sind in Tabelle 1 aufgelistet. Der Anteil der Unternehmen, bei denen mindestens eine Person im Unternehmen Social Media für Unternehmenszwecke verwendet, beträgt 35% der Stichprobe (Nutzer). In 65% der Unternehmen werden dementsprechend keine Social Media Anwendungen eingesetzt (Nicht-Nutzer).

Tabelle 1 zeigt die deskriptive Statistik für die Barrieren der Verwendung von Social Media. Die Ergebnisse zeigen, dass die größte Barriere bei der Nutzung von Social Media der fehlende wahrgenommene Ertrag (Mittelwert=3.08) ist, gefolgt von der Wahrnehmung, dass die Nutzung von Social Media ungeeignet für das eigene Unternehmen (Mittelwert=2.92) oder für die Kunden nicht von Interesse ist (Mittelwert=2.86) sowie dass der Aufwand für die Verwendung von Social Media übermäßig hoch sind (Mittelwert=2.86). Alle zehn latenten Variablen werden in der explorativen Faktorenanalyse berücksichtigt.

3.3 Explorative Faktorenanalyse

In einem nächsten Schritt wird eine Faktorenanalyse durchgeführt, um die wahrgenommenen Barrieren bei der Nutzung von Social Media Anwendungen zu kategorisieren. Dazu wird eine Hauptkomponentenanalyse mit einer Varimax-Rotation angewendet. Die Ergebnisse zeigen eine Drei-Faktoren-Lösung gemäß dem latenten Stammkriterium (drei Faktoren mit Werten größer als 1). Um die Ergebnisse weiter zu interpretieren, wurde ein Grenzwert von 0.6 für die Faktorladungen gesetzt. Es waren keine multiplen Faktorenladungen der Elemente gegeben. Tabelle 2 zeigt die Faktorladungen und die Varianzen.

Variable	Faktor 1	Faktor 2	Faktor 3
Label / Interpretation der Faktoren	Wahrgen. Risiken	Wahrgen. Nützlichkeit	Wahrgen. Einfachheit
1. Zu hoher Aufwand		0.77	
2. Zu geringer Ertrag		0.85	
3. Zu geringe Kontrollmöglichkeiten	0.65		
4. Risiko der öffentlichen Kritik	0.68		
5. Ungeeignet für das Unternehmen	0.71		
6. Fehlende Strategie			0.88
7. Fehlende Kenntnisse für Social Media Umsetzung			0.83
8. Nicht von Interesse für Kunden	0.62		
9. Unsichere rechtliche Lage (Datenschutz)	0.80		
10. Fehlende Notwendigkeit, den Trend mitzumachen	0.74		
Erklärte Varianz	38.44%	13.52%	11.34%
Cronbachs Alpha	0.82	0.61	0.71

Tabelle 2: Ergebnisse der Faktorenanalyse

Die Faktorenanalyse ergab die folgenden drei Faktoren (bezeichnet in Anlehnung an das Technologie-Akzeptanz-Modell):

(1) wahrgenommene Risiken (6 Elemente)
(2) wahrgenommene Nützlichkeit (2 Elemente)
(3) wahrgenommene Einfachheit der Anwendung (2 Elemente)

Diese stellen 63.3% der Gesamtvarianz in der Analyse. Um die Reliabilität der Drei-Faktoren-Lösung zu testen, wird Cronbachs Alpha für jeden Faktor berechnet. Cronbachs Alpha für Faktor 1 („wahrgenommene Risiken") ist 0.82, für Faktor 2 („wahrgenommene Nützlichkeit") ist 0.61 und für Faktor 3 („wahrgenommene Einfachheit der Anwendung") liegt der Wert bei 0.71. Nach Nunnally (1978) ist davon auszugehen, dass Werte bei Cronbachs Alpha unter 0.70 eine zu schwache Reliabilität des jeweiligen Faktors anzeigen. Daher bleibt der zweite Faktor („wahrgenommene Nützlichkeit") in der weiteren Untersuchung unberücksichtigt. Stattdessen werden die beiden dem Faktor zu Grunde liegenden einzelnen Barrieren „zu hoher Aufwand" und „zu geringe Erträge" als separate Variablen in die folgende Regressionsanalyse einbezogen.

3.4 Deskriptive Statistik

Das Durchschnittsalter der Antwortenden (Führungskräfte), die den Fragebogen retourniert haben, beträgt 47 Jahre. Das Durchschnittsalter der Unternehmen beträgt 37 Jahre, die Durchschnittsgröße der KMU beträgt 14 Mitarbeiter mit einem jährlichen Durchschnittsumsatz von 3.7 Mio. Schweizer Franken. Unter den antwortenden Führungskräften waren 70% Geschäftsführer, des weiteren Inhaber sowie Bereichsleiter aus Marketing, Personal oder Finanzen. Tabelle 3 zeigt die Korrelationen der Variablen der Untersuchung untereinander.

Variablen	1	2	3	4	5	6	7	8	9
1 Social Media Nutzung	1.000								
2 Faktor 1: Wahrgen. Risiken	.416*	1.000							
3 Faktor 3: Wahrgen.Einfachheit	-.095	.000	1.000						
4 Barriere: zu hohe Aufwände	-.039	.070	.198*	1.000					
5 Barriere: zu geringe Erträge	-.140	.248*	.002	.435*	1.000				
6 Alter der Führungskraft	-.322*	.263*	.097	.130	.056	1.000			
7 Alter Unternehmen	-.058	.089	.035	-.023	-.035	.081	1.000		
8 Mitarbeiteranzahl	.063	-.088	-.035	-.056	-.138	-.096	.319*	1.000	
9 Umsatz (Schweizer Franken)	.081	.060	-.123	-.070	-.052	.015	.091	.418*	1.000

Anmerkungen: * Pearsons Korrelationskoeffizient mit Signifikanzniveau $p \leq 0.01$.

Tabelle 3: Ergebnisse der Korrelationsmatrix

3.5 Ergebnisse der Regression

Für die Regressionsanalyse werden die Faktoren 1 und 3, die in der explorativen Faktorenanalyse identifiziert wurden, als erklärende Variablen berücksichtigt (sowie die beiden Einzelvariablen zu Faktor 2). Zusätzlich werden das Alter der verantwortlichen Führungskraft, das Alter des Unternehmens und die Unternehmensgröße als Kontrollvariablen einbezogen. Die abhängige Variable der logistischen Regressionsanalyse, die Nutzung von Social Media, ist eine dichotome Variable, die misst, ob mindestens ein Angehöriger des KMU mindestens eine Social Media Anwendung aktiv nutzt oder nicht. Die Dummy Variable nimmt den Wert 1 an, wenn mindestens eine Person aktiv eine oder mehrere Social Media Anwendungen für Unternehmenszwecke nutzt. Andernfalls nimmt die Dummy Variable den Wert 0 an. Um Unterschiede in den Messskalen herauszurechnen, wurden für die Regression die unabhängigen Variablen und die Kontrollvariablen standardisiert. In den Ergebnissen der Regression (Tabelle 4) zeigen sich mit Hinblick auf die Kontrollvariablen lediglich signifikante Einflüsse auf den Einsatz von Social Media beim Alter der Führungskraft (negativ) und der Unternehmensgrösse nach Umsatz (positiv).

Variablen	Koeffizienten	
Konstante	-1.233	***
Alter der Führungskraft	-0.635	**
Unternehmensalter	-0.232	
Unternehmensgröße (Mitarbeiter)	-0.438	
Unternehmensgröße (Umsatz)	0.792	**
Barriere (wahrgen. Nützlichkeit): zu hohe Aufwände (H1)	0.124	
Barriere (wahrgen. Nützlichkeit): zu geringe Erträge (H1)	-0.612	**
Wahrgenommene Einfachheit der Anwendung (H2)	0.194	
Wahrgenommene Risiken (H3)	-1.027	***
Beobachtungen	132	
Nagelkerkes R^2	0.362	

Anmerkungen: * $0.1 > p \geq 0.05$; ** $0.05 > p \geq 0.01$; *** $p < 0.01$

Tabelle 4: Ergebnisse der logistischen Regression (Abhängige Variable: Social Media Nutzung)

Die Ergebnisse bestätigen die bereits aufgezeigte Heterogenität des Faktors „wahrgenommene Nützlichkeit" (Hypothese 1) aus der Faktorenanalyse. Während die Barriere zu „hoher Aufwand" keine Auswirkungen auf die Nutzung von Social Media hat, zeigt der Faktor „zu geringe Erträge" einen signifikant negativen Effekt ($p<0.05$). Anscheinend sehen die meisten Unternehmen nicht, auf welche Weise Social Media Anwendungen einen Nutzen für ihr Geschäft generieren können und wie sie diese Verbindung herstellen können. Entsprechend werden Social Media Anwendungen häufig als nicht nützlich wahrgenommen. Wenn Unternehmen dies allerdings so wahrnehmen, dann ist es auch weitestgehend irrelevant, falls die Aufwände einer Social Media Nutzung als gering wahrgenommen werden. In der Regression zeigt die „wahrgenommene Einfachheit der Anwendung" entsprechend keinen Einfluss auf die Nutzung von Social Media. Demgemäß wird Hypothese 2 nicht bestätigt. Dies zeigt auch, dass Unternehmen größtenteils nicht definiert haben, wie eine Strategie für die Verwendung von Social Media aussehen soll und wie eine derartige Strategie in den Geschäftsbetrieb integriert werden kann. Im Gegensatz dazu wird Hypothese 3 klar bestätigt ($p<0.01$). Der Hauptfaktor, der Führungskräfte von KMU davon abhält, Social Media zu nutzen, ist demnach ihre Wahrnehmung der damit verbundenen Risiken.

4 Diskussion und Implikationen

Diese Studie leistet einen Beitrag sowohl zur Forschung im Bereich der Nutzung von Social Media in KMU im speziellen als auch allgemein zur Weiterentwicklung des Technologie-Akzeptanz-Modells. Die Nutzung von Social Media nimmt zwar in der Gesellschaft und auch in Unternehmen generell zu. Dennoch fällt es gerade KMU schwer, Social Media für ihre Zwecke nutzenstiftend einzusetzen. Die vorliegenden Studie zeigt die bedeutenden Barrieren der Nutzung von Social Media auf und weist die wahrgenommenen Risiken als derzeit grösste Barriere bei der Entscheidung für den Einsatz von Social Media in KMU nach. Die zukünftige Forschung könnte sich auf ausgewählte Elemente derartiger Risiken ausrichten. Insbesondere wurden in der letzten Zeit Datenschutzrisiken mit der Verwendung des Internets und von web-basierten Dienstleistungen in Verbindung gebracht (Steinman und Hawkins 2010). Datenschutzrisiken umfassen jedoch unterschiedliche Facetten. Einerseits befürchten Führungskräfte den Verlust der Kontrolle über personen- und unternehmensbezogene Informationen. Andererseits fürchten sie, dass Mitarbeiter inkonsistente unternehmensbezogene Informationen nach außen kommunizieren, sich unangemessen verhalten oder vertrauliche Informationen verbreiten (Väyrynen et al. 2013). Darüber hinaus unterscheiden sich auch Datenschutzstrategien zwischen großen und kleinen Unternehmen. Zukünftige Forschung könnte diese Formen von Risiken in bestimmten Organisationsbereichen validieren und prüfen, inwieweit Investitionen in interne Prozesse zur Unterstützung von Social Media Initiativen die wahrgenommenen Risiken reduzieren.

Es erscheint zudem erforderlich, dass die Individuen-bezogene Betrachtung des ursprünglichen TAM generell im Kontext von Social Media Anwendungen in KMU erweitert wird um verschiedene organisationale Aspekte. So müssen Einschätzungen insbesondere bezüglich der Einfachheit und Nützlichkeit von Social Media neben der individuellen Ebene der rein operativen Anwendung auch Betrachtungen auf einer organisationalen Ebene der strategischen Anwendung auf Unternehmensebene gegenübergestellt werden. Nur weil eine Person operativ eine Facebook Page anlegen kann heisst dies noch nicht, dass ihr auch klar ist, welche Zwecke im Sinne der Unternehmensstrategie mit deren Verwendung erreicht werden können (Nützlichkeit) oder wie dies genau zu bewerkstelligen wäre (Einfachheit). Wenn dies aber nicht klar ist, wonach richten sich dann die Handlungen der Beteiligten in Social Media aus? Entsprechend ergeben sich weitere Fragen aufgrund der hohen Freiheitsgrade bei der Anwendung von Social Media durch Unternehmensbeteiligte. Insbesondere ist noch weitgehend offen, wie eine Integration der Vielfalt an persönlichen Einschätzungen und Verhaltensweisen bei den Beteiligten erfolgen kann (Semrau und Beier 2015), um die Nützlichkeit von möglichen und tatsächlichen Social Media Anwendungen im Unternehmen aufzeigen zu können, sowie notwendige Verhaltensweisen diesbezüglich abzuleiten bzw. zu koordinieren.

Der regionale Fokus der Studie muss als Limitation aufgefasst werden. Die Befragung basiert auf einer Stichprobe von Unternehmen in der deutschsprachigen Ostschweiz, welche hauptsächlich von peripheren und halbperipheren Regionen mit kleineren Städten als regionalen Zentren charakterisiert wird. Obwohl die Größe und das Alter der Unternehmen in der Stichprobe im Allgemeinen repräsentativ für die Unternehmen der Schweiz sind, weist die Stichprobe einen relativ hohen Anteil an Unternehmen im produzierenden Gewerbe auf. Daher können die Ergebnisse nicht ohne weiteres auf andere Teile der Schweiz bzw. auf städtische Regionen oder andere Länder übertragen werden.

Die erarbeiteten Erkenntnisse liefern wertvolle Implikationen für die verantwortlichen Führungskräfte von KMU. Grundsätzlich stellt die Nutzung von Social Media Plattformen für Unternehmenszwecke eine kostengünstige Alternative zu traditionellen Kommunikationsmassnahmen dar. Jedoch begegnen Geschäftsführer von KMU oftmals bedeutenden Herausforderungen, diese Potenziale auch auszuschöpfen und mit den relevanten Geschäftsprozessen zu verknüpfen. Dabei scheinen insbesondere die wahrgenommenen Risiken einen grossen Einfluss auf die Entscheidung zu haben, ob Social Media genutzt werden. Subjektiv wahrgenommener (Kontroll-)Verlust führt zu Unbehagen und Ängsten, weil mögliche negative Konsequenzen auftauchen können (Featherman und Pavlou 2003). Allgemein müssen Unternehmen die zu erwartenden Vorteile mit den möglichen negativen Konsequenzen gegeneinander abwägen. Der relativ geringe Anteil an Social Media nutzenden Unternehmen in der untersuchten Stichprobe zeigt dabei nicht nur, dass Risiken der Social Media Anwendung insgesamt als relativ hoch eingeschätzt werden. Sie zeigen auch, dass mögliche Vorteile (z.B. Kostenreduktion, Erträge) einer Social Media Anwendung demgegenüber als sehr gering angesehen werden. Social Media Plattformen bieten das Potenzial, einen Beitrag zur Profitabilität und zum Unternehmenswachstum zu leisten. Dies kann jedoch nur gelingen, wenn die Verantwortlichen wirklich verstehen, wie sie Social Media Aktivitäten strategisch in die Geschäftsprozesse integrieren und festlegen, auf welche Weise diese Aktivitäten Mehrwerte für bestimmte Geschäftszwecke generieren können. Nur wenn durch die Anwendung von Social Media nachvollziehbar Mehrwerte für KMU geschaffen werden, werden auch mehr KMU diese nutzen.

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Digitalisierung des inhabergeführten stationären Einzelhandels: Zur Rolle der Wahrnehmung von Wettbewerbsdruck und Kundenerwartungen

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Abstract

Die WI-Forschung hat mehrfach einen positiven Einfluss der Wahrnehmung von Wettbewerbsdruck und Kundenerwartungen auf die Adaptionsentscheidung im Hinblick auf Technologien in KMUs nachgewiesen. Aktuell stehen inhabergeführte stationäre Einzelhändler (ISEH) im Kontext der fortschreitenden Digitalisierung unter wachsendem Druck, ihre Geschäftsmodelle an sich ändernde Wettbewerbsumfelder und Einkaufsgewohnheiten anzupassen. Digitalisierung bedingt dabei nicht nur Handlungsdruck, sondern ermöglicht auch die Erschließung von Wettbewerbspotenzialen. Der vorliegende Beitrag basiert auf einer ISEH-Befragung, die den von den Händlern wahrgenommenen Einflussfaktoren Wettbewerbsdruck und Kundenerwartungen untersucht und mit ihrer aktuellen bzw. ihrer zukünftigen Bereitschaft zur Nutzung von digitalen Services in Beziehung setzt.

Die Ergebnisse bestätigen, dass die Wahrnehmung von Wettbewerbsdruck und Kundenerwartungen auch im ISEH einen positiven Einfluss auf die Adaptionsentscheidung hat. Ein Großteil der befragten Händler schätzt allerdings die Kundenerwartungen bzgl. digitaler Services überraschend gering ein und zögert bei der Entwicklung digitaler Geschäftsmodelle.

1 Einführung

Der Einzelhandel befindet sich in einer intensiven Phase der Veränderung. In einem von geringem Wachstum geprägten Marktumfeld steht der inhabergeführte stationäre Einzelhandel (ISEH) hierbei besonders unter Druck (vgl. HDE 2015, p. 7). Der Marktanteil des ISEH ist von 30% im Jahr 1995 auf 14% im Jahr 2014 gesunken (vgl. Collier International 2015). Im Jahr 2014 war der ISEH die Händlergruppe mit den höchsten Umsatzrückgängen in Deutschland, und auch für die Zukunft werden Umsatzrückgänge im ISEH um bis zu 30% bis 2020 bzw. bis 2023 prognostiziert (vgl. IFH Köln 2015; vgl. Heinemann 2014). Den starken Wachstumsraten des Online-Handels zum

Trotz (17,8% in 2014 (vgl. HDE 2015)), ist der deutsche Einzelhandel weiterhin deutlich stationär geprägt und der stationäre Handel stellt in vielen Städten und Gemeinden einen bedeutenden Wirtschaftsfaktor dar (HDE 2015, p. 9). Obgleich der Online-Handel im Jahr 2014 lediglich einen Marktanteil von 11,1% (vgl. Statista 2015) erreicht hat, hat er sich dennoch im Hinblick auf Service-Qualität und Shopping-Convenience bereits zum Taktgeber der gesamten Branche entwickelt (vgl. Heinemann, Schwarzl 2010). Dieser wachsende E-Commerce-Einfluss, der sich nicht nur durch den Erfolg prominenter „pure Player“, sondern auch durch eine zunehmende Digitalisierung originär stationär agierender Filialisten manifestiert, sowie das sich wandelnde Einkaufsverhalten der Kunden (vgl. IFH 2014; ECC 2011) setzen dem ISEH stark zu und führen insbesondere Händler mit klassischen Geschäftsmodellen an ihre Grenzen. Auf der anderen Seite birgt eine individuelle und zielorientierte Digitalisierungsstrategie auch für ISEH Potenziale im Hinblick auf Marktentwicklung, Kundenzufriedenheit und Wettbewerbsfähigkeit (vgl. Navickas et al. 2015).

Noch aber scheint die Diffusion digitaler Handlungsansätze im ISEH auf hohe Barrieren zu stoßen, denn es sind nur vereinzelt entsprechende Aktivitäten zu beobachten (vgl. Bollweg et al.). Dieses Phänomen ist beachtenswert, da die Forschung zu E-Business / E-Commerce-Technologien in kleinen und mittelständischen Unternehmen (KMU) immer wieder gezeigt hat, dass die Wahrnehmung von Wettbewerbsdruck und von Kundenerwartungen im Hinblick auf digitale Services und Angebote einen positiven Einfluss auf die Adaptionsentscheidung der Unternehmen hat (siehe Literatur Analyse Tabelle 1). Viele der entsprechenden Studien basieren dabei auf dem Technology-Organisation-Environment-Framework (TOE) (vgl. Tornatzky et al. 1990) bzw. einer Weiterentwicklung davon.

Die vorliegende Untersuchung geht vor diesem Hintergrund den folgenden Fragen nach: 1) Nehmen die ISEH in der befragten Stadt E-Commerce-basierten Wettbewerbsdruck wahr und wie schätzen Sie die Erwartungen ihrer Kunden im Hinblick auf digitale Services und Angebote ein? 2) Bestätigen die Befragungsergebnisse die oben dargestellten Erkenntnis der TOE-basierten Forschung eines positiven Einflusses von wahrgenommenem Wettbewerbsdruck und Kunden-erwartungen auf die Adaptionsentscheidung der Unternehmen (hier ISEH)? 3) Entsprechen der wahrgenommene Wettbewerbsdruck und die wahrgenommenen Kundenerwartungen den in aktuell verfügbaren Studien dokumentierten Ergebnissen und welche Erkenntnisse lassen sich aus einer etwaigen Übereinstimmung bzw. Dissonanz ableiten? Zur Beantwortung der Fragen wird u.a. ein Strukturgleichungsmodell herangezogen, das die Wahrnehmung des Wettbewerbsdrucks und die Wahrnehmung der Kundenerwartungen des ISEH mit der von den Befragten kommunizierten aktuellen und geplanten zukünftigen Nutzung von E-Business / E-Commerce-Technologien im ISEH in Beziehung setzt. Die zur Datensammlung durchgeführte Händlerbefragung im ISEH in (Stadt wird nach dem Begutachtungsprozess ergänzt) adressierte dementsprechend den Grad des (1) wahrgenommenen Wettbewerbsdrucks und (2) der wahrgenommenen Kundenerwartungen, sowie (3) den aktuellen Stand der Digitalisierung und (4) die Absicht einer zukünftigen Nutzung von digitalen Technologien im ISEH.

Die in Abschnitt 2 folgende strukturierte Literaturanalyse gibt zunächst einen Überblick über die auf dem TOE-Framework aufbauenden Studien zur Adaption von E-Business / E-Commerce-Technologien in KMUs und zeigt den jeweilig festgestellten Einfluss von wahrgenommenem Wettbewerbsdruck und wahrgenommenen Kundenerwartungen. In Abschnitt 3 werden darauf aufbauend das formulierte Strukturgleichungsmodell sowie die zugrundeliegenden Hypothesen erläutert. Abschnitt 4 beinhaltet schließlich die Ergebnisse im Hinblick auf die formulierten

Forschungsfragen und Abschnitt 5 schließt den Beitrag mit einer Zusammenfassung und einem Ausblick ab.

2 Literaturanalyse

In der Wirtschaftsinformatik existiert eine Vielzahl an theoretischen Modellen zur Adaption von Innovationen und Technologien in kleinen und mittleren Unternehmen. Ramdani und Kawalek (2007) haben neben dem bereits angesprochenen Technology-Organisation-Environment-Framework (TOE-Framework) acht weitere in diesem Kontext genutzte Modelle identifiziert:

- Technology Acceptance Model (TAM)
- Theory of Planned Behaviour (TPB)
- Combined TAM and TPB
- TAM2
- Innovation diffusion theory
- Resource-based view
- Stage theory
- Unified Theory of Acceptance and Use of Technology (UTAUT)

Ramdani und Kawalek (2007) zeigen, dass auch bei den acht genannten Modellen typischerweise Faktoren aus den Bereichen Technologie, Organisation und Umwelt / Umfeld in Bezug auf die Adaptionsentscheidung untersucht werden. Das vor diesem Hintergrund hier gewählte und in Abbildung 1 dargestellte Technology-Organisation-Environment (TOE) Framework von Tornatzky und Fleischer (1990) adressiert diese Bereiche unmittelbar und wurde in vielen Studien getestet und validiert (Siehe Tabelle 1).

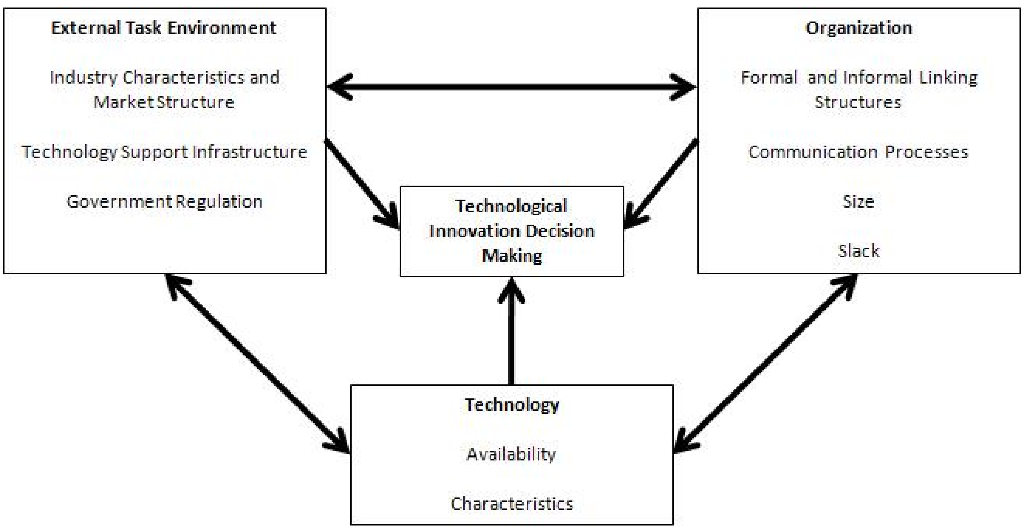

Abbildung 1: TOE-Framework (vgl. Tornatzky et al. 1990)

Das TOE-Framework wurde dabei je nach Studie angepasst und weiterentwickelt, z.B. insbesondere durch Ergänzung spezifischer Kategorien oder neuer Faktoren innerhalb der definierten Kategorien. Ein großer Teil der hier erfassten TOE-Studien hat die einzelnen Datenwerte für die untersuchten Einflussfaktoren primär, also in Befragungen und Interviews erhoben. Tabelle 1 fasst die Ergebnisse der Literaturanalyse zu TOE-basierten Untersuchungen im

Hinblick auf die jeweils verwendeten Einflussfaktoren und den identifizierten Zusammenhang zwischen der Wahrnehmung von Wettbewerbsdruck und Kundenerwartungen auf die Adaptionsentscheidung zusammen.

Autoren	Technologien	Untersuchte Faktoren	Auswirkung auf Adaption (Positiv / Negativ / Neutral)	
			Kundenerwartungen	Wettbewerbsdruck
Premkumar, Roberts (1999)	Email, Online Datenzugang, Internetzugang und EDI	Relative Advantage, Cost, Compatibility, Complexity, Top-Management Support, IT Expertise, Size, Competitive Pressure, External Pressure, Vertical Linkages, External Support	-	Positiv
Rashid (2001)	Allgemeines Framework	Relative Advantage, Complexity, Compatibility, Cost, Image, Competitive Pressure, Suppliers / Buyers Pressure, Public Policy, Governments Role, Size, Quality of IS Systems and Capabilities, Information Intensity, Specialization, Top-Management Support, CEOs Innovativness, CEOs IS / IT / EC Knowledge	Positiv	Positiv
Zhu et al. (2002)	Allgemeines Framework	Consumer Readiness, Competitive Pressure, Technology Competence, IT-Infrastructure, IT Expertise, E-business Know How, Firm Size, Lack of Trading Partner Readiness	Positiv	Positiv
Wymer, Regan (2005)	E-Commerce Technologies	Competitive Pressure, Government, Market, Partners / Vendors, Suppliers Readiness, Change Experience, Executive Experience, Innovativness, Models, Need, Prior Experience, Trust, Understanding, Value, Capital, Employee Reduction, Priority, Profitabilty, Technical Expertise, Cost, EC TEchnology, Infrastructure, Reliability, Security, Technology Availability, Other	-	Positiv
Lippert, Govindarajulu (2006)	Web Services	Security Concerns, Reliability, Deployability, Firm Size, Firm Scope, Technology Knowledge, Preceived Benefits, Competitive Pressure, Regulatory Influence, Dependend Partner Readiness, Trust in Web Service Provider	-	Positiv
Al-Qirim (2007)	Internet, Internal Email, External Email, Intranet, Extranet / VPN, Internet - EDI, Website	Size, Information intensity of product, Competition, Buyer / Supplier pressure, Support from Technology vendors, Relative Advantage, Cost, Compatibility, CEOs Innovativeness, CEOs Involvement	Positiv	Positiv
Chong (2008)	E-Commerce Technologies	Firm Size, Firm Age, Management Support, Perceived Readiness, International Orientation, Relative Advantage, Complexity, Compatibility, Trialability, Observability, Information Sources, Communication Channels, Communication Amount, Pressure from Trading Partners, Competitive Pressure, Relevant Environmental Participation, Non-trading, Institutional Influence, Government Support, Customer Pressure, Supplier Pressure	Positiv	Positiv
Ramdani, Kawalek (2007)	Allgemeines Framework	Relative Advantage, Compatibility, Complexity, Trialability, Observability, Top-Mangement Support, Organisational Readiness, IS Experience, Size, Industry, Maket Scope, Competitive Pressure, External IS Support	-	Positiv
Oliveira, Martins (2010)	Allgemeines Framework	Technology Readiness, Technology Integration, Firm Size, Perceived Benefits and Obstacles of E-business, Country, Industry, Competitive Pressure, Trading Partner Collaboration	-	Positiv
Ghobakhloo et al. (2011)	Email, Intranet, Extranet / VPN, EDI, Website, ESCM, EFT	Perceived Relative Advantage, Perceived Compatibility, Cost, Information Intensity, CEO Knowledge, CEO Innovativness, Business Size, Competition, Buyer / Supplier Pressure, Support from Technology Vendors	Positiv	Positiv
Alshamaila et al. (2013)	Cloud Computing	Relative advantage, Uncertainty, Compatibility, Complexity, Trialability, Size, Top-Management Support, Innovativness, Prior IT Experience, Competitive Pressure, Industry, Market Scope, Supplier Efforts and External Computing Support	-	Positiv
Jones et al. (2013)	Enterprise Applications	Relative Advantage, Compatibility, Complexity, Trialability, Observability, Top-Mangement Support, Organisational Readiness, IS Experience, Size, Industry, Maket Scope, Competitive Pressure, External IS Support	-	Positiv
Rahayu, Day (2015)	E-Commerce Technologies	Perceived Benefits, Compatibility, Cost, Technology Readiness, Firm Size, Customer / Supplier Pressure, Competitor Pressure, External Support, Innovativness, IT Ability, IT Experiences	Positiv	Positiv

Tabelle 1: Literaturanalyse zu Einflussfaktoren in TOE-Frameworks

3 Hypothesen und Strukturgleichungsmodell

Um der im ersten Abschnitt formulierten zweiten Forschungsfrage „Bestätigen die Befragungsergebnisse die oben dargestellten Erkenntnis der TOE-basierten Forschung eines positiven Einflusses von wahrgenommenem Wettbewerbsdruck und Kundenerwartungen auf die Adaptionsentscheidung der Unternehmen (hier ISEH)?“ nachzugehen, werden im vorliegenden Kapitel die folgenden Hypothesen mit Hilfe eines Strukturgleichungsmodells untersucht:

H1: Die Wahrnehmung von hohem Wettbewerbsdruck hat einen positiven Einfluss auf die aktuelle Nutzung von digitalen Services im ISEH.

H2: Die Wahrnehmung von hohem Wettbewerbsdruck hat einen positiven Einfluss auf die Absicht im ISEH digitale Services zukünftig zu nutzen.

H3: Die Wahrnehmung von hohen Kundenerwartungen gegenüber digitalen Services hat einen positiven Einfluss auf die aktuelle Nutzung von digitalen Services im ISEH.

H4: Die Wahrnehmung von hohen Kundenerwartungen gegenüber digitalen Services hat einen positiven Einfluss auf die Absicht im ISEH digitale Services zukünftig zu nutzen.

H5: Die aktuelle Nutzung von digitalen Services im ISEH hat einen positiven Einfluss auf die Absicht im ISEH digitale Services zukünftig zu nutzen.

Die Datengrundlage für die Untersuchung wurde im Februar 2015 durch eine Befragung unter inhabergeführten stationären Einzelhändlern in einer mittleren Kleinstadt (46.000 Einwohner) (Name wird nach der Review ergänzt) geschaffen, die von der Wirtschafts- und Marketing GmbH (WMS) der Stadt unterstützt wurde. Die WMS stellte 135 Adressdatensätze von lokalen Einzelhändlern zur Verfügung, von denen 85 den Anforderungen der Untersuchung an inhabergeführte stationäre Einzelhändler (ISEH) entsprachen (z.B. Ladenlokal, gängige Öffnungszeiten, Konsumgüterangebot). Von den 85 ISEH, die persönlich aufgesucht und zur Teilnahme an der Umfrage eingeladen wurden, nahmen 44 in Papierform (51,8%) und 8 (9,4%) über ein Online-Formular teil. Die Befragung umfasste insgesamt 227 Fragen im Likert-Skalen Format.

Zur Auswertung der gesammelten Daten und um die Beziehungen zwischen den verschiedenen durch die Hypothesen vorgegebenen Konstrukten untersuchen zu können, wurde das nachfolgende Strukturgleichungsmodell (SGM) entwickelt. Das äußere Modell, auch Messmodell genannt, spezifiziert dabei die Beziehungen zwischen den Konstrukten und deren Indikatoren, während das innere Modell, welches Strukturmodell genannt wird, die Beziehungen zwischen den Konstrukten abbildet (vgl. Fornell und Larcker 1981; Chin 1998a).

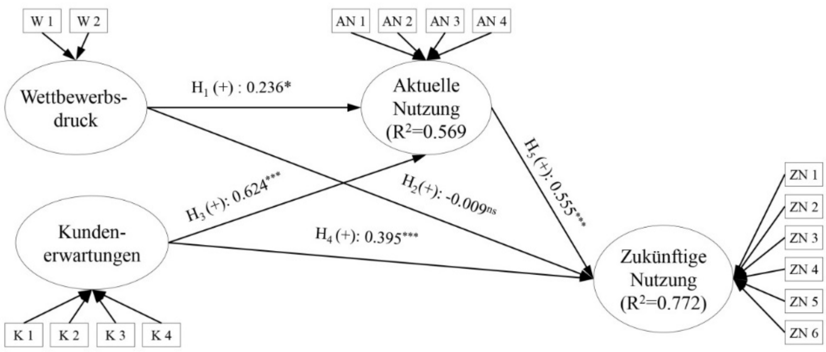

Abbildung 2: Das Strukturgleichungsmodell

Tabelle 2 zeigt die verwendeten Konstrukte und Indikatoren sowie die zugehörigen Fragen aus der Befragung im Zusammenhang.

Konstrukt	Indikator	Frage
Zukünftige Nutzung	ZN1	Wie ist Ihre Absicht einer zukünftigen Nutzung von Videotelefonie in Ihrem Unternehmen?
	ZN2	Wie ist Ihre Absicht einer zukünftigen Nutzung einer Smartphone Zahlungsoption in Ihrem Unternehmen?
	ZN3	Wie ist Ihre Absicht einer zukünftigen Nutzung einer Service-App (Beratung / Verkauf) in Ihrem Unternehmen?
	ZN4	Wie ist Ihre Absicht einer zukünftigen Nutzung eines Onlineshops in Ihrem Unternehmen?
	ZN5	Wie ist Ihre Absicht einer zukünftigen Nutzung von sozialen Netzwerken in Ihrem Unternehmen?
	ZN6	Wie ist Ihre Absicht einer zukünftigen Einbindung von Kunden in Entscheidungen über Ihr Produktangebot?
Aktuelle Nutzung	AN1	Wie schätzen Sie die Häufigkeit der aktuellen Nutzung von Emails zur Unternehmenskommunikation in Ihrem Unternehmen ein?
	AN2	Wie schätzen Sie die Häufigkeit der aktuellen Nutzung von Zahlung per EC / Kreditkarte in Ihrem Unternehmen ein?
	AN3	Wie schätzen Sie die Häufigkeit der aktuellen Nutzung Ihrer bestehenden Internetseite ein?
	AN4	Wie schätzen Sie die Häufigkeit der aktuellen Nutzung einer Kundenkarte in Ihrem Unternehmen ein?
Wettbewerbs-druck	W1	Wie stark übt der lokale Handel Konkurrenzdruck aus?
	W2	Wie stark übt der Online-Handel Konkurrenzdruck aus?
Kunden-erwartungen	K1	Wie häufig nehmen Sie wahr, dass Ihre Kunden digitale Anwendungen begleitend zum Einkauf nutzen?
	K2	Wie stark fragen Ihre Kunden einen Onlineshop von Ihnen nach?
	K3	Wie stark fragen Ihre Kunden Kundenkarten bei Ihnen nach?
	K4	Wie stark fragen Ihre Kunden Lieferung frei Haus nach?

Tabelle 2: Fragebogen

Zur empirischen Datenanalyse kam SmartPLS zum Einsatz, was die Anwendung eines PLS-Algorithmus und von Bootstrapping als Resampling-Methode ermöglichte (vgl. Ringle et al. 2005; Nkhoma et al. 2013). Da der PLS-Algorithmus nicht alle Beziehungen gleichzeitig, sondern immer Teilmengen evaluiert oder überprüft (vgl. Hair 2014), führt seine Anwendung auch bei kleinen Stichproben zu zuverlässigen Ergebnissen. Das Bootstrapping mit 5000 Stichproben und 52 Fällen kommt zur Bestimmung der Signifikanz der Ladungen, Gewicht und Pfadkoeffizienten zum Einsatz (vgl. Chin 1998b). Um eine Multikollinearität der Indikatoren eines formativen Konstruktes ausschließen zu können erfolgte zudem eine Überprüfung mit Hilfe von SPSS.

3.1 Messmodell

Die in Messmodellen zu unterscheidenden reflektiven und formativen Konstrukte gehen mit jeweils unterschiedlichen Anforderungen einher (vgl. Fornell, Bookstein 1982). Da jedoch das vorliegende Modell ausschließlich aus formativen Konstrukten besteht, werden reflektive Konstrukte hier nicht weiter betrachtet (vgl. Henseler et al. 2009; Straub 1989). Die gegebenen formativen Konstrukte werden von ihren Indikatoren bestimmt, was bedeutet, dass eine Veränderung eines Indikators das Konstrukt verändert. Andersherum hat jedoch die Veränderung eines Konstrukts keinen Einfluss auf seine Indikatoren (vgl. Bollen, Lennox 1991; Jarvis et al.). Um die Signifikanz der Indikatoren zu analysieren, müssen die Gewichte und die t-Werte den folgenden Anforderungen entsprechen: Der t-Wert eines signifikanten Indikators muss die Grenze von 1.65 überschreiten, was ein Signifikanzniveau von 10% impliziert (vgl. Hair 2006). Für ein Signifikanzniveau von 5% (1%) muss der t-Wert 1.96 (2.57) überschreiten (vgl. Hair 2006; Huber et al. 2007). Das Gewicht muss zudem größer als 0.1 sein (vgl. Chin 1998b). Tabelle 3 zeigt alle Indikatoren des vorliegenden Modells sowohl die t-Werte und die zugehörigen Gewichte, als auch das resultierende Ergebnis im Hinblick auf die Signifikanz.

Konstrukt	Indikator	Gewicht	*t*-Wert	Signifikanz
Zukünftige Nutzung	ZN1	0.183	1.366	ns
	ZN2	0.431	2.667	***
	ZN3	-0.107	0.851	ns
	ZN4	0.277	2.145	**
	ZN5	0.383	3.218	***
	ZN6	0.064	0.629	ns
Aktuelle Nutzung	AN1	0.544	3.261	***
	AN2	0.024	0.301	ns
	AN3	0.273	1.909	*
	AN4	0.495	3.291	***
Wettbewerbs-druck	W1	0.602	2.241	**
	W2	0.612	2.370	**
Kunden-erwartungen	K1	0.118	0.853	ns
	K2	0.807	5.542	***
	K3	0.245	1.764	*
	K4	0.175	1.548	ns

ns= nicht signifikant; *p<0.10; **p<0.05; ***p<0.01.

Tabelle 3: Testergebnisse

In dem Konstrukt „Zukünftige Nutzung“ sind drei von sechs Indikatoren mit positivem Einfluss signifikant. Das Konstrukt „Aktuelle Nutzung“ beinhaltet mit AN1, AN2 und AN3 ebenfalls drei signifikante Indikatoren mit jeweils positivem Einfluss. Für das Konstrukt „Wettbewerbsdruck“ überschreiten beide t-Werte die Grenze von 1.96 und erreichen damit einen Signifikanzlevel von 5%. Auch hier liegt ein positiver Einfluss der Indikatoren auf das zugehörige Konstrukt vor. Im Konstrukt „Kundenerwartungen“ sind lediglich die Indikatoren K2 und K3 signifikant, wobei der t-Wert von K2 die Grenze von 2.57 (1%) und im Falle von K3 die Grenze von 1.65 (10%) überschreitet. Beide Indikatoren liegen zudem über der Gewichtuntergrenze von 0.1. Zu der Signifikanz der Indikatorgewichte ist auch die Diskriminanzvalidität für die formativen Konstrukte erfüllt. Die höchste Korrelation zwischen den latenten Variablen besteht zwischen den Konstrukten „Aktuelle Nutzung“ und „Zukünftige Nutzung“ mit 0.8357 und überschreitet nicht die Höchstgrenze von 0.9. Die mit SPSS durchgeführte Untersuchung auf Multikollinearität ergab schließlich, dass alle verwendeten Indikatoren des Modells unterschiedlich und unabhängig sind.

3.2 Strukturmodell

Zur Modellvalidierung wurden auch die enthaltenen Konstrukte mit Hilfe des VIF (Varianzinflationsfaktor, $VIF=1/(1-R^2)$) auf Multikollinearität untersucht (vgl. Weiber, Mühlhaus 2010). Der VIF liegt dabei unter der erforderlichen Grenze von 10, so dass auch hier keine Multikollinearität vorliegt (vgl. Diamantopoulos, Winkelhofer 2001; Huber et al. 2007). Dabei handelt es sich bei R^2 um das Bestimmungsmaß, welches auf einen großen Einfluss hinweist, wenn der Wert die Grenze von 0.67 überschreitet. Oberhalb der Grenze von 0.33 ist von einem mittleren Einfluss der unabhängigen latenten Variablen auf die abhängige latente Variable auszugehen. Ein zumindest geringer Einfluss wird durch ein R^2 von über 0.19 begründet (vgl. Chin 1998b). In der Abbildung 2 oben sind die Werte der unterschiedlichen Kriterien unseres Modells aufgezeigt. Der VIF ist deutlich unter 10 und R^2 erreicht mit $R^2=0.569$ einen mittleren Wert für die „Aktuelle Nutzung“ und mit $R^2=0.772$ einen hohen Wert für die „Zukünftige Nutzung“.

Die in Abbildung 2 dargestellten t-Werte und Pfadkoeffizienten geben nun Aufschluss über die Richtigkeit der formulierten Hypothesen. Demnach sind mit Ausnahme der Beziehung von

„Wettbewerbsdruck“ und „Zukünftiger Nutzung“ alle Beziehungen bedeutsam und weisen tWerte von mindestens 1.65 auf (vgl. Weiber und Mühlhaus 2010).

4 Ergebnisse

Im Hinblick auf die in Abschnitt 1 formulierten Forschungsfragen lassen sich nun die folgenden Ergebnisse ableiten.

Zu Frage 1): Abbildung 3 fasst ausgewählte Ergebnisse der Befragung zusammen. Die vollständigen deskriptiven Umfrageergebnisse sind online verfügbar unter: (Wird nach der Review ergänzt)

Abbildung 3: Ausgewählte Befragungsergebnisse (n=44)

Die befragten ISEH schreiben der Digitalisierung demnach eine hohe zukünftige Bedeutung zu und sie nehmen einen insgesamt ausgeprägten Wettbewerbsdruck wahr, den sie auch wesentlich auf den zunehmenden Online-Handel zurückführen (54% = starker bis sehr starker Wettbewerbsdruck durch Online-Händler, (ergänzend: 45,2% = starker bis sehr starker Wettbewerbsdruck durch lokale Konkurrenten)). Die Antworten auf die Frage zur Kundenabwanderung in Richtung Online-Handel lassen dagegen darauf schließen, dass diesbezüglich bisher noch kein klares Bild vorhanden ist. Gleiches gilt für die Wahrnehmung der Nutzung von digitalen Anwendungen, die von den Kunden begleitend zum Einkauf genutzt werden. Überraschenderweise nehmen die befragten ISEH bisher kaum Kundenerwartungen in Bezug auf digitale Services wahr (64,1% = geringe bis sehr geringe Kundenerwartungen). Die eigene Personalsituation in den meistens sehr kleinen Unternehmen (36 ISEH < 10 Mitarbeiter, nur 2 > 20 Mitarbeiter) wird als überwiegend positiv eingeschätzt und stellt damit zumindest nach eigener Einschätzung der Händler keinen Hinderungsgrund im Hinblick auf die Implementierung digitaler Services / Angebote dar.

Zu Frage 2): Die Wahrnehmung von Wettbewerbsdruck (H1) und von Kundenerwartungen (H3) führen auch im vorliegenden Betrachtungskontext der ISEH zu einer höheren aktuellen Nutzung von digitalen Services. Es konnte dagegen kein Zusammenhang zwischen der Wahrnehmung von Wettbewerbsdruck (H2) und einer zukünftigen Nutzung von digitalen Services ermittelt werden. Dies erreicht nur die Wahrnehmung von Kundenerwartungen (H4), die somit eine besondere Rolle bei der Digitalisierung des ISEH spielt. Darüber hinaus geht eine aktuelle Nutzung von digitalen Services auch mit einer höheren Bereitschaft im Hinblick auf eine zukünftige Nutzung einher (H5), was darauf schließen lässt, dass die entsprechenden Händler mit den Effekten ihrer bisherigen Bemühungen zufrieden sind bzw. zumindest Erfolgspotenziale daraus ableiten.

Zu Frage 3): Setzt man die Ergebnisse der Befragung nun mit den Ergebnissen der Hypothesenüberprüfung mit Hilfe des SGM und den im ersten Abschnitt angeführten Studien zur Änderung des Kundenverhaltens in Beziehung, zeichnet sich das folgende Bild: Die ISEH nehmen den nachweislich für Digitalisierungsaktivitäten relevanten Wettbewerbsdruck wahr und fühlen sich personell auch gut aufgestellt. Im Hinblick auf die zusätzlich auch für ein zukünftiges Digitalisierungsbestreben relevanten Kundenerwartungen offenbart sich jedoch ein Widerspruch. Während eine in der gleichen Stadt nur zwei Monate vor der vorliegenden Befragung durchgeführte Kundenbefragung durch das IFH zeigt, dass bereits über 45% der befragten Innenstadtkunden ihr Verhalten in Richtung Onlinehandel geändert haben (IFH 2014), nehmen die ISEH kaum Erwartungen in Bezug auf digitale Angebote und Services ihrer Kunden wahr.

Zieht man das in Abbildung 4 dargestellte SERVQUAL Gap-Model nach Parasuraman et al. 1985 für eine erste Interpretation heran, weisen die Ergebnisse auf eine wachsende Lücke 1 (tatsächliche Kundenerwartung – wahrgenommene Kundenerwartung) hin. Diese Lücke birgt die Gefahr, dass die Services und Angebote der Händler an den Erwartungen der Kunden vorbei konzipiert werden, was bei der Qualitätswahrnehmung der Kunden, die als Abgleich der erwarteten und letztlich erlebten Services / Angebote zu einer Über- bzw. Untererfüllung und damit negativen Einschätzung führen kann (Lücke 5).

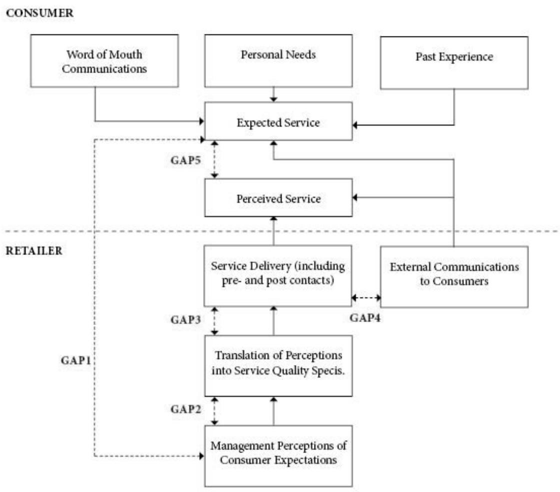

Abbildung 4: SERVQUAL Gap-Model (Parasuraman et al. 1985)

5 Zusammenfassung und Ausblick

Die dem vorliegenden Beitrag zugrunde liegende Untersuchung bestätigt die bestehenden auf dem TOE-Framework aufbauenden Untersuchungen zur Adaption von Innovationen und Technologien in kleinen und mittleren Unternehmen. Die Wahrnehmung von Wettbewerbsdruck und Kundenerwartungen hat auch im ISEH einen positiven Einfluss auf die aktuelle Nutzung und im Falle der Kundenerwartung auch auf die Adaptionsneigung der befragten Händler im Hinblick auf digitale Services und Angebote.

Besondere Aufmerksamkeit verdient die Beobachtung, dass trotz einer hohen Wahrnehmung von Wettbewerbsdruck (Online wie Offline) fast Zweidrittel (64,1%) der ISEH nur geringe bis sehr geringe Kundenerwartungen bezüglich digitaler Services sehen. Dieses Ergebnis weist auf eine wachsende Kluft zwischen tatsächlichen und wahrgenommenen Kundenerwartungen mit zumindest potenziell negativen Implikationen für die ohnehin problematische Wettbewerbssituation des ISEH hin.

Andererseits sieht sich der ISEH im Hinblick auf die Einführung von digitalen Services und Angeboten aber zumindest personell gut gerüstet und sollte dann seine Digitalisierungsoptionen unter Wettbewerbsgesichtspunkten entsprechend konsequent sichten, bewerten und nutzen (vgl. Navickas et al. 2015). Hieraus ergeben sich für die Autoren zwei sich anschließende zukünftige Forschungsfragen: 1) „Wie realistisch ist die Selbsteinschätzung der ISEH im Hinblick auf die digitale Kompetenz in ihren Unternehmen?“ und 2) „Welche Handlungsoptionen sowohl technischer als auch nichttechnischer Natur bieten sich dem ISEH überhaupt und welche Anforderungen bzw. Herausforderungen und Potenziale würden mit einer Implementierung dieser Optionen einhergehen?

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Mutual Understanding in e-Negotiations

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Abstract

Communication is a central aspect of the negotiation process. Ultimately, the communicative acts need to be understood to create the wanted effect for the involved parties. Negotiation support systems (NSS) focus on the support of a particular form of communication, namely of negotiations conducted over an electronic medium. In addition to communication support they also deliver decision support, document management, and sometimes conflict management. Current approaches to communication support mainly focus on making the intent of messages explicit whilst not considering the content of the message. We argue that both intent and content need to be understood to create general understanding. Consequently, we focus on the content and propose the introduction of ontologies as a means to enhance the message content by formalised constructs for explicitly stating the relevant knowledge and its relationships.

1 Introduction

Negotiations are part of almost every business transaction. Intra-organisational as well as inter-organisational negotiations consist of communication tasks and decision making. Traditionally, negotiations have been conducted face-to-face. By now, electronic negotiations have been established as a valid alternative to face-to face negotiations. A study conducted in 2005 showed that this new kind of negotiation had already been accepted by more than 50% of the participating companies (Schoop et al. 2008). Ten years on, this number has increased significantly.

Communication plays an important role in negotiations of all kinds. A critical part of this role is the discovery and ultimately prevention of misunderstandings and errors which appear during negotiations. Lai et al. (2010) mention that language familiarity plays a critical role in successful e-negotiations and Lewicki et al. (2006) show that high quality negotiations require clear and accurate communication, but these terms are quite abstract.

Schoop et al. (2010) looked into what constitutes good communication in e-negotiations and came up with the construct of communication quality in e-negotiations. They mention that good communication quality "… implies a shared understanding of the terms and spirit of the deal…" and can be measured in terms of the difference between the self-evaluation and evaluation of the partner in factual, relational, and procedural communication elements.

This aspect of shared understanding can be found again in Te'eni's cognitive-affective model of organizational communication (Te'eni 2001). The mutual understanding between the communicating parties is one of the impact factors of successful communication. He finds three different influences on the communication quality which can be changed during the communication process, namely the strategy, the medium of communication, and the message form.

Attempting to support the process of negotiation with ICT would, therefore, not only consist of a support in terms of decision making but also in the support of the whole communication process with the goal to improve the mutual understanding between the parties which in turn would improve the communication quality, leading to more successful negotiations. While there are many ways to support negotiations (Kersten and Lai 2007), our paper will discuss the support of negotiations with negotiation support systems.

The research goal of this paper is the design of a new approach for supporting communication in negotiation support systems. To fulfil this goal, the work is structured in the following way: First, the state-of-the-art in communication support via NSS is established. Communication complexity and communication quality are then further analysed. On this basis, the quality elements such a communication support approach needs to fulfil are discussed. Our approach is then presented and in the last part, its implications are reported on.

2 Theoretical Background

2.1 Negotiation

Negotiation has been described by Bichler et al. (2003) as "an iterative communication and decision making process between two or more agents (parties or their representatives) who cannot achieve their objectives through unilateral actions, exchange information comprising offers, counter-offers and arguments, deal with interdependent tasks and search for a consensus which is a compromise decision." Gulliver (1979) defines the negotiation process as "one of information exchange and of consequent learning and adjustment by the parties." Both of these definitions have the exchange of information as a central idea for negotiations, which allows the parties to find a consensus, which is not possible through unilateral action.

E-negotiation, therefore, is the process of conducting negotiations over an electronic medium which supports the communication and decision making process in some way that is only enabled by means of technology (Ströbel and Weinhardt 2003).

Whilst there are several different philosophies for the support of e-negotiations, this paper focusses on the idea of supporting negotiations with a negotiation support system (NSS). An NSS is defined by Kersten and Lai (2007) as "a software which implements models and procedures, has communication and coordination facilities, and is designed to support two or more parties and/or a third party in their negotiation activities." These systems therefore support the user during the negotiation process by providing tools for communication, decision making and document management (Schoop 2003). This paper focusses on the communication part of NSSs.

2.2 Theories of Communication

In order to understand the problems of communication during a negotiation, a deeper look into what constitutes as good communication is required. According to Schoop et al. (2010), the quality of communication has to be analysed on different levels. On a syntactic level, the communication has to be noise-free, i.e. the recipient needs to be able to access the whole message without distortions. But just being able to receive this message is not enough. It also has to make sense on a semantic level which means that there has to be a common interpretation of the transmitted signals. Lastly, this message has a certain intent which is measured on the pragmatic level. Duckek (2010) notes that since communication is not a unidirectional process but rather bidirectional, only assessing the quality of the communication is not enough. Efficiency of the communication i.e. the effort needed to create this common understanding, is also important as well as the impact on the relationship between the negotiating parties like changes in trust. This means that the goal of communication support is not only to be effective in transferring the message on all semiotic levels but also needs to keep the efficiency and its impact on the relationship between sender and receiver in mind.

Having clarified the requirements of good communication, the next step is to analyse the process of communication in order to understand the impacts of low-quality. For the purpose of analysing communication under these aspects, the cognitive-affective model of organisational communication (Te'eni 2001) is used. It describes communication as a combination of communication inputs, the communication process itself and the communication impact and builds on the ideas of Habermas (1984). The inputs include the task which is being communicated, the distance between the sender and receiver(s) in both affective and cognitive dimension, and their values and norms. These inputs fit the communication quality of Schoop et al. (2010) in (i) cognitive distance as the difference in interpretation of messages on a semantic level and (ii) the values and norms as well as the affective distance the relationship dimension, especially the aspect of shared identities. The process starts off with the goal of the planned communication – the pragmatic intent – for which a strategy is chosen. This strategy then influences both the medium used to transfer the message as well as the form of this particular message with the aim of reaching the previously set goal. The impact of this choice then leads to changes in the relationship between the parties as well as on the mutual understanding between them.

Since the resources for communication are most likely to be limited in some way and because the communication concerns itself with some kind of uncertainty, it is safe to assume that the perfect combination of choices for a certain communication is unavailable more often than not. In the model, this is referred to as communication complexity. This complexity is a construct of three different factors – the cognitive complexity, the dynamic complexity, and the affective complexity. Cognitive complexity is created “due to the intensity of information exchange, the multiplicity of views and the incompatibility between representation and use of information” while dynamic complexity is caused by “time constraints, deficient feedback, and changes during the process” and affective complexity describes the complexity due to “sensitivity to attitudes and changes in dispositions” (Te'eni 2001). Linking back to the construct of communication quality, it is possible to match its dimensions to these complexities. A high cognitive complexity means that the task of understanding and, therefore, the effectiveness of the communication is impeded. This increased effort also means a lower efficiency of communication. A high dynamic complexity lowers the efficiency of the communication by lowering the coherence and increasing the efforts spent in structuring tasks. A high affective complexity negatively impacts the relationship factor of communication.

He also notes that “High levels of communication complexity can lead to communication failures. Cognitive complexity and dynamic complexity impede mutual understanding by making it difficult to understand and share knowledge", therefore a focus on cognitive and dynamic complexity seems fitting.

3 System Support

The NSS Negoisst (Schoop et al. 2003) already has a dedicated communication support module. It adapts the Theory of Speech Acts from Searle (1969) and Habermas' Theory of Communicative Action (Habermas 1984). Searle defines the smallest unit of communication not as a word or a sentence but as a speech act. Each speech act consists of the illocutionary force F (which represent the mode of utterance describing the speaker's intention) and of the propositional content P (which describes what the utterance is all about). Each speech act has the form F(P) and both the illocutionary force and the propositional content need to be understood to achieve understanding of the speech act. Based on the illocutionary force, Searle proposes a classification of speech acts as follows. Assertives convey facts of the real world (e.g. statements, reports, assertions); commissives represent the speaker's intention to perform the action described in the propositional content (e.g. promises, announcements); directives represent the speaker's intention to get the hearer to perform the action described in the propositional content (e.g. requests, orders, assignments); expressives show the speaker's psychological states and attitudes (e.g. congratulations, insults, apologies); declaratives change the facts of the world through the expression of that speech act and require a normative background (e.g. declaration of marriage, convicting a prisoner; opening a meeting). Habermas agrees on the distinction between mode and content but elaborates further on the concept of understanding. In addition to understanding the propositional content and the illocutionary force, he introduces four validity claims that need to be fulfilled to achieve mutual understanding. Comprehensibility means that speaker and hearer understand each other; truth means that the hearer can agree on facts; truthfulness means that the hearer can trust the speaker; appropriateness means that the hearer can share the speaker's norms and values. If any of the claims is not fulfilled, a communication problem is present that needs to be resolved.

Negoisst is based on elements of both theories. First of all, each message has a message type which is the equivalent of the illocutionary force. By explicitly declaring the illocutionary force in each message exchanged via the system with a set of pre-defined message types, the intention and the mode is unambiguous. For example, the recipient can distinguish between informal questions and a formal request. The message type is used to classify the messages and thus to infer the duties of each party. Knowing what is expected lowers the communication complexity by requiring less effort to keep the negotiation coherent. If validity claims are not fulfilled, the negotiators are supported in their dedicated discussions about the claims and can solve these. For example, the message sender will provide more detail and explain if the truth of the message is questioned.

This approach has its focus on the illocutionary force and assumes that it is the greatest cause of misunderstandings. Understanding the content of messages is only indirectly supported. As the communication theories state, the propositional content is created by the propositional act, which in turn consists of two acts – referring and predicating. This means that a propositional content always consists of some object which serves as a reference point and a predication of some kind to this object. As has been discussed earlier, it can no longer be assumed that an unambiguous intent suffices to understand the negotiation communication due to the cross-domain nature of e.g. requirements negotiations, which makes this propositional content another valid point for communication support.

Misunderstandings of the content rather than the intent of the communication have been discussed by Clark and Brennan (1991). They propose the grounding approach, which has the creation of a mutual understanding as its central idea. Duckek (2010) mentions grounding as a valid approach to increase the effectiveness of negotiation. Grounding also influences the efficiency by both facilitating the communication as well as the possibility of (unnecessarily) increased effort. But even with this approach, there is an underlying problem with communication.

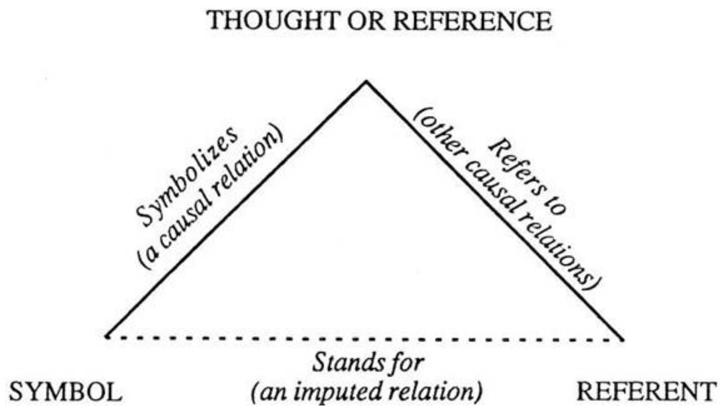

Figure 1: The Semiotic Triangle of Ogden et al. (1923)

Ogden et al. (1923) introduce the so-called Semiotic Triangle. It argues that referring to some object by its name reduces this object and its underlying concept to a single term which is then used to communicate some thoughts about it. This means that the communication can only be successful, if both the sender as well as the receiver either have the same underlying concept of the objects they are talking about, or that this underlying concept needs to be communicated as well. As an example, the term “tree” could be interpreted as a plant, as well as a data structure in computers. Depending on the background of the communicating parties, these obvious problems can have serious impact on the ongoing communication. This is also mentioned by Schoop et al. (1999) who show that the communication via terms frequently leads to misunderstandings.

This problem has been discussed by Clark and Brennan (1991) who propose Grounding, an approach to communication which has the creation of mutual understanding as its central idea. But even this approach has the ultimate limitation of communication described by Ogden and Richards – in the end, the communication which creates the grounding is based on the exchange of terms. Also, it is unclear, how the understanding can be signalled to the other parties involved. Clark (1996) categorizes understanding into four different levels. On the first level, the receiver notifies the sender by body language or short utterances of agreement. The second level of understanding works through implication, continuing the conversation means that the previously said information has been understood. On the third level, understanding is shown by answering questions or relating to the information to show that it has been understood. The last level is conducted by repeating the information in the receivers own words, which requires the most effort. Duckek (2010) notes that the first level cannot be adapted for e-negotiation because of restrictions of the medium and that the third and fourth level are the most promising.

Following from this, it should be clear that supporting the communication via the propositional content requires a way to explicitly link the terms to a specification of the required concept so that the receiver can interpret its meaning accordingly.

3.1 Redefining the Goal

Support for the communication of e-negotiation is no new research subject. As discussed earlier, support can come from two different approaches, if the ideas of the Speech Act Theory are followed. Whilst earlier approaches focus on the illocutionary act, this paper focusses on the possibilities given by the propositional act. Refining the previously mentioned research goal, this leads to the following research question:

How can the propositional content of a message be enhanced to lower the cognitive and dynamic complexity and thereby ultimately improve communication quality?

Focussing on the propositional content therefore means looking at research disciplines dealing with the clear structuring and formal definition of message content. The next section thus intro-duces ontologies in information systems as a possible solution.

4 Ontologies

Semiotics is the study of meaning-making, the study of sign processes and meaningful communication. As mentioned by Schoop et al. (2010) communication is a process that involves all semiotic layers. Sowa (1999) discusses the transfer of semiotics in communication using an electronic medium. He proposes the use of ontologies to create metadata which can be used to define specific vocabularies which can then be compared to find the differences hindering the interoperability or in our case creating misunderstandings between the communicating parties.

Ontologies – originally a philosophical idea – were adapted for the use in computer science during the 1980s. Ontology in this specific context was defined by Gruber (1993) and modified by Borst (1997) the following way:

An ontology is a formal, explicit specification of a shared conceptualization.

The idea behind these ontologies is therefore the creation of a formally sound, complete specification of all relevant aspects of the concept which is to be specified. Additionally, this model can only be called an ontology, if the specific view on this concept is shared between all involved interest groups.

Another interesting definition is given by Jasper et al. (1999):

An ontology may take a variety of forms, but it will necessarily include a vocabulary of terms and some specification of their meaning. This includes definitions of terms and an indication of how concepts are interrelated which collectively impose a structure on the domain and constrain the possible interpretation of terms.

Looking back at the initial problem of explicitly defining the relations between terms used in the communication as well as their connection to their underlying constructs one can see strong parallels between the described problem and the intention behind ontologies.

4.1 Ontologies in NSS

The NSS Negoisst already has a dedicated communication support component which uses ontologies (Schoop et al. 2003) to improve the understanding between the parties by formally defining the negotiation agenda during the creation of the negotiation. Gaspoz and Wand (2012) propose the use of soft systems methodology in combination to ontologies to help structure the issues of an negotiation. They propose to divide the task into the creation of the ontology by decision analysts and the use of this ontology by the negotiation expert. This makes the modification of the ontology during the process very cumbersome, since the decision analyst does not have the information he needs to make the changes, and the negotiation expert does not have the knowledge to modify the ontology. This static approach of pre-emptively creating ontologies therefore fails in adapting to the dynamic nature of knowledge in negotiations. According to Gulliver's (1979) phase model of negotiation, one central aspect of negotiations is the gap individual knowledge between the negotiating parties, which gets smaller during the negotiation. Assuming that all knowledge is already present at the beginning of the negotiation and that there will be no changes necessary over the course of the process is very optimistic. If this knowledge was not available, it would mean that either the concerned parties already sat together and worked this agenda out – the negotiation therefore would already have started – or that this agenda is incomplete which conflicts with its unchangeable nature.

Using ontologies to modify the propositional content, therefore, would require the use of an ontology which can be modified during the process by the negotiating parties. Gómez-Pérez et al. (2004) name four different classes of languages which can be used to model ontologies and compare these under the aspect of ambiguity of the modelled ontologies. They note that, while informal languages can be used to build some kind of ontology, the category of semi-formal languages like OWL (Horrocks 2005). Nevertheless, these languages do not guarantee the successful creation of an ontology. There exist several approaches to the creation of an ontology from an ontology engineering perspective e.g. the Cyc method (Lenat et al. 1990) or METHONTOLOGY (Fernández-López et al. 1997). Since it cannot be expected of the negotiators to be experts in the creation of ontologies, the replacement of the natural language messages with formalized ontologies does not seem viable. Even an addition of ontologies to these messages would require the correct use of ontology technology to benefit from this explication of knowledge.

There have been successful applications of ontologies that do not directly require the knowledge of ontological engineering. One of these applications – the OptiqueVQS project (Soylu et al. 2014) uses ontologies to formulate queries. The system allows domain experts who are not versed in the use of ontologies to create these queries on the structure of the domain ontology. The users have the concepts visualized as items that can be used with drag&drop to define the problem visually, therefore abstracting from the actual technology of ontologies to something that needs no further knowledge except the understanding of the problem domain. While the OptiqueVQS project uses these queries to receive data from a distributed network of heterogeneous databases, the exact same approach should be able to mask the complexity of ontologies from the user in the NSS. The approach of an additional layer of abstraction between user and ontologies would therefore require the use of a negotiation ontology which defines the constructs the participants can use to model their knowledge. One possibility of creating such an negotiation ontology could be the extension of the Montreal Taxonomy of Ströbel and Weinhardt (2003). Using such an ontology as the basis for the creation of a negotiation case specific ontology, one could iteratively create an ontology which contains knowledge concerning all discussed topics put into relation with each other. In addition to negotiation ontologies one would also need a domain ontology which already exists for various business domains.

4.2 Supporting Communication with Ontologies

Communication in NSS is generally based on individual messages which taken together create the knowledge base of the particular negotiation. This knowledge is rather unstructured. Once a certain amount of messages has been exchanged, it gets harder and harder to find the exact message in which a particular argument was mentioned or a specific piece of information was exchanged. Correctly remembering all arguments, therefore, requires either a huge cognitive effort of the negotiators and consequently makes communication inefficient. Using an ontology as an extension of the exchanged message would make searching for information concerning different issues much faster and without much impact from the amount of messages exchanged since the newest message should always have all relevant information that has been brought up until this point, thereby considerably improving the communication quality in both understanding as well as efficiency.

Another important point is the graph which can be created using the relations specified in the ontology. This graph can be used to create a visualisation of it, which makes understanding much easier. Also, as Clark (1996) mentions, visualisation can be a very strong tool for signalling understanding. The receiver, therefore, could always compare the visualisation of an ontology with his own arguments to make sure nothing is misunderstood, increasing the mutual understanding of the situation at hand. This visualisation could also prove to be a useful decision aid in more complex problems.

While the previously mentioned aspects can probably be solved by other means, one of the most important aspects of ontologies is the automated reasoning which comes with the high level of formalisation through specialized languages for ontologies (Motik et al. 2009). This reasoning power could be used to check the internal consistency of the ontology periodically and thereby make the negotiators aware of conflicts which they should probably address during the negotiation process before reaching an agreement. This internal consistency check could also be used to extract additional implicit knowledge in the ontology, showing logical contradictions as well as improving the understanding of the relationships between the issues.

Once a negotiation is finished and the outcome is satisfactory for all involved parties, the ontology created during this negotiation can be used as the starting point for similar negotiations in the future. This ontology could also be transferred to other tools which e.g. assist in analysing the commitments necessary for the implementation of the agreement or analyse the results of the agreement in some way.

5 Conclusion

Negotiations often struggle with the need of a mutual understanding concerning the issues that are being talked about. NSS therefore try to give the negotiators not only support for the decision making but also for the communication itself. It has been shown that creating this understanding has some constraints in this electronic setting since the responsiveness of such an asynchronous system is limited and therefore requires more effort. While previous attempts (Schoop et al. 2003) concentrated on the idea of explicitly stating the intent of a message to make it less ambiguous, our approach aims at the modification of the content of the message. This is based on the theories of Searle (1969) and Habermas (1984) who stated that a communicative act does not only consist of the intent of stating some utterance but also of its propositional content. Integrating a support for the creation and transfer of the propositional content, therefore, promises success especially in those areas that concern themselves with more difficult or more complex negotiations. Once it becomes unclear what a term means or – even worse – if a term is deemed unambiguous while meaning completely different things for the negotiating parties, communication support needs to incorporate something to make these relationships explicit.

Ontologies, while not the easiest tool to handle, provide very interesting potentials in terms of helping create an understanding. Furthermore, the automatic reasoning as part of ontology approaches can be used for discovering inconsistencies in the knowledge of the parties which in turn could be used to create a shared vocabulary that can be re-used in other processes or tools.

The limitations of our approach must not go undiscussed. The technology to work with ontologies only works well with very strictly designed ontologies. Since our approach builds on the automatic transfer of input into ontologies, there needs to be some kind of automatic mapping. Ontology mapping is currently not able to map ontologies in a completely automatic way without loss of knowledge. The more abstraction an editor would have to deliver from the underlying ontology, the less expressive the resulting ontology would be, the worst case being an ontology incapable of useful reasoning. There needs to be a very fine balance between the complexity of creating an ontology and the complexity of understanding the negotiation communication to improve the communication complexity and not worsen it.

Another problem is posed by the negotiation ontology which delivers the constructs through which the knowledge can be created by the negotiatorsThe Montreal Taxonomy by Ströbel and Weinhardt (2003) was an important first step but the authors note themselves that this was only a first attempt and needs further work and discussion. The consequence is that there is not yet a general negotiation ontology.

To summarise, there are limitations of operationalising ontologies for the propositional content of negotiation messages. However, we expect the benefits of doing so to more than justify the efforts needed to integrate ontologies for the purpose of extending the communication support of an NSS such as Negoisst which will be our next step of research work.

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Personalisierungsmöglichkeiten von mobilen Apps

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Abstract

Die Personalisierung hat sich auf dem elektronischen Markt in den letzten Jahren als ein wichtiges Instrument zu einer besseren Anpassung von Produkten und Informationen an die Wünsche der Nutzer etabliert. Viele Branchen könnten von dieser Entwicklung profitieren, indem sie durch personalisierbare Apps die Bedürfnisse potentieller Käufer ermitteln und diesen maßgeschneiderte Produkte oder Dienstleistungen vorschlagen. In dem vorliegenden Beitrag wird eine Literaturanalyse durchgeführt, um eine Übersicht aktueller Personalisierungsmöglichkeiten von mobilen Applikationen (Apps) zu erhalten. Neben einer allgemeinen Klassifizierung in die implizite und die explizite Personalisierung werden alle gefundenen Methoden der Personalisierung in weitere Subkategorien eingeteilt. Durch die Literaturanalyse soll herausgefunden werden, welche Personalisierungsmöglichkeiten bei Apps in der Literatur existieren. Das Ziel ist es, diese zu kategorisieren und in eine einheitliche Struktur zu überführen.

1 Notwendigkeit der Personalisierung im Mobile Commerce

Der rapide Anstieg der Mobilfunknutzung hat zu einer weitreichenden Etablierung des Mobile Commerce (M-Commerce) geführt (Lee und Park 2006). M-Commerce stellt eine besondere Ausprägung des elektronischen Handels (E-Commerce) unter der Benutzung mobiler Endgeräte dar. Mobile Endgeräte, insbesondere Smartphones, haben gegenüber dem elektronischen Handel über Desktop-Computer entscheidende Vorteile wie beispielsweise die Ubiquität, die Möglichkeit der Nutzung standortbezogener Dienste oder die Personalisierung (Khansa et al. 2012). Um sich auf diesem Markt durchzusetzen und einen Mehrwert für die Nutzer zu generieren, neigen Unternehmen verstärkt dazu, innovative mobile Anwendungen (Apps) zu entwickeln (Lee und Park 2007). Trotz des technologischen Fortschritts bei Smartphones stehen Unternehmen bei der Entwicklung von Apps nach wie vor großen Herausforderungen gegenüber (Lee und Park 2006). Neben technischen Beschränkungen, müssen auch weitere Faktoren wie sich kontinuierlich ändernde Nutzerbedürfnisse (Tarasewich 2003), verschiedene Präferenzen aufgrund des Alters (Olwal et al. 2011) oder der kulturelle Wandel berücksichtigt werden (Hong et al. 2013). Um all diese Erwartungen zu erfüllen, haben viele Unternehmen in den letzten Jahren ihren Nutzern die Möglichkeit der Produktpersonalisierung angeboten (Gehring et al. 2010). Personalisierung hat im Bereich des M-Commerce trotz der hohen Komplexität der Umsetzung eine entscheidende Rolle eingenommen. Die Informationsüberflutung im Internet (Asif und Krogstie 2013), der kleine Bildschirm des Smartphones (Findlater und McGrenere 2008) und der insgesamt steigende Bedarf an Personalisierung (Tossell et al. 2012) haben die Implementierung von Personalisierungsmöglichkeiten bei Apps für Unternehmen notwendig gemacht, um auf dem Markt erfolgreich zu sein. Ein hoher Bedarf an personalisierbaren Apps ist vorhanden (Gehring et al. 2010) und die Nutzer wären sogar bereit, Geld für personalisierte Elemente zu bezahlen (Rose 2001). Personalisierung generiert jedoch nicht nur eine bessere Übereinstimmung zwischen einer App und den Bedürfnissen der Nutzer, sondern stärkt auch deren Loyalität zum Unternehmen (Kim und Han 2014) und führt zu einer höheren Nutzungszufriedenheit (van Velsen et al. 2008). Die Personalisierungsmöglichkeiten einer App sind aufgrund der vielfältigen Funktionalitäten des Smartphones nahezu unbegrenzt (Vico et al. 2011). Obwohl jedoch personalisierte vor nicht-personalisierten Services bevorzugt werden (Blom und Monk 2003), sollte der Grad der Personalisierung in einem sinnvollen Rahmen liegen (Tarasewich 2003), um Nutzer nicht durch Überladung mit personalisierten Elementen zu verwirren (Kim und Han 2014). Jedoch existiert keine aktuelle Übersicht, welche Personalisierungsmöglichkeiten in der wissenschaftlichen Literatur beschrieben und diskutiert werden, so dass die in diesem Artikel zu beantwortende Forschungsfrage lautet: *Welche Arten und Formen von Personalisierungsmöglichkeiten von mobilen Apps werden in der aktuellen, wissenschaftlichen Literatur diskutiert?* Um diese Frage zu beantworten, wird eine Literaturanalyse durchgeführt, um eine umfassende Sammlung an Personalisierungsmöglichkeiten zu erhalten. In Kapitel zwei wird hierzu zunächst die Methodik der Literatursuche beschrieben. Die Erstellung einer Struktur für eine einheitliche Darstellung der Ergebnisse erfolgt in Kapitel 3. Die ermittelte Klassifizierung der Personalisierungsmöglichkeiten wird in Kapitel 4 dargelegt. In Kapitel 5 werden die Limitationen der durchgeführten Suche aufgezeigt und abschließend ein Fazit gezogen.

2 Methodik der Literatursuche

Eine transparente Dokumentation der Datenerhebung ist für eine Literaturanalyse unentbehrlich. Um diese sicherzustellen wurde eine strukturierte Vorgehensweise, orientiert an der Methodik von Baker (2000), ergänzt um von David und Han (2004) beschriebenen Elemente, gewählt.

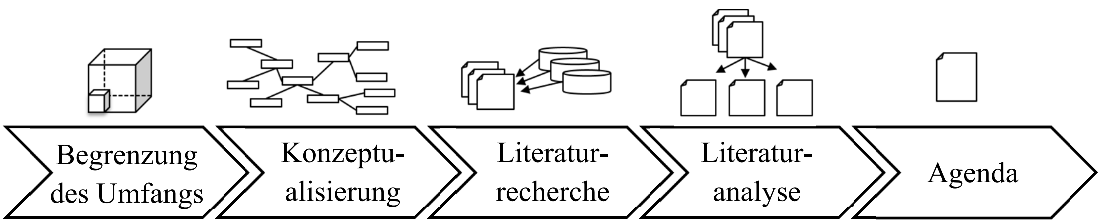

Abbildung 1: Grundgerüst der Literaturanalyse, in Anlehnung an Baker (2000, 221)

Im Bereich des M-Commerce gibt es viele unterschiedliche mobile Endgeräte, über die Informationen übertragen werden können (Fan und Poole 2011). Da sich die Verkaufszahlen der Smartphones in den letzten Jahren weltweit gesteigert haben und deren technische Weiterentwicklung neue Personalisierungsmöglichkeiten eröffnet haben (Gerber et al. 2010), wird der Umfang der Literatursuche mit einem Fokus auf dieses Medium begrenzt. Da einige der Personalisierungsmöglichkeiten aus dem elektronischen Geschäftsverkehr auf Apps von Smartphones adaptiert werden können (Ho 2012), wird jedoch auch der Bereich des E-Commerce berücksichtigt. Auf eine zeitliche Einschränkung hinsichtlich der Veröffentlichung der Artikel wurde verzichtet, damit auch relevante Personalisierungsmöglichkeiten älterer Studien ermittelt werden können, die auf Apps adaptierbar sind. Der dritte Schritt beschreibt die Suche und Evaluation der relevanten Studien und ist in Abbildung 2 inklusive der verwendeten Suchwörter ausführlich dargestellt. Bei der Auswahl der Datenbanken wurde auf die Online-Datenbanken EBSCO-Host/Business Source Premier, ScienceDirect, ACM Digital Library und Wiley Online Library zurückgegriffen.

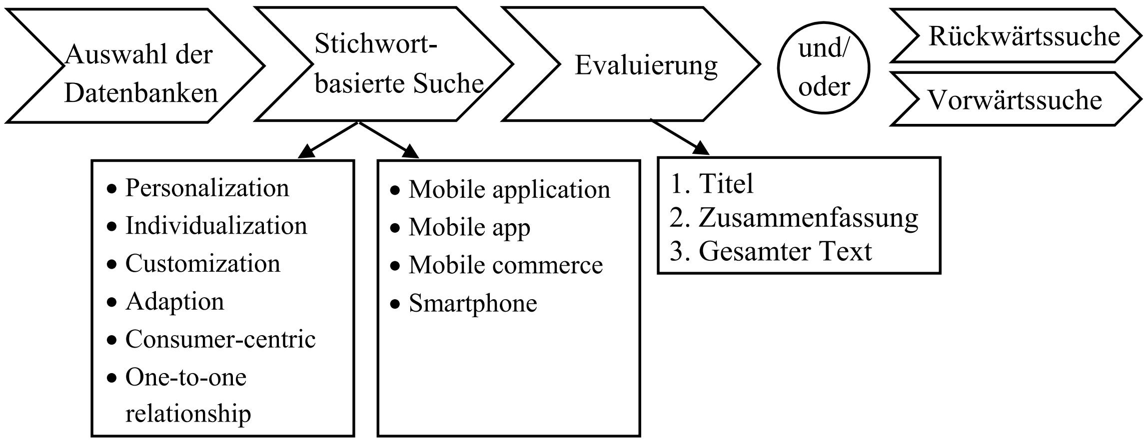

Abbildung 2: Prozess der Datenerhebung (Eigene Darstellung)

In der dritten Phase, in Abbildung 2, wird der Prozess der Evaluierung beschrieben, dessen Ergebnisse in Tabelle 1 dargestellt sind. Auf Basis der Analyseergebnisse der ausgewählten Artikel wird im folgenden Kapitel die Struktur für eine einheitliche Darstellung bestimmt.

Schritte der Suche und Evaluierung	Stichwortsuche	Grobe Überprüfung des Titels	Inhaltliche Überprüfung der Zusammenfassung	Vollständige Überprüfung des gesamten Textes	Inklusive Rück- und Vorwärtssuche
Anzahl der ermittelten Artikel	5668	415	212	70	119

Tabelle 1: Detaillierte Suchergebnisse der Literaturrecherche

3 Festlegung der Struktur für eine einheitliche Darstellung

Aufgrund der großen Anzahl und der Heterogenität der ermittelten Personalisierungsmöglichkeiten wird eine Methodik entwickelt, um diese in einer einheitlichen Form abzubilden. Die Darstellung dieser Struktur ist in Abbildung 3 skizziert und basiert primär auf der von Wu et al. (2003) entwickelten Klassifizierung, die von Fan und Poole (2011) ergänzt und in der vorliegenden Studie zusätzlich um eine zusätzliche Kategorie erweitert wurde, was im Folgenden erläutert wird.

Ausgangspunkt: Der Ausgangspunkt der Personalisierung ist die oberste der drei Dimensionen und bezieht sich auf den Grad bis zu dem die Personalisierung automatisiert durchgeführt wird (Fan und Poole 2011). Dabei wird zwischen der impliziten und der expliziten Personalisierung unterschieden. Während bei der expliziten Personalisierung sämtliche Daten lokal gespeichert sind und der Nutzer die Eingaben eigenständig durchführt (Gerber et al. 2010), werden ihm bei der impliziten Personalisierung zugeschnittene Informationen oder Produkte vorgeschlagen, welche auf der Beobachtung seines Verhaltens und den daraus resultierenden Rückschlüssen basieren (van Velsen et al. 2008). Des Weiteren werden für die explizite Personalisierung in der Literatur die Begriffe „client-side“, „user-based“ und „adaptable system“ sowie für die implizite Personalisierung die Begriffe „server-side“, „computer-based“ und „adaptive system“ synonym verwendet (Fan und Poole 2011; Tossell et al. 2012; Lee und Park 2006).

Ziel: Die zweite Dimension, das Ziel der Personalisierung, ist entweder auf eine Kategorie von Personen oder auf eine bestimmte Einzelperson ausgerichtet (Fan und Poole 2011). Bei der Kategorisierung werden mehrere Nutzer anhand gleicher oder ähnlicher Merkmale wie beispielsweise Interessen, sportliche Aktivitäten oder anhand des Familienstatus kategorisiert (Rose 2001) und in Gruppen eingeteilt. Aufgrund ähnlicher Attribute und Präferenzen werden den Nutzern innerhalb dieser Gruppe gleiche oder verwandte Produkte und Services angeboten, die von anderen Nutzern derselben Gruppe bereits in Anspruch genommen wurden (Kobsa et al. 2001). Das Prinzip der Kategorisierung ist nicht nur deutlich ressourcenschonender, sondern auch einfacher umzusetzen, da oft nicht ausreichend Informationen über einzelne Nutzer vorhanden sind, um die Personalisierung konkret auf Individuen zuzuschneiden (Kenteris et al. 2011).

Aspekt: Die dritte Dimension bezieht sich auf die konkreten Teile des Systems, die personalisiert werden. Fan und Poole (2011) haben hierfür vier Aspekte im Bereich der Informationssysteme identifiziert: Die Information selbst (Inhalt), die Präsentation der Information (Benutzeroberfläche), das Medium über das die Information übertragen wird (Informationskanal) und durchführbare Änderungen am System (Funktionalität). Da bei der Begrenzung des Umfangs das Smartphone als Übertragungsmedium ausgewählt wurde, wird der Aspekt des Informationskanals hinfällig und nicht mehr betrachtet. In dieser Arbeit wurde diese Dimension zudem um den Aspekt „Auditive Signale“ ergänzt. Hiermit ist die Personalisierung von akustischen und phonetischen Zusatzfunktionen gemeint, was sich in keine der anderen Aspekte einordnen lässt.

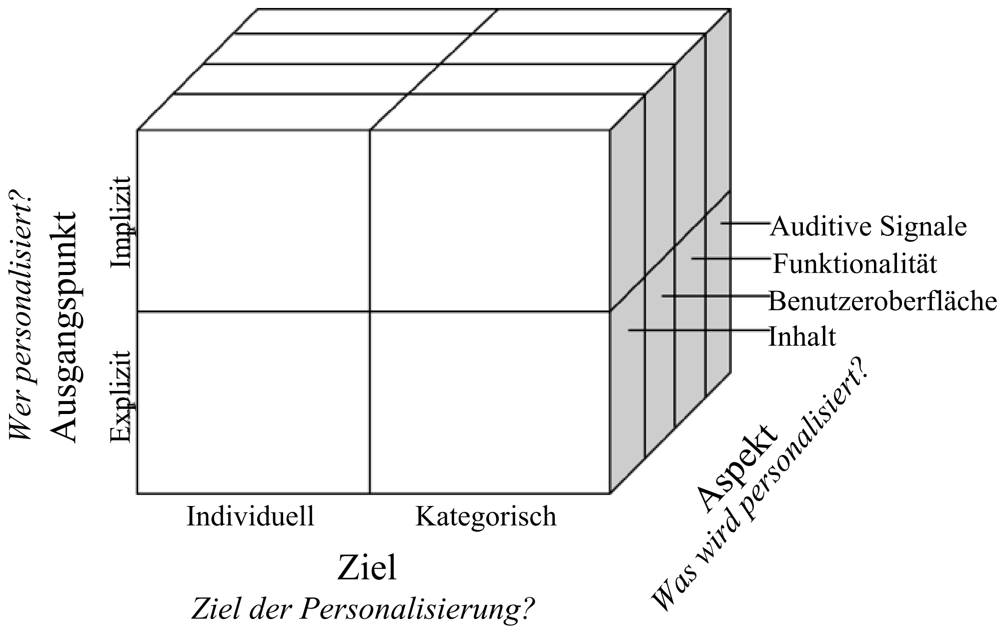

Abbildung 3: Die drei Dimensionen der Personalisierung, in Anlehnung an Fan et al. (2011, 187f.))

4 Ergebnisse der Literaturanalyse

In Tabelle 2 ist eine Übersicht der in der Literatur diskutierten Personalisierungsmöglichkeiten von Apps nach der Klassifizierung aus Abbildung 3 beschrieben. Da einige Personalisierungsmöglichkeiten sehr häufig Diskussionsgegenstand waren, erfolgt im Folgenden lediglich eine Erwähnung der Autoren exemplarischer Artikel, nicht die Nennung aller Autoren.

Möglichkeiten der Personalisierung				n
Implizit	Individuell	Inhalt	Produkt wird anhand der Kaufhistorie vorgeschlagen	76
		Funktionalität	Produkt wird anhand des Standorts in nahem Geschäft empfohlen	66
		Benutzeroberfläche	Anordnung der Schaltflächen wird durch Anzahl der Klicks bestimmt	10
		Auditive Signale	Klingeltöne werden an abgespielte Musiktitel des Nutzers angepasst	1
	Kategorisch	Inhalt	Produkt wird empfohlen, das Nutzer mit ähnlicher Historie kauften	67
		Funktionalität	Alarm wird empfohlen, den Nutzer mit ähnlicher Historie nutzen	24
		Benutzeroberfläche	Benutzeroberfläche anderer Nutzer wird automatisch eingestellt	12
		Auditive Signale	Sprachausgabe für Text in ausgewählter Sprache wird empfohlen	4
Explizit	Individuell	Inhalt	Nutzer kann die Inhalte einer App selbst bestimmen / ausblenden	17
		Funktionalität	Nutzer kann Spitznamen für Begrüßung bei Start der App bestimmen	14
		Benutzeroberfläche	Layout und Hintergrundbild können vom Nutzer geändert werden	28
		Auditive Signale	Nutzer kann Melodien für Eingangsbildschirm einer App festlegen	7
	Kategorisch	Inhalt	Nutzer wählt Kategorien bestimmter Produkte eigenständig aus	9
		Funktionalität	Nutzer kann Navigationshilfen nutzen, um Produkte hervorzuheben	7
		Benutzeroberfläche	Nutzer kann aus einer Sammlung von Hintergrundbildern wählen	14
		Auditive Signale	Nutzer kann die Sprache der Sprachausgabe selbst festlegen	8

Tabelle 2: Übersicht und Klassifizierung der Personalisierungsmöglichkeiten von Apps

4.1 Implizite Personalisierung

Bei der impliziten Personalisierung analysiert ein System das Verhalten des Nutzers, leitet daraus Rückschlüsse ab und präsentiert diesem die zugeschnittenen Ergebnisse (van Velsen et al. 2008). Die Informationen sind an den Bedürfnissen der Nutzer ausgerichtet und werden entsprechend angepasst. Das Ziel ist, eine möglichst exakte Übereinstimmung zwischen den Präferenzen der Nutzer und angebotenen Informationen zu erreichen. Ebenfalls ist es wichtig, dass der Nutzer die Empfehlung zum Zeitpunkt erhält, in der der Bedarf noch vorhanden ist (Germanakos et al. 2005).

4.1.1 Implizite Personalisierung des Inhalts

Eine inhaltliche Personalisierung ist nach Rossi et al. (2001) die Präsentation heterogener Inhalte für Nutzer. Eine weitverbreitete Methode, um Nutzern Inhalte vorzuschlagen, ist die Implementierung eines Nutzerprofils (Fink et al. 2002; Rose 2001). Ein Nutzerprofil stellt oftmals die Basis der Personalisierung dar und kann die Relevanz und Interpretierbarkeit von Empfehlungen erhöhen (Cappiello et al. 2003). Mit Hilfe einer Eingabemaske wird ein Profil bei erstmaliger Anwendung der App vom Nutzer initial mit Daten gefüllt. Diese Daten können beispielsweise persönliche Informationen sein (Lee 2007), sich auf präferierte Freizeitaktivitäten des Nutzers beziehen (Zhang 2003) oder unterschiedliche Themengebiete enthalten (Riemer und Brüggemann 2007). Rossi et al. (2001) sprechen hier von einer statischen Personalisierung, da die Eingabe der

Daten im Nutzerprofil bei erstmaliger Anmeldung oft auf eine festgelegte Auswahl an Themenbereichen beschränkt ist. Falls Daten eines Nutzers wie Name, Geburtstag oder produktbezogene Informationen in der Datenbank eines Unternehmens vorhanden sind, können diese dem Nutzer bei der Dateneingabe vorgeschlagen werden (Dhaouadi et al. 2014; Ferreira et al. 2013). Da die einzugebenden Daten im Nutzerprofil häufig demografischer Natur und somit unbrauchbar für eine effektive implizite Personalisierung sind (Bose und Chen 2009), werden zusätzliche Daten, wie etwa verhaltensbezogene Informationen des Nutzers, über einen längeren Zeitraum gespeichert. Diese sind beispielsweise der Kauf eines Produktes, der Aufruf einer Internetseite oder der Besuch eines Theaters (Rostambeik et al. 2007). Die Sammlung dieser verhaltensbezogenen Daten erfolgt durch intelligente Agenten, welche darüber hinaus versuchen, die Daten zu interpretieren und Muster für weitere Empfehlungen zu erkennen (Ho 2010; Tang et al. 2013). Da sich diese Informationen im Laufe der Zeit ändern können, sollte der Algorithmus hinter dem Nutzerprofil in der Lage sein, sich diesen Änderungen dynamisch anzupassen. Für sich wechselnde Bedürfnisse, wie beispielsweise Trends, fordern Cai et al. (2014) eine Synchronisierung der Daten in Echtzeit, um zeitnah auf Änderungen zu reagieren. Sind noch keine oder zu wenig Daten über einen neuen Nutzer bekannt, sodass eine Empfehlung von Produkten nicht möglich ist, wird von einem Kalt-Start-Problem gesprochen (Aktolga et al. 2013; Natarajan et al. 2013). Diesem Mangel an Informationen kann durch die Zuteilung der Nutzer zu einem Cluster durch einen intelligenten Agenten begegnet werden (Dhaouadi et al. 2014). Die Einordnung in ein Cluster ist abhängig von gleichen oder ähnlichen Angaben des Nutzers und kann auf Attributen (Raghu et al. 2001), der Kaufhistorie (Riemer und Brüggemann 2007) oder auf definierten Stereotypen basieren (Adomavicius und Tuzhilin 2005). Bei der Technik des kollaborativen Filterns werden die von Nutzern abgegebenen Bewertungen auf Produkte analysiert, um somit die Interessen einzelner Nutzer zu erschließen (Adipat und Zhang 2005). Anschließend sucht das System Nutzer mit ähnlichen Interessen und schlägt diesen beispielsweise neue Produkte vor, die hoch bewertet wurden. Die Grundannahme ist, dass Nutzer, welche dieselben Produkte gekauft haben, ähnliche Präferenzen oder Interessen haben (Cai et al. 2014). Das kollaborative Filtern ist die am häufigsten umgesetzte Suchmethode für den Bereich der Personalisierung (Shi et al. 2014). Eine ähnliche Personalisierungstechnik wie das kollaborative Filtern sind die inhaltsbasierten Empfehlungen. Diese basieren auf einer Analyse der Beschreibungen der Produkte, die vom Nutzer bewertet wurden, und auf der Beschreibung der Produkte, welche diesem empfohlen werden sollen (Cai et al. 2014). Das System passt die Empfehlungen an die Interessen des Nutzers an, welche entweder explizit von diesem eingegeben wurden oder von dessen Kaufhistorie abgeleitet werden (Han et al. 2014). Die Grundlage für die meisten Formen der impliziten Personalisierung bildet die Nutzer-Bewertung (Adipat und Zhang 2005). Obwohl der Nutzer die Bewertung explizit durchführt, hat er keinen direkten Einfluss darauf, wie das System die abgegebenen Bewertungen interpretiert und in weiteren Empfehlungen berücksichtigt (Adomavicius und Tuzhilin 2005). Um Präferenzen eine unterschiedlich hohe Bedeutung zu geben, können abweichende Gewichtungen zugeordnet werden (Lee und Park 2007).

4.1.2 Implizite Personalisierung der Funktionalität

Nach Panayiotou und Samaras (2004) ist der wichtigste Bestandteil der Personalisierung die Nutzung standortbezogener Dienste. In der Literatur wird vielfach angenommen, dass anhand des aktuellen Standortes eines Nutzers auf dessen Interessen geschlossen werden kann (Lee 2007; Lee und Park 2006; Bose und Chen 2009). Ho (2010) hat die standortbezogenen Dienste weiter in zwei Kategorien unterteilt. In der ersten Kategorie, „Wo bin ich?“, ermittelt der Service einer App mittels

GPS den aktuellen Standort des Nutzers (Mahatanankoon et al. 2005) und sendet diesem die gewünschte Information, wie beispielsweise eine Stadtkarte, zu. Bei der zweiten Kategorie, „Wo will ich hin?“, werden zusätzlich zum aktuellen Standort die Präferenzen des Nutzers bei der Generierung einer Empfehlung berücksichtigt (Rostambeik et al. 2007). Insgesamt ist die Implementierung standortbezogener Dienste bei Apps in den letzten Jahren bei Nutzern zunehmend beliebter geworden und in Bezug auf deren Umsetzung bei App rasant angestiegen (Ho 2012). Die Erweiterung des Standortes um kontextsensitive Informationen steigert die Relevanz und Interpretierbarkeit der Daten (Mahatanankoon und Vila-Ruiz 2007; Cappiello et al. 2003). Unter Kontext wird jede nützliche Information verstanden, die eine Situation hinsichtlich der Interaktion zwischen Nutzer und App beschreibt. In der Literatur herrscht ein Konsens darüber, dass die Berücksichtigung kontextsensitiver Informationen eine effektivere Personalisierung ermöglicht (Mahatanankoon et al. 2005). Ähnlich wie beim Nutzerprofil sollen die kontextsensitiven Informationen dynamisch erfasst werden, um schnell auf sich ändernde Standorte des Nutzers zu reagieren (Germanakos et al. 2005). Der personalisierte Startbildschirm einer App, welcher den Namen des Nutzers anzeigt und ihn auf anstehende Termine in seinem Kalender hinweist, wird anthropomorphe Personalisierung genannt (Blom und Monk 2003). Die anthropomorphen Möglichkeiten reichen von einfachen Begrüßungstexten mit dem Vornamen des Nutzers (Chellappa und Sin 2005) bis hin zum digitalen Fremdenführer, welcher eine Person durch verschiedene Sehenswürdigkeiten leitet (Gabrielli et al. 2014). Je menschlicher sich ein System verhalten soll, desto höher ist der Grad der künstlichen Intelligenz (Wu et al. 2003) und somit die Komplexität der Umsetzung.

4.1.3 Implizite Personalisierung der Benutzeroberfläche

Die Ziele einer personalisierten Benutzeroberfläche sind sowohl eine hohe Nutzerzufriedenheit als auch eine einfache Bedienung der App (Germanakos et al. 2005). Obwohl statische Menüs ohne Personalisierung schneller waren, werden in einer Studie von Findlater und McGrenere (2004) höhere Zufriedenheitswerte der Nutzer bei dynamischen Benutzeroberflächen erreicht. Da die Benutzeroberfläche im M-Commerce nicht so ansprechend und benutzerfreundlich darstellbar ist, wie auf Web-Plattformen, soll der Fokus bei Apps auf das Look-and-Feel gelegt werden (Negahban und Chung 2014; Olwal et al. 2011). Da das Feedback der Nutzer über die Benutzeroberfläche von Apps schwierig zu ermitteln ist (Choeh und Hong 2008), kann dessen Gestaltung anhand der im Nutzerprofil angegebenen Präferenzen erfolgen (Gil et al. 2012). Die implizite Personalisierung der Benutzeroberfläche ist durch die Anordnung der Schaltflächen anhand der Klicks denkbar (Vico et al. 2011). Ebenfalls kann einem Nutzer aufgrund des Feedbacks, welches von weiteren Nutzern des gleichen Clusters abgegeben wurde, eine individuelle Anordnung der Schaltflächen vorgeschlagen werden (Vico et al. 2011; Panayiotou und Samaras 2004). Prinzipiell soll die personalisierte Organisation des Menüs so gestaltet sein, dass die eher geringe Zeitspanne der Aufmerksamkeit des Nutzers bei Betrachtung einer App berücksichtigt wird (Mahatanankoon und Vila-Ruiz 2007). Des Weiteren beschreiben Findlater und McGrenere (2008) eine Studie, bei der sich die Größe einer Schaltfläche im Hauptmenü der Frequenz der Nutzung anpasst. Bei Smartphones mit älteren Prozessoren ist einstellbar, dass Grafiken mit einer kleineren Auflösung dargestellt werden (Adipat und Zhang 2005). Nach Zhang (2003) ist es möglich, die Benutzeroberfläche bei Smartphones mit einem kleinen Bildschirm anzupassen, damit dessen Größe bei Produktvorschlägen optimal ausgenutzt wird. Ist die Gestaltung der Benutzeroberfläche nicht personalisiert, kann dies eine Barriere für den Nutzer darstellen (Lee und Park 2007).

4.1.4 Implizite Personalisierung der auditiven Signale

Neben der Anpassung visueller Elemente sollte auch der auditive Kanal der Nutzer angesprochen werden, um die Personalisierung noch genauer auf die Bedürfnisse zuzuschneiden (Díaz-Bossini und Moreno 2013). Da eine ausreichende Bandbreite zur Verfügung steht, ist eine Integration auditiver Signale technisch kein Problem (Zhang 2003). Nach Kenteris et al. (2011) stellen auditive Signale einen Mehrwert für Navigationssysteme oder begleitende Fremdenführungen dar.

4.2 Explizite Personalisierung

Bei der expliziten Personalisierung führt der Nutzer die Änderungen in einer App eigenständig durch (Gerber et al. 2010). Das Ziel dabei ist es, diesem viele Freiheiten bei der Bedienung und Gestaltung zu geben, was immer häufiger in Apps implementiert wird (Asif und Krogstie 2012).

4.2.1 Explizite Personalisierung des Inhalts

Bei der expliziten Personalisierung spielt das Nutzerprofil, wie bei der impliziten Personalisierung, eine entscheidende Rolle (Fink et al. 2002). Oft können bei der erstmaligen Nutzung einer App bestimmte Themen- oder Interessensgebiete explizit im Nutzerprofil ausgewählt werden, die dem Nutzer anschließend zur Verfügung stehen (Raghu et al. 2001). Alternativ können die präferierten Inhalte auch durch Fragen ermittelt werden, damit der Nutzer eine größere Auswahl hat (Aktolga et al. 2013; Lee und Park 2007). Somit ist die Zusammenstellung der Inhalte aus unterschiedlichen Themengebieten bestimmbar (Rossi et al. 2001). Der Grad der Ausführlichkeit der angezeigten Informationen soll vom Nutzer regelbar sein (Ferreira et al. 2013). Darüber hinaus können Hilfstexte bei schwer verständlichen Texten für ein besseres Verständnis eingeblendet werden (Calvo et al. 2013). Eine weitverbreitete Personalisierung ist die Auswahlmöglichkeit mehrerer Sprachen, in denen die Inhalte dargestellt werden (Díaz-Bossini und Moreno 2013).

4.2.2 Explizite Personalisierung der Funktionalität

Der Unterhaltungsfaktor spielt bei Apps eine immer größer werdende Rolle (Khansa et al. 2012). Durch die Integration des Nutzers in personalisierte Prozesse und Funktionalitäten werden nicht nur positive Emotionen hervorgerufen (Jung 2014), sondern auch die Nutzungsfrequenz der App erhöht (Fan und Poole 2011). Eine häufig genannte Möglichkeit in der Literatur ist die Feedback-Funktion, durch welche der Nutzer erworbene Produkte bewertet und somit zugleich den Input für eine implizite Personalisierung schafft (Natarajan et al. 2013). Eine weitere, spielerisch umgesetzte Funktion ist die Anpassung des Preises durch Verschieben eines Balkens, um den finanziellen Rahmen bei Produktsuchen einzugrenzen (Gehring et al. 2010). Wu et al. (2003) präsentieren in ihrem Artikel die Möglichkeit der Erstellung von Shortcuts für Informationen und Produkte, welche vom Nutzer am häufigsten aufgerufen werden. Für Personen mit motorischen oder kognitiven Störungen ist die Implementierung von Assistenz-Technologien denkbar, um ihnen einen verständlicheren sprachlichen Ausdruck anzubieten (Calvo et al. 2013; Díaz-Bossini und Moreno 2013). Bei einigen Apps können Nutzer einen Spitznamen eintragen und ein Profilbild bestimmen. Dies führt zu einer besseren Identifikation des Nutzers mit der App und erzeugt durch die Schaffung einer vertrauensvollen Basis eine höhere Nutzungsfrequenz (Calvo et al. 2013).

4.2.3 Explizite Personalisierung der Benutzeroberfläche

Bei der grafischen Benutzeroberfläche von Apps gibt es grundlegende Unterschiede zwischen den Präferenzen von Männern und Frauen. Während männliche Nutzer eine sinnvolle, durchdachte

Struktur bevorzugen, streben weibliche Nutzer eher eine grafisch ästhetische Benutzeroberfläche an (Tossell et al. 2012). Hinsichtlich der Gestaltung der Benutzeroberfläche wird bemängelt, dass die Möglichkeiten begrenzt sind und die Bedürfnisse der Nutzer ignoriert werden. Um diesem Problem entgegenzuwirken, werden umfangreiche grafische Editoren implementiert (Gil et al. 2012), mit deren Hilfe die Nutzer ihr eigenes Look-and-Feel erzeugen können (Vico et al. 2011). Dies ist etwa durch die Änderung der verwendeten Schriftarten (Olwal et al. 2011), der dargestellten Farben (Chellappa und Sin 2005) oder durch eine Änderung der Größe der Schaltflächen umsetzbar (Findlater und McGrenere 2004). Neben weiteren Einstellungen hinsichtlich der Helligkeit oder des Kontrastes (Díaz-Bossini und Moreno 2013) wird die Implementierung von sich ändernden Farben vorgeschlagen (Webster 2014). Eine weitere Personalisierung der Benutzeroberfläche ist die Bestimmung des Hintergrundbildes (Blom und Monk 2003). Dieses Bild kann heruntergeladen, aus einer bestehenden Sammlung ausgewählt oder vom Nutzer selbst erstellt werden (Calvo et al. 2013). Neben einer rein visuellen Anpassung schlagen Riemer und Brüggemann (2007) die Personalisierung des Layouts vor. Dies umfasst die Platzierung der Schaltflächen, die Gliederung des Hauptmenüs oder den allgemeinen Aufbau der Benutzeroberfläche (Ferreira et al. 2013). So werden dem Nutzer verschiedene Personalisierungen zur Verfügung gestellt, damit dieser die Oberfläche seinen Präferenzen nach gestalten kann (Kenteris et al. 2011; Rossi et al. 2001).

4.2.4 Explizite Personalisierung der auditiven Signale

Durch die Berücksichtigung des auditiven Kanals ist eine genauere Personalisierung möglich (Díaz-Bossini und Moreno 2013). Eine Möglichkeit ist dabei die Umwandlung von Text in Gesprochenes (Kobsa et al. 2001). Diese Personalisierung ist für sehschwache Nutzer von Vorteil, die Probleme beim Lesen haben (Olwal et al. 2011). Individuelle Töne können beim Eintreffen von Nachrichten (Ferreira et al. 2013) oder als Erinnerung abgespielt werden (Calvo et al. 2013).

5 Zusammenfassung der Ergebnisse der Literarturanalyse

Bei der Vorgehensweise wurde sich an der Methodik von Baker (2000) orientiert und für die Datenerhebung eine leicht modifizierte Methodik nach David und Han (2004) verwendet. Obwohl dabei nur eine geringe Anzahl an Limitationen festgelegt wurde, kann der Untersuchungsfokus ausgeweitet werden. So wurde der Schwerpunkt auf Personalisierungsmöglichkeiten gelegt. Eine erneute Literaturanalyse mit dem Fokus auf den gefundenen Methoden und Modellen, welche mehrere Kombinationen von Personalisierungen enthalten, ist denkbar. Trotz einer größeren Anzahl an Artikeln und weiteren Beispielen zu den gefundenen Personalisierungsmöglichkeiten sind durch diese Änderung jedoch keine neuen Erkenntnisse zu erwarten, da die Suche nach relevanten Artikeln sehr sorgfältig durchgeführt wurde. Durch die ausgeführte Literaturanalyse wurde eine Übersicht diverser Personalisierungsmöglichkeiten des elektronischen Marktes erstellt. Sämtliche dieser Möglichkeiten wurden mit Hilfe einer Klassifizierung mit drei unterschiedlichen Ebenen, Ausgangspunkt, Ziel und Aspekt kategorisiert und mit Beispielen und exemplarischen Beiträgen beschrieben, wodurch die aufgestellte Forschungsfrage als beantwortet angesehen werden kann.

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On the Changing Nature of Inter-organizational Technologies, Their Success Factors, and the Impact on Modern B2B Relationships – a Literature Review

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Abstract

Establishing interoperability with business partners through the use of information technologies (IT) is regarded as a primary source of business value for today's organizations. The ubiquitous and open nature of Internet-based technologies, however, is transforming the utilization of IT within inter-organizational business processes and rendering its use increasingly infrastructural. This paper presents the results of a review of extant empirical findings within novel studies in the stream of inter-organizational information systems (IOIS) research aiming to uncover if and how research has witnessed the evolution of IOIS from proprietary systems towards open standard and open technology-based digital infrastructures (DI). Mechanisms that drive success of DI-enabled inter-organizational business processes are discussed, and areas of special attention particularly for further research are uncovered.

1 Introduction

Organizations of today operate within an increasingly networked economy (Markus and Loebbecke 2013), and have to constantly compete within and adapt to a highly networked and dynamic business environment (Bandiera et al. 2011). The enablement and establishment of interoperability with trading partners and customers through the use of information technologies (IT) is therefore regarded as a primary source of business value (Lempinen and Penttinen 2009), efficiency gains, and innovation (Loukis and Charalabidis 2012). While early electronic inter-organizational relationships required costly up-front investments into proprietary custom-built systems such as electronic data interchange (EDI) systems (Zhu et al. 2006a), the ubiquitous and open nature of Internet-based technologies (E-Mail, FTP, XML, etc.) allows them to be utilized by organizations of practically any size at low cost (Kauffman and Mohtadi 2004). Consequently, hierarchical „command-and-control" like strategic arrangements are continuously giving in to market-based "connect-and-coordinate" ones, while the utilization of IT within inter-organizational business processes is transforming from a dedicated utilization of custom-built proprietary systems to an infrastructural use of systems within system arrangements that are built around open technologies and standards (Tilson et al. 2010). Thereby, open standard and open technology-based inter-organizational systems are increasingly utilized within digital infrastructures (DI) of systems to digitalize inter-organizational business processes of firms that compete in today's business environment (Markus and Loebbecke 2013). DI can be defined as the basic information technologies, systems and organizational structures, along with the related services and facilities, necessary for an enterprise or industry to function (Tilson et al. 2010).

However, the pervasive integration of open technologies and standards within inter-organizational business processes introduces network effects, meaning that the value of open technologies and standards for each participating firm largely depends on the total number of participants using them (Zhu et al. 2006a). Furthermore, as systems become interconnected, organizations in most cases are faced with controlling an entire array of systems and technologies that drive particular inter-organizational business processes, typically introduced over many years and for different purposes (Tilson et al. 2010). Thus, the effectiveness of a particular system is largely conditional on its interplay in an arrangement of systems that are utilized to drive a particular inter-organizational business process, proving the analysis of such arrangements of systems and technologies a matter of scope beyond one single system (Henfridsson and Bygstad 2013).

From an IS research perspective, DI provide a modern counterpart to classic inter-organizational information systems (IOIS). Research results generated from investigations of older systems on the other hand might therefore be not very insightful to understand the next generations of IOIS based on open technologies and standards (Robey et al. 2008). The emerging concept of DI seems to be particularly suitable in this context to investigate modern IOIS that constitute arrangements of multiple open systems and technologies, as it supports the inherent interconnectedness of today's business environment, as well as the particular evolved nature of modern IOIS that are based on open technologies and standards, and are employed in an infrastructural way to drive inter-organizational business processes (Tilson et al. 2010).

This paper thus sets out to investigate extant empirical findings within novel investigations in the research stream of IOIS with the aim to uncover if and how research has taken notice of the evolution of IOIS towards DI, and has investigated mechanisms that drive success of DI-enabled inter-organizational business processes. Therefore, we pose the following research questions:

RQ1: How did prior research witness the evolution of IOIS towards DI?

RQ2: What are the factors that drive successful DI integration within inter-organizational business processes and how do they drive integration success?

A structured literature review is conducted to answer the posed research questions. Results of the literature review provide a sound foundation for future research endeavors in the field of IOIS, and can also be seen as a useful starting point for further empirical research. The remainder of the article is structured as follows. Following a thorough introduction to and definition of IOIS, the scope of the literature review is explained, and extant research is reviewed at length. Subsequently, the reviewed literature is analyzed to reveal patterns and trends in academics as well as business practices with particular focus on DI. Finally, areas that need special attention from academics, and should be researched in more depth are uncovered.

2 Inter-organizational Information Systems and Inter-organizational Communication

Inter-organizational communication in a digital format through the use of IT has been a research topic long before the advent of the Internet. Early definitions describe IOIS as custom-tailored systems primarily directed towards enabling the transmission of business information across organizational boundaries between at least two or more organizations (Johnston and Vitale 1988). A more precise definition of IOIS, following the uptake of the Internet, is given by Eom (2005), defining IOIS as an information system that transcends organizational boundaries via electronic linkages to share data, information, and business applications with business partners for the purpose of increasing efficiency, effectiveness, competitiveness, and profitability. As organizations cooperate and communicate on many different levels, IOIS exist in many shapes and forms depending on each organization's needs or abilities. Kumar and van Dissel (1996) define three main forms of IOIS – binary, the market, and hub-and-spoke as a hybrid between the two. De Corbière and Rowe (2009) further see the dyad as one extreme of an IOIS, with the multilateral IOIS on the other end of the spectrum. Similarly, Lyytinen and Damsgaard (2011) identify dyadic, hub-and-spoke, industry-wide, and community-wide forms of IOIS as configurational arrangements of particular strategic and structural characteristics of participating organizations. As Figure 1 shows, the continuum of IOIS types can therefore be described to reach from dyadic electronic inter-organizational linkages (e.g. direct EDI-driven links) to hub-and-spoke-like hybrid forms (e.g. use of consolidator service providers), and to systemic industry- or community-wide inter-organizational arrangements (e.g. use of open standards and technologies such as PDF, XML, or E-Mail in an infrastructural, systemic way).

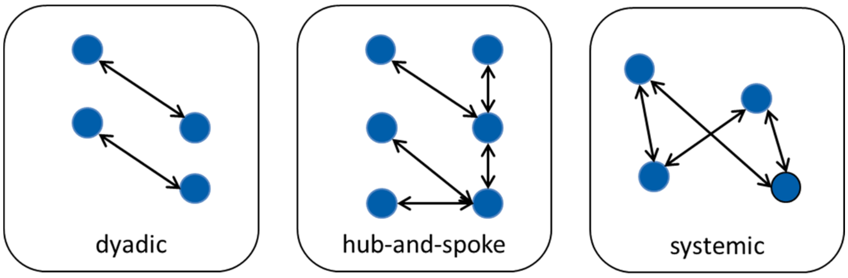

Figure 1: The continuum of IOIS types

The emergence of proprietary standards and systems for electronic data interchange (EDI), using direct electronic linkages between participating organizations, can be seen as the earliest de facto standard for IOIS (Robey et al. 2008) and has been extensively researched, likely owing to its relative longevity. More recently, however, increasingly Internet-based forms of IOIS have been deployed. These newer types of IOIS take advantage of the ever more ubiquitously available Internet and include among others extranets, electronic catalogues, and electronic marketplaces (de Corbière and Rowe 2009). The most striking differences between early EDI and more recent types of IOIS highlight an important trend in electronic relationships between companies – the move from proprietary towards open standard-based technologies. The diffusion of the Internet has played an integral role in this development by providing a relatively easily and inexpensively accessible network for a new generation of modular, scalable, and flexible IOIS that are based on open standards such as XML (Nelson and Shaw 2005). Lower adoption and implementation costs of modern IOIS allow participation in digitally enabled inter-organizational relationships that are viable even for small companies (Hong and Zhu 2006; Zhu et al. 2006a). Considering the adaptive nature of XML, networks of firms have been quick to collaborate on business standards that meet their needs (Zhao et al. 2007). An often-cited, industry-based example is RosettaNet, a non-profit consortium which was launched in 1998 in order to develop "XML-based open process standards in the information technology and electronics industries" (Chang and Shaw 2009). More recently, cloud-based services such as E2open, geared towards paying customers, have emerged as examples of modern cloud-based IOIS in B2B settings (Rodón and Sesé 2010), with open, non-proprietary, and independent technical standards being implemented at the heart of these systems (Staykova and Damsgaard 2014). Similarly, emerging open standard-based electronic B2B marketplaces such as Covisint for the automotive industry enable electronic inter-organizational trade relationships (Howard et al. 2006), while Internet-based ordering platforms such as PharmX for the pharmaceutical sector enable electronic B2B purchases (Reimers et al. 2014). Electronic invoice exchanges between firms that are based on open standards and technologies, and are used in a systemic, infrastructural way further increase interoperability between business partners (Kuehne et al. 2015).

This trend towards open standards and open standard-based technologies uncovers a critical evolution step of the IOIS artifact – alike the ubiquitous and open nature of IT in other settings such as personal IT use (Schlagwein et al. 2010), the utilization of IOIS technology in B2B settings is evolving from hierarchical control to inter-organizational collaboration and value co-creation (Han et al. 2012). Thereby, IOIS technology that is adopted and implemented in these highly networked B2B settings is increasingly becoming ever more open and interoperable, as it has to integrate and interact with various systems of participating organizations (Henfridsson and Bygstad 2013). The increasing openness and interoperability of these modern IOIS allows them to be utilized together with various organizational systems (e.g. ERP) on an infrastructural level, ultimately providing firms with open, transparent, and interoperable digital infrastructures for digitally enabled inter-organizational business processes (Tilson et al. 2010). However, prior investigations in the stream of IOIS research largely neglected the critical role of the highly networked business environment (Kreuzer et al. 2014), as well as the evolved nature of the IOIS artifact (Robey et al. 2008). Returning to Eom's (2005) definition of IOIS in the Internet age, it can likewise be observed that while the Internet attributes a multitude of ways by which firms can share information by utilizing IOIS, like prior definitions of IOIS it lacks evidence of a change in the nature of the IOIS artifact itself.

In summary, several key observations can be made from a first look at prior research on IOIS and inter-organizational communication. First, while the technologies that are in use in the context of modern open standard-based IOIS have changed dramatically within the last decade, the scientific view of IOIS has not changed significantly during that time. Second, the ubiquitous natures of the Internet and open standard-based technologies have dramatically changed the way in which modern IOIS are developed and inter-organizational relationships are formed. The latter observation in particular, in accordance with previous findings (Robey et al. 2008), illustrates the need for a theoretical re-examination of the IOIS artifact and its particular properties.

3 Research Methodology

To identify relevant empirical literature for analysis and to structure the search according to accepted scientific norms, the search process followed broadly accepted recommendations for identifying relevant research and structuring the search process (Webster and Watson 2002). As literature relevant to the stream of IOIS research is furthermore not restricted to the discipline of IS research only, and likewise touches other major disciplines such as management and e-commerce research (Robey et al. 2008), the search featured journals from multiple fields being information systems, management, and e-commerce respectively. Each of these areas has their own academic journals, of which relevant journals were analyzed in the following. For information systems, all journals analyzed were part of the AIS Senior Scholars' Basket of Journals. For the other two areas named above, all journals included in the analysis were ranked at the top in different comparisons (e.g. Eigenfactor, SJR, Journal Citation Reports).

As a first step to find articles pertaining to the aim of the analysis, a generic search for the terms "Interorganizational Information Systems" (in both American and British spelling), "interfirm", "B2B e-commerce" and "EDI" was undertaken in Google Scholar in the time period from 2001 to 2014. As it became apparent which journals would yield the best crop of papers, another search was started using these journals' archives' own search engines, as well as their keyword systems in the same time period. In order to ensure that no papers had been overlooked, the titles of all papers in the time period in the archives were skimmed.

After careful deliberation, the following journals were chosen to provide the source material for the literary review. While Table 1 shows the end result of the search process, several outlets were included in the search that yielded no results.

Management	*Management Science*	Forman 2005, Mukhopadhyay and Kekre 2002, Yao et al. 2009, Zhu et al. 2006b
Information Systems	*Information Systems Research*	Bharadwaj et al. 2007, Chatterjee and Ravichandran 2013, Chi et al. 2010, Chwelos et al. 2001, Dong et al. 2009, Im and Rai 2014, Malhotra et al. 2007, Mishra and Agarwal 2010, Rai and Tang 2010, Saraf et al. 2007, Venkatesh and Bala 2012, Yao and Zhu 2012, Zhu and Kraemer 2002
	Management Information Systems Quarterly	Barua et al. 2004, Chatterjee et al. 2002, Klein and Rai 2009, Malhotra et al. 2005, Mithas et al. 2008, Rai et al. 2006, Rai et al. 2012, Subramani 2004, Teo et al. 2003, Wang et al. 2013, Zhu et al. 2006a
	Journal of Management Information Systems	Gosain et al. 2004, Kishore et al. 2004, Son and Benbasat 2007, Straub et al. 2004, Zhao and Xia 2014
	Journal of Strategic Information Systems	Bell et al. 2012, Dedrick and Kraemer 2010, Kendall et al. 2001, Pavlou 2002, Tay and Chelliah 2011, Wang and Ahmed 2009
E-Commerce	*International Journal of Electronic Commerce*	Chang and Shaw 2009, Chi et al. 2007, Hsu et al. 2006, Molla and Licker 2005, Mouzakitis et al. 2010, Ranganathan et al. 2004
	Journal of Electronic Commerce Research	Chau 2001, Janita and Miranda 2013, Karakaya and Stahl 2009, Wang et al. 2004, Yu 2007
	Electronic Markets	Al-Qirim 2005, Beck et al. 2005, Beck and Weitzel 2005, Chompis et al. 2014, Hadaya 2008, Hadaya and Cassivi 2009, Peng and Woodlock 2009, Plomp et al. 2012, Wymer and Regan 2005
	Electronic Commerce Research	Hadaya 2006, Kheng and Al-Hawamdeh 2002, Sila 2013

Table 1: Studies by focus area and journal

As Table 1 shows, four papers in this analysis pertained to the field of management, 35 studies pertained to the field of IS, and 23 studies pertained to the field of e-commerce research, bringing the total number of identified studies to 62. From the area focusing on management, the only journal carrying papers with quantitative research on IOIS adoption was Management Science. The remaining analysed journals from the area focusing on management – Academy of Management Journal, Academy of Management Review, Organization Science, Journal of Accounting, and Economics and the Journal of Management – yielded no relevant papers. Predictably, more papers were found in journals focused on IS, namely in Information Systems Research, Management Information Systems Quarterly, the Journal of Management Information Systems, and the Journal of Strategic Information Systems. Still, two analysed IS journals – Information Systems Journal, and the Journal of the Association for Information Systems – yielded no relevant papers. Finally, all of the journals focused on e-commerce – the International Journal of Electronic Commerce, the Journal of Electronic Commerce Research, Electronic Markets, and Electronic Commerce Research – yielded relevant papers. The final set of 62 articles was then transformed into a concept-centric representation as recommended by (Webster and Watson 2002), which will be discussed in the following.

4 A Critical Review of the IOIS Artifact in Prior Research

Considering the relative novelty of the Internet and IOIS, it comes as no surprise that according to the results of the conducted literature analysis, in the beginning of the 2000s IOIS research primarily focused on factors influencing initial adoption decisions (Chatterjee et al. 2002). Chief among factors were technology readiness, perceived benefits and expected costs of adopting IOIS. Researchers tried to explain why some firms would readily accept e-business for inter-firm relations while others would hesitate, and findings were aimed at giving guidelines to help managers discern if they should or should not invest in IOIS. Research was also more focused on dyadic-type exchanges via proprietary EDI-based systems, the most common type of IOIS at the time (Iacovou et al. 1995). What is surprising, however, is the lack of development away from limiting research to this first step of the innovation process, i.e. the decision to adopt or not adopt. While some studies started to make distinctions between different levels of adoption (e.g. Zhu et al. (2006b); Mouzakitis et al. (2009)), most still explore only deciding factors. In our analysis, only 27 out of the 62 studies did examine performance impacts of adoption or added value of integration. Nevertheless, it must be mentioned that research into the significance of adoption factors often comes to very different results with little answer as to why (Al-Qirim 2005), explaining the urge for research in this direction. As many of the investigated studies however either focus on one industry or a small sample, or disregard industry as a factor altogether, this leads to an obvious lack of research on the influence that organizational characteristics such as industry type might have on IOIS adoption and diffusion. Consequently, academics call for more studies that apply the same model to IOIS adopters across different industries (Zhu et al. 2006b).

An obvious problem within IOIS research, and another possible explanation for varying results in prior investigations, however, is the ambiguity or complete absence of meaningful definitions and discussions of the IOIS artifact that researchers use to narrow down their research or survey samples. In our analysis, only 24 out of the 62 studies explicated the actual IOIS artifact under inquiry in detail. Some studies define what exact type of IOIS they target in their research, as is the case for EDI-focused studies (Chau 2001; Yao et al. 2009), but most use the term IOIS without explaining what it constitutes in their context. The 24 studies that do include at least some kind of definition can be grouped by their prominent use of three non-mutually exclusive characteristics: an emphasis on multilateral inter-organizational relationships over bilateral links (8 studies); an emphasis on the inter-organizational integration and/or automation of relations (12 studies); and the technological basis of the Internet as a prerequisite versus private networks (15 studies). The general trend here shows studies on technologies like proprietary EDI to look at dyadic relationships, while most of the studies focusing on multilateral relationships resemble DI in terms of definition. Private networks are exclusively examined as part of proprietary EDI systems, while the Internet is considered an important foundation for DI. However, these defining characteristics are often not mentioned clearly as such. This lack of proper definitions in most of the reviewed studies makes it difficult to compare studies and results as it is sometimes not clear if they analyze things and processes that are comparable at all. This finding might as well be primarily responsible for the negligence that research shows towards the evolved nature of the IOIS artifact. Thus, while current research still treats the IOIS artifact as a black box to a high degree, placing confidence in prior research and findings that are based upon potentially outdated technologies (Robey et al. 2008), the detailed discussion of the properties of the IOIS artifact within novel investigations in particular could very well uncover the dramatic change in its nature.

Nevertheless, a development that can be seen even from the titles of the papers surveyed here is the focus moving from proprietary dyadic-type IOIS, usually EDI-based, to newer open standard-based hub-and-spoke and systemic IOIS. In our analysis, 27 papers investigated dyadic EDI-style IOIS, 15 papers focused on hub-and-spoke types such as B2B e-marketplaces, and 17 papers investigated systemic types such as modern electronic invoice exchanges. Notably, research explicitly looking at EDI-based IOIS, focusing on open EDI standards, is still present even in more recent literature, as it is still very commonly used in large organizations (Chatterjee and Ravichandran 2013). However, in terms of depth of research on modern open standard-based IOIS, while 30 of 62 papers at least address the open nature of the IOIS artifact in some way, a superficial view of IOIS persists in research that does not go beyond the idea of Internet-based e-business connecting firms electronically. Notable exceptions here are Venkatesh and Bala (2012), who explore open standards underlying modern IOIS. However, with the move towards more open, transparent, and interoperable IOIS, common or best-practice standards will likely be an important part of research in the future (Markus and Loebbecke 2013), as they provide the framework that previously came built-in with proprietary systems in an open and infrastructural way, and also foster the emergence of digital infrastructures (Tilson et al. 2010).

5 Discussing Success Factors of Digital Infrastructure Integration Within Inter-organizational Business Processes

From the analyzed studies, though none of them explicitly focused on DI, several critical success factors can be derived that drive integration of open standards and open technologies in an infrastructural way as constituents of particular DI that drive corresponding inter-organizational business processes. One primary factor in this context is external pressure, in both an economic and regulatory sense (Forman 2005; Hsu et al. 2006; Zhu et al. 2006b). Regulatory pressure may be more noticeable under a central, influential authority advocating adoption of particular DI, while the deployment of specialized systems or technologies as part of a DI within a particular business community may be subject to higher industry pressure (Chwelos et al. 2001). Consequently, participating actively in government-sponsored efforts at promoting DI or in councils committed to promote open standards and open technologies can be very advantageous for organizations as they gain direct influence on the development of these standards and technologies. Through sharing experiences and expertise in adopting or even innovating DI, firms can multiply their influence in their respective industry or business community (Chau 2001; Teo et al. 2003). Considering the important role that governments play, a supportive regulatory environment will ease organizations' shifting to DI, e.g. through incentives such as tax advantages (Molla and Licker 2005; Zhu et al. 2006a). Likewise, extensive support from technology vendors (e.g. B2B marketplace owners) can make or break adoption intent in organizations (Al-Qirim 2005; Chompis et al. 2014). While DI emphasize partnership, cooperation, and open innovation (Han et al. 2012), the main expected benefit of adopting DI particularly for smaller firms is to gain a relative advantage over competitors, not necessarily to cooperate with them (Kendall et al. 2001). Thus, decision-makers should gain knowledge about the potential range and reach of their organizations' inter-organizational linkages in order to maximize benefits (Chi et al. 2007).

Likewise specific to inter-organizational relationships, network effects also play a primary role in the context of DI adoption. This is especially the case for suppliers and/or small companies, where buyers may require deployment of particular systems or technologies for their own efficiency (Beck and Weitzel 2005; Hsu et al. 2006). Just as decisions made by trading partners will influence a firm, a firm's decisions will influence all partners' choices in turn (Mukhopadhyay and Kekre 2002). Consequently, and despite potential advantages through deploying a particular system or technology, organizations should carefully evaluate their needs in relation to the wishes of their customers and partners in order to realize as many benefits as possible (Zhu et al. 2006a; Chang and Shaw 2009; Chatterjee and Ravichandran 2013). Furthermore, while deployment of a DI is likely to benefit firms on the buyer side, advantages for their dependent supplying partners are less certain (Yao et al. 2009). Establishing good communication and information exchange not only within the company but especially among trading partners is therefore found to be key by many researchers (Malhotra et al. 2007; Saraf et al. 2007; Dong et al. 2009; Chi et al. 2010; Rai et al. 2012; Im and Rai 2014). This ties in with the trend towards an infrastructural use of open standards and technologies – suppliers trading with multiple companies will more likely profit from adopting DI if they can use one system for all of their buyers. If suppliers need to implement several parallel systems, each tailored towards one buyer, they lose potential benefits to managing these duplicate structures, and this will be exacerbated with growing supplier interdependence (Ranganathan et al. 2004; Malhotra et al. 2005). Other investigations find that even more important than trading partners' adoption decisions are peer decisions, i.e. global network effects, possibly due to the importance of DI growing with their diffusion (Zhao and Xia 2014).

Taking a technology-centric viewpoint, several studies further conclude that recent investments in IT can have unintended consequences, as firms are often unwilling to spend money, time and energy on several adoptions within a short time frame, especially if they cannot be certain of their success. If they do adopt, they tend to choose a technology that is complementary to the IT infrastructure already in place (Forman 2005; Chatterjee and Ravichandran 2013). Nevertheless, technology readiness, along with keeping interoperability up to date at all times, is an important factor in making the adoption of new electronic linkages successful (Mouzakitis et al. 2009). On the other hand, while expected benefits in terms of higher efficiency and lower costs are a decisive factor in organizational adoption plans (Dedrick and Kraemer 2010), their realization is not certain in all cases and under all circumstances (Beck and Weitzel 2005; Yao and Zhu 2012). Thus, the amount of expected benefits has only limited value as an indicator of long term success.

From an organizational viewpoint, managerial innovativeness is concluded to be a very important factor that drives success. Constant adjustments of management practices and open-minded experimentation with new technology are crucial to successful adoption and implementation, as is managers' in-depth knowledge and understanding of underlying technologies and their skills in handling it (Zhu et al. 2006b; Karakaya and Stahl 2009; Dong et al. 2009; Sila 2013). Likewise, managerial supportiveness and focus are equally important, as a well-coordinated approach towards DI adoption and finding a good balance between technology assimilation and business strategies is key to long-term success (Chatterjee et al. 2002; Chi et al. 2010). As adopting and integrating DI is not merely a technological update, but influences business processes on a multitude of levels, constant in-depth communication within the organization is likewise crucial to support long-term success (Mishra and Agarwal 2010; Rai et al. 2012).

Summarizing, based on the results of the literature review, the changed nature of the IOIS artifact towards DI favors mutually beneficial collaboration and active participation of business partners over the rigid structures of vertical integration predominant in the classical case. This leads to an increase in importance of mutually beneficial non-coercive mechanisms – such as the promotion of DI through incentives, or the active commitment to open standard-setting consortia – in applying external pressure over coercive ones. In the highly networked business environment of today, DI thus favor the establishment of ample communication and information exchange among business partners over the establishment of dependence structures among them. Finally, while the inherent openness of DI enables flexibility in choosing technologies that are compatible and complementary to a firm's existing IT infrastructure, DI's ubiquitous nature facilitates the acquisition of in-depth knowledge and understanding for innovating decision-makers, supporting them in shaping a well-coordinated approach towards DI adoption and integration.

6 Conclusion

Owing to the rapid development of new technology, it can be reasonably expected that IOIS research will move away from proprietary systems and onto new, open standard- and technology-based systems at a growing pace. The present study conducted an analysis of prior empirical studies in the research stream of IOIS, likewise uncovering that the focus both in research and practice is moving from proprietary dyadic-type IOIS to open standard- and technology-based hub-and-spoke and systemic types.

For researchers, the analysis of prior literature uncovered the fact that the IOIS artifact has remained largely unchanged, owing to a lack of attention towards the discussion of its changing nature in novel investigations of open standard- and technology-based systems. As these inter-organizational technologies and systems are becoming ever more deeply integrated into organizations' internal structures, research will have to take the bigger picture of DI into account. New approaches to integrating DI into organizational processes will require more studies that respect new peculiarities of the DI artifact. The extent and nature of complementarities between a multitude of processes, IT components and IT readiness within each organization needs to be unravelled in order to fully understand the impact of DI. This also means that more systematic research into standards and standards-making need to be undertaken, as they also foster the emergence of digital infrastructures through the provision of a framework for openness and interoperability (Tilson et al. 2010). Thus, we urge IS researchers to be reasonably cautious when applying the black box IOIS artifact and respective findings from investigations of potentially outdated technologies in future studies, and encourage them to place higher emphasis on a meaningful definition and discussion of the particular artifact that is investigated.

For decision-makers, the analysis further provides a timely overview of success factors of DI integration within inter-organizational business processes and provides explanations for the ways in which these factors drive success of DI adoption and integration approaches. Most critical to success of DI adoption and integration according to the results is therefore an active participation in open innovation and value co-creation approaches within the respective business communities, and the careful consideration and analysis of external pressures as well as network effects present within the firm's external business environment.

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Sometimes You Win, Sometimes You Learn – Success Factors in Reward-Based Crowdfunding

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Abstract

Crowdfunding has enabled various entrepreneurs, artists and other individuals and organisations to bring projects to life. Despite all success stories, 63% of all projects initiated on the biggest crowdfunding platform kickstarter.com and 46% of all projects initiated on the biggest German crowdfunding platform startnext.com, do not raise enough money to be realised. This study investigates which factors beyond project quality and personal network impact the success of a crowdfunding campaign. Using data collected from startnext.com, we analyse the impact of six factors on the probability of success and provide practical recommendations for initiators. The six factors we analyse are: inclusion of a video, length of project description, communication with backers, curation by a third party, crowdfunding activity of the project initiator and number of rewards. In particular, we show that the inclusion of a video, an intensive communication with backers via blog posts, a history in supporting projects and the creation of a variety of rewards can significantly increase the likelihood that a project succeeds.

1 Introduction

Sometimes you win, sometimes you learn – the title of this study reflects the spirit of our approach. By drawing on crowdfunding literature as well as current practices, we identify six factors that potentially influence the probability of success of a crowdfunding campaign. Based on data collected from the reward-based crowdfunding platform startnext.com, we then analyse empirically whether the identified factors influence the likelihood that a crowdfunding campaign succeeds. We use our findings to identify implications for research and practice.

Crowdfunding has been defined as "an open call, essentially through the Internet, for the provision of financial resources either in form of donation or in exchange for some form of reward and/or voting rights" (Belleflamme et al. 2014, 4). As an alternative or additional source of financing for a variety of different projects, crowdfunding has gained a lot of attention in recent years (Agrawal et al. 2010). The basic principle of crowdfunding is to pool relatively small amounts of money from a large number of supporters (Leimeister 2015). Crowdfunding essentially involves three stakeholders: a project initiator who seeks funds for a project; the crowd of supporters (or backers) who support a project through a financial contribution; a crowdfunding platform that serves as an intermediary between initiators and supporters (Belleflamme et al. 2013).

Crowdfunding can take very different forms. Based on the return supporters receive for their contribution, a common classification differentiates four categories of crowdfunding (Hemer 2011). In reward-based crowdfunding, supporters receive a non-financial reward (e.g. an early version of a product) in return for their support. In equity-based crowdfunding, supporters (or rather crowdinvestors) receive a financial return, such as a share in the company. In lending-based crowdfunding, supporters also receive a financial return (e.g. interest on the money invested). In donation-based crowdfunding, supporters do not receive any material or financial reward.

Our study analyses data from startnext.com, a German reward-based crowdfunding platform that also created a platform for the Austrian and the Swiss market. With €22.8m raised up until September 2015, startnext.com is the most successful German crowdfunding platform. Startnext.com uses a fan-function during the starting phase of a project. Depending on the defined funding threshold, initiators need to acquire a certain number of fans (e.g. 25 fans for funding thresholds between €501 and €2,500) to be able to move to the funding stage. Startnext.com (just like kickstarter.com) operates on an all-or-nothing basis, meaning that project initiators have to define a funding threshold for their project. If they reach the threshold, they receive the money to realise their project. If they do not reach the threshold, the money will be returned to the backers. For the purposes of this research, we consider a project that reached its funding target a successful project and a project that has not reached its funding target an unsuccessful project. On startnext.com, the share of unsuccessful projects is at 46% (Startnext 2015). When regarding the market leader, kickstarter.com, an even higher rate of failure – 63% – (Kickstarter 2015) can be found. It goes without saying that not all projects that are created have the potential to succeed. As the crowd evaluates whether to support a project, to a certain extent bad projects and incompetent initiators are refused funding for a good reason. After all, the wisdom of the crowd can help to decide which projects deserve to be funded and which do not. However, during the preparation of this research, we found that many innovative projects that were created by motivated and competent initiators, still failed to reach their funding threshold. This subjective observation sparked our interest for the present study. By analysing success factors in reward-based crowdfunding, we intend to give recommendations to project initiators on how to improve their crowdfunding campaign to increase the probability of success.

While some studies already started to address success factors in reward-based crowdfunding and to create lists of success factors (see for instance Mollick 2014, Lim et al. 2013, Leite and Moutinho 2012), research is still in a relatively early state. The high share of unsuccessful projects indicates that more research is desirable. Where a project fails because of a lack of quality, such failure is part of the selection inherent in economic processes. Where, however, a project that would otherwise have sufficient quality to succeed, fails due to ineffective presentation, the failure is inefficient. Most studies so far focussed on the market leader, kickstarter.com. The main contribution of our research relates to the fact that we generate our data from another crowdfunding platform, startnext.com. Startnext.com has thus far not received much attention in the relevant literature with respect to empirical studies. Our results thereby help to confirm or rebut findings in the existing literature. While kickstarter.com and startnext.com are similar platforms, we still consider it important to extend the body of literature by data collected from another crowdfunding platform. This appears to be of particular importance when comparing the diverging success rates between kickstarter.com (37%) and startnext.com (54%). These diverging success rates imply that findings from kickstarter.com are not necessarily applicable for project initiators on startnext.com. Further, as the two platforms primarily address different geographical markets, it is important to assess whether findings from one geographical market can be maintained in a market with different cultural particularities. As our analysis focuses on reward-based crowdfunding, parallels to e-commerce research can be found. In many cases, project initiators actually provide the product they intend to create as a reward. In such cases, reward-based crowdfunding is a form of pre-selling (Ahlers et al. 2015) and its dynamics are similar to e-commerce transactions (Bradford 2012). Our findings are therefore of importance beyond the context of crowdfunding. As many of the factors we analyse are relevant in the context of e-commerce transactions, our study also adds to e-commerce literature, in particular in the field of online product presentation.

In the following chapter, we will develop our hypotheses based on the relevant literature and actual practices in the field of reward-based crowdfunding. Chapter 3 will explain our methodology. In chapter 4, we outline our findings. Based on these findings, we discuss implications for research and practice in chapter 5. Chapter 6 provides a summary of our approach and outlines the limitations this study is subject to.

2 Theoretical Background and Development of Hypotheses

The success of a crowdfunding campaign depends on a large variety of factors. Based on data collected on kickstarter.com, Mollick (2014) suggests that project quality and the network of the project initiator are of crucial importance. A number of studies have investigated in more detail how certain factors influence the probability of success of a crowdfunding campaign. Intuitively, some of these factors would appear to be of rather marginal importance and would therefore not necessarily receive as much attention by project initiators as deserved. At the same time, in many cases project initiators can modify the respective factors with relatively small costs. Such factors include, for instance, project updates (Carr 2013; Kuppuswamy and Bayus 2014; Leite and Moutinho 2012; Mollick 2014; Qiu 2013; Xu et al. 2014), campaign duration (Colombo et al. 2015; Cordova et al. 2013; Frydrych et al. 2014; Hahn and Lee 2013) and video message by project initiators (Frydrych et al. 2014; Marom and Sade 2013; Mollick 2014). It appears that research into success factors is of particular importance as it has a great potential to give indication to project initiators on how to efficiently improve their campaign. Due to the identified lack of research and the importance of improving the understanding of success factors, our study will investigate the impact of selected success factors. We have selected the following success factors: project presentation, communication with backers, curated projects, project initiator profile and reward structure. While there is a large amount of potential success factors to be analysed, we had to restrict our research to a limited number of factors to ensure a sufficiently focussed research design. We based our selection on the availability of data, the existence of previous research and the costs for modification. When choosing these success factors, we considered it important to cover various aspects and stakeholders of a crowdfunding campaign. Our factors therefore cover the communication with the general public (project presentation), the communication with backers, the involvement of external entities as a quality signal (curated projects), characteristics of the project initiator (project initiator profile) and incentives to backers (reward structures).

2.1 Project Presentation

Every project page on startnext.com is based on the same template. Project initiators can fill the template with information and embed pictures and videos. The template contains a section for project description, in which initiators can provide detailed information on their project. To ensure comprehensiveness of information and to increase comparability, startnext.com implemented default headlines which project initiators use to describe their project. Despite these default settings, project initiators retain a large amount of freedom regarding the presentation of their project. This shows, firstly, with respect to the elaborateness of the information provided. While, to a certain extent, due to the relatively small sums usually contributed, backers might be reluctant to read extensive information, we still assume that a more detailed description contributes to a successful campaign. This assumption is based on the consideration that an elaborate description signals expertise and diligence, reduces information asymmetries and thereby increases trust and decreases perceived risks. We hypothesise:

H1a: *As the elaborateness of a project description increases, the probability of success of a crowdfunding campaign increases.*

The freedom of project initiators, secondly, shows with respect to the choice of whether to embed media files. Mollick (2014) found that project initiators who include videos into their description are more likely to succeed. This finding may be explained by the consideration that a video signals quality as it communicates that the project initiator is confident to show the respective product (Mollick 2014). Moreover, videos can transport further information and thereby reduce information asymmetries (Yao and Zhang 2014). In addition, it has been established in e-commerce research that videos can generate trust (Aldiri et al. 2008), a factor that can be of crucial importance in crowdfunding. We hypothesise:

H1b: *Embedding a video into the project description increases the probability of success of a crowdfunding campaign.*

2.2 Communication with the Crowd

Startnext.com offers three ways in which project initiators can communicate with the crowd. Firstly, a messaging system allows initiators to contact backers and fans directly, either individually or in groups. Secondly, initiators can post updates regarding their project description which will be displayed above the project description. This function is necessary as the project description cannot be altered once the project is running. Thirdly, a blog integrated into the project page allows initiators to inform the crowd about the progress of the crowdfunding campaign. Initiators can choose to distribute their blog post via e-mail directly among registered fans and backers. In addition, startnext.com provides a wall on which individuals can ask questions and provide feedback. Such posts can then be commented by the project initiator.

To investigate how the communication with the crowd influences the success of a project, we will focus on blog posts as they present a relatively efficient way for initiators to communicate with the crowd and, from a research perspective, are relatively easy to compare from project to project. Previous research indicates that increased communication with the crowd via blog posts increases the likelihood of a successful campaign (Mollick 2014; Xu et al. 2014). Xu et al. (2014) analysed this success factor in more detail. They identified seven different categories of blog posts, including posts that announce new rewards, posts that answer questions and posts that announce new contents. Xu et al. 2014 found that (with different levels of significance) all blog posts had a positive influence on the probability of success. We therefore decided to regard all blog posts together and hypothesise:

H2: *As the number of blog posts increases, the probability of success of a crowdfunding project increases.*

2.3 Curated projects

With the feature „curated pages“, startnext.com allows third party organisations to help certain projects with their funding. Such organisations include cities, universities and companies. A similar feature exists on kickstarter.com. Curating organisations usually select projects based on content-related or geographical criteria. Often, curating organisations link to the project page from their own website to increase web traffic. In addition, the curating organisation‘s logo is displayed on the project page which can serve as a quality signal. We hypothesise:

H3: *The probability of success of a curated project is higher than the probability of success of a non-curated project.*

2.4 Initiator Profile

The project initiator's profile is not project specific. It sums up the user's history on the platform by indicating how many projects the initiator has already created, supported and favorited. Further, initiators can introduce themselves and provide a profile picture. In this context, it needs to be remembered that whenever backers pledge to a project, they take the risk of losing their money. In the case of e-commerce, a certain reputation of an online shop or a vendor usually creates trust that decreases a buyer‘s perceived risk. In crowdfunding, where initiators usually do not have a reputation and products are often innovative, such trust needs to be created by other means. The first contact point between an initiator and a potential backer is usually the project description. However, once an initial interest has been created, the initiator's profile can serve as an important tool to generate trust. Blass and Ketchen (2014) argue that it is important for project initiators to avoid the impression that they are pursuing a hobby rather than a serious business project. Research on an Australian equity crowdfunding website showed that higher business degrees lead to a more successful project outcome (Ahlers et al. 2015). It follows that project initiators should try to communicate their expertise and competence to complete the project. In this context, the project page can be seen as a selling point for their crowdfunding activities (Aldiri et al. 2008). An indication of previous crowdfunding activities signals knowledge with respect to the dynamics of crowdfunding. We hypothesise:

H4: *As the number of previously supported projects increases, the probability of success of a crowdfunding campaign increases.*

2.5 Reward Structure

The provision of a non-financial reward is the key feature of reward-based crowdfunding. Project initiators can choose the type of rewards they offer, the amount of money backers need to pledge to receive a reward and whether to limit the quantity of a reward. Agrawal et al. (2014) points out that backers have a variety of incentives to contribute to crowdfunding projects. Such incentives include immaterial factors, such as community participation and the support of a product, service or idea. However, it appears obvious that rewards (in particular in pre-purchase crowdfunding) also provide an important incentive. It has been argued above that crowdfunding is very much based on the idea of collecting a large number of relatively small funding amounts. Small funding sums enable backers to participate without exposing themselves to high risks (Kuppuswamy and Bayus 2014). Research in the context of reward-based crowdfunding for film projects showed that projects that require a higher minimum pledge attract fewer backers (Buttice et al. 2015). It therefore appears reasonable to provide rewards for a variety of different funding sums and to start at a relatively low price. Moreover, the large amount of backers usually involved in a crowdfunding project also entails that the crowd of backers has very diverse interests and motivations (Rakesh et al. 2015). Due to different financial resources and interests, we assume that a wider range of rewards offered will help to attract more backers. We hypothesise:

H5: *As the number of rewards offered increases, the probability of success of a crowdfunding campaign increases.*

3 Methodology

Using a web crawler, we collected data from startnext.com. We consider projects that started on 4 October 2010 or later and ended on 4 May 2015 the latest. These criteria left us with an initial data set of 3991 projects. We then excluded 146 projects due to data inconsistencies. The remaining 3845 projects had a success rate of 63.7%, where a successful project is a project that reaches or exceeds the funding threshold. We applied logistic regression for the validation of hypotheses. To carry out our calculations, we used IBM SPSS Version 23.

The success of a project is reflected by a dichotomous variable. The variable is „1“ where the funding amount equals or exceeds the funding threshold (successful project) and „0“ where the funding amount is below the funding threshold (unsuccessful project). Table 1 shows the different variables we crawled. It contains the name of the variable, a short description, the associated hypothesis and an indication of whether the respective variable is a dummy variable. Every dummy variable is dichotomous. A value „1“ for a dummy variable indicates that the respective characteristic exists, a value „0“ indicates that it does not exist.

Dummy	Variable	Description	Associated hypothesis
	description_word_count	Word count in project description	H1a
X	media_video_dummy	Project description includes a video	H1b
	communication_blog_posts	Number of blog posts by initiator	H2
X	curated_dummy	Project is curated	H3
	fprofile_projects_supported	Number of projects the initiator has supported	H4
	reward_count	Number of different rewards offered	H5

Table 1: List of variables crawled

4 Findings

Table 2 shows the descriptive statistics of the data set. In 508 cases, the respective project initiator did not have a profile. We have excluded these cases from our analysis with respect to the variable fprofile_projects_supported. In such cases, the remaining data set consisted of 3337 projects.

Variable	N	Min	Max	Mean	Std. Deviation
description_word_count	3845	91.0	3728.0	636.910	326.3328
media_video_dummy	3845	.0	1.0	.810	.3922
communication_blog_posts	3845	.0	348.0	9.047	10.7120
curated_dummy	3845	.0	1.0	.014	.1177
fprofile_projects_supported	3337	.0	90.0	1.484	4.1130
reward_count	3845	1.0	115.0	10.421	6.1111

Table 2: Descriptive statistics

In order to validate a hypothesis, it needs to be determined whether the respective result of the regression analysis rejects the null hypothesis. In order to assume significance, the Sig. value of our regression analysis needs to be below the significance level of $\alpha = 0.05$. If a variable has a significant influence, it needs to be established whether this effect is positive or negative. Such determination is based on the coefficient B. A positive B indicates a positive impact on the dependent variable (i.e. an increased probability of success) and a negative B indicates a negative impact on the dependent variable (i.e. a decreased probability of success). Table 3 indicates the results of our regression analysis.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
description_word_count	.099	.110	.816	1	.366	1.104
media_video_dummy	.763	.152	25.019	1	.000	2.144
communication_blog_posts	.049	.008	37.136	1	.000	1.050
curated_dummy	-1.105	.423	6.830	1	.009	.331
fprofile_projects_supported	.135	.023	32.977	1	.000	1.144
reward_count	.093	.013	50.816	1	.000	1.098

Table 3: Results of regression analysis

Based on the values indicated above, hypotheses H1b, H2, H4 and H5 can be accepted. H1a (not significant) and H3 (significant, but negative B) need to be rejected.

5 Discussion

While it appears logical that the project quality and the personal network are of crucial importance for the success of a project, our research implies that various other variables can significantly increase the probability of success in reward-based crowdfunding. The success factors we identified are relatively easy to implement. In the following, we will outline the implications of our research.

With respect to the project description, we could not establish a significant impact of the word count on the success of a project. This finding, however, should not be misinterpreted as meaning that the project description is not relevant for a project's success. To the contrary, Harzer (2013) found that 89% of the surveyed in her study, considered the description to be very important or important. Our results rather indicate that the length of a project description is not the decisive factor in this respect. Instead, qualitative factors, such as the relevance of information and the style of writing might be more important. Harzer (2013) provides some recommendations on how to design a project description. Future research in this context could generate more insights on the factors that are of particular importance when it comes to the project description. In this context, we encourage future research to identify certain patterns in project descriptions of successful as well as unsuccessful projects by using tools such as text mining and linear discriminant analysis.

Further, we found that the inclusion of a video has a positive effect on the success of a project. Out of the 3845 projects regarded, 3115 (89%) displayed a project video. 68.6% of initiators who included a video in their project description succeeded, while only 42.7% of projects without a video managed to reach their funding threshold. From a research perspective, these results confirm findings of previous studies, such as Mollick (2014) and Zvilichovsky et al. (2013). From a practical point of view, it follows that it is strongly advisable to support the textual components of the project description with a video message. When creating such a video, initiators should try to generate trust. Showing the project initiator in the video will help to create a personal connection. In addition, if possible, a prototype, a model, the project team etc. can be shown to transmit visual information. While this finding appears relatively straight-forward, we consider it necessary to emphasise that the creation of trust through a video message can have a great impact on the probability of success of a project and should therefore not be neglected.

Our results indicate that 1,721 projects published five or less blog posts. In this category, 47.5% of the projects succeeded. As the number of blog posts increased, the rate of successful projects increased significantly. We found that 280 initiators published 16-20 blog posts. The success rate in this category was 88.5%. In this context it is important to emphasise that this variable contains a potential endogeneity as also higher success rates may lead project initiators to publish more blog posts. Our results therefore need to be interpreted with caution. From a research perspective our results confirm the findings of previous studies (such as Mollick 2014, Leite and Moutinho 2012, Kuppuswamy and Bayus 2014 and Qiu 2013) who also found a positive influence of updates regarding the progress of a project on probability of success. From a practical point of view, our findings indicate that project initiators are well advised to invest some of their time in communication while the project is running. Regular progress reports, comments on new developments, replies to questions and comments etc. transmit expertise and convey the initiator's commitment to the project. Previous research showed that most of the funding activity takes place either in the beginning or towards the end of the project (Kuppuswamy and Bayus 2014). Communication via blog posts is a useful way to keep up the tension in the meantime and to increase the funding activity in this period. While we analysed blog posts based on the number of posts published, we also encourage future studies to look into blogging behaviour in more detail and from a more content-based perspective to derive actionable advice for project initiators.

With respect to curation, we found that out of 54 curated projects, only 21 were successful. While we hypothesised that curation would increase the probability of success of a crowdfunding project, our results indicate a decreased probability of success. This finding appears counter-intuitive at first. It should, however, not be interpreted as meaning that the curation itself decreased the likelihood of success. Rather, we presume that many of the projects that received a curation, had a lower probability of success to begin with. In many cases, the decision of a third party to curate a project is based on geographical or categorical criteria and not on aspects of quality. In particular, with respect to regional projects that are supported by a city or another regional organisation, a lower probability of success may be presumed as a smaller crowd of potential backers exists. Our results therefore do not imply that curation has a negative effect. At the same time, the fact that a positive effect could not be found, suggests that organisations curating a project should put more effort into supporting the project. For future research, it would be useful to compare projects of a similar kind, some curated, some not, in order to establish the real effects of curation as a quality signal. Due to the relatively small number of projects considered for this variable, our findings need to be considered with caution.

When looking at the projects that initiators had previously supported, we found that 1638 project initiators did not indicate a previous funding. In this category, 48.5% of projects were successful. In contrast, 64 initiators indicated that they previously funded five projects. In these cases, 81.3% of projects were successful. We consider it important to highlight that due to the relatively small number of initiators who funded more than five projects, our results need to be interpreted with caution. Further, it cannot be excluded that unobserved characteristics distinguish people who previously funded crowdfunding projects from the general population and that these characteristics make such initiators more likely to run a successful crowdfunding campaign. From a research perspective our results confirm the findings of Colombo et al. (2015). From a practical perspective, our results indicate that it is important for project initiators to back a few projects before they start to run their own. Such experience is important for two reasons. Firstly, previous crowdfunding activity sends a signal to the crowd. It indicates that a project initiator understands the dynamics of crowdfunding, believes in the idea of crowdfunding (i.e. is not just there to get the money) and understands himself as part of the crowdfunding community. Secondly, initiators can learn from their own experience as a backer. Funding other projects will help them to understand which factors are relevant to generate trust and which needs potential backers and actual backers have throughout the course of a crowdfunding campaign. In addition, initiators can learn from other initiators' solutions to problems that may occur throughout the course of a crowdfunding campaign. In this context, we consider it important to point out that our findings are not meant to indicate that simply clicking on the "support"-button for various projects will greatly improve the probability of success. Rather, we advise project initiators to actually collect experience in other crowdfunding campaigns before and while running their own campaign. In addition to supporting other projects, it is, of course, important to communicate this activity. In our analysis, we found that in 508 cases, project initiators did not create a profile. Based on the findings from our analysis, we would highly advise initiators to create a profile and to communicate their previous crowdfunding activities there.

Among the projects regarded in our study, the number of different rewards ranged from 1 to 115. We found a mean number of different rewards of 10. The mean price for the first reward was €6.20, with a range from €1 to €69. Our analysis shows that a higher number of different rewards increases the likelihood of success of a crowdfunding project. Our results in this respect differ from the findings in the relevant literature. While Frydrych et al. (2014) did not find a clear relation between the number of rewards and the project success, Leite and Moutinho (2012) even established a negative influence of an increased number of reward stages on probability of success. When combining our results with those in the previous literature, it appears advisable for project initiators to create a variety of rewards while not implementing too many price categories. To find appropriate rewards, we advise project initiators to reflect, depending on the type of project, which rewards may fit to potential funders' interests. To do so, initiators can draw inspiration from other projects. They may also ask potential backers (e.g. from their circle of friends and family) which rewards they would find attractive. Our results indicate that a thoroughly selected reward structure that respects the different financial resources and interests of individuals in the crowd will benefit a project's probability of success.

6 Conclusion

Intending to learn from the characteristics of successful and unsuccessful reward-based crowdfunding campaigns, we first analyse different potential success factors. Such factors have been chosen based on the relevant literature and actual practices in crowdfunding. We selected factors that can be modified by project initiators with relatively little costs. As a next step, we investigated based on data collected from startnext.com whether such factors had a significant influence on the success of a project. Based on our results, we derived theoretical and practical implications. The specific implications have been outlined in the discussion above. For academics, our research extends the results of previous studies, especially by considering a crowdfunding market that has thus far not been the subject of many empirical studies. Using data from the crowdfunding platform startnext.com, our research confirms previous findings regarding the influence of video messages, communication with backers and initiators' funding activity. With respect to the word count of the project description and the effect of curation we found somewhat counterintuitive results. Regarding the reward structure, we posed and accepted a hypothesis that can thus far not be found in the literature. We provide a variety of interesting starting points for future research. From a practical perspective, our results are of interest to both, project initiators and intermediaries. Project inititators can derive approaches on how to efficiently design their crowdfunding campaign. Intermediaries can, in particular, derive insights on how to advise project initiators.

Our analysis is subject to limitations in three dimensions. Firstly, all projects regarded have been selected from one platform. We have selected this approach to add another perspective to the current literature that predominantly focuses on US platforms (Kuppuswamy and Bayus 2014; Mollick 2014; Xu et al. 2014). For future research, however, it would be interesting to conduct a similar analysis with respect to further platforms from different countries. Such insights would help to create a more comprehensive picture of success factors. Secondly, our analysis does not take into account controlling variables that may explain certain relationships. The most important controlling variables would relate to project quality and the size of a network of a project initiator. Such variables are, however, difficult to quantify and would therefore necessarily add a subjective element to the analysis. To avoid such subjective influence, we decided not to include such controlling variables. Instead, we opted for a long time span for our analysis, in order to benefit from the correcting effects of a large sample size. Thirdly, it is obvious that a great number of factors can have an influence on the success of a campaign. Our research only regards a few of those factors. Future research that takes into account further factors would greatly benefit the understanding of success factors.

It needs to be remembered that project quality and acquisition of backers are the two most important factors when intending to design a successful crowdfunding campaign. Both of these factors require hard work by project initiators and are inevitable for the success of a project. In order to ensure that such hard work yields the results it deserves, project initiators should keep in mind that some relatively small changes can make a great difference with respect to a project's success. Our study identified and analysed some of these details, helping to ensure the long-term efficiency and sustainability of crowdfunding. By providing specific recommendations, we hope to help project initiators to harvest the fruits of their hard work.

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Supplier Relationship Management in Information Systems Research: A Literature Review

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Abstract

Academics and practitioners from various disciplines and functions are highlighting an increasing dependence on relationships with suppliers. As a result, there has been a shift in organizations' perceptions about the significance and impact of supplier relationships on overall value creation. Managing supplier relationships has transformed from a tactical function without impact on overall performance into a strategic function with major influence on supply chain success. Consequently, organizations have been focusing increasingly on the implementation of supplier relationship management (SRM) systems and IS research has emphasized the importance of IT-supported SRM. Despite the widely acknowledged benefits of electronic-facilitated SRM, the understanding of this area remains limited. This systematic literature review provides an overview structuring efforts in the field of SRM in the domain of IS research. We analyze the existing literature by using a concept matrix, reveal gaps in the current literature and provide directions for future research. The results indicate that the topic is worthwhile for IS research but still understudied and in a developing phase.

1 Introduction

During the past two decades, nothing has changed business operations like the emergence of the Internet and its related information and communication technologies (Johnson and Whang 2002; Sanders 2007). Hence, means of conducting business have been constantly moving away from face-to-face human interaction towards a virtual business environment (Chong et al. 2009). This rapid growth of information technology (IT) and web-based information sharing has particularly influenced the field of supply chain management and has become important for both research and practice (e.g. Cagliano et al. 2003; Sanders 2007; Klein and Rai 2009; Rajaguru and Matanda 2013). As a result, the various approaches and the transformative power of IT integration and IT deployment have been studied extensively from different perspectives, mostly under the umbrella term "e-business" and its different forms and integration strategies along the supply chain, including e-procurement, e-commerce, e-collaboration and e-manufacturing, as well as their relating and facilitating technologies (Johnson and Whang 2002).

Academics have paid particular attention to the improvement and integration of supply chain front-end operations in order to develop and enhance efficient and insightful relationships with both business and final customers. This approach, well known as customer relationship management (CRM), has gained much attention in both research and practice (Ngai 2005). Since its development in the mid-1990s, CRM has become one of the most discussed and dynamic issues in the field of IT (Bose 2002) as well as one of the fastest growing and most essential practices in today's business environments (Foss et al. 2008). As a result, the literature on CRM and the facilitating role of IT is massive; various academic literature reviews have already been published, summarizing and highlighting the importance of this topic (e.g. Ngai 2005; Paulissen et al. 2007; Das 2009; Kevork and Vrechopoulos 2009).

More recently, however, there has been a shift in organizations' perceptions of the importance and impact of supplier relationships on overall value creation (Moeller et al. 2006). While supply has long been treated as a more or less separate, strategically insignificant function (Reid and Plank 2000) and has therefore not been recognized as source of competitive advantage, this perception has changed (Moeller et al. 2006). Unlike in the past, the performance of an organization now depends greatly on the performance of its suppliers along the supply chain (Choy et al. 2004). Since partnerships can be seen as "supply chain's blood" (Rosenzweig 2009) in today's scale-driven and technology-intensive global economy, managing relationships with suppliers has become more important, transforming from a tactical function with no impact on overall performance into a strategic function with major influence on supply chain success (Carter and Narasimhan 1996; Moeller et al. 2006). As a result, organizations increasingly focus on the implementation of supplier relationship management (SRM) systems (Wu and Shen 2006; Park et al. 2010).

Despite the widely acknowledged potential benefits of electronic-facilitated SRM, the understanding of this area remains – at least in contrast to the well-investigated field of CRM – limited. Though research pinpointed IT-supported SRM early on as an important but understudied topic (e.g., Große-Wilde 2004; Tanner et al. 2007), there is, to the best of our knowledge, still no overview identifying and structuring the efforts that have been invested in this field. To close this gap in the current literature, this study provides an overview of the state of the art on the topic of SRM in the IS discipline. In particular, we aim to answer the following research questions: First, to what extent has the body of literature in information systems (IS) research already explored the concept of SRM? Second, which areas provide potential directions for future research?

The remainder of this paper is organized as follows: Initially, we will frame the concept of SRM, followed by an examination of the facilitating role of IT in the context of SRM. We then discuss our methodological approach as well as present and analyze our results. Finally, we will provide directions for future research and discuss our findings as well as limitations.

2 Background

2.1 Framing Supplier Relationship Management

The roots of SRM can be traced back to the late 1980s and are based on the seminal works of Dwyer et al. (1987) regarding relationship theory and Davenport and Short (1990) about the redesign of business processes (Mettler and Rohner 2009). However, the emergence of SRM in its present form has its roots in the shift of organizational buying behavior from transaction-oriented domestic sourcing to relationship-oriented global sourcing (Sheth and Sharma 2007). Owing to volatile economic conditions, global competition and an increased complexity of products and customer demands, the main function of SRM today is to enhance competitiveness by streamlining and improving the effectiveness of processes between an organization and its suppliers (Mettler and Rohner 2009). In this context, SRM represents a new category of supply chain applications that increase the competitive advantage of an organization through three primary mechanisms: (1) support of improved business processes across the supply chain, (2) a next-generation architecture that can handle multi-firm processes and (3) facilitation of rapid product cycles and new product introduction. Together, these mechanisms drive competitive advantage through substantial reductions in costs, increased flexibility and faster cycle times, which can enhance customer satisfaction and increase market share (Choy et al. 2003c).

Thus far, the body of literature has presented a wide range of definitions of SRM, but there is still no common agreement about what exactly SRM comprises. Despite their differences, nearly all definitions refer to common themes, including cooperation, coordination and communication between an organization and its suppliers. Our understanding follows the definition of Moeller et al. (2006): SRM is the process of engaging in the activities of setting up, developing, stabilizing and dissolving relationships with suppliers as well as the observation of suppliers to create and enhance value within relationships.

2.2 IT Support of Supplier Relationship Management

The evolvement of relationships between an organization and its suppliers has often been described as a lifecycle or a stage-based process (Camarinha-Matos et al. 2009; Dwyer et al. 1987; Moeller et al. 2006). Hence, when examining SRM one typically considers the distinct stages of relationship development: creation and formation, operation and evolution, and dissolution or metamorphosis. According to these phases, IT supports different tasks and key processes as well as strategic and operative management functions of SRM. As a result, software vendors have developed a wide range of information and communication technology functionalities to support SRM activities. Figure 1 provides an overview of IT support of SRM.

The first stage deals with both the initial incubation of relationships as well as constitution and start up. In this stage, IT supports the strategic sourcing function and primarily deals with the search process and the evaluation of potential suppliers, which facilitate the creation and strengthening of supplier relationships. The operation stage can be described as the regular phase of operation.

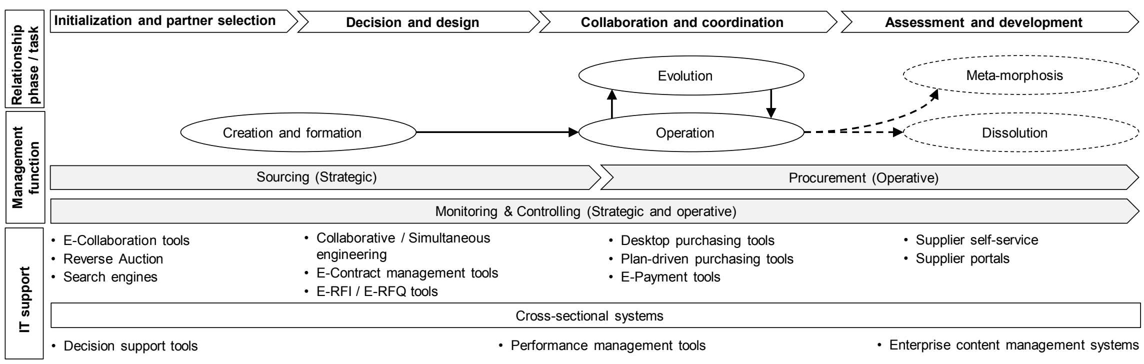

Figure 1: Overview of IT support of SRM

During this stage, IT supports the operative procurement function and facilitates collaboration and transactions with suppliers. Furthermore, it supports coordination as well as changes in operating principles, resulting in the evolution of relationships. The dissolution stage represents the planned cessation of a relationship with a supplier, while during the metamorphosis stage the assessment and development of suppliers lead to improved relationships.

3 Research Methodology

3.1 Data Collection

To identify the extent to which the body of literature in IS research has already explored the concept of SRM, we conducted an in-depth, topic-based literature review following the principles of Webster and Watson (2002).

In thoroughly examining a new research domain, all relevant literature should be discussed. Therefore, despite the rigor of conference proceedings being potentially lower than that of leading journals, we include both, as this is still an emerging field of research. In this context, the query of scholarly databases is reasonable (vom Brocke et al. 2009). Therefore, to explore the literature base we included the available databases suggested by Levy and Ellis (2006): ProQuest, ACM, IEEE, EBSCOhost and Elsevier. These databases cover all MIS journals in IS research ranked in the top 50. We also added the AIS electronic library to access a wider range of leading IS conference proceedings.

To provide a comprehensive overview of the concept of SRM in the context of IS research, we used both *supplier relationship management* as well as its common abbreviation *SRM* as search strings in combination with the keywords *information technology* and *information systems*. Furthermore, the analysis was not restricted to a specific time frame.

The collection of data followed a three-stage process. In the first step, a query of databases was conducted from June to July 2015. The initial search yielded more than 440 articles. However, because we used multiple databases and similar search strings, a number of results appeared more than once. Moreover, the search for *SRM* led to multiple articles concerning topics irrelevant for this research, such as security risk management. Such identical or irrelevant results were removed. In the second step, the titles and abstracts of the remaining 113 articles were scanned and analyzed to sort out further irrelevant results, resulting in the exclusion of 79 articles from further investigation for two main reasons: First, some deal with the topic of IT integration with suppliers on a very general and aggregated level, rather than focusing on relationship-specific issues. Second, a large number of articles do not refer to the underlying understanding of SRM in terms of IT supported, business-to-business relationships that go beyond simple buyer–seller transactions. Subsequently, the content of the remaining 34 results was analyzed and again sorted out. In the final step, the list of references of the remaining 22 articles was used to conduct a backward search following the same procedure, which led to 7 more publications. In the end 29 publications were included for further investigation.

3.2 Data Analysis

We followed the principles of Webster and Watson (2002), categorizing the articles into topic-related concepts. In addition, we distinguished between different units of analysis. We derived five concepts for structuring the literature on SRM in the context of IS research. These concepts reflect the existing literature on IT-supported SRM research, including perspective, scope, level of analysis, focus and methodology used.

When analyzing SRM-related literature, it is possible to determine a dichotomy of perspectives (Mettler and Rohner 2009). First, the management-oriented perspective deals mainly with aspects of IT-supported collaboration and coordination, focusing on the proactive and IT-supported development of relationships between organizations and its suppliers. Second, the technology-oriented perspective concentrates on the development of new possibilities for electronic communications. This perspective deals with aspects of the technical integration of suppliers as well as the automation of processes between an organization and its suppliers.

Previous research has already highlighted SRM and CRM as closely related concepts and stressed the potential benefits that can be achieved through their integration (Choy et al. 2004a; Große-Wilde 2004; Lambert and Schwieterman 2012). Therefore, we differentiate the scope of the reviewed literature and classify the articles according to whether they focus on SRM or discuss the concept from a more integrated viewpoint in combination with aspects of CRM.

The differentiation of relationships within supply chains along different perspectives has a long tradition in research (Choi and Wu 2009; Harland 1996; Wilhelm 2011). Accordingly, research on interorganizational relationships with suppliers can be referred to on three distinct levels of analysis: the dyadic, chain, and network levels. Dyadic-level analysis examines the two-party relationship between an organization and an immediate supplier. In comparison, chain-level analysis covers the management of a chain of businesses – also including, for example, a supplier's supplier – and thus encompasses multiple tiers of relationships with upstream business partners. Lastly, network-level analysis deals with the management of a network of interconnected organizations involved through upstream linkages in the provision of an ultimate product or service. These levels of analysis can be transferred in order to classify research on IT-supported SRM.

In addition, literature on IT-supported SRM has proposed a wide range of frameworks for classifying the role of IT in regard to related management functions and processes. Despite their differences, nearly all of the frameworks refer to SRM as a stage-based process. In this context, the supporting role of IT can be classified along the various dimensions of a market transaction, including sourcing and procurement as well as monitoring and controlling (Große-Wilde 2004). Therefore, we differentiate the literature accordingly and consider the different focuses of the studies.

The concepts described above reflect the prevailing research on SRM and grant an appropriate categorization of the literature in the context of IS research. Furthermore, the literature was classified with regard to the methodology used. To do so, we followed the systematization of Palvia et al. (2004), which provides an exhaustive scheme of different quantitative and qualitative methods used in IS research.

To ensure reliability, the literature was first classified independently by two researchers. In a second step, inconsistencies were discussed until a common understanding was reached.

4 Findings

Our review of the literature encountered (see Table 1) reveals that SRM has already been studied from both management-oriented and technology-oriented perspectives. The technology-oriented perspective mainly discusses the development of IS that support the strategic decision-making process of supplier selection and thus focuses primarily on the sourcing function of SRM. For example, Choy et al. (2004a–c) extensively study the design, implementation and evaluation of collaborative systems that facilitate selecting the most appropriate suppliers based on past performance. In contrast, studies with a management-oriented perspective often take a broader focus by considering multiple dimensions of SRM. These articles deal predominantly with the development of theoretical frameworks and conceptual models for SRM and are often limited to theoretical discourses on a general level (Eyholzer et al. 2002; Riemer and Klein 2002; Park et al. 2010). We identified only three articles that consider both perspectives simultaneously.

The literature review also demonstrates that the distinct units of analysis have thus far been explored disproportionately. None of the articles we reviewed carries out a network-level analysis; instead, most studies focus on the dyadic level and examine single relationships between a focal organization and its suppliers. Furthermore, Muessigmann and Albani (2006) and Pala et al. (2013) are the only ones to examine IT-supported SRM on a chain level of analysis, considering multiple tiers along the supply chain. However, these articles are limited to mathematical models and descriptive surveys on how organizations manage their relationships with extended supply chain tiers and the range of IT used in this context. Thus, insights and empirical evidence from multi-firm environments remain limited.

When analyzing the scope of the existing literature, it can be seen that researchers are aware that SRM and CRM are closely related concepts. Interestingly, this is reflected largely in technology-oriented studies. For instance, Choy et al. (2003a) develop an integrated customer–supplier relationship management system and highlight the potential benefits of integrating customer demands and requirements with supplier selection criteria. In contrast, management-oriented studies generally focus on SRM without analyzing or considering CRM-related aspects. Although the similarities of both concepts and the resulting benefits for research on SRM seem to be widely acknowledged, theoretical models and frameworks do not apply an integrated analysis.

Most articles reviewed focus on the sourcing function of SRM and, as stated earlier in this section, deal primarily with technology-related issues of supplier selection. These studies also often discuss aspects of supplier monitoring and supplier controlling (Choy et al. 2003a–c). In addition, we found various articles that focus on the procurement function. For example, the potential benefits, trends and main difficulties in the use of IT-supported procurement have already been examined by several studies (Barking and König 2002; Corsten and Felde 2002; Nissen and Mauß 2002; Tanner et al. 2007). However, publications that consider all three dimension of SRM are rare and are mostly limited to frameworks and models (Becker et al. 2008; Beckmann et al. 2002; Eyholzer et al. 2002; Riemer 2008; Riemer and Klein 2002), though we found one exception: Park et al. (2010) suggest a framework for an integrative SRM system by analyzing comprhensive approaches to overall SRM functions and verfiy its applicability using a case study approach. Overall, following the classification of Palvia et al. (2004), five of the fourteen methodologies were applied. Qualitative research in terms of case studies dominates the literature reviewed, followed by theoretical frameworks and models. Only five studies applied large-scale surveys. In addition, we found three IS-related publications on mathematical models for supplier selection and one general research commentary.

Literature	Pers-pective		Level of Analysis			Scope		Focus/ Dimension			Methodology				
	Management-oriented	Technology-oriented	Dyadic	Chain	Network	Basic Analysis	Integrative Analysis	Sourcing	Procurement	Monitoring & Controlling	Case Study	Survey	Frameworks and Models	Commentary	Mathematical Model
Ageron et al. (2013)	●		●			●		●				●			
Becker et al. (2008)		●				●		●	●	●			●		
Beckmann et al. (2002)		●				●		●	●	●			●		
Chang (2013)	●		●			●		●			●				●
Chou and Chang (2008)	●		●			●		●			●				●
Choy and Lee (2002)		●	●			●		●			●				
Choy and Lee (2003)		●	●			●		●			●				
Choy et al. (2003a)		●	●				●	●		●	●				
Choy et al. (2003b)		●	●				●	●		●	●				
Choy et al. (2003c)		●	●				●	●		●	●				
Choy et al. (2004a)		●	●				●	●			●				
Choy et al. (2004b)		●	●				●	●			●				
Choy et al. (2004c)		●	●				●	●			●				
Corsten and Felde (2002)	●		●			●			●			●			
Große-Wilde (2004)	●	●					●	●	●	●				●	
Eyholzer et al. (2002)	●	●				●		●	●	●			●		
Humphreys et al. (2005)		●					●			●	●				
Barking and König (2002)		●	●			●			●		●				
Mettler and Rohner (2008)		●				●		●	●		●				
Mettler and Rohner (2009)	●	●				●		●	●		●				
Muessigmann and Albani (2006)	●			●		●		●							●
Nissen and Mauß (2002)		●	●			●			●		●				
Pala et al. (2013)	●			●		●		●	●	●		●			
Park et al. (2010)	●		●			●		●	●	●	●		●		
Riemer (2008)	●					●		●	●	●			●		
Riemer and Klein (2002)	●					●		●	●	●			●		
Simon et al. (2008)		●	●			●			●		●				
Tanner et al. (2007)	●					●			●			●			
Wu and Shen (2006)	●		●			●		●				●			
***N* = 29**	14	18	17	2	0	21	8	23	15	12	17	5	6	1	3

Table 1: Concept matrix of SRM in IS research

5 Discussion and Research Agenda

Our first research question deals with the extent to which the body of literature in IS research has already explored the concept of SRM. Although our literature review includes an extensive search of various databases and topic-related search strings, only 29 relevant articles were found. Moreover, although our analysis was not restricted to a specific time frame, the earliest articles found were published in 2002 and the number of publications per year has fluctuated during the past decade. Nevertheless, recent publications as well as special issues in IS journals on IT-supported SRM indicate that the topic is worthwhile to IS research but still understudied and in a developing phase. Moreover, surveys among practitioners highlight the broadly diversified potentials of SRM as a crucial future topic in organizations (Tanner et al. 2007). As the IS discipline mainly emphasizes practical relevance and with the growing importance of establishing and maintaining efficient relationships with suppliers, we expect that this topic will become as important for our research domain as it already is in practice. The large number of studies with practical orientation included in our review also signal this trend. However, to guide future research and answer our second research question, we identified five gaps in the concepts under study that may provide promising directions for this emerging field.

First, the literature reviewed indicates that the network level of analysis is as relevant as it is in traditional research on supply chain management and interorganizational relationships (Harland 1996; Wilhelm 2011). Therefore, this might also be a promising direction for future IS-related research on SRM. Muessigmann and Albani (2006) as well as Pala et al. (2013) already made a first step towards moving the level of analysis from dyadic to network structures by considering multiple tiers of suppliers. However, this chain-level analysis still greatly simplifies the complexities and dynamics involved in supply networks. For instance, transferring the concept of SRM to the network level of analysis could enhance our understanding of how IT-supported SRM practices affect or are affected by different organizations with diverse positions and relationships within the same network. *Second*, because the different dimensions of SRM are highly interrelated, various frameworks and theoretical models have highlighted the need for an integrative view on the concept of SRM. Nevertheless, most articles tend to consider only a single dimension, thus focusing only on domain-specific issues. In contrast, Park et al. (2010) demonstrate that the integration of all three dimensions can play a major role in enhancing the efficiency and effectiveness of SRM. However, the proposed integrative framework has only been evaluated within a single case study and therefore empirical evidence remains limited. We suggest that future research proceed in this direction to validate findings and to deepen the understanding of how integrative SRM concepts can influence performance. *Third*, the articles reviewed do not consider the distinct operating environments that organizations face, which influence their relationships with suppliers. For example, supplier relationships differ in terms of their strength, attractiveness, importance and management difficulties, which are influenced by various factors, such as product, market, or environmental characteristics (Olsen and Ellram 1997). These differences must be taken into account when studying the design and implementation of IT-supported SRM in order to balance the degree of technical integration. For example, Wu and Shen (2006) demonstrate that different purchasing strategies and supplier relationships significantly influence the performance of use requirements determination for electronic facilitated SRM. *Fourth*, very few theoretical lenses have been applied to study SRM in the context of IS research. The majority of the articles reviewed do not refer to any specific theory or conceptual foundation, though there are some exceptions. For example, transaction cost economics as well as relationship theory and social network theory have been used as references to differentiate between the perspectives on SRM (Mettler and Rohner 2009). Because research on interorganizational relationships provides a vast number of different approaches that are also valuable for IS research (e.g., Barringer and Harrison 2000; Straub et al. 2004), future studies on IT-supported SRM should proceed in this direction to strengthen the theoretical foundation. *Lastly*, the use of multiple methods increases the robustness of results and helps to improve the accuracy of judgments. As no single approach can provide the richness that IS research needs for further advancements, the combination of different research methods is highly relevant (Kaplan and Duchon 1988). Thus far, research in this specific domain has concentrated primarily on qualitative methods, such as the single case study approach. However, quantitative approaches, such as large-scale surveys, remain scarce and have been largely limited to descriptive statistics (Ageron et al. 2013; Corsten and Felde 2002; Pala et al. 2013). Therefore, we look forward to seeing a more balanced use of methods.

6 Conclusion and Limitations

In this paper we reviewed the existing literature on SRM in the context of IS research. The aim was to determine the extent to which the body of literature has already explored the role of IT in the field of SRM. Moreover, we wanted to present an agenda for future research. Our search yielded a rather limited number of articles, which were often practice driven and written in German, indicating that the topic has not yet attracted broader attention to IS research. However, in accordance with previous research, we expect that the topic will become as important for research as it already is in practice. Therefore, we hope that our review inspires future research and encourages academics to advance in the directions proposed. While our literature review led to interesting publications and results, there are some limitations that must be addressed. The selection of databases mainly covers IS journals and conference proceedings, which might have resulted in missing relevant sources and publications from adjacent research areas. We also identified various publications dealing with supplier selection processes, especially in the domain of operation research. However, these articles do not explicitly refer to SRM and related technologies as the unit of analysis. Accordingly, we excluded them from our review.

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Teilkonferenz
E-Government – Informations- und Kommunikationstechnologien im öffentlichen Sektor

Öffentliche Verwaltungen sehen sich im Kontext von E-Government zurzeit Herausforderungen an vielen verschiedenen Fronten gegenüber. Themen wie Bürokratieabbau oder Kosteneinsparungen fordern Verwaltungen insbesondere hinsichtlich ihrer internen Strukturen und Abläufe. Transparenz und Vergleichbarkeit sind unabdingbar, um die Effizienzziele und -erwartungen zu erreichen. Neben organisatorischen Veränderungen sind verstärkte organisationsübergreifende Zusammenarbeit und technische Neuerungen notwendig, um die Ziele und Anforderungen nicht nur in einer leeren Hülle, sondern in der Tiefe umzusetzen. Die gemeinsame Erarbeitung von Lösungen rückt hier ebenso in den Fokus wie die Nutzung von Standards, um das berühmte Rad nicht wieder und wieder neu zu erfinden.

Darüber hinaus spielt auch die Außendarstellung, beispielsweise in Social Media oder im Kontext von Open Government, eine zunehmende Rolle, insbesondere wenn es um die Akzeptanz und Anwendung von E-Government-Anwendungen durch die Bürgerinnen und Bürger und die Unternehmen geht. Neben einer einfacheren Wahrnehmung der Verwaltungsdienstleistungen fordern immer mehr Bürger darüber hinaus auch Beteiligungsmöglichkeiten an der Verwaltungssteuerung zwischen den Wahlen ihrer Vertreter vor Ort ein. Sei es, dass nötige Daten offengelegt werden, die Bürger sich an der Haushaltsplanung beteiligen oder an städtebaulichen Konzepten mitwirken können.

Zusammenfassend werden von den Verwaltungen gewaltige Umstrukturierungen und die Öffnung gegenüber der Dienstleistungslandschaft erwartet. Das Forschungsfeld E-Government adressiert diese Themenbereiche und diskutiert im Rahmen der Teilkonferenz „E-Government" innovative Forschungsideen, empirische Untersuchungen zum Wandel der Verwaltungen und konkrete Umsetzungen von Konzepten, die zeigen, dass E-Government-Konzepte funktionieren.

Jörg Becker, Sara Hofmann, Helmut Krcmar, Petra Wolf

(Teilkonferenzleitung)

Attitude vs. Attitude – The Problem of Competing Attitudes in E-Government Adoption

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Abstract

Attitudes are a commonly used concept in adoption research among E-Government scholars and have been proven to be consistent predictors of behavior. However, most studies have only considered attitudes towards the adopting technology, while ignoring attitudes towards the incumbent technology. This is understandable as technology innovations have been very rapid, with vast improvements over their predecessors. When technological leaps become less apparent, users might perceive the benefits from new technologies as less beneficial and adoption becomes less attractive. This can cause a competition between two technologies and thus their associated attitudes. In our study we analyze this competition by incorporating dissonance theory in our adoption model. In order to investigate these competing attitudes, we have conducted a study among employees of public institutions. Our results show that established attitudes and habits towards an incumbent system can significantly lower the intention to adopt a new system.

1 Introduction

Researchers in the E-Government field have done a tremendous job identifying the determinants of E-Government adoption for more than two decades now. Within their scientometric literature review, Weerakkody et al. (2013) showed that 132 research articles related to the E-Government topic have been published since 1992. An overwhelming majority of these approaches analyzed the opportunities and benefits provided by E-Government as well as analyzing the drivers and inhibitors of E-Government adoption. Past research has underlined potential drivers of adoption decisions, such as effort expectancy, performance expectancy, trust in the government, facilitating conditions, hedonic motivation, or perceived ease of use (Carter 2008), but it has also recognized inhibitors of E-Government adoption as inertia (Titah and Barki 2008). However, multiple researchers called for further analysis of general determinants for adoption or hesitation (Tung and Rieck 2005; Schaupp and Carter 2008; Weerakkody et al. 2013). A prevalent problem of current E-Government implementations is often the organizational reluctance to adapt to changes within public institutions, despite the many efforts by governments (Titah and Barki 2008). Past literature reviews show that virtually no study acknowledges the competition between the incumbent and the new system and analyzes effect of the perception of the old system (Carter 2008; Titah and Barki 2008; Weerakkody et al. 2013). The current models are usually concerned with the focal technology and do not consider the civil servants' attitude of the incumbent system, even though most users can get basically the same results from both systems (Schwarz and Schwarz 2015). Users always have an attitude towards the old option and in times of more mature systems, the perceived improvements might not justify an adoption decision. In such a case, the positive attitude towards a new system cannot solely predict an adoption decision, because it does not incorporate the attitude towards the the old, which is already in place for the individual user. In a case, where the incumbent system receives a more positive attitude and thus leads to no change is explainable by prior research with the absence of perceived usefulness or the negative influence of established habits, inertia, or status quo bias (Polites and Karahanna 2012). Considering both attitudes is essential in order to identify the reason for an underwhelming adoption rate and a weak transition from a positive attitude towards a new system to actually using the new system, because attitudes are ordered and linked hierarchically in what is called an inter-attitudinal structure (Ajzen 2005). Without considering both attitudes, the prediction of the adoption outcome is not reliable.

Competing attitudes and habits share similar premises, as both require a positive attitude towards a behavior (Verplanken and Aarts 1999) and habits can inhibit the adoption of a new technology as well (Limayem et al. 2007; Polites and Karahanna 2013). With our study, we take both concepts into account and extend the current theory in E-Government by integrating competing attitudes and the habitual use of the incumbent system into one model of E-Government Adoption. We subsequently test our model among employees of a large German public institution. We also offer a differentiation between competing attitudes, habits, and related concepts. Consequently, our research questions are:

RQ1: Do competing attitudes have an impact on the intention to adopt a new E-Government system?

RQ2: Can the habitual use of an incumbent system inhibit the intention to adopt a new E-Government system?

2 Theoretical Background

Many behavioral theories identified attitude as a major predictor of individual behavior (Ajzen 1991; Ajzen 2005). In E-Government research this relationship is incorporated in several models in order to predict and explain the adoption of new technology systems (Carter 2008; Weerakkody et al. 2013). The acceptance of a new technology is a result of a psychological process, in which the resulting behavior depends on past experience, behavioral cues, established habits, attitudes, or intentions (Bagozzi 1981; Ajzen 1991; Verplanken and Aarts 1999; Betsch et al. 2004).

The behavioral decision process is differentiated from a habitual process, which is less conscious. A habit is an intentional behavioral program, which is efficient, controllable to a certain extent, and occurs without much awareness (Verplanken and Aarts 1999). The typical habitual process is triggered by a goal activation, which reflects a desired behavior, followed by an assessment of the perception of the situational sensory input, an appreciation of possible choices, a conscious integration of context and choices, and finally the resulting behavioral choice (Verplanken and Aarts 1999). Strong habits usually result in a more automated behavior, which are activated by a goal and lead directly to a behavioral choice (Verplanken and Aarts 1999). If there is a fit between the intended behavior and the outcome (Ajzen 1991; Verplanken and Aarts 1999; Betsch et al. 2004), behaviors with corresponding past behaviors can turn into habits, if they are sufficient, frequent and satisfactory (Verplanken and Aarts 1999). The cognitive process involves an evaluation of the potential behavior (Ajzen 1991), which results in an attitude. Attitudes are either directly linked to performed behaviors or influence it through the intention formulation (Bagozzi 1981), whereas intentions capture the motivational factors of triggering a behavior (Heckhausen and Beckmann 1990; Ajzen 1991). A stronger motivation increases the probability of the actual behavior (Ajzen 1991). The relationship between attitudes, intentions, and behavior is called the attitude-behavior correspondence and describes the fit between the attitude and the subsequent behavior (Ajzen 2005). The fit is not understood as being fixed, but growing with increasing consciousness about the behavior (Glasman and Albarracín 2006).

Most behavioral options do face competition from alternative behaviors, such as using incumbent systems. As long as the old system or behavior is less preferable to the new system, one's own beliefs and attitudes stay consistent with the intention to adopt the new system and the current models are appropriate (Sheppard et al. 1988). If this is not the case, models only considering the focal attitudes are insufficient (Sheppard et al. 1988). The decision between those mutually exclusive options is intriguing, because the expected outcome of the competing behaviors is very similar the attitudes are also expected to be similar (Sheppard et al. 1988). In order to make a decision, the individual needs to somehow resolve this problem. The positive evaluation of multiple similar and mutually exclusive options leads to inconsistent internal attitudes, which causes stress (Festinger 1957; Brehm 2007). The resulting stress inhibits decision making, because multiple options seem viable and a state of cognitive consonance is necessary for a decision, which prompts a desire to resolve the dissonance of multiple options (Gawronski 2012). A theory to explain the resolution of such issues is the cognitive dissonance theory by Festinger (1957).

The state of dissonance can be resolved by changing one of the attitudes (Festinger 1957). Festinger (1957) argued that dissonance resolution is a basic psychological need, which urges a resolution of conflicting beliefs or attitudes (Gawronski 2012). A dissonance between two options is prevalent if both attitudes are logically connected through a common function or goal (Gawronski and Strack 2004; Gawronski 2012). Recent discoveries also show that dissonance reduction and attitudinal change can occur during the actual decision process (Jarcho et al. 2011). Given a situation whereby one's own attitudes are positive towards both options, the dissonance is often reduced towards the direction of the most recently activated attitude as this is more resistant to change (Harmon-Jones and Harmon-Jones 2007). Although habits can have an influence on the resolution of dissonances, through recent activation or past behavior, they are not usually understood as a part of the evaluative layer – where a cognitive dissonance is usually expected (Gawronski and Strack 2004; Brehm 2007). We distinguish between three layers, which impact an individual's decision to adopt a new technology – either positively or negatively. The habitual layer includes the behaviors associated with routines and habits. A sufficient amount of repetitions is usually necessary before a routine is established as a habit and thus the habitual layer is only relevant for the incumbent technology. Verplanken and Aarts (1999) suggest that the evaluative part of the behavioral process is skipped in a habit. At the same time, habits interfere with the formation of intentions and overrule them (Betsch et al. 2004). This results in weak motivation for the intended behavior (Ajzen 2005). The habitual layer is mostly understood as an automatic process, with only minor cognitive aspects. The adoption of a new technology is usually inhibited by weakening the intention formation and activation through performing subconscious behaviors (Verplanken and Aarts 1999; Betsch et al. 2004; Limayem et al. 2007; Polites and Karahanna 2012).

The evaluative layer on the other hand includes the consideration of multiple aspects of potential behavior, in our case either using an incumbent system or a new system. The conscious consideration of outcomes, past experience, eventual rewards, and composing factors of attitude results in a positive or negative attitude, which can lead to a behavioral intention (Ajzen 1991). As soon as the evaluation does not lead to just a single positive evaluation, a dissonance between both attitudes arises (Festinger 1957; Gawronski and Bodenhausen 2007). The resolution of the dissonance towards a single attitude determines which behavioral intention will be activated on the behavioral layer (Festinger 1957; Gawronski 2012). Figure 1 summarizes the three relevant layers involved in an adoption decision between an incumbent and new technology.

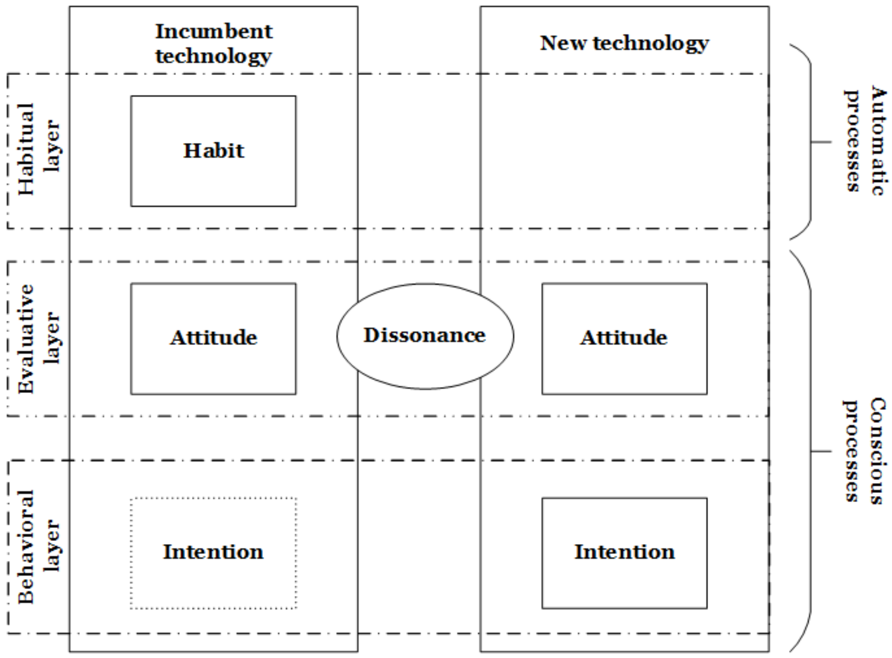

Figure 1: Layers of Behavior

Past experience is known to influence the attitude towards a behavior and thus has influence on the attitude towards the old system (Ajzen 1991). If the attitude towards using the old system is positive, it is likely that a habit will be formed through a frequent repetition of the behavior (Verplanken and Aarts 1999). A more frequent habit becomes less dependent on the evaluation of the behavior and the predictive effect of attitudes therefore decreases (Bagozzi 1981). Habits can lead to behavioral lock-ins or result in being stuck with a habit (Betsch et al. 2004). Extensive past behavior also reduces the predictive effect of intentions (Bagozzi 1981). However, certain mechanisms are known to inhibit a desirable resolution. A frequent past behavior with satisfying results, inhibits the attitudinal change towards the new system (Harmon-Jones and Harmon-Jones 2007), as does increased importance and a personal relation towards one of the attitudes (Brehm 2007; Gawronski 2012). We call the resulting situation a competition of attitudes. The competition is solved with the means of dissonance reduction between the competing attitudes and the established habit.

2.1 Related Concepts in E-Government Research

Attitudes towards using an E-Government system are regarded as a strong determinant of future adoption and often the main building block in theoretical models to explain and predict future behavior (Tung and Rieck 2005; Carter 2008; Weerakkody et al. 2013). Attitudes present the general evaluation towards a behavior, but the relevant factors are highly dependent on the behavior in question (Ajzen 2005). As a result, most adoption models are based on the attitude-intention-behavior relationship, but with the inclusion of relevant background factors for the context of information systems (Carter and Belanger 2005; Tung and Rieck 2005). The predictive power of such models are sufficient for most cases (Ajzen 1991), but lack a consideration of competing attitudes. In adoption research, this can be a decision between using an old system and new system. If the evaluation of using the new system is significantly better, the current models work just fine. But as soon as the picture is less obvious and an adoption fails despite a positive evaluation, the sole analysis of the attitude towards using the new system is not sufficient to explain the underwhelming adoption.

Multiple concepts have been picked up by E-Government scholars to explain inhibiting factors and close the gap between the assumed superiority of the emergent system and the disappointing adoption attitude, such as inertia (Titah and Barki 2008). General IS research also provided insights with the concepts of status quo bias (SQB) (Polites and Karahanna 2012), and action slips (Polites and Karahanna 2013). Table 1 gives a summary of these concepts in IS and E-Government research. Our approach seems similar to these concepts at first sight, but there are some differences. Inertia describes the persistence of behavioral patterns (Polites and Karahanna 2012), irrespective of the attitude towards the incumbent system. Inertia can persist even if other options are perceived as a better option and there are incentives to change (Polites and Karahanna 2012). Inertia is also used to describe continuing use, based on a favorable attitude towards the incumbent system (Polites and Karahanna 2012). The latter usage of inertia matches our described problem, but the former tackles a different phenomenon in which there is no dissonance between both systems and the user nonetheless stays with the old system. Status quo bias offers more consistent and simpler explanations for staying with an incumbent system by stating that decision makers tend to prefer the status quo (Samuelson and Zeckhauser 1988; Polites and Karahanna 2012). The reasons for a bias towards the status quo can be multipartite, such as the strength of preference towards the actual state or a result of uncertainty (Samuelson and Zeckhauser 1988), but the preference can also result from a wrong assessment of the benefits and risks (Polites and Karahanna 2012). Nevertheless, SQB is not contrary to the concept of dissonance theory, but focuses on a different level. While dissonance theory addresses the internal mechanism of decision making in situations of conflicting beliefs and attitudes, SQB is concerned with the results of the underlying mechanisms (Samuelson and Zeckhauser 1988). We argue that dissonance theory and status quo bias are not contrary but in fact complementary, as the first addresses the underlying psychological mechanisms, while the latter is concerned with the results of these mechanisms. Action slips address situations where unintended actions are performed, usually based on strong and frequently performed habits (Norman 1981; Betsch et al. 2004; Polites and Karahanna 2013). In contrary to both former concepts, action slips occur irrespective of an attitude-behavior relationship and the intention formation by skipping the behavioral process (Heckhausen and Beckmann 1990; Verplanken and Aarts 1999; Betsch et al. 2004). This is consistent with the decreased dependency of attitudes and evaluations in general for habits (Bagozzi 1981). Action slips are less concerned with attitudinal formation and intentions, but they are again not contrary to dissonance theory but complementary. Both concepts address different problems and phenomena.

3 Research Model and Hypotheses

The underlying research focus of our study is the gap between a positive prediction by current adoption models and the underwhelming actual adoption by individuals. Recent work by Polites and Karahanna (2012) uncovered that adoption decisions rarely occur in a vacuum, but usually replace a preceding system. It is to be expected that habits and attitudes towards the old systems interfere with the intention to adopt a new system (Polites and Karahanna 2012). We want to investigate the impact of a positive attitude towards the incumbent system and at the same time the influence of habits on the attitude towards using the new system. Our research model is basically divided between the three layers introduced in Figure 2: The habitual layer, the evaluative layer, where the cognitive dissonance occurs, and the behavioral layer, where the intentions towards a particular behavior are formed and activated (Ajzen 1991).

The evaluative layer of behavior includes the cognitive evaluation of a potential behavior, based on relevant background factors (Ajzen 2005). All relevant determinants, experiences, and potential outcomes of an behavior are summarized into one general evaluation of a behavior into an attitude (Ajzen 1991). In a case where two competing systems are present and the individual has extensive experiences with the old information system and a positive attitude towards using this system, the theory expects a kind of positive feedback loop, because past experience is a determinant of attitudes (Ajzen 1991) and habits tend to overrule the intention formation of the cognitive process (Verplanken and Aarts 1999; Betsch et al. 2004). Thus habits are shaped by past behaviors and by established attitudes. In situations of cognitive dissonance during the evaluations of the old and the new system, individuals tend to dissolve the cognitive dissonance by sticking with the most resistant attitude, which is usually the most recently activated attitude system (Harmon-Jones and Harmon-Jones 2007; Brehm 2007). The change of the attitude towards using the old system becomes even less probable if the past outcomes have been consistently desirable (Harmon-Jones and Harmon-Jones 2007). We expect that a positive attitude towards the old system has a negative impact on the attitude towards the new system and therefore hypothesize:

H1: A positive attitude towards using the old system has a positive impact on the habitual use of the old system.

H2: A positive attitude towards using the old system has a negative impact on the attitude towards using a new system.

Habits are built by past experience and exposure to an information system (Limayem and Hirt 2003). Established and strong habits of system usage result in subconscious behaviors (Limayem and Hirt 2003), which can interfere with the formation or activation of conscious intentions (Verplanken and Aarts 1999; Brehm 2007). In the case of competing attitudes, established habits support the attitude towards using the old system through more personal experience and more recent activation, which results in a tendency towards resolving the dissonance in favor of the old system (Verplanken and Aarts 1999; Harmon-Jones and Harmon-Jones 2007; Brehm 2007; Gawronski 2012). Frequent habitual routines become less dependent on the evaluative process of planned behavior and might even skip it altogether (Bagozzi 1981; Heckhausen and Beckmann 1990; Verplanken and Aarts 1999). With relative stable, external conditions like using one system for the same tasks and goals over and over again, less cognitive planning is involved in performing the behavior (Limayem et al. 2007), which results in a suppression of the relationship of intention and behavior. Consequently, the skipping of the evaluative process results in a weak implementation of intentions (Ajzen 2005) and thus we hypothesize:

H3: Habits have a negative impact on the attitude towards using the new system.

H4: Habits have a negative moderating effect on the attitude-intention relationship to use a new system.

Attitudes are consistent predictors of intentions, especially if the intention is directed towards a behavior rather than an object (Bagozzi 1981). We subsequently hypothesize:

H5: A positive attitude towards using a new system has a positive effect on the intention to use a new system.

Habits serve the purpose to induce certain behaviors by simply triggering a behavior with a high goal fit (Verplanken and Aarts 1999). The habitual behavior formation takes several contextual pieces of information into account, but is still less cognitive in comparison to the intention formation process and less controllable by the user (Verplanken and Aarts 1999). The less controllable triggers and automated behaviors lower the influence of intentions and thus the relationship between intentions and behavior becomes weaker and becomes effectively overruled, resulting in behavioral lock-ins (Bagozzi 1981; Verplanken and Aarts 1999; Betsch et al. 2004; Limayem et al. 2007). To take such strong habits into account, we subsequently hypothesize:

H6: A habitual use of the old system has a negative effect on the intention to adopt a new system.

4 Methodological Approach

In order to answer our two research questions, we conducted a study among employees of public institutions in Germany. As a focal task we chose the invoicing process. Invoice processing is one of the main responsibilities of the participating employees and the chance to establish a habitual use of the current system through frequent use is likely and therefore fits our research purpose. In our case, electronic invoicing of E-Government services and a complete, electronic invoice processing acts as our new E-Government system. Paper-based invoices with partial support by information systems serve as the old system. We understand electronic invoicing as a mean to exchange and process invoices with citizens and businesses fully digitally, without any format discontinuity throughout the whole process. Recent research focused solely on drivers of and barriers to electronic invoices (Juntumaa and Oorni 2011; Penttinen and Tuunainen 2011; Haag et al. 2013; Kreuzer et al. 2013) or on the slow adoption levels of electronic invoicing (Edelmann and Sintonen 2006). Due to the frequency of the process itself and the assumed familiarity of the employees with the process, invoicing is a suitable focal technology, because it can be analyzed in relation to competing attitudes and habitual use. We tested our hypothesis by the means of a survey among the staff members of a public university in Germany. The selected recipients were in charge of processing invoices throughout the whole process and are usually employed as secretaries at a department level. Since the participants are employed by a German public institution, they enjoy a strong job security and relative weak directive power by the administration. Those employees tend to show less partisan allegiances.

We were able to collect 69 unique responses during a span of three weeks. The cover page of our questionnaire contained a page long explanation of our study's intention and a description of electronic invoicing and how it would potentially be incorporated in their daily work routine and their information systems environment. Due to privacy concerns expressed by the university administration, we coded the demographics resulting in six different categories for age, educational level, and position. Almost 80% of the subjects are either in the range of 41 to 50 or 51 to 60 years old, which is almost identically distributed. The highest degree achieved is almost perfectly distributed between high school diploma, AP level high school diploma, and some form of university degree. Furthermore, the sample only contains responses from women.

5 Analysis

For the analysis of our hypothesis, we chose to analyze the data using partial least square structural equation modeling (PLS-SEM), which we performed with SmartPLS as PLS is less restrictive on the underlying data distribution, needs smaller sample sizes, and is appropriate for testing theories and relationships between constructs (Hair et al. 2013). We tested our measurement model for internal consistency reliability, construct validity, convergent, and discriminant validity. For construct validity we calculated the composite reliability of the constructs, which exceeds the threshold of 0.707 in all cases (Hair 2006). For convergent validity we estimated the average variance extracted (AVE) which also exceeds the threshold of 0,5 in all cases (Fornell and Larcker 1981). To test for discriminant validity we used the Fornell-Larcker-Criterion (Fornell and Larcker 1981), which states that the square root of the AVE should be higher than the correlation with other latent variables. Our measurement model exceeds this criterion as shown in Table 1.

	AVE	Composite Reliability	Attitude$_{New}$	Moderator	Attitude$_{Old}$	Habit	Intention
Attitude$_{New}$	0,864	0,9624	**0.930**				
Moderator	0,513	0,9261	-0.304	**0.716**			
Attitude$_{Old}$	0,655	0,8500	-0.556	-0.069	**0.809**		
Habit	0,551	0,7620	-0.527	-0.308	0.610	**0.742**	
Intention	0,911	0,9763	-0.827	-0.394	-0.487	-0.511	**0.955**

Table 1: Measurement Model

For the evaluation of the structural model, we first tested for collinearity by assessing the VIF of our constructs. A VIF below 5 indicates that the structural model does not have collinearity issues. Our assessment shows that no attitude new or old (VIF: 2,28 and 1,85, respectively) neither habit (VIF: 2,83), or the moderator variable (VIF: 1,91) show indications of collinearity (Hair et al. 2013). Next, we calculated the t-values for each path. The results from the t-tests and the path coefficients can be taken from Figure 2.

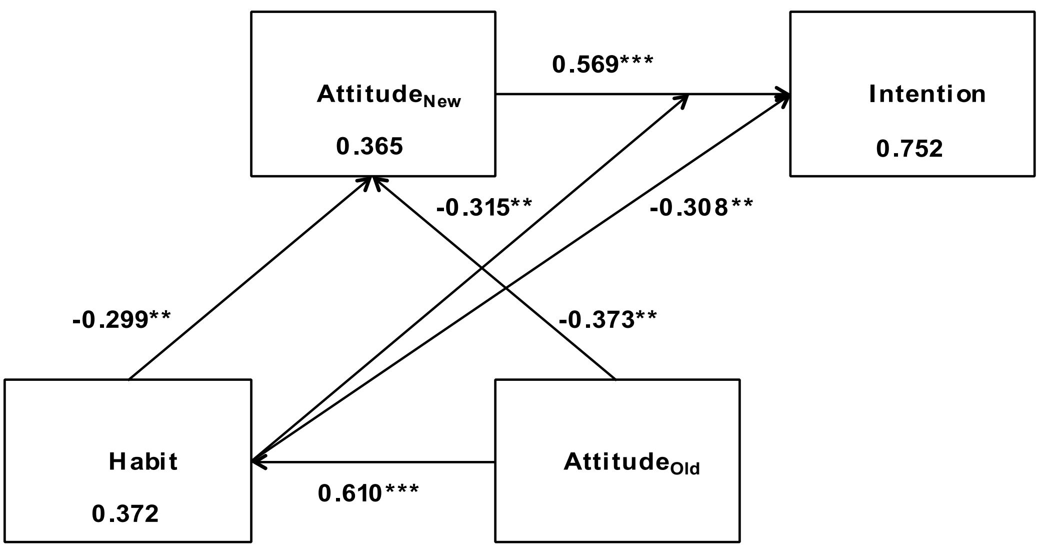

Figure 2: Structural Model

All hypotheses have been confirmed. The paths are significant, either on a 1% level (two asterisks) or even on a 0.1% level (three asterisks). We also calculated the R^2 values for our endogenous latent variables, resulting in a relatively strong predictive accuracy for intention to use, and weak predictive accuracy of habit and attitude towards the new system (Hair et al. 2011). The outcome of our study indicates that not only does attitude towards the new system have an impact on the intention to use the system. The relationship between the new attitude and the intention is positive (**H5)** and in line with prior research (Bagozzi 1981; Ajzen 1991). **H1** is also supported by our data as expected. The attitude towards an established behavior can turn into a habit under certain conditions, like a rewarding outcome, frequent performance, and efficiency (Verplanken and Aarts 1999). **H2** has been supported by our data, indicating that competing attitudes are in fact a significant inhibitor for the adoption of new technologies. The underlying theory of cognitive dissonance offers an explanation for this result, because it suggests a mechanism to deal with consonant and dissonant beliefs in relation to one's behavior (Harmon-Jones and Harmon-Jones 2007). It can be argued that dissonance reduction predominantly occurs in the post-decision state as outlined in prior research (Brehm 1956; Festinger 1957), but recent studies have been able to show the dissonance reduction and attitudinal changes decision making, even in a relatively short period of time as a natural by-product of decision making (Jarcho et al. 2011).

6 Discussion and Limitations

We have shown that attitude towards a competing system and a habitual use of this system has a significant effect on the decision to adopt and use a new technology. We can draw several implications for theory and practice. First, existing theory should take the influence of the attitude towards the incumbent system into account, because the new technology is related to the prior technology and therefore psychological connected in terms of potentially causing a dissonance (Brehm 2007). The old behavior can interfere with the adoption decision and even inhibit the adoption. We suppose that the potential dissonance between both options was relatively small since one of the options was clearly better, yet our hypothesized effect is significant and sound. Even disruptive and entirely new technologies might be affected by dissonance. Second, habits are relevant if the replaced technologies have been perceived as efficient by the users and the task was performed frequently (Verplanken and Aarts 1999). Which leads us to our third implication, namely that habits and a state of dissonance are likely to occur simultaneously. Both require a positive attitude towards a behavior at the beginning and if the outcome is perceived as satisfying users are more likely to perform it again and, more importantly, they are more likely to change competing attitudes in order to keep their satisfactory and less stress causing state (Harmon-Jones and Harmon-Jones 2007; Brehm 2007; Gawronski 2012).

Our study offers an extension of theory in terms of unifying several common concepts in IS and E-Government research with the inclusion of dissonance theory. It offers explanations for the evident status quo bias among decision makers, because it covers the same problems and offers an explanatory mechanism for the existence of status quo bias without neglecting the existing results. There are also practical implications from our study. Habits and positive attitudes towards an incumbent system are usually beneficial till government or ministry administration undertakes changes for economic and productivity reasons. However, these problems can be overcome using findings from dissonance theory. A state of arousal usually occurs with personal commitment to a decision. However, high incentives can lower the perceived commitment to a decision and thus reduce the dissonance by an externalization of the decision (Gawronski 2012). As soon as the user does not recognize the decision as his or her own, because the behavior is justified by a high incentive a state of dissonance is not likely to occur. Therefore, the implementation of suitable incentives by the administration can drive successful adoption and restrain the potential negative effects of a state of dissonance. Especially in settings, where employees and civil servants enjoy a strong job security and weak extrinsic pressure, the administration needs a guiding theory to set functioning incentives for their civil servants to adopt and use the new E-Government system. It is thus crucial to understand how the civil servants make their decision towards or against the E-Government system.

While we have been able to support every one of our hypotheses, our sample does not qualify for generalization. This is justified by the relatively small number of participants and the uneven distribution; namely, only women, predominantly in the age group of 40-60 years. However, our sample accounts for a broad range of educational levels and is almost evenly split between them. Finally, we did not incorporate measurement items for the strength of habitual behaviors, which supposedly leaves our study with a relatively weak R^2 for habit. Further research should therefore include these measures in order to further explain habits and the direct and indirect effect of habit on intention.

7 Conclusion

To sum up our study, by building upon dissonance theory we have been able to show that competing attitudes can interfere with the intention to adopt and use new E-Government systems. As soon as the user perceives the incumbent system to be beneficial and satisfying, the intention is inhibited by the status quo. Simultaneously, a habitual use of the E-Government system can arise due to the positive perception of the system. By answering both research questions positively, a negative effect on the adoption decision is evident. Our findings suggest that the attitude towards the incumbent E-Government system should be taken into account for future adoption analyzes, since it can contribute to an explanation of underwhelming adoption rates through change of attitude towards a new system, triggered by dissonance reduction. Additionally, habitual use of the incumbent system is shown to have multiple effects on the intention formation process for adoption behavior. We can also contribute to existing theory and offer a few starting points for future research and practice for overcoming these negative effects.

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Bürgerzufriedenheit durch E-Government? – Eine Analyse auf Basis des Kano-Modells

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Abstract

In den letzten Jahren haben E-Services im öffentlichen Sektor zunehmend an Bedeutung gewonnen. Doch obwohl E-Services zahlreiche Vorteile versprechen – z. B. eine Steigerung der institutionellen Effizienz und die Partizipation von Bürgern bei demokratischen Vorgängen – liegt die aktuelle Nutzung durch Bürger in vielen Ländern weit hinter den Erwartungen zurück. Wissenschaftliche Arbeiten haben gezeigt, dass die Zufriedenheit der Bürger mit E-Services ein wesentlicher Faktor für deren Nutzung ist. Vor diesem Hintergrund ist es Ziel des vorliegenden Beitrags, auf Basis des Kano-Modells zu untersuchen, inwiefern E-Services einen Beitrag zur Zufriedenheit leisten bzw. bei Nichtvorhandensein zu Unzufriedenheit von Bürgern führen. Um einen strukturellen Vergleich zu ziehen, wurden Daten von 290 Bürgern in zwei Regionen (Stadt und Land) in Deutschland untersucht. Die Ergebnisse lassen darauf schließen, dass E-Services zwar zu einer Steigerung der Bürgerzufriedenheit beitragen können, das Nichtvorhandensein aber nicht in gleichem Maße zu Unzufriedenheit auf Seiten der Bürger führt. Zudem tragen E-Services in der Stadt tendenziell stärker zur Zufriedenheit der Bürger bei als auf dem Land.

1 Einleitung

Die wachsende Bedeutung der Digitalisierung und damit einhergehende Entwicklungen im Bereich der Kommunikations- und Informationstechnologie haben dazu geführt, dass Institutionen des öffentlichen Sektors vermehrt E-Services anbieten (Moon und Norris 2005). Von E-Services wird erwartet, dass sie zu einer besseren Effizienz, Effektivität und Transparenz im öffentlichen Sektor beitragen und auch die Qualität und den Zugang zu Services für Bürger verbessern (Asgarkhani 2005; Yildiz 2007). So zielt beispielsweise die Stadt München durch eine stärkere Digitalisierung von Services darauf ab, den kürzlich aufgetretenen Kapazitätsgrenzen in Bürgerbüros entgegenzuwirken und lange Wartezeiten zu vermeiden (Rahmsdorf und Riedel 2015).

Um von den Vorteilen von E-Government profitieren zu können, müssen Bürger und Unternehmen E-Services nutzen. Laut Studien (z. B. Eurostat 2015; OECD 2009; United Nations 2012) ist jedoch die Nutzung von E-Services im Vergleich zum Angebot derzeit nach wie vor gering – in Deutschland lässt sich dies am Beispiel des elektronischen Personalausweises verfolgen, dessen Nutzung weit hinter den angestrebten Nutzungszahlen zurückliegt. In der Literatur wurden bereits verschiedene Faktoren untersucht, welche die Adoption von E-Services beeinflussen (z. B. Akkaya et al. 2012). Einen zentralen Faktor, der die Nutzung eines Angebots bestimmt, stellt dabei die Zufriedenheit dar (DeLone und McLean 2003). Insbesondere empirische Forschungsarbeiten haben sich daher dem Zusammenspiel von E-Services und Zufriedenheit gewidmet. Nach Kenntnis der Autoren existieren bislang jedoch im Bereich E-Government keine Forschungsarbeiten, die untersuchen, inwiefern das Angebot von E-Services Zufriedenheit bei Bürgern stiftet bzw. das Nichtangebot von E-Services Unzufriedenheit bei Bürgern hervorruft. Vor diesem Hintergrund ist es Ziel dieses Beitrags zu untersuchen, inwiefern E-Services einen Beitrag zur Zufriedenheit von Bürgern leisten bzw. bei Nichtvorhandensein zu Unzufriedenheit von Bürgern führen. Hierzu wird auf Basis des Kano-Modells eine Untersuchung in zwei Regionen (Stand und Land) in Deutschland für drei exemplarisch ausgewählte E-Services (*Personalausweis beantragen*, *Wohnsitz anmelden* und *Eheschließung/Lebenspartnerschaft anmelden*) durchgeführt.

Der Beitrag ist wie folgt aufgebaut: In Kapitel 2 wird zunächst ein Überblick über den Untersuchungsgegenstand gegeben. Im dritten Kapitel wird die Forschungsmethodik erläutert, bevor in Kapitel 4 die Ergebnisse im Detail vorgestellt werden. Im Anschluss werden in Kapitel 5 die Ergebnisse diskutiert. Der Beitrag schließt mit einem Fazit in Kapitel 6.

2 Theoretischer Hintergrund

Im Hinblick auf die für unsere Untersuchung relevanten bestehenden Forschungsarbeiten können die beiden Forschungsstränge Angebot von E-Services und Nachfrage bzw. Nutzung von E-Services im E-Government unterschieden werden. Im Folgenden soll ein kurzer Überblick über den aktuellen Stand der Forschung zu beiden Forschungssträngen gegeben werden.

2.1 Angebot von E-Services im E-Government

In der Literatur, welche sich mit dem Angebot von E-Services beschäftigt, werden zahlreiche Themen, wie beispielsweise die Art der angebotenen E-Services (Belanger und Carter 2008; Jiang und Ji 2014; Layne und Lee 2001; Reddick 2004), Erfolgsfaktoren von E-Services (Al-Rashidi 2010; El-Haddadeh et al. 2010; Moon und Norris 2005; Norris 2009; Palanisamy 2004; Rana et al. 2013; Weerakkody und Choudrie 2005) und Effekte des Angebots von E-Services (Asgarkhani 2005; Müller et al. 2014; West 2004), untersucht. Bezüglich der hier vorliegenden Studie ist insbesondere die Art der angebotenen E-Services für die Einordnung der Untersuchung relevant.

Dabei umfasst die bisherige Literatur im Bereich E-Government überwiegend Studien, welche bereits existierende Angebote unter Verwendung empirischer Daten untersuchen. Dabei wird zum einen zwischen dem Reifegrad des E-Government-Angebots und zum anderen zwischen den beteiligten Transaktionspartnern unterschieden (Belanger und Carter 2008). In Anlehnung an Reddick (2004) können E-Government-Services in zwei Phasen unterschieden werden. Die erste Phase stellt dabei auf die Darstellung und den Austausch von Informationen ab (E-Information, E-Interaktion), während die zweite Phase die Abwicklung von Vorgängen fokussiert (E-Abwicklung) (Jiang und Ji 2014; Layne und Lee 2001; Reddick 2004; United Nations 2014). Dabei zeigte sich, dass bestehende E-Service-Angebote überwiegend der ersten Phase (E-Information und E-Interaktion) zuzuordnen sind (United Nations 2014) und die Angebote je nach betrachtetem Land variieren (Gulati et al. 2012). Die vorliegende Untersuchung teilt E-Services ebenfalls in die Bereiche E-Information, E-Interaktion und E-Abwicklung ein. Die Entwicklungen im Zuge der Digitalisierung unterstreichen dabei die Bedeutung des Angebots von E-Services. So werden E-

Government im Vergleich zum traditionellen Government in den Vordergrund gerückt (PwC 2015) und beispielsweise eine effizientere Arbeitsweise und Bürokratieabbau unterstützt (Klein 2015).

Neben dieser Kategorisierung wird zwischen den beteiligten Transaktionspartnern unterschieden. In der Literatur finden sich hier Services für die Bereiche Government-to-Consumer (G2C), Government-to-Business (G2B) und Government-to-Government (G2G). E-Services im Bereich G2C, die im vorliegenden Beitrag fokussiert werden, beschränken sich zumeist auf E-Information und E-Interaktion (Hahamis et al. 2005; Reddick 2004), wohingegen Services für G2B und G2G zunehmend auch transaktionsorientiert sind (Moon 2002). Auch für Deutschland zeigen aktuelle Studien auf, dass die Mehrheit angebotener kommunaler E-Services für Bürger (G2C) momentan noch dem Bereich E-Information und E-Interaktion zuzurechnen ist (McKinsey&Company 2015).

2.2 Nachfrage von E-Services im E-Government

In der Literatur, die sich mit der Nachfrage von E-Services im E-Government beschäftigt, lassen sich unter anderem Arbeiten finden, die sich mit dem Grad der Nachfrage auf Seiten von Bürgern und Unternehmen beschäftigen oder Faktoren untersuchen, welche diese Nachfrage beeinflussen. Bisherige Studien zur Nutzung von E-Services zeigen, dass im Hinblick auf Nutzungszahlen noch deutliches Steigerungspotenzial besteht. Laut OECD (2009) liegt der Nutzungsgrad von E-Government-Services teilweise deutlich hinter dem Angebot. So werden diese nur für 30% der von den United Nations (2012) betrachteten Basisservices genutzt, obwohl für 90% dieser Basisservices E-Service-Angebote existieren. Dabei variiert der Nutzungsgrad stark im Hinblick auf einzelne Länder (Hahamis et al. 2005; Lee et al. 2005; United Nations 2014). Während in Deutschland nur 39% angeben, bereits E-Government-Angebote genutzt zu haben, ist der Anteil in den anderen deutschsprachigen Ländern um 30% höher (eGovernment MONITOR 2015). Dabei beeinflusst gerade auch die Komplexität der Services den Nutzungsgrad. So werden nach Erkenntnissen von Eurostat (2015) Services, die auf E-Information abzielen, weit häufiger genutzt als auf E-Abwicklung ausgerichtete Services. Dennoch geben 80% der Befragten einer repräsentativen Studie an, online Transaktionen bei Bürgerservices zu bevorzugen (Thiel 2016).

Die Nutzung von E-Services wird durch verschiedene Faktoren beeinflusst. Zahlreiche Forschungsarbeiten basieren dabei auf den theoretischen Grundlagen aus dem Bereich der Technologie-Adoption, wie etwa dem Technology Acceptance Model (TAM) (Davis et al. 1989) oder dem IS Success Model (DeLone und McLean 2003), die das Zusammenspiel diverser Faktoren (z. B. Qualität) im Hinblick auf den Erfolg von E-Services untersuchen. Dabei kommt auch dem Thema Zufriedenheit eine zentrale Rolle zu, welche die Basis für die vorliegende Untersuchung darstellt. Weitere Faktoren, welche die Nutzung von E-Services beeinflussen, sind beispielsweise der Mehrgewinn an Komfort (Gilbert et al. 2004), Informationsqualität und Servicequalität (Gilbert et al. 2004; Jiang und Ji 2014; Wang und Liao 2008), persönliche Erfahrungen und Fähigkeiten (Gilbert et al. 2004) sowie soziale Einflüsse (Carter et al. 2012).

3 Forschungsmethodik

3.1 Setting und Datensammlung

Um zu analysieren, inwiefern E-Services einen Beitrag zur Zufriedenheit leisten bzw. bei Nichtvorhandensein zu Unzufriedenheit von Bürgern führen, wurde ein explorativer Forschungsansatz gewählt. Dazu wurde eine Umfrage unter Bürgern der Stadt Regensburg (141.642 Einwohner) sowie der Verwaltungsgemeinschaft Ihrlerstein (5.193 Einwohner; Gemeinde Ihrlerstein und Markt Essing) durchgeführt. Beide Orte wurden ausgewählt, um einen Vergleich zwischen einer städtischen und einer ländlichen Region zu ermöglichen. Die Umfrage fokussiert die drei Services *Personalausweis beantragen*, *Wohnsitz anmelden* und *Eheschließung/ Lebenspartnerschaft anmelden*. Jeder Service umfasst die Teilschritte Information, Interaktion und Abwicklung. Die Services *Personalausweis beantragen* und *Wohnsitz anmelden* wurden ausgewählt, da beide Services verhältnismäßig häufig nachgefragt werden und für den Bürger mit geringem Aufwand verbunden sind (Routine). Die *Anmeldung einer Eheschließung/ Lebenspartnerschaft* wird dagegen von Einzelnen nur sehr selten vorgenommen, ist für Bürger ggf. von tieferer emotionaler Bedeutung und aufgrund der benötigten Dokumente aufwendiger und komplexer. Die Wahl der betrachteten Services erlaubt somit einen Vergleich zwischen Services unterschiedlicher Charakteristika. Zur Erhebung der Daten wurde auf eine schriftliche Befragung mittels eines Kano-Fragebogens zurückgegriffen. Durch die Entscheidung für eine schriftliche Befragung konnten gezielt Personen angesprochen werden, um einen möglichst breiten Querschnitt durch die Bevölkerung zu erreichen, was bei einer Internetbefragung nicht ohne weiteres möglich ist. In Regensburg wurde die Befragung im Zeitraum vom 11.08.2015 bis 12.08.2015 im Wartebereich des Bürgerzentrums Stadtmitte durchgeführt. Dadurch wurden ausschließlich Bürger befragt, die gerade Bürgerservices benötigten. Da in Regensburg die Abwicklung der betrachteten Services als E-Service nicht möglich ist, kann ausgeschlossen werden, dass sich die offline Präsenz der Befragten auf die Ergebnisse auswirkt. Aufgrund der geringen Frequentierung des Bürgerzentrums in Ihrlerstein wurden die Fragebögen dort im Zeitraum vom 03.08.2015 bis 07.08.2015 an ausgewählte Bürger verteilt. Insgesamt beteiligten sich in Regensburg 227 Bürger, wobei der Fragebogen in 201 Fällen vollständig ausgefüllt wurde. In Ihrlerstein beteiligten sich 96 Personen, wobei 89 den Fragebogen vollständig ausfüllten. Der Stichprobenumfang umfasst damit insgesamt n = 290 Personen für beide Regionen.

Merkmal		**Gesamt (n = 290)**	**Regensburg (n = 201)**	**Ihrlerstein (n = 89)**
Geschlecht	Männlich	50%	48%	53%
	Weiblich	50%	52%	47%
Alter (in Jahren)	< 30	46%	56%	22%
	30 - 49	31%	31%	30%
	> 50	23%	13%	48%
Nutzung von E-Services	Ja	26%	30%	16%
	nein	74%	70%	84%

Tabelle 1: Demographische Daten

Tabelle 1 gibt einen Überblick über die demographischen Informationen der Teilnehmer der Umfrage sowie deren Nutzung von E-Services. Dabei wird deutlich, dass der Nutzungsgrad von E-Services im ländlichen Bereich (16%) deutlich geringer ausfällt als in der städtischen Region (30%). Der hohe Anteil an Teilnehmern unter 30 Jahren in Regensburg (56%) scheint darauf zurückzuführen zu sein, dass das Bürgerbüro in Regensburg während des Zeitraums der Befragung vermehrt von Studierenden frequentiert wurde.

3.2 Kano-Methode

Die Kano-Methode baut auf dem Kano-Modell auf (Kano 1984), in welchem Anforderungen an eine Dienstleistung auf Basis ihres Beitrags zur wahrgenommen Zufriedenheit bzw.

Unzufriedenheit des Kunden differenziert werden. Mittels der Kano-Methode können Leistungsmerkmale oder Teildienste einer Dienstleistung hinsichtlich ihrer Bedeutung klassifiziert werden (Berger et al. 1993). Dabei wird zwischen den Kategorien 1) Must-be, 2) One-dimensional, 3) Attractive, 4) Indifferent 5) Reverse und 6) Questionable unterschieden (Berger et al. 1993; Kano 1984). Als Must-be (M) werden Basisfaktoren einer Dienstleistung bezeichnet, deren Nichterfüllung zu einer negativen Qualitätswahrnehmung und somit zu Unzufriedenheit des Kunden führt. Sie werden vom Kunden oftmals als selbstverständlich vorausgesetzt. Die Kategorie Must-be steht im Gegensatz zu Attractive (A), deren Elemente auch als Begeisterungsfaktoren bezeichnet werden. Die Erfüllung von Merkmalen dieser Kategorie hat positive Auswirkungen auf die Wahrnehmung einer Dienstleistung. Eine Nichterfüllung hat dagegen kaum negative Auswirkungen. Unter One-dimensional (O), oder auch Leistungsfaktoren, werden Merkmale gefasst, bei denen sich die vom Kunden wahrgenommene Qualität proportional zum Erfüllungsgrad des Merkmals verhält. Bei Vorhandensein haben diese stark positiven bei Nichtvorhandensein stark negativen Einfluss auf die Kundenzufriedenheit. Indifferent (I), oder auch Indifferenzfaktoren, haben dagegen kaum Einfluss auf die Kundenzufriedenheit, wogegen sich bei Reverse (R) das Vorhandensein eines Merkmals negativ auf die Kundenwahrnehmung auswirkt. Wird ein Merkmal als Questionable (Q) klassifiziert, deutet dies auf Widersprüchlichkeiten in den Antworten der Befragten hin (Berger et al. 1993; Kano 1984).

Bei der Kano-Methode werden für jedes Merkmal eine funktionale Frage (Zufriedenheitsreaktion im Falle der Erfüllung) und eine dysfunktionale Frage (Unzufriedenheitsreaktion bei Nichterfüllung) gestellt. Im Rahmen des vorliegenden Beitrags wurde dabei bei allen Fragen auf die von Berger et al. (1993) vorgeschlagenen Antwortskalen zurückgegriffen. Anhand der Kombination der Antwortmöglichkeiten lassen sich dann die Merkmale oder Teildienste den oben genannten Kategorien zuordnen.

3.3 Vorgehen und Methodik

Das Vorgehen für die Konzeption und Durchführung der Umfrage orientiert sich an Berger et al. (1993) und umfasst folgende Schritte: 1) Entwicklung des Fragebogens 2) Testen des Fragebogens, 3) Durchführung der Umfrage, 4) Auswertung der Ergebnisse, 5) Analyse und Interpretation der Ergebnisse. In Schritt 1) wurde der Fragebogen für die drei E-Services *Personalausweis beantragen*, *Wohnsitz anmelden* und *Eheschließung/Lebenspartnerschaft anmelden* entworfen. Als abzufragende Merkmale wurden jeweils die Teilschritte E-Information, E-Interaktion und E-Abwicklung gewählt. Anschließend beinhaltet Schritt 2) eine Vorevaluation des Fragebogens. Die Durchführung der Kano-Befragung (Schritt 3)), die Auswertung der Umfrage (Schritt 4)) sowie die Interpretation der Ergebnisse (Schritt 5)) sind Gegenstand der Kapitel 3.1, 4 und 5.

Für die Auswertung der Umfrage wurde auf in der Literatur gängige Methoden und Maße zurückgegriffen (z. B. Berger et al. 1993). Unter Verwendung der Kano-Tabelle wurde für jedes abgefragte Merkmal und jeden Teilnehmer die entsprechende Kategorie bestimmt. Anschließend wurde anhand der Häufigkeitsverteilung der Kategorien für ein Merkmal über alle Teilnehmer die Kategorie des Merkmals ermittelt, indem die am häufigsten genannte Kategorie ausgewählt wurde. Um die Güte der ermittelten Kategorien zu überprüfen, wurden die beiden Maßzahlen Category Strength (Differenz zwischen der Kategorie mit den häufigsten Nennungen und der Kategorie mit den zweithäufigsten Nennungen) und Total Strength (Summe A, O und M) herangezogen (Lee und Newcomb 1996). Mittels der Category Strength kann die Eindeutigkeit der Zuordnung eines Merkmals zu einer Kategorie ermittelt werden. In Anlehnung an Lee und Newcomb (1996) gelten nur Kategorien mit einer Category Strength von mindestens 6% als eindeutig zugeordnet. Die Total Strength gibt dagegen den Anteil der Befragten an, für die das betrachtete Merkmal von Relevanz ist. Anhand der Ergebnisse der oben genannten Maßzahlen wurde in Ausnahmefällen, in denen keine eindeutige Zuordnung möglich war, auf die von Berger et al. (1993) vorgeschlagenen Entscheidungsregeln zurückgegriffen.

1. Entscheidungsregel:

   Wenn (M + A + O) > (I + Q + R), dann wähle das Maximum von M, A oder O

   Wenn (M + A + O) < (I + Q + R), dann wähle das Maximum von I, Q oder R

2. Entscheidungsregel:

   M > O > A > I

Eine Methode zur detaillierten Analyse des Beitrags eines Merkmals zur Kundenzufriedenheit stellt die Ermittlung des von Berger et al. (1993) entwickelten Zufriedenheitskoeffizienten (Better) sowie des Unzufriedenheitskoeffizienten (Worse) dar:

$$Better = \frac{A+O}{A+O+M+I} \in [0;1] \qquad Worse = -\frac{O+M}{A+O+M+I} \quad [-1;0]$$

Ein Wert nahe 0 impliziert, dass ein Merkmal bei Vorhandensein bzw. Nichtvorhandensein einen geringen Einfluss auf die Zufriedenheit bzw. Unzufriedenheit hat, wogegen Werte nahe 1 bzw. –1 implizieren, dass ein Merkmal bei Vorhandensein bzw. Nichtvorhandensein die Zufriedenheit bzw. Unzufriedenheit stark beeinflusst. Als kritisch werden Werte größer 0,5 bzw. kleiner -0,5 erachtet (Berger et al. 1993).

4 Ergebnisse

4.1 Städtische Region (Regensburg)

Im Folgenden werden zunächst die Ergebnisse für die drei E-Services für die Stadt Regensburg dargestellt. Dazu wurden alle vollständig ausgefüllten Fragebögen anhand der von Berger et al. (1993) vorgeschlagenen Methodik ausgewertet und die Häufigkeitsverteilung hinsichtlich der Kategorien ermittelt. Aufbauend auf den beiden Maßzahlen Category Strength und Total Strength wurde anschließend die finale Zuordnung der Services und ihrer Teilschritte zu den sechs möglichen Kategorien vorgenommen.

Die in Tabelle 2 dargestellten Ergebnisse deuten darauf hin, dass das Vorhandensein von E-Informationen für alle drei betrachteten E-Services eine starke Zufriedenheit bei den Bürgern stiften kann (Zuordnung zur Kategorie O). Zudem wurden, mit Ausnahme des Teilschritts Abwicklung *Eheschließung/Lebenspartnerschaft anmelden* (Kategorie I), für alle drei E-Services die Teilschritte E-Interaktion und E-Abwicklung als A klassifiziert. Dies bedeutet, dass das Angebot von E-Services mittels denen Bürger mit ihrer Behörde interagieren oder einen Service sogar vollständig online abwickeln können, vom Bürger nicht erwartet wird, jedoch bei Vorhandensein einen begeisternden Effekt auf die Bürger hat. Darüber hinaus weisen die Ergebnisse für den Zufriedenheitsstifter Better, die für alle E-Services und Teilschritte über dem kritischen Wert von 0,5 liegen, darauf hin, dass ein Angebot von E-Services in allen Teilschritten in hohem Maße Zufriedenheit bei den Bürgern stiften würde. Am größten fällt hier der positive Einfluss des Angebots für den Service *Wohnsitz anmelden* aus. Demgegenüber trägt das Nichtvorhandensein von E-Services nicht in kritischem Maße zur Unzufriedenheit der Bürger bei (siehe Ergebnisse für den Unzufriedenheitsstifter Worse). Lediglich die Werte für den Teilschritt E-Information liegen für die Services *Personalausweis beantragen* (-0,49) und *Wohnsitz anmelden* (-0,49) nahe dem kritischen Wert von -0,5.

Service	Teilschritt	A	O	M	I	R	Q	Kategorie	Category Strength	Total Strength	Better	Worse
Personalausweis beantragen	Information	23%	29%	15%	24%	7%	1%	O	5%	68%	0,57	-0,49
	Interaktion	38%	26%	9%	24%	2%	0%	A	11%	74%	0,66	-0,37
	Abwicklung	44%	25%	2%	20%	7%	1%	A	18%	72%	0,76	-0,30
Wohnsitz anmelden	Information	29%	30%	16%	18%	5%	1%	O	1%	75%	0,63	-0,49
	Interaktion	38%	30%	7%	21%	2%	1%	A	8%	76%	0,71	-0,39
	Abwicklung	43%	29%	3%	17%	7%	0%	A	14%	75%	0,78	-0,34
Eheschließung/ Lebenspartner-schaft anmelden	Information	24%	27%	10%	29%	8%	1%	O*	2%	62%	0,56	-0,41
	Interaktion	28%	23%	5%	39%	4%	1%	A*	10%	56%	0,54	-0,29
	Abwicklung	27%	18%	2%	36%	13%	2%	I	9%	47%	0,54	-0,24
* Anwendung der 1. Entscheidungsregel												

Tabelle 2: Ergebnisse städtische Region (n = 201)

4.2 Ländliche Region (Ihrlerstein)

Um einen Vergleich mit der städtischen Region zu ermöglichen, werden im Folgenden die Ergebnisse für die drei E-Services für die Verwaltungsgemeinschaft Ihrlerstein (ländliche Region) dargestellt. Auch hier wurden die Ergebnisse anhand der von Berger et al. (1993) vorgeschlagenen Methodik ermittelt und die Zuordnung ggf. basierend auf den Ergebnissen für die Maßzahlen Category Strength und Total Strength angepasst. Die Ergebnisse der Analyse sind in Tabelle 3 zusammengefasst.

Insgesamt lässt sich feststellen, dass sich die Ergebnisse für die ländliche Region zum Teil deutlich von denen für die städtische Region unterscheiden. Besonders auffallend ist, dass der Teilschritt E-Information für zwei von drei Services (Ausnahme *Wohnsitz anmelden*) als I klassifiziert wird. Folglich hat die Bereitstellung oder auch Nichtbereitstellung von E-Informationen kaum Einfluss auf die Zufriedenheit der Bürger. Darüber hinaus wurden die Teilschritte E-Interaktion und E-Abwicklung der Services *Personalausweis beantragen* und *Wohnsitz anmelden* als A klassifiziert; sie stellen für Bürger somit Begeisterungsfaktoren dar. So würde ein Angebot dieser beiden Teilschritte als E-Service die Zufriedenheit der Bürger deutlich steigern. Ein Nichtvorhandensein würde wiederum kaum Unzufriedenheit auslösen. Schließlich wurden auch für Ihrlerstein der Zufriedenheitsstifter Better und der Unzufriedenheitsstifter Worse berechnet. Die Ergebnisse verdeutlichen, dass ein Nichtvorhandensein von E-Services für alle betrachteten Services nur in geringem Maße zur Unzufriedenheit der Bürger führt, da die Werte für keinen der Services im kritischen Bereich (kleiner -0,5) liegen. Obwohl auf Basis der Ergebnisse für Better ein größerer Einfluss der Services auf die Bürgerzufriedenheit abgeleitet werden kann, können die Werte nur für einen Teil der Services, wie etwa die Teilschritte Interaktion und Abwicklung der Services *Personalausweis beantragen* (0,59 und 0,56) und *Wohnsitz anmelden* (0,55 und 0,56), als kritisch bezeichnet werden.

Service	Teilschritt	A	O	M	I	R	Q	Kategorie	Category Strength	Total Strength	Better	Worse
Personalausweis beantragen	Information	17%	20%	11%	33%	18%	1%	I	12%	48%	0,46	-0,39
	Interaktion	28%	25%	8%	29%	10%	0%	A*	1%	61%	0,59	-0,36
	Abwicklung	27%	20%	4%	33%	16%	0%	A*	6%	52%	0,56	-0,29
Wohnsitz anmelden	Information	24%	24%	11%	31%	10%	0%	O*	8%	58%	0,53	-0,39
	Interaktion	28%	25%	9%	34%	4%	0%	A*	6%	62%	0,55	-0,35
	Abwicklung	30%	19%	4%	35%	11%	0%	A*	4%	54%	0,56	-0,27
Eheschließung / Lebenspartner-schaft anmelden	Information	18%	18%	6%	42%	17%	0%	I	24%	42%	0,43	-0,28
	Interaktion	22%	16%	7%	40%	15%	0%	I	18%	45%	0,45	-0,26
	Abwicklung	18%	13%	2%	44%	21%	1%	I	22%	34%	0,41	-0,20
* Anwendung der 1. Entscheidungsregel												

Tabelle 3: Ergebnisse ländliche Region (n = 89)

5 Diskussion der Ergebnisse

Aus den dargestellten Ergebnissen lassen sich vier zentrale Implikationen ableiten. Erstens ist dieser Beitrag nach bestem Wissen der Autoren der erste, der Teilschritte von E-Services auf Basis von Kundenanforderungen kategorisiert und dabei berücksichtigt, wie sich das Angebot von E-Services für die Teilschritte Information, Interaktion und Abwicklung auf die Zufriedenheit der Bürger auswirkt. Die Anwendung der Kano-Methode und die Berechnung von Better und Worse erlauben es zudem, fundierte Aussagen über die Auswirkungen des Angebots auf die Zufriedenheit der Bürger zu treffen, ohne dass die Bürger den Service bereits genutzt haben müssen. Diese Bewertung hilft Entscheidungsträgern bei der Ausgestaltung von E-Government-Strategien und dem Auf- und Ausbau von E-Service-Angeboten.

Zweitens haben wissenschaftliche Untersuchungen gezeigt, dass Zufriedenheit ein zentraler Faktor ist, der entscheidend zur Nutzung von E-Government-Angeboten beiträgt (Rana et al. 2013). Unsere Ergebnisse verdeutlichen, dass gerade in städtischen Regionen das Angebot aller drei E-Services *Personalausweis beantragen*, *Wohnsitz anmelden* und *Eheschließung/Lebenspartnerschaft anmelden* deutlich zu einer höheren Zufriedenheit der Bürger beitragen kann. Für Städte, die eine stärkere Bürgerzentrierung anstreben, liefert dies somit einen wertvollen Ansatzpunkt. In ländlichen Regionen haben E-Services hingegen geringeres Potenzial, die Zufriedenheit der Bürger in erheblichem Maße zu steigern (siehe Ergebnisse für Better in Tabelle 3). Allerdings führt in beiden Regionen das fehlende Angebot von E-Services nicht in kritischem Maße zur Unzufriedenheit der Bürger (siehe Ergebnisse Worse in Tabelle 2 und Tabelle 3). E-Services werden somit von den Bürgern – zumindest Stand heute – nicht als selbstverständlich erachtet und deren Angebot vorausgesetzt. Vielmehr führt das Angebot von E-Services zu einer deutlich höheren positiven Wahrnehmung – dies kann von der Praxis gezielt genutzt werden – wobei das Fehlen von E-Services nur in wenigen Fällen deutlich negativen Einfluss hat.

Drittens, die Anforderungen an das E-Service-Angebot unterscheiden sich nach städtischer und ländlicher Region. In der städtischen Region wird die Bereitstellung von E-Informationen von den Bürgern als One-dimensional artikuliert. Das Fehlen ruft somit im gleichen Maße Unzufriedenheit hervor, wie das Angebot eine stärkere Zufriedenheit bewirkt. Laut verschiedenen Studien (z. B. United Nations 2001) stellt die Bereitstellung von E-Informationen lediglich die erste und einfachste Phase im E-Government dar. Somit wird in städtischen Regionen von den Bürgern die Umsetzung der ersten Phase des E-Government (siehe Kapitel 2.1) bereits vorausgesetzt, wogegen transaktionsbasierte Angebote (zweite Phase) noch nicht erwartet werden, jedoch auf den Bürger begeisternd wirken können.

Im ländlichen Bereich wird die Bereitstellung von E-Informationen überwiegend als Indifferent kategorisiert. Allerdings können auch hier E-Services zur Interaktion mit der Behörde und Abwicklung von Services, die regelmäßig oder häufig von Bürgern benötigt werden, einen begeisternden Effekt haben. Die Attraktivität der Services zur E-Interaktion und E-Abwicklung scheint dabei auf die Verfügbarkeit der Services in Bürgerbüros zurückzuführen zu sein. Oftmals sind diese nämlich aufgrund ihrer Öffnungszeiten von Berufstätigen nur schwer zu erreichen und es müssen eventuell lange Wartezeiten in Kauf genommen werden. Daher würde ein Angebot der Teilschritte E-Interaktion und E-Abwicklung auch in der ländlichen Region einen deutlichen Anstieg der Bürgerzufriedenheit mit sich bringen.

6 Fazit und Ausblick

Im Zuge der Digitalisierung haben E-Services in der öffentlichen Verwaltung in Wissenschaft und Praxis in den vergangenen Jahren zunehmend an Bedeutung gewonnen. Dabei stellt sich insbesondere die Frage, inwieweit E-Services der öffentlichen Verwaltung die Zufriedenheit von Bürgern beeinflussen. Im vorliegenden Beitrag wurde daher auf Basis des Kano-Modells untersucht, inwiefern E-Services einen Beitrag zur Bürgerzufriedenheit leisten bzw. bei Nichtvorhandensein zu Unzufriedenheit bei den Bürgern führen. Um einen strukturellen Vergleich zu ziehen, wurden dazu exemplarisch Daten von 290 Bürgern in zwei Regionen (Stadt Regensburg und Verwaltungsgemeinschaft Ihrlerstein) in Deutschland untersucht. Die Umfrage fokussiert auf die drei E-Services *Personalausweis beantragen*, *Wohnsitz anmelden* und *Eheschließung/ Lebenspartnerschaft anmelden*. Jeder E-Service umfasst die Teilschritte Information, Interaktion und Abwicklung. Zentrale Ergebnisse der Untersuchung sind, dass E-Services zwar zu einer Steigerung der Bürgerzufriedenheit beitragen können; das Nichtvorhandensein aber nicht in gleichem Maße zu Unzufriedenheit auf Seiten der Bürger führt. Zudem tragen E-Services in der Stadt tendenziell stärker zur Zufriedenheit der Bürger bei als auf dem Land. Auf Basis der Ergebnisse konnten verschiedene Implikationen für Theorie und Praxis abgeleitet werden.

Obwohl der Beitrag erste interessante und wissenschaftlich fundierte Einblicke zur Zufriedenheitsstiftung von E-Services im E-Government liefert, unterliegt er dennoch einigen Limitationen. Erstens wurde initial nur jeweils eine Stadt sowie eine ländliche Verwaltungsgemeinschaft in Deutschland betrachtet. Aufgrund des Stichprobenumfangs von n = 290 kann jedoch davon ausgegangen werden, dass die Ergebnisse auch auf weitere Regionen übertragen werden können. Ziel zukünftiger Forschungsarbeiten sollte es dennoch sein, weitere Städte, Gemeinden und ggf. auch Länder wissenschaftlich fundiert zu untersuchen, um tiefere Einblicke zu gewinnen und die Ergebnisse zu untermauern. Zweitens wurden bisher nur die drei exemplarisch ausgewählte Bürgerservices *Personalausweis beantragen*, *Wohnsitz anmelden* und *Eheschließung/Lebenspartnerschaft anmelden* analysiert. Wenngleich diese drei Services für Bürger zentral sind, sollten dennoch in einem nächsten Schritt weitere Services analysiert werden, um einen umfassenderen Überblick zu erhalten. Drittens erlaubt die Kano-Methode nur Aussagen darüber, ob das Angebot eines Services die Zufriedenheit beeinflusst. Die Auswirkung der Qualität des Angebots auf die Kundenzufriedenheit wird nicht berücksichtigt. Zwar gibt es bereits Messansätze, die dies abbilden (wie z. B. SERQUAL nach Parasuraman et al. (1988)). Jedoch setzen diese Messansätze überwiegend voraus, dass der E-Service von den Teilnehmern der Umfrage bereits genutzt wurde. Trotz alledem ist die Kano-Methode eine in der Wissenschaft und Praxis verbreitete und akzeptierte Methodik, mit welcher fundierte und interessante Ergebnisse abgeleitet wurden. Insgesamt stellen die Ergebnisse unserer Studie somit einen ersten Schritt in diesem relevanten Themenkontext dar und können so als Basis für weiterführende Analysen dienen. Interessante Fragestellungen für zukünftige Arbeiten umfassen beispielsweise die folgenden: Wie wirkt sich die Qualität von E-Services auf die Zufriedenheit bzw. Unzufriedenheit der Bürger aus? Gibt es Unterschiede im Hinblick auf verschiedene Personengruppen? Wieso trägt das Nichtvorhandensein von E-Services nicht im kritischen Maße zur Unzufriedenheit der Bürger bei?

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Krisenkommunikation 2.0: Potenziale und Risiken am Beispiel des Elbehochwassers 2013 in Dresden

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Abstract

Beim Elbehochwasser im Jahr 2013 dienten erstmals neue Web 2.0 Kommunikationskanäle, wie Soziale Netzwerke, zur Mobilisierung und Koordination freiwilliger Helfer, die eine wichtige Instanz im Kampf gegen eine Naturkatastrophe bildeten. Da die Kommunikation durch Soziale Medien im Krisenfall nicht nur positive Effekte nach sich ziehen kann, wird in diesem Beitrag ein Überblick über die Rolle der Sozialen Medien beim Elbehochwasser 2013 in der Stadt Dresden gegeben. Dabei wird die Sicht der Gründer, helfender Gruppen und des zuständigen Personals der öffentlichen Verwaltung einbezogen. Es werden sowohl die Vorteile und die damit verbundenen Potenziale dieser Medien für Krisenkommunikation durch „ungebundene Helfer" beleuchtet, als auch ihre Nachteile und die daraus resultierenden Risiken verdeutlicht. Die häufige Nutzung von virtuellen sozialen Plattformen führte beim Elbehochwasser 2013 gegenüber konventionellen Medien und Kommunikationskanälen zu einer höheren Informationsaktualität und Kommunikationsflexibilität, verursachte jedoch gleichzeitig Ordnungsprobleme an einzelnen betroffenen Standorten und führte sogar zu gefährlichen Aktivitäten der ungebundenen Helfer.

1 Einleitung

Nach dem Jahrhunderthochwasser 2002 ereignete sich bereits 11 Jahre später in vielen Städten entlang der Oberelbe eine weitere Flutkatastrophe. Dies betraf auch die sächsische Landeshauptstadt Dresden. Die gegenseitige bürgerliche Unterstützung war in dieser Zeit ein fundamentaler Bestandteil der Katastrophenbewältigung. Dabei entstand 2013 eine neue Form der freiwilligen selbstorganisierten Helfer: Die sogenannten „ungebundenen Helfer", welche sich unabhängig von Katastrophenschutzbehörden und Hilfsorganisationen über Soziale Medien, vor allem Facebook, organisierten, eigene Krisenkarten mit Google Maps entwickelten und gemeinsam physische und monetäre Hilfe koordinierten und leisteten.

1.1 Ausgangssituation und Fragestellung

Das spontane Engagement und die selbstinitiierten Aktivitäten der freiwilligen Helfern haben die Rolle der Sozialen Medien in solch einer Krisensituation insofern verdeutlicht, dass der „Bericht der Kommission der Sächsischen Staatsregierung zur Untersuchung der Flutkatastrophe 2013“ erstmals den Mehrwert von Sozialen Medien im Krisenfall des Elbehochwassers 2013 in einer offiziellen Darstellung anerkannt hat. Der Bericht spricht von einem „Phänomen“ der Sozialen Netzwerke und gibt die folgende Empfehlung:

„Die Kommission hält es für geraten, an dem Phänomen Soziale Netzwerke nicht vorbeizugehen. Vielmehr sollten Soziale Netzwerke, zurzeit vor allem Facebook, in die zentrale Krisenkommunikation des Freistaates einbezogen werden“ (Nowak et al. 2013, 51).

Der umfangreiche Einsatz von Sozialen Medien beim Elbehochwasser 2013 wurde bereits in vergangenen Studien sowie in den Medien untersucht, diskutiert und zum Teil kritisiert (u.a. Kaufhold und Reuter 2014; Kern und Zisgen 2014; Breuer 2014; Mildner 2013; Ebert 2013; Etzrodt 2013; Könau 2013). Dabei wurden auf der einen Seite der Nutzen und auf der anderen Seite Probleme geschildert, die mit der Anwendung von Web 2.0-Werkzeugen wie Facebook, Google Maps und Twitter während des Hochwassers verbunden waren. Die Vorteile bestanden u.a. in einer höheren Kommunikationsflexibilität, breiteren Informationsreichweite und schnelleren Mobilisierung der Hilfskräfte. Zu bezweifeln waren die Effektivität und Effizienz dieser Kommunikationskanäle aufgrund der Koordinations- und Ordnungskomplikationen, die mit in den Maßen mobilisierten unerfahrenen Helfern und nicht überprüften Informationen verbunden sein können. Es fehlte bisher jedoch eine empirische Studie, die einen Überblick der Vor- und Nachteile sowie Potenziale und Risiken solch eines Einsatzes von Sozialen Medien in einer Katastrophensituation aus Sicht der freiwilligen Helfer, aber auch der professionellen staatlichen Katastrophenschutzbeauftragen darstellt.

Dieser Beitrag beschäftigt sich daher mit folgender Frage: Welche Potenziale und Risiken waren mit dem Einsatz von Sozialen Medien durch ungebundene Helfer beim Elbehochwasser 2013 in Dresden verbunden? Dazu wurden Erfahrungen des Leiters der Abteilung „Katastrophenschutz und Vorbeugender Brandschutz“ der Landeshauptstadt Dresden, sowie der Gründer zwei der während des Hochwassers am meisten besuchten Seiten auf Sozialen Medien, die Facebook-Seite „Elbpegelstand“ und die Google Map „Hochwasserkarte Dresden“, erhoben und qualitativ ausgewertet.

Zunächst werden die drei Kernelemente des Betrachtungsgegenstands erläutert, danach das Studiendesign und die Methodik beschrieben und im Anschluss die Ergebnisse der durchgeführten Studie präsentiert und diskutiert.

1.2 Krisenkommunikation

Der Kommunikationsprozess beschreibt im Wesentlichen die Übertragung einer Nachricht von einem Sender zu einem Empfänger unter der Nutzung der gleichen Codierung bzw. Decodierung, um eine eindeutige Verständigung beider Akteure zu gewährleisten und mögliche Störungen in der Kommunikation zu vermeiden (Krotz 2009). Aufgrund des Fokus auf die Naturkatastrophe des Elbehochwassers 2013 wird der Begriff „Krise“ in diesem Beitrag mit dem Begriff „Katastrophe“ gleichgesetzt. Dieser bezeichnet nach sächsischer Gesetzgebung ein Geschehen, „welches das Leben, die Gesundheit, die Versorgung zahlreicher Menschen mit lebensnotwendigen Gütern und Leistungen, die Umwelt oder erhebliche Sachwerte in so außergewöhnlichem Maße gefährdet oder schädigt, dass Hilfe und Schutz wirksam nur gewährt werden können, wenn die zuständigen Behörden und Dienststellen, Organisationen und eingesetzten Kräfte unter der einheitlichen Leitung einer Katastrophenschutzbehörde zusammenwirken“ (SächsBRKG §3Abs.3). Daraus folgt, dass „Krisenkommunikation die Kommunikation in der Krise [ist], mit der Absicht dem steigenden Informationsbedürfnis von Führungskräften, Mitarbeitern, Stakeholdern sowie der Öffentlichkeit in Krisensituationen nachzukommen“ (Reuter et al. 2011, 172). Dieses Bedürfnis sollte neben den spezifischen Bedarfen der Akteure, auch Ängste und Nöte der Bevölkerung abdecken und so detailliert und präzise wie möglich befriedigt werden (Lorenz 2010).

1.3 Die ungebundene Helfer

Bürgerliche HelferInnen spielen in Krisensituationen und der Katastrophenbekämpfung eine wichtige Rolle, indem sie professionelle Einsatzkräfte der Katastrophenschutzorganisationen bei verschiedenen Aufgaben ehrenamtlich unterstützen. HelferInnen, die sich über die Berichterstattung in klassischen und Sozialen Medien zu Hilfebedarfen in Krisengebieten informieren, diese aus eigener Initiative selbstorganisieren und mobilisieren, werden oft ungebundene Helfer, Ad-hoc-Helfer oder Spontanhelfer genannt (Kircher 2014). Das Deutsche Rote Kreuz empfiehlt die Definition:

„Ungebundene HelferInnen im Bevölkerungsschutz sind nicht betroffene BürgerInnen, die eigenständig aktiv werden aus dem Bedürfnis heraus anderen in einer Notlage zu helfen. Sie sind nicht als Mitglieder einer Organisation des Katastrophenschutzes im Einsatz. Somit kann nicht von einer entsprechenden Ausbildung ausgegangen werden. Sie bringen eine Vielzahl von Fähigkeiten aus ihrem persönlichen und ggf. beruflichen Hintergrund mit. Ihre Hilfeleistung findet gemeinwohlorientiert und unentgeltlich und im Rahmen ihrer eigenen Möglichkeiten statt. Sie wird i.d.R. außerhalb ihres unmittelbaren räumlichen wie sozialen Umfelds erbracht“ (DRK 2013, 2).

1.4 Soziale Medien

Soziale Medien, auch Social Media genannt, beschreiben eine Menge an digitalen Medien und Technologien, die es den Anwendern erlaubt, miteinander zu kommunizieren und multimediale Inhalte allein oder kollektiv zu gestalten. Durch das Kommentieren, Bewerten und Empfehlen von Beiträgen beziehen sich die Nutzer aktiv auf die Inhalte der anderen und knüpfen auf diese Weise soziale Bindungen (Velev und Zlateva 2012). Im Kontext der Krisenkommunikation wurden Soziale Medien beispielsweise bei den Erdbeben in Haiti 2010 und Neuseeland 2011, beim Seebeben vor Japan 2011 und beim Hurrikan Sandy an der Ostküste der USA 2012 genutzt, um Freunde und Familienangehörige zu kontaktieren, Informationen über die Lage einzuholen oder um Hilfe anzubieten, zu organisieren und zu koordinieren (Kern und Zisgen 2014).

1.5 Der Fall des Elbehochwassers 2013

Beim Elbehochwasser 2013 kam es erstmals in Dresden zu einem ausgeprägten Einsatz von Sozialen Medien zur Krisenkommunikation. Die ungebundenen Helfer nutzten diese zur eigenständigen Organisation, Koordination und dem Austausch von Informationen. Dabei wurde Facebook, als das in Deutschland mit Abstand am häufigsten genutzte Soziale Netzwerk (ACTA 2012), am meisten eingesetzt. Vier Wochen nach dem Hochwasser konnten 157 Facebook-Seiten bzw. -Gruppen deutschlandweit zum Stichwort „Hochwasser“ gezählt werden, die von mehr als 600.000 Menschen „geliked“ wurden (Kern und Zisgen 2014). Der Großteil der, oft auf kleinere geografische Gebiete begrenzten, Seiten übernahm zwei essentielle Aufgaben. Einerseits wurden die Menschen mit möglichst aktuellen Lageupdates zur Schadensituation versorgt, sowohl per Textnachrichten als auch über Bilder. Andererseits wurde versucht, die vielen Hilfsgesuche und -angebote zu organisieren, zu filtern und zu koordinieren (Velev und Zlateva 2012). Mit dem interaktiven Kartendienst „Google Maps“ wurden georeferenzierte katastrophenrelevante Informationen wie Krisengebiete, Standorte der Hilfskräfte, sowie Verpflegungs- und Unterbringungsstationen von ungebundenen Helfern gesammelt und in Form öffentlicher Krisenkarten (englisch: Crisis Maps) kartografisch dargestellt (Breuer 2014).

2 Studiendesign und Datenerhebung

Der Fokus dieses Beitrags liegt auf der Generierung von Deutungswissen, das vor allem subjektive Sichtweisen, Interpretationen und Erfahrungen liefert, die jedoch nicht grundsätzlich als „sachliches“ Wissen verstanden werden können (Bogner et al. 2014). Um eine umfassende Betrachtung des Untersuchungsgegenstandes, nämlich der Nutzung von Sozialen Medien durch ungebundene Helfer beim Elbehochwasser 2013 im Dresden und den damit verbundenen Vor- und Nachteilen, zu gewährleisten, wurden die Perspektiven der professionellen Einsatzkräfte und der freiwilligen Gründer der Helferseiten in den Sozialen Medien einbezogen. Die Informanten wurden aufgrund ihrer unmittelbaren Beteiligung als Experten identifiziert und zu teilstrukturierten Experteninterviews eingeladen, die ihnen die Flexibilität und den Raum für ausführliche Äußerung ihrer Erfahrungen boten. Die Interviews wurden im November 2014 und Februar 2015 auf Basis einer Sammlung teilstandardisierter Leitfadenfragen durchgeführt und dauerten zwischen 22 und 96 Minuten. Mit Genehmigung der Teilnehmer wurden die Interviews digital audioaufgezeichnet und im Anschluss transkribiert. Für das Ziel dieses Beitrags wurde die qualitative Inhaltsanalyse zur Auswertung der Interviewtransskripte verwendet (Gläser und Laudel 2010).

Mit dem Fokus auf das Hochwassergeschehen 2013 in Dresden konnten der Leiter der Abteilung „Katastrophenschutz und Vorbeugender Brandschutz“ der Stadt Dresden sowie der Gründer der Facebook-Seite „Elbpegelstand“ und der Gründer der Google Map „Hochwasserkarte Dresden“ für die Experteninterviews gewonnen werden. Die Auswahl der zwei repräsentativen Fallbeispiele aus den Sozialen Medien erfolgte aufgrund der intensiven Nutzung, des hohen Bekanntheitsgrades und den umfangreichen Inhalten. Der Inhalt der Fallbeispiele wird zunächst kurz beschrieben.

2.1 Die Facebook-Seite „Elbpegelstand“

Eine der größten und aktivsten Facebook-Seiten zum Hochwasser im Raum Dresden ist die bereits im Februar 2013 gegründete Seite „Elbpegelstand“. Bis zum Hochwasser wurden lediglich die Wasserstände der Elbe automatisch aus dem Twitter-Account des Gründers im Viertelstunden-Takt in die Facebook-Seite importiert. Verfolgt wurden diese Einträge bis zum 30. Mai 2013 gerade einmal von 20 „Fans“. Alleine am ersten Tag der Flutkatastrophe stiegen die „Likes“ der Seite auf 22.405 an. Jeden weiteren Tag kamen weitere 20.000 bis 30.000 neue „Folger“ hinzu, bis am 7. Juni 2013 das Tagesmaximum von 84.076 „Gefällt-mir“-Klicks gezählt wurde. In der ersten Woche des Hochwassers erreichte die Seite mehr als 2,8 Millionen Facebook-Nutzer. Ein Großteil aller „Likes“ (24.556 von 59.800 in den ersten beiden Tagen) erfolgte über mobile Endgeräte. Demografisch gesehen „gefiel“ die Seite in der ersten Flutwoche vor allem 18- bis 35-Jährigen (71,4%). Bis Ende August 2013 waren 59% dieser Nutzer weiblich und 90% der erreichten Menschen jünger als 45 Jahre (Facebook 2013).

2.2 Die Google Map „Hochwasserkarte Dresden“

Neben Facebook war die Google Karte „Hochwasserkarte Dresden“ eines der am meisten genutzten sozialen Werkzeuge der ungebundenen Helfer im Raum Dresden, um Krisenherde schnell zu erkennen und zu bekämpfen. Die in kurzer Zeit entstandene Karte stellte neben allgemeinen Hinweisen zur Gefahrenlage den Bedarf an Hilfskräften an konkreten Standorten dar, markierte Einrichtungen, die die Helfer mit Verpflegung und Material versorgten, und gab detaillierte Informationen über lokale Krisensituation. Ebenfalls wurde privater Hilfebedarf, wie das Räumen eines Kellers, im System erfasst und konnte von der Öffentlichkeit, den ungebundenen Helfern und den professionellen Einsatzkräften eingesehen werden. Innerhalb des einwöchigen Betriebs wurde mehr als drei Millionen Mal auf die Seite zugegriffen. Bereits am Erstellungstag der Karte verzeichnete diese teilweise über 1.000 Aufrufe pro Minute. Für eine einheitlich grafische Darstellung und einfache Sortierung der Informationen auf der Karte wurde von dem Gründer eine zweckgebundene Darstellungskonvention festgelegt (siehe Bild 1) (Mildner 2013).

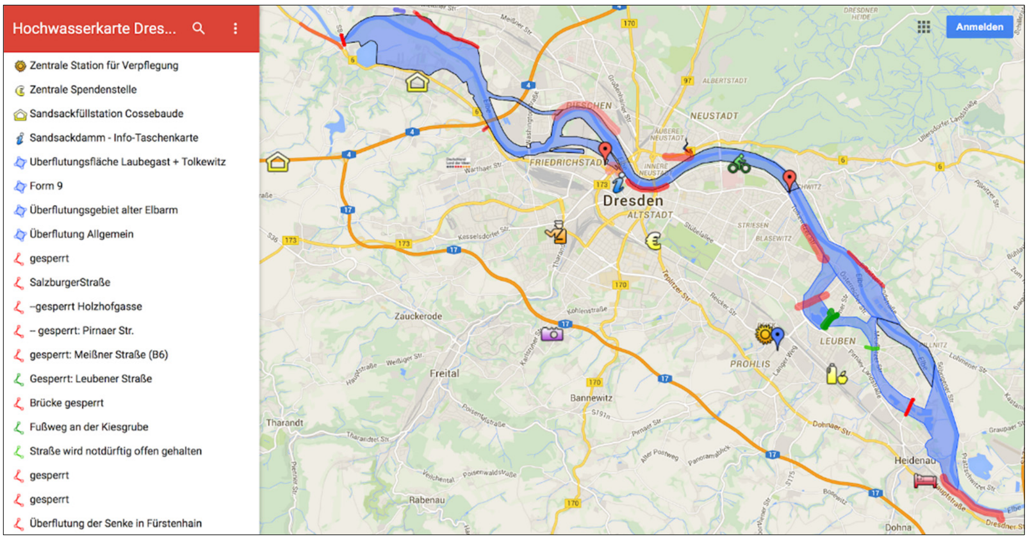

Bild 1: Screenshot der „Hochwasserkarte Dresden“ (Bearbeitungsstand 10.07.2013)

3 Ergebnisse

Die Analyse der Interviews diente der Ermittlung von Gemeinsamkeiten und Unterschieden bei den Expertenmeinungen zum Einsatz von Sozialen Medien in der Krisenkommunikation auf Basis ihrer eigenen Erfahrung. Daraus resultierend konnten die Vorteile und Potenziale sowie die Nachteile und Risiken des Einsatzes in vier Hauptkategorien zusammengefasst werden, welche die Eigenschaften von Sozialen Medien und ihrer Nutzer umfassen. Die Kategorien entstanden aus Aussagen der interviewten Personen zum konkreten Fallbeispiel des Elbehochwassers 2013 in Dresden und sind keine Abbildung sämtlicher Eigenschaften, die diesen Einsatz beeinflusst haben könnten. Ein negativer Effekt der „schnellen Verbreitung“ von Informationen in Sozialen Medien, der in (Max 2015) erwähnt wurde, konnte hier beispielsweise nicht festgestellt werden.

Tabelle 1 fasst die Ergebnisse der Datenanalyse zusammen, die zunächst detailliert diskutiert werden.

	Soziale Medien als Kommunikations-kanal	**Soziale Medien als technische Plattformen**	**Inhalte und Informationsgehalt in Sozialen Medien**	**Die Nutzer der Sozialen Medien als ungebundene Helfer**
Merkmale	- Breite Reichweite - Zwei-Wege-Kommunikation	- Technische Verfügbarkeit - Betreiber-abhängigkeit - Anwendungs-funktionen - Speicherung und Nutzung von Daten - Verwaltung durch Einzelnutzer	- Erstellung durch Einzelnutzer - Durchgehende Veröffentlichung und Änderung - Wiederverwendung in Gruppen - Große Informationsmengen	- Anonym - Ungebunden und freiagierend - Überwiegend jung - Unterschiedlich motiviert
Vorteile / Potenziale	- Zahlreiche Helfer / Entlastung der professionellen Einsatzkräfte - Interaktion ungebundener Helfer / schnelle Selbstorganisation	- Mobile Nutzung / ständiger Zugriff auf Informationen - Belastbare Infrastruktur / dauerhafte Verfügbarkeit der Informationen	- Ständige Änderung / schnelle Aktualisierung von Informationen	- Körperliche Fitness / Leistungsfähige Helfer - Freiwillige Beteiligung / motivierte Helfer
Nachteile / Risiken	- Zu viele Helfer / Behinderungen - Ortsunkundige Helfer / Handlungs-beschränkung	- Betreiber-abhängigkeit / ungesicherte Nachhaltigkeit - Gründer-abhängigkeit / ungesicherte Nachhaltigkeit - Fehlende technische Funktionen / beschränkte Verwaltung von Benutzern und Inhalten - Externe Anbieterserver / unklare Urheberrechte und Datensicherheit - Dezentrale Verwaltung / schwere Koordination mit der Stadt	- Übertriebene Inhalte / fehlerhafte Anweisungen - Viele Ersteller / Verlust der Informationshoheit - Veröffentlichung durch Privatpersonen / Datenschutz-verletzung - Wiederholte Teilung / redundante oder veraltete Informationen - Sehr viele benutzererstellte Inhalte / Informationsflut - Filterungsbedarf / Moderationsaufwand für die Seitengründer - Durchgehende Postings / keine Überprüfung	- Unbekannte Personen / kein Schutz der Helfer - Spontane Hilfsentscheidung / Ablehnung von Verbindlichkeit - Selbstorganisation / fehlerhafte oder unnötige Maßnahmen - Frustrationsgeführte persönliche Beteiligung / Ablehnung der offiziellen Maßnahmen oder „Staatsnegation“ - Wechselnde Nutzer / unplanbare Hilfskapazitäten - Unterschiedliche Interessen / selektive Hilfsbereitschaft oder „Katastrophen-tourismus“ - Unseriöse Nutzer / Missbrauch der Medien - Unerfahrene Helfer / uninformiertes Handeln mit behindernden oder gefährdenden Maßnahmen

Tabelle 1: Potenziale und Risiken der Nutzung von Sozialen Medien in Krisensituationen

3.1 Soziale Medien als Kommunikationskanal

Mit dem bereits beschriebenen interaktiven Charakter der Web 2.0-Anwendungen bieten Soziale Medien neue Möglichkeiten für den Informationsaustausch zwischen Einzelnutzern im Internet, wodurch sie sich als, für viele flexibel zugänglicher, Kommunikationskanal eignen. Folgende Merkmale dieses Kanals können die Kommunikation in Krisensituationen beeinflussen:

- Breite Reichweite: Mit Hilfe von Sozialen Medien können Nachrichten einen großen Empfängerkreis erreichen. Dieser kann über diese Medien, im Gegensatz zu konventionellen Massenmedien, nicht nur sich informieren sondern auch Nachrichten weitergeben. Dies führt zur Mobilisierung von zahlreichen Helfern, die eine anstrengende Aufgabe schnell erledigen können und dabei die professionellen Hilfskräfte entlasten. Die folgenden Ausschnitte aus den Interviews belegen diese Schlussfolgerung:

  „Der Sandking [ein Hilfsmittel zur Befüllung von Sandsäcken] wird überhaupt nicht mehr benutzt und die Kammeraden der Feuerwehr dienen nur dazu, die Leute anzuleiten.“ [UF,00:12:56]

  „...wo es an professionellen Hilfskräften knapp wird, wie es beim Hochwasser zum Beispiel der Fall ist, da können natürlich Situationen [...] über solche Plattformen natürlich schon abgedeckt werden.“ [SM,00:06:56]

  Der Nachteil bei selbstinitiierter Mobilisierung besteht darin, dass große Mengen an zum Teil ortsunkundigen Helfer sich an einem Ort sammeln, wo sie zu unnötiger Behinderung werden.

  „Das waren aber über 2.000 Leute, die sich da auf den eineinhalb Kilometern getummelt hatten...“ [UF,00:15:22]

  “Es bringt nichts, wenn wir sagen: Oh in Hamburg ist ein Hochwasser, lass uns loslegen. Wir kennen uns gar nicht aus da oben.“ [MG,00:10:00]

- Zwei-Wege-Kommunikation: Die Steigerung der zweckmäßigen bürgerlichen Kommunikation beim Elbehochwasser 2013 ging über den Informationsempfang hinaus zum aktiven Austausch, was mit der Beteiligungsmöglichkeit in Sozialen Medien einfacher geworden ist.

  „Positiv war erst einmal, dass die Leute sich so spontan zusammengefunden haben und gesagt haben: ‚Ich helfe jetzt'.“ [MG,00:15:03]

  „...das ist eine neue Entwicklung und diese sozialen Medien wie Facebook und so, die geben denen die Möglichkeit sich zu organisieren, was sie vorher ja nicht hatten.“ [UF,00:03:23]

3.2 Soziale Medien als technische Plattformen

Neben ihren Eigenschaften als Kommunikationskanal verfügen Soziale Medien über funktionale Merkmale, die ihren Einsatz in Krisensituationen beeinflussen. Diese beinhalten:

- Mobile Zugänglichkeit: Der Zugriff auf Sozialen Medien erfolgt immer mehr über mobile Endgeräte wie Smartphones und Tablets (siehe 2.1), was eine ständige Verbindung ermöglicht.

  „...die Leute haben ja über das Handy immer Facebook dabei.“ [MG,00:26:20]

  „Es ist ja auch der Vorteil, dass man mit so einem Smartphone auch von unterwegs die Informationen her bekommen kann.“ [SM,00:19:53]

- Technische Verfügbarkeit: Eine Voraussetzung für den effektiven Einsatz technischer Plattformen ist ihre ununterbrochene Erreichbarkeit. Verbreitete Soziale Medien werden von spezialisierten Großunternehmen betrieben, die eine stabile Infrastruktur zur Verfügung stellen können. Dieses kann die technische Infrastruktur der Katastrophenschutzbehörden entlasten.

  „...hat mich die Agentur angeschrieben, ob ich denn bitte aufhören könnte auf Dresden.de zu verlinken [...] innerhalb von Sekunden sind von der Facebook-Seite 25.000 Mann auf den Server.“[MG,00:12:20]

- Betreiberabhängigkeit: Die Betreiberstärke kommerzieller Sozialer Medien hängt u.a. von Nutzerzahlen ab, was bei zukünftiger Marktänderung ihre Existenz gefährdet. Dieses kann den nachhaltigen Einsatz von Sozialen Medien in Krisenkommunikation beeinflussen.

  „Es kann nächstes Jahr sein, es kann in 10 Jahren sein. Es weiß niemand, gibt es dann überhaupt noch Facebook?“ [MG,00:07:05]

  „...Google Maps ist natürlich auch ein kommerzielles Produkt und man weiß nie, ob dann irgendwann mal jemand von Google den Stecker zieht und dann, wenn man sich darauf verlässt, steht man dumm da...“ [SM,00:06:07]

- Anwendungsfunktionen: Die Nutzung von vielen Sozialen Medien ist für Privatnutzer kostenfrei. Dabei bleiben für sie aber fortgeschrittene Funktionen, wie Analyse- und Verwaltungswerkzeuge, unzugänglich, die für effektive Krisenkommunikation nötig sind.

  „...die Karte ist insofern nicht optimal gewesen, dass halt einfach Tools gefehlt haben, Werkzeuge, mit denen man halt das ganze besser verwalten kann. Zum einen die Benutzerverwaltung [...] So etwas hat komplett gefehlt. Oder auch Revisionsverwaltung...“ [SM,00:04:18]

- Speicherung und Nutzung von Daten: Nutzergenerierte Inhalte in Sozialen Medien werden oft auf, im Ausland gelagerten, Anbieterservern gespeichert. Die Urheber-, Nutzungs- und Wiederverwendungsrechte unterliegen dabei den Geschäftsbedingungen des Betreibers.

  „...wenn man irgendwie ein Projekt hat, was quelloffen ist, Open Source, wo man vielleicht auch die wichtigen Daten auf seinem eigenen Server [...] speichern kann, dann ist das sicherlich die sicherere Sache.“ [SM,00:06:11]

- Verwaltung durch Einzelnutzer: Die Verwaltung bürgerlicher Gruppen und Seiten in Sozialen Medien erfolgt durch den jeweiligen Gründer, der sie jederzeit schließen oder löschen kann. Dadurch werden sowohl die Sicherung, als auch die Koordination der Initiativen erschwert.

  „...ich habe dieses Projekt dann wirklich nur in diesem Zeitraum betreut, wo das Thema aktuell war, weil ich ja beruflich in dem Bereich gar nicht tätig bin. Und das war eigentlich eine einmalige Sache gewesen.“ [SM,00:06:32]

  „Wir werden eben nicht in der Lage sein, die Stadt Dresden, mit einem Dutzend oder noch mehr solcher Vereinigungen zusammenzuarbeiten und schon gar nicht mit Einzelbürgern.“ [UF,00:24:11]

3.3 Inhalte und Informationsgehalt in Sozialen Medien

Interaktive Web 2.0-Anwendungen haben den Informationsgehalt im Internet quantitativ sowie qualitativ verändert, was sich bei den Inhalten in Sozialen Medien u.a. wie folgt zeigt:

- Erstellung durch Einzelnutzer: Jeder Nutzer kann eigene Inhalte in Sozialen Medien veröffentlichen und ist für ihre Qualität, wie Korrektheit und Zweckmäßigkeit, zuständig. Dadurch können falsche bzw. ungenaue Informationen sowie geschützte Personendaten verbreitet werden. Aus folgenden Interviewteilen kann dies entnommen werden:

  „‚Hilfe für Cossebaude' hieß der Thread. ‚Der Deich in Cossebaude läuft über. Dringend Leute zum Sandsäcketragen benötigt.' Da gehen bei mir schon die Alarmglocken an." [UF,00:25:24]

  „Wir hatten ja Telefonnummern frei zugänglich, dass die Leute sich untereinander verständigen können, gepostet. Ist so eine Sache mit dem Datenschutz." [MG,00:05:49]

- Durchgehende Veröffentlichung und Änderung der Inhalte: Besonders mit mobilen Endgeräten können die Nutzer Inhalte ständig und einfach in Sozialen Medien erstellen, aktualisieren und teilen. Dieses dient zur schnellen Beseitigung veralteter Informationen durch den Benutzer.

  „...dass man zum Beispiel Informationen, die veraltet sind, aus der Karte löscht. Dann sind die Punkte weg und [er ist] nicht mehr mit den Zusatzinformationen belastet, die gar nicht mehr hilfreich sind." [SM,00:02:11]

- Wiederverwendung in Gruppen: Soziale Medien werden deshalb sogenannt, weil sie zahlreiche Internetnutzer in virtuellen Communities zusammenbringen, wo sie Inhalte anderer Mitglieder unkompliziert teilen bzw. wieder veröffentlichen können, was in Krisensituationen problematisch sein kann.

  „...viele haben selber Informationen gepostet: ‚Da werden 100 Helfer gesucht' und wenn das natürlich 3 Seiten posten und auf einmal dann 250, 300 Leute da stehen, wo eigentlich die Hälfte nicht gebraucht wird." [MG,00:07:05]

- Große Informationsmengen: Angesichts der hohen Nutzerzahlen in Sozialen Medien trägt die dort erstellte Informationsmenge zu dem Big Data Phänomen bei. In Krisenkommunikation kann die große Menge an benutzererstellten Informationen einen erheblichen Aufwand zur Verwaltung, Filterung und Überprüfung verursachen, der zusätzliche Kapazitäten erfordert. Außerdem verlieren die zuständigen Behörden damit schnell den Überblick und die Kontrolle.

  „...aber jeder konnte halt auch nicht mitmachen, weil es im Chaos geendet hat" [SM,00:15:55]

  „...wir hatten im Stadion teilweise bis zu 10 Mann sitzen, die sich nur um Facebook gekümmert haben [...] Wir hatten dann auch irgendwann den Punkt, dass die Postings nicht ungeprüft raus gehen..." [MG,00:20:18]

  „Also wir [die Stadt Dresden] haben die Kontrolle komplett verloren über dieses Thema." [UF,01:30:10]

3.4 Die Nutzer der Sozialen Medien als ungebundene Helfer

Eine wesentliche Rolle für den Erfolg der Sozialen Medien spielen ihre Nutzer. Diese beeinflussen die Abläufe, wenn sie als Helfer in Krisensituationen agieren. Denn sie sind:

- Anonym: Je nach selbstdefinierten Einstellungen kann ein Nutzerprofil in Sozialen Medien sehr wenige bis sehr viele persönliche Informationen zu seinem Inhaber öffentlich anzeigen. In Krisensituationen ist die Identität der Helfer zum Schutz und Planung aber besonders wichtig.

  „...die waren da und keiner kannte die. So, was ist in dem Fall, derjenige verletzt sich? Man hat absolut gar keine Informationen." [MG,00:18:32]

> „Ich kann mich nicht darauf verlassen, dass 2.000 ungebundene Helfer zur Verfügung stehen. Was ist denn, wenn die nicht kommen und die sollen aber einen bestimmten Verteidigungsabschnitt übernehmen?“ [UF,00:57:34]

> „... dann auch eben irgendwelche Spaßbolde da teilgenommen haben, die dann irgendwelche sinnlosen Punkte in den Atlantik gesetzt haben.“ [SM,00:14:15]

- Ungebunden und freiagierend: Viele Nutzer entschieden sich spontan über Soziale Medien bei Bedarf zu unterstützen, wollten sich aber keineswegs verbindlich dazu verpflichten. Die Unverbindlichkeit bietet den Helfern die Flexibilität, erschwert aber ihre zentrale Anleitung.

> „Die Leute wollen helfen, wollen sich jetzt aber nicht an eine Vereinsmitgliedschaft binden“ [MG,00:24:54]

> „Die wollen selbstorganisiert sein. Das führt aber eben dazu, dass sie dann leider nicht das machen, was sinnvoll ist...“ [UF,00:56:14]

- Überwiegend jung: Soziale Medien sind vor allem für jüngere Generationen besonders attraktiv, was sich in den Nutzungsstatistiken widerspiegelt (siehe 2.1). Beim Elbehochwasser in Dresden in 2013 erbrachte die große Menge junge Helfer eine höhe körperliche Leistung.

> „...ohne diese Zivilisten, die hier mit geschaufelt haben, bei weitem nicht so eine Leistungsfähigkeit erreicht worden wäre...“ [UF,00:13:47]

- Unterschiedlich motiviert und erfahren: Die Nutzer, die in Sozialen Medien gemeinsamen Seiten „folgen“, würden sich aus unterschiedlichen Gründen aktiv an einer Aktion beteiligen und bringen unterschiedliche Erfahrungen mit. So mobilisieren sich freiwillige Helfer nach eigenem Ermessen und Interesse und können unbewusst in gefährlichen Situationen geraten.

> „Wir hatten halt 2013 den Nachteil, [...] dass es ein paar Personen dabei damals noch gab, die gegen die Stadt geschossen haben.“ [MG,00:20:03]

> „...wenn man dann dort den Punkt hat und da steht: ‚Ok, hier werden 10 Leute benötigt’, aber es ist etwas, was mich besonders interessiert, geh ich da vielleicht trotzdem hin...“ [SM,00:12:56]

> „...wobei 2006 ein niedrigeres Hochwasser war. Da gab es sowieso keine ungebundenen Helfer. Das fanden die nicht interessant genug.“ [UF,01:28:43]

> „Was wollen die Leute auf dem Deich in Cossebaude? Das handelt sich um einen Spundwanddeich, der überflutet wird. Das ist lebensgefährlich, sich dort aufzuhalten. Auch dahinter.“ [UF,00:25:24]

4 Fazit

Der vorliegende Beitrag untersucht Erfahrungen von Personen, die beim Elbehochwasser 2013 in der Stadt Dresden unmittelbar mit dem Phänomen der ungebundenen Helfer konfrontiert wurden, welche sich zum großen Teil selbst über Soziale Medien organisierten und zur Unterstützung spontan vor Ort trafen. Trotz der bekannten Vorteile Sozialer Medien, wie schnelle und ständige Kommunikation sowie kollaborative Informationserstellung und Zusammenarbeit, zeigen sich in den Ergebnissen dieser Studie eine ganze Reihe an Risiken, die ein unkontrollierter Einsatz dieser Medien in Krisensituationen nach sich ziehen kann. Besonders negativ zu betrachten waren selbstinitiierte Maßnahmen, die entweder zur Behinderung der professionellen Einsatzkräfte oder zur Gefährdung der Sicherheit der ungebundenen Helfer geführt haben bzw. zu dieser hätten führen können. Ein rein bürgerlicher Einsatz Sozialer Medien in Krisensituationen kann daher kontraproduktiv sein, wenn er ohne Abstimmung mit den zuständigen öffentlichen Behörden erfolgt. Der selbstinitiierte Einsatz von Sozialen Meiden zur Organisation und Mobilisierung von freiwilligen Helfer gewinnt jedoch zunehmend an Bedeutung, nicht nur bei Naturkatastrophen, sondern auch in weiteren Krisensituationen, welche die offiziellen Hilfsbeauftragten herausfordern, beispielsweise die größte Flüchtlingswelle in Europa seit dem zweiten Weltkrieg. Aus den Ergebnissen dieses Beitrags lassen sich Handlungsempfehlungen schlussfolgern, die den staatlichen Einrichtungen sowie nicht staatlichen Hilfsorganisationen bei der Vorbereitung eines solchen bürgerlichen Einsatzes helfen, um flexibel und zielführend reagieren, Potenziale ausschöpfen und Risiken vermeiden zu können. Beispiele für notwendige Maßnahmen lassen sich wie folgt ableiten:

- Organisatorische Maßnahmen: Wie die Einrichtung einer offiziellen Anlaufstelle für freiwillige Helfer, die in Sozialen Medien präsent ist und dadurch Informationen bereitstellt, um den Helfer zu motivieren, zentrale Koordination und Anweisungen zu akzeptieren.
- Technische Maßnahmen: Wie die Bereitstellung von stabilen technischen Lösungen, auch mit verbreiteten Sozialen Medien, die eine intensive Nutzung unter Beachtung des Datenschutzes und der Datensicherheit ermöglichen, ohne die staatliche technische Infrastruktur zu belasten.
- Personelle Maßnahmen: Wie Qualifikationsmaßnahmen zum Umgang mit Sozialen Medien für den zuständigen Mitarbeiter, um qualifizierte personelle Ressourcen zur Verwaltung der Informationen und zur Moderation der Kommunikation bereitzustellen.

Weiterführende Studien sollen die Planung, Einführung und Auswirkung solcher Maßnahmen detailliert untersuchen, um den Nutzen eines geplanten Einsatzes von Sozialen Medien in der Krisenkommunikation ausführlich einzuschätzen. So können weitere Handlungsempfehlungen für die beteiligten Stakeholder und ggf. in unterschiedlichen Krisensituationen herausgestellt werden.

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Immer noch werden allerdings die Erfahrungen anderer Branchen bei der erfolgreichen Erstellung und Vermarktung von Dienstleistungen im E-Learning-Kontext nur vereinzelt berücksichtigt. Daher ist neben der Erarbeitung und Reflektion spezifischer E-Learning-Konzepte insbesondere auch die Übertragung, Adaption und Integration von Konzepten und Ansätzen aus der Wirtschaftsinformatik und dem Dienstleistungsmanagement gefragt, da hier bereits überzeugende und nachweislich erfolgreiche Ansätze für vergleichbare Herausforderungen geschaffen wurden.

Von den insgesamt 17 Einreichungen wurden im Rahmen des doppelt-blinden Begutachtungsprozesses durch ausgewiesene Themenexpertinnen und -experten insgesamt 8 Beiträge positiv evaluiert und zur Annahme vorgeschlagen (Annahmequote = 47%). Die Beiträge beziehen sich dabei auf alle drei Säulen des E-Learning: Technik, Didaktik und Wirtschaftlichkeit.

Die Präsentationen im Rahmen des Konferenzprogramms werden bei Einverständnis der Autoren per Video aufgezeichnet, so dass neben den Beiträgen im Tagungsband zusätzlich eine webbasierte Dokumentation auf http://www.ccec-online.de/mkwi-2016 realisiert werden kann.

Michael H. Breitner, Roland Gabriel, Martin Gersch, Eric Schoop, Peter Weber

(Teilkonferenzleitung)

Towards the Conceptual Development of a Business Model for Massive Open Online Courses

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Abstract

Massive Open Online Courses (MOOCs) have become increasingly important in many settings. This popularity is accompanied by a large number of emerging companies, which focus on the provision of the required contents, the technical infrastructures as well as the required services. Thus, companies emerging in this dynamic market must be aware of the constituent elements of their business model in order to remain competitive. In response to these developments, this paper presents the derivation of a business model for MOOC providers. The business model builds upon existing research on generic business model concepts as well as aspects regarding MOOCs. In a first step, the basic elements of the MOOC business model are elaborated, which form the fundamental framework for the assignment of MOOC-specific characteristics to each business model element.

1 Introduction

Mobile access to learning contents has come along with revolutionary possibilities of knowledge transfer in the educational setting. Since 2011, Massive Open Online Courses (MOOCs) have become increasingly important. To date, the "Big-Three-MOOC-Providers" Udacity, Coursera and edX provide more than 500 courses in different disciplines with an overall number of 7 million participants (Jonathan 2014). MOOCs are an extraordinary example for mobility: Participants of MOOCs have the possibility to virtually participating in lectures and seminars without being present (Lemke and Brenner 2015). At the same time, lecturers have the possibility to reach millions of listeners. Thus, participants of MOOCs can access learning contents of several domains anytime and anywhere (Lemke and Brenner 2015). Furthermore, universities have the possibility to provide course materials via MOOCs as not every university has an own learning management system (Rensing 2013). MOOCs are characterized by a an increasing number of participants, particularly for Computer Science, Mathematics, Statistics and Physics (Schulmeister 2013). Motivated by these developments, further fundamental changes in the educational sector are expected in the next years (Rensing 2013). The former vision of MOOCs – "educational freedom for everybody as a business model" – has completely changed (Schulmeister 2013). MOOCs have developed from open and free courses to new business models and courses of studies (Schulmeister 2013; Wulf et al. 2014), which differ in the provided program of services and the revenue sources (Dellarocas and Van Alstyne 2013). Since 2014, the Georgia Institute of Technology offers specific courses in Computer Science solely in form of MOOCs, which lowers student fees far lower than for regular courses. The concept of business models has already been addressed in several scientific contributions (Amit and Zott 2001; Betz 2002; Chesbrough 2006; Di Valentin et al. 2012; Mahadevan 2000). In order to be able to analyze the business model in a standardized manner, companies must be aware of the constituent components of their business model. However, most business model concepts so far cover generic aspects not taking into consideration the specifics that are particularly relevant for MOOC providers. Based on the large number of participants as well as the required tools to realize MOOCs, the creation, organization and accomplishment of courses is very complex and thus requires a comprehensive preparation (Rensing 2013). At the same time, the quality of the offered courses has to be ensured (Ehlers and Pawlowski 2006). One more central characteristic for MOOCs is to ensure privacy for course participants as well as the recognition of accomplished courses (Küchemann 2013). This paper addresses the following research questions: *"What kind of business models ensure a successful development of MOOCs?; What kind of business model elements are required to address the requirements for MOOC providers?"*

This paper presents the conceptual derivation of a business model framework for MOOC provider. Business model related aspects have already been discussed by several authors in the last years such as (Dellarocas and Van Alstyne 2013; Kalman 2014; Wulf et al. 2014). However, most approaches focus on generic aspects about business models by not taking into account the characteristics of MOOCs. This paper proposes a holistic framework that covers all relevant aspects of business models for companies that specialize in the provision, creation and services for MOOCs. First, we derive basic business model components based on a literature review. Similar components are classified into major components. In total, we derived five major business model components: Value Proposition, Customer Interface, Infrastructure, Financials and Competition Model. Each of major category is subdivided into more detailed business model elements categories. In a next step, we analyzed existing literature on business models for MOOCs. We described each of the derived business model elements according to MOOC-specific aspects that we derived from literature. The developed business model provides companies in the MOOC sector a blueprint for the implementation of their business model. Business model research should benefit from the novel MOOC framework, which has been derived on the basis of established, generic business model concepts that have been enriched with MOOC-specific characteristics.

2 Term Definitions of Business Models and MOOCs

2.1 Business Models

The term business model first appeared in scientific literature in 1957 (Bellman et al. 1957). Although in the last years the development and the design of business models gained in importance and a number of definitions have arisen, so far, there exists no omnipresent definition of this term (Osterwalder 2004; Al-Debei and Avison 2010; Wirtz 2011). Zott et al. (2011) define a business model as *"[...] a template that depicts the way the firm conducts its business.*" Osterwalder (2004) describes a business model as a *"conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money."* Fast evolving dynamics in information and communication technologies enforce companies to adapt their business models to these current developments (Veit et al. 2014). In many cases, a transformation from traditional business models to MOOC-specific aspects is pointless, as digital and IT-driven companies act in a dynamic environment with specific conditions regarding the market and competitors (Wirtz 2010). Thus, there is a growing need to develop business models that take into consideration these dynamic aspects. Therefore, it is crucial for companies to be aware of the constituent elements and key drivers of their business model (Casadesus-Masanell and Ricart 2010). We analyzed in a first step literature dealing with generic business model elements, which form the basis for our MOOC business model. Many of the considered sources have already been analyzed in previous research (Burkhart et al. 2012; Di Valentin et al. 2012). The first literature analysis shows that in literature there is consensus regarding the components Value Offering, Customer Interface, Infrastructure, Financials and Competition. The following figure shows the results of literature analysis about the constituent elements of business models.

Business Model Categories and Elements		Authors				
Major Business Model Categories	Business Model Elements	Wirtz [24]	Gordijn and Akkermans [25]	Klett et al. [26]	Osterwalder and Pigneur [17], [24]	Rusnjak [28]
Value Offering	Value Proposition	■	■	■	■	■
Customer Interface	Customer Segments	■	■	■	■	■
	Customer Relationships	■	□	■	■	■
	Distribution Channels	■	■	■	■	■
Infrastructure	Performance Creation/ Key Activities	■	■	■	■	■
	Key Resources	■	□	□	□	□
	Key Partnerships	■	□	■	■	■
Financials	Finance Model	■	□	□	□	□
	Cost Model	□	□	■	■	■
	Service Model	□	□	■	□	□
	Revenue Model	■	□	■	■	■
Competition	Market Model / Competition Model	■	■	□	□	■
Other	Technology	□	□	□	□	■
	Vision	□	□	□	□	■
	Strategy	□	□	□	□	■

Legend:
■ present
□ absent

Figure 1. Results from the Literature Analysis on Generic Business Model Elements

The analysis shows that value offerings, key activities and financials have been mentioned most often in the analyzed literature. Based on the findings of the literature review we derived the following main pillars for the MOOC business model: 1) Value Offering, 2) Customer Interface, 3) Infrastructure, 4) Financials and 5) Competition Model. Each of the five major categories consists of sub-business model elements as shown in Figure 1.

2.2 Massive Open Online Courses

Several forms of integrated learning, like "Blended Learning" represent predecessors of MOOCs (Rensing 2013). However, within these approaches the number of participants is smaller compared to MOOCs (Rensing 2013). The term MOOC first came up in 2008 for the course "Connectivism & Connective Knowledge (CCK08)" of George Siemens and Stephen Downes at the University of Manitoba (Küchemann 2013). The success of MOOCs can be traced back to the free courses of the Khan Academy, which, so far, has offered more than 4000 lectures covering several domains (Cusumano 2013). MOOCs distinguish between cMOOCs and xMOOCs (Clow 2013). CMOOCs refer to the learning theory of connectivism, which puts individual learners into the focus of attention (Pscheida et al. 2014). It consists of linked contents, which increase with the learning activities of its participants. Several kinds of social media tools like Twitter, blogs, etc. can be integrated into a cMOOC (Pscheida et al. 2014). Participants of the MOOC can decide what kind of tools, media types or communication channels to use in order to reach their learning goals, which are neither defined nor are examinations planned (Pscheida et al. 2014), (Küchemann 2013). Thus, cMOOCs focus on the collaborative process of learning with the use of educational technologies (Rensing 2013). xMOOCs focus on behavioristic teaching methods (Clow 2013). In contrast to cMOOCs, xMOOCs are characterized by a clear structure and pre-defined learning goals by focusing on the instruction-oriented didactical concept (Rensing 2013). Courses of xMOOCs consist of asynchronous elements like videos (e.g. recorded lectures), multiple choice questionnaires, discussion forums but also synchronous elements like live-events (Wedekind and Harries 2006). Summing up, xMOOCs differ in several aspects from cMOOCs. Whereas cMOOCs are network-oriented and focus on collaboration techniques, xMOOCs make use of the possibilities of distribution in the web. Thus, xMOOCs are more content-oriented than process-oriented (Ehlers and Pawlowski 2006). Most courses are offered in form of xMOOCs. For this reason, the proposed framework particularly focuses on aspects related to xMOOCs.

3 Related Work and Requirements Derivation

Since MOOCs first came up, many researchers have already paid attention to this topic. However, in literature, aspects related to business models for MOOCs have not been discussed extensively. This section presents some of the most established MOOC business models. Kalmann (2014) focuses on companies providing MOOCs for universities by classifying business models into three major components: 1) Customer Value Proposition, 2) Infrastructure and 3) Financials. He emphasizes, that between all components exist strong dependencies. If, for instance, changes on the business model component “Customer Value Proposition” are made, this will have an impact on the “Infrastructure” and “Financials”. However, most MOOC providers follow the freemium-model, by offering the basic course contents for free (Kalman 2014), whereas premium services have to be paid (Osterwalder and Pigneur 2010; Kalman 2014). Main drivers for the freemium model are fees for certifications and examinations as they represent direct sources of revenues (Schulmeister 2013). Dellarocas and Van Alstyne (2013) have a stronger focus on financial aspects about MOOCs by analyzing who pays for which service offered in MOOCs. The main players are the state, students, employers, sponsors and learning platforms. Furthermore, they describe which services should be offered for free or against a fee. Similar to the framework of (Kalman 2014), the authors also describe the usability of the freemium model. Their analysis shows that the customer segment mainly consists of participants that only make use of free learning contents. Only a small number of users pays for additional services like certifications or examinations. The authors describe several sources of revenue and possibilities for generating revenues based on MOOC business models. According to them, the most profitable business model is the hybrid form, the so-called “blended format course”, which is currently tested by the startup company 2U. The blended format course consists of a network of universities, in which all participants provide courses that can be accessed by all members of the network. Wulf et al. (2014) propose three major components for MOOC business models: 1) Direct Model, 2) Operating Model and 3) Third-party Financing. The authors describe business models from the perspective of information systems research by classifying business models into three major business model types: 1) Finance, 2) Teaching

Planning and 3) Platform Operations and Marketing. Providers of teaching activities are universities and companies. They are responsible for the provision of teaching materials as well as the preparation and provision of learning contents. According to their framework, the main players in MOOCs are universities, companies, IT service providers, participants as well as third-party institutions. MOOC providers should address the following aspects in order to establish successfully in the market: Quality assurance of course contents, identification of members in examinations, course accreditation of external reviewers, recognition of achievements and data protection of the subscribers (Bershadsky et al. 2013; Haug and Wedekind 2013).

In order to address the aforementioned aspects for the successful implementation of a business based on MOOCs, the MOOC business model should fulfill the following requirements: 1) The framework should enable practitioners and researchers to describe their business model in a standardized way. 2) The MOOC business model should be divided into several major categories. Each category contains detailed information and is subdivided into more detailed business model elements. 3) The MOOC business model should build upon existing research results in business model research. Basic business model components should be enhanced with MOOC-specific characteristics.

4 Derivation of the MOOC Business Model

The literature analysis in Chapter 2.1 revealed, that the major business model categories consist of the Value Offering, Customer Interface, Infrastructure, Financials and Competitor Model. Each of these major categories is subdivided into basic business model elements. We identified for each business model element MOOC-specific characteristics based on the related work.

4.1 Business Model Element: Value Offering

A business model should not only take into consideration the benefits and usefulness of a MOOC's participants but also for other involved stakeholders, like suppliers, distributors, etc. (Bershadsky, Bremer, and Gaus 2013). The following table depicts the MOOC-specific aspects that take into consideration the value delivery and the value proposition of MOOC providers.

<table>
<tr><td>Core Services of MOOC Providers
<u>Direct Model</u>: MOOC providers and operators (universities / companies)
• Course contents
• Planning of learning activities for each course
• Studies for apprenticeships and further education
<u>Operating Model</u>: MOOC providers as platform providers
• Provision of the required technical infrastructure
• Platform operations, course marketing and user management
<u>Third-party Financing</u>
• Provision of the required technical infrastructure adapted to the involved institution
• Recruitment of graduates
• Selling participation certificates</td><td rowspan="3">[1]
Value Proposition / Value Offering</td></tr>
<tr><td>Benefits for participants
• Free course offerings
• Premium services (certifications, examinations, etc.)</td></tr>
<tr><td>Additional (indirect) benefits for
<u>Participants</u>
• Individualization of teaching materials
• Better career opportunities
<u>Course Providers</u>
• Generating and selling information of participants</td></tr>
</table>

• Revenues from certifications and license fees • Revenues from crowdsourcing and advertisement Partners (Universities) • Better reputation through enhanced teaching offerings Partners (Companies) • Recruitment of potential employees	

Table 1. Classification of MOOC-specific characteristics to the business model component Value Offering (according to Bershadsky et al. (2013); Dellarocas and Van Alstyne (2013); Wulf et al. (2014); Kalman (2014))

The main actors involved in MOOCs are participants, course providers and partners. Participants can also be co-designers for the preparation of lessons, as based on the principles of MOOCs, users are integrated into the processes of learning (Wulf et al. 2014). MOOC providers are not only represented by universities and companies but also by providers of learning platforms (Wulf et al. 2014). Core services of MOOC providers in their role as a **university or a company** encompass the operation of platforms and the marketing of courses offered via MOOCs (Wulf et al. 2014). Further services are the preparation and teaching of courses. OpenHPI of the Hasso Plattner Institute and the open SAP program for instance provide MOOCs for employees and customers in terms of further education. Universities have the possibility to enhance these teaching offerings (Wulf et al. 2014). MOOC providers having the role of a **platform provider** are responsible for the maintenance and provision of the technical infrastructure in order to ensure the platform operations, course marketing and user management (Wulf et al. 2014). Furthermore, they support companies in recruitment activities (Dellarocas and Van Alstyne 2013). The technological basis enables logging the participants' user interactions when carrying out a MOOC. By this means, platform operators can collect a huge amount of data (Koller 2012), in order to carry out learning analytics (Wulf et al. 2014). This data is highly relevant for potential employers. MOOC providers have the rights and licenses for course contents and can sell them to other universities (Wulf et al. 2014). Through crowdsourcing, companies have the possibility to submit specific real-life business problems to a MOOC, which can be solved by the participants. Hence, participants can benefit from practical applicability as well as improved career opportunities, whereas MOOC providers achieve provisions (Dellarocas and Van Alstyne 2013; Wulf et al. 2014). Advertising companies have the possibility to tailor advertisements to the interests and profile information of course participants. In addition to free courses, participants can also gain **certificates** for achieved degrees and have the possibility to accomplish a **graduate degree** (Wulf et al. 2014). Furthermore, the participants' knowledge can be deepened based on peer grading and peer support (Wulf et al. 2014; Sadlar and Good 2006). Learning analytics enables an individual adaptation of course contents and teaching services to the users' knowledge profile (Bershadsky et al. 2013). Additionally, learning analytics allows to detect overall weaknesses of course structures (Dellarocas and Van Alstyne 2013). Universities, platform providers for learning solutions, private organizations as well as teaching staff are potential cooperation partners in MOOCs. Professors as well as participating universities can achieve worldwide popularity based on the large number of participants. MOOCs support these stakeholder groups to establish a good reputation for potential students by offering courses of high quality. Peter Lange, provost of the Duke University says that since the beginning of Coursera he could establish among subscribers a mental strength in form of a global classroom (Langmead 2013). Employers can recruit matching employees or enrich the qualifications and skills of their employees (Dellarocas and Van Alstyne 2013). In doing so, MOOCs are suitable for open as well as cost-based offerings for further education.

4.2 Business Model Element: Customer Interface

The customer interface consists of three business model components: 1) Customer Segments, 2) Customer Relationships and 3) Distribution Channels. The following table summarizes these business model components regarding the characteristics of MOOCs.

• Workforce • (Potential) students and universities • Individuals interested in further education	[2] Customer Segments
• Automated customer relationships • Complex form of self service • Personalized supervision, when using premium services and the ability to participate in examinations • Communities • Online forums	[3] Customer Relationships
• Direct distribution channels: website (own website and partner website)	[4] Distribution Channels

Table 2. Classification of MOOC-specific characteristics to the business model component Customer Interface (according to Bershadsky et al. (2013); Wulf et al. (2014))

So far, the educational sector has been mainly supply-led. However, there is an increasing trend towards a customer-oriented educational market (Schulmeister 2013), which comes along with the need of designing MOOCs more consumer-driven (Bershadsky et al. 2013). Furthermore, it is important to provide sufficient support in learning processes (Kalman 2014). Thereby, user experiences play an important role (El Sawy and Pereira 2013). A company's customers can be divided into several segments, e.g. according to specific needs or cost effectiveness (Osterwalder and Pigneur 2010). Thus, offering products and services related to MOOCs should be adapted to the needs of customers, who are classified into workforce, students and universities and individuals interested in further education.

4.3 Business Model Element: Infrastructure

This major business model category consists of Key Resources, Key Activities and Key Partnerships (Osterwalder 2004), which are described in Table 3.

• Preparation of lessons, deployment and transfer of knowledge, control of social learning interactions between participants, implementation and execution of examinations, course evaluations • Platform operation • Marketing activities, user management • Storage of the subscriber's information • Crowdsourcing	[5] Performance Creation / Key Activities
• Course materials, licenses for course content • Mechanisms and technologies for digitizing and scaling of courses • MOOC implementation and provision of the required technical platform • Reputation of a university or a professor • Network of test centers	[6] Key Resources
• Universities (e.g. MIT, Stanford, etc.) • Private companies (e.g. AT&T, Deutsche Telekom AG) • IT service providers (e.g. edX) • Investors (e.g. Kleiner Perkins Caufied & Byers)	[7] Key Partnerships

Table 3. Classification of MOOC-specific characteristics to the business model component Infrastructure (according to Bershadsky et al. (2013); Wulf et al. (2014); Kalman (2014) and Franken et al. (2014))

[5] Performance Creation / Key Activities: Key Activities of MOOCs differentiate between platform- and network oriented business processes. Depending on the realized business model, the impact on business processes can differ. Within the **direct model**, MOOC providers and platform operators are represented by the same organization. Key activities in the direct model include platform management and operations as well as activities related to learning like planning and controlling of teaching activities, the creation of course contents or user management (Wulf et al. 2014). The **operating model** focuses on processes for the maintenance of key partnerships in terms of an educational establishment. Further key activities are storing and exchanging subscriber's information to potential employers and advertising agencies recruitment (Wulf et al. 2014).

[6] Key Resources: Carrying out value creating activities requires key resources (Rusnjak 2014). Technical equipment, digital course materials and the administrative infratsructure are examples for physical resources. For platform providers like Iversity or edX23 this aspect represents the most important key resource as they are focusing their business activities on technical infrastructures for the implementation of courses (Rensing 2013). Licences for course content and technologies for course digitizing and scaling represent intangible resources (Wulf et al. 2014). But also a university's or professor's reputation represents a key resource for MOOCs and MOOC providers (Kalman 2014). The most important financial resources are third party organizations, sponsors and government subsidies supporting the production and provision of courses (Dellarocas and Van Alstyne 2013).

[7] Key Partnerships: Key Partnerships focus on optimizing the distribution of resources and activities (Osterwalder and Pigneur 2010). For the composition and expansion of course offerings, MOOC providers increasingly establish partnerships with universities and academic staff. Coursera, e.g. closes fee-based user contracts with universities that publish their events via the MOOC platform (Bershadsky et al. 2013). Additionally, companies, recruiting graduates are also attracted as partners (Küchemann 2013). The recognition of specific MOOCs (e.g. courses of Coursera and Udacity) by the American Council on Education (ACE) may also be considered as an important partnership to a qualifying institution (Schulmeister 2013). Furthermore, new collaborations between universities are made in order to avoid missing chances that come along with the constantly changing educational market (Franken et al. 2014).

4.4 Business Model Element: Financials

Many private and public investors are interested in MOOCs (Bershadsky, Bremer, and Gaus 2013). For instance, in some cases, the development and participation in a specific MOOC is financed by the state. However, MOOCs receive most support by venture capital inflows (Schulmeister 2013). Due to increasing innovations in the IT sector, starting up a business without a high start-up capital or a secure source of financing has become possible (Kalman 2014). Table 4 depicts the characteristics of the business model category Financials.

Fix Costs • For implementation / provision of a MOOC, technical support, as well as for ensuring communication among subscribers **Variable Costs** • Minimal marginal cost for each participant **Cost Advantages** • Cost reduction through peer support and peer grading • Outsourcing the technical infrastructure to platform providers	[8] Cost Model
Direct sources of profit • Certification fees, tuitions for completed courses, examination fees • Production and use of MOOCs by universities	[9] Revenue Model

Indirect sources of profit • Selling subscriber's information to potential employers or advertisers • Selling MOOC licenses to universities • Government subsidies • Sponsoring	

Table 4. Classification of MOOC-specific characteristics to the business model component Financials (according to Dellarocas and Van Alstyne (2013), Wulf et al. (2014), Kalman (2014) and Franken et al. (2014))

[8] Cost Model: Processes of performance creation and the maintenance of the partner network cause fix and variable costs. Fix costs per period are caused by the academic and technical personnel to develop and maintain courses (Kalman 2014). TU Munich, for instance, charges ten hours for one hour of teaching contents (Küchemann 2013). Lately, a drastic decline in variable costs for IT infrastructure could be noticed (Kalman 2014). The cost structure of each MOOC business model is based on minimizing the variable costs with the increasing number of students (Cusumano 2013; Kalman 2014). This allows MOOC providers to offer free courses at higher fixed costs. The cost structure for MOOC producers and providers must also consider cost savings for participating universities through outsourcing the technical infrastructure to platform providers (Rensing 2013).

[9] Revenue Model: The original conception of MOOCs changed from "freedom of education for all" to an economic and market-based view on the MOOC as a product or a service, which generates profits (Bershadsky et al. 2013). A study about platform operators for MOOCs shows that private investments in digital training and education have been continuously increasing in the last years (Franken et al. 2014). Iversity, for instance, was funded by an EXIST founder scholarship. After the successful establishment in the educational market, further public and private funds have followed (Franken et al. 2014). Iversity's courses are free of charge and free of advertisements (Franken et al. 2014). Other direct revenue sources for MOOC providers are fees for certificates and for absolving exams within courses (Schulmeister 2013; Wulf et al. 2014; Franken et al. 2014). Coursera e.g. achieves direct earnings through the provision of MOOCs to partner universities, whereas Udacity receives significant revenues from state fees for additional options of selected MOOCs as well as from contributions to Georgia Tech Masters Courses. Furthermore, Udacity receives incomes from investments by AT&T in form of venture capital (Franken et al. 2014). These examples show that indirect sources of revenues through MOOCs differ significantly. Further examples of sources of revenues are license fees, sale of subscriber's data and recruitment services (Dellarocas and Van Alstyne 2013; Wulf et al. 2014; Kalman 2014; Franken et al. 2014). Price combinations and pricing for certificates as well as the use of other services by MOOCs vary from company to company and thus, cannot be standardized.

4.5 Business Model Element: Competition Model

The ecosystem of a digital business model goes far beyond its company boundaries, taking into consideration the collaboration with customers and partners (El Sawy and Pereira 2013). A business model must take into consideration current and potential changes from the external environment (Osterwalder and Pigneur 2010). Thereby, changes in customer demands within further education play an important role (Schulmeister 2013).

Competition • Reputation and university branding as factor of competition • Complete digitalization of learning services as competitive advantage for MOOCs towards traditional university education	[10] Competition/ Market Model

Market • Niche market "further education" in the main market "E-Education" within the area of e-business **Market strategies** • Market leadership (e.g. Coursera) • Cooperations, outsourcing of value performance (e.g. Udacity) • Manufacturer-wide market strategy (e.g. openSAP program)	

Table 5: Classification of MOOC-specific characteristics to the business model component Competition Model (according to Wulf et al. (2014) and Kalman (2014))

The market model determines the relevant actors and markets (Wirtz et al. 2010). In doing so, it differentiates between customers and competitors (Wirtz et al. 2010). These encompass MOOC-specific customer segments (see Section 4.2) and competing MOOC companies. Companies producing MOOCs operate on the niche market for further education, which represents a part of e-education of the main market E-Business (Wirtz 2013). Coursera has the biggest course offering and tries to maximize the number of partnerships with universities worldwide in order to increase the marketing of its courses (Schulmeister 2013). Thus, Coursera carries out the strategy of market leadership (Franken et al. 2014). Udacity has strategic partnerships with universities developing their own MOOCs as well as with companies like Google Inc. in terms of employment services (Franken et al. 2014). Thereby, some services are outsourced to external institutions. SAP offers free courses within a further education program. These courses are not only offered to internal employees but also to SAP's customers, which enables them to better use products and services of SAP. Thus, SAP and its customers as well benefit from the digital course offering, as the courses are accompanied by a high customer value and customer loyalty. In summary, it can be said that a unique value proposition comes along with competitive advantages (Rusnjak 2014). For instance, participants of a MOOC offered by an elite university may benefit from job offerings by involved companies. Many of the analyzed publications on MOOC business models consider the production and application of MOOCs as a promising market for further education at universities, which is going to further develop in the future (Bershadsky et al. 2013; Küchemann 2013; Franken et al. 2014).

5 Conclusions and Outlook

This paper presented the derivation of a MOOC business model framework in order to answer the research questions "What kind of business models ensure a successful development of MOOCs? What kind of business model elements are required to address the requirements for MOOC providers?" Most established business model frameworks focus on generic aspects. Although there exist e-learning business model frameworks, they do not take into consideration the characteristics of MOOCs. The business model presented in this paper identifies the main aspects about the production and delivery of MOOCs from the perspectives of educational and commercial organizations. First, a systematic literature review about generic business model elements has been carried out. The results of the literature analysis have been classified into major business model categories. To each of the major components, we assigned several business model elements. Then, the authors performed an analysis of established business model concepts in the domain of MOOCs. The results of this analysis have been classified to the generic business model elements. The popularity of MOOCs comes along with an increasing number of emerging start-up companies. The developed MOOC business model framework helps practitioners to align and classify their proprietary strategies. Research benefits from the structured classification of MOOC-related aspects to already established generic business model components. The business model helps researchers to carry out an analysis of business model components from a MOOC-oriented perspective. It serves as a foundation for subsequent investigations particularly regarding underlying business processes within the domain of MOOC delivery. Thus, the framework should serve as a basis to analyze how operative processes are affected by a specific business model. In a next step, the interdependencies between the derived business model components and their sub-elements will be analyzed. Furthermore, the structured description of the developed business model framework can serve as a basis to develop software tools that help company-founders in the MOOC domain to determine their business model.

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Wie die Analyse von Entscheidungsdaten Planspielveranstaltungen verbessern kann und warum sich der Aufwand lohnt – Eine Fallstudie

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Abstract

Planspielveranstaltungen haben sich in den vergangenen Jahren als feste Methode im Bereich der Aus- und Weiterbildung etabliert. Der konkreten Auswertung von Entscheidungsdaten kommt bislang lediglich eine untergeordnete Bedeutung zu, obwohl entsprechende Analysen einen maßgeblichen Beitrag zur Verbesserung des Gesamtkonzepts von Planspielveranstaltungen leisten können. Eine Schwierigkeit liegt im großen Umfang und in der hohen Dynamik der Entscheidungsdaten. Die IT-Unterstützung von Planspielen kann hier einen wichtigen Zugangspunkt schaffen. Der vorliegende Beitrag stellt ein Modell zur Konstruktion entsprechender Analysegrößen vor. Gleichzeitig wird anhand des Anwendungsfalls einer großzahligen IT-gestützten Planspielveranstaltung der Nutzen derartiger Analysen aufgezeigt.

1 Einleitung

In der Aus- und Weiterbildung ermöglichen Unternehmensplanspiele (UPS) die praxisnahe Vermittlung insbes. wirtschaftswissenschaftlicher Handlungskompetenzen. Die TeilnehmerInnen werden in die Rolle von Entscheidern versetzt, wo sie typische Entscheidungen des Unternehmensalltags treffen. Die Realität wird auf ein verständliches Modell an Parametern und Wirkungszusammenhängen zurückgeführt und die kausalen Zusammenhänge werden aus einer integrierten Perspektive erfahrbar (Matschiok 1999, Kriz 2011). Als aktive Lernmethode wird Planspielen (PS) eine motivationsstärkende Wirkung zugeschrieben (Geuting 1992). Während sich zu den Einsatzpotentialen von PS zahlreiche Veröffentlichungen finden (vgl. Kapitel 2), fehlt es der Literatur an Beiträgen, die sich mit der Auswertung von Entscheidungsdaten beschäftigen.

Es bieten sich zwei Erklärungsansätze: Entscheidungsdaten in PS werden i. d. R. nicht direkt zur Leistungsbeurteilung herangezogen, so dass dieser Bereich in der Vergangenheit nicht als Treiber für die Entwicklung entsprechender Auswertungswerkzeuge dienen konnte. Ursache ist ein grundlegender Widerspruch zwischen dem Bewertungs- und dem Lernprozess (Birgmayer 2011). Die TeilnehmerInnen können (und sollen) mit Entscheidungen experimentieren und deren Erfolg oder Misserfolg anhand der Ergebnisse erkennen (Baume 2009). Bereits das Bewusstsein einer direkten Beurteilung könnte hier zu einer defensiveren Spielweise verleiten oder das spielerische Element und Gefühl der Selbstbestimmtheit – die jeweils zentral für den Motivationseffekt von PS sind (Baume 2009, Kern 2003) – abschwächen. Der zweite Erklärungsansatz besteht im hohen Aufwand entsprechender Analysen. Selbst einzelne Entscheidungen in PS beruhen i. d. R. auf zahlreichen Parametern, die untereinander dynamisch in Wechselbeziehung zueinander stehen. Eine identische Budgetentscheidung kann bspw. bei gleicher Parametrisierung aber unterschiedlichem Konkurrenzverhalten zu hoch oder zu niedrig ausfallen und demnach allenfalls anhand eines sehr groben Intervalls sehr ungenau als grundsätzlich zielführend eingestuft werden.

Unabhängig davon scheint die Auswertung von Entscheidungsdaten jedoch von großem Interesse. So können entsprechende Auswertungen maßgeblich zur Verbesserung des Gesamtkonzepts von PS beitragen, indem sie einen unmittelbaren Zugangspunkt zum Verständnis und Lernfortschritt der TeilnehmerInnen eröffnen. Dieses gilt umso mehr, als der Mehrwert von PS gegenüber klassischen Lehrmethoden in entscheidender Weise von ihrem reflektierten Einsatz abhängt (Kern 2003, Trautwein 2011). Zur Beherrschung der Komplexität in der Auswertung bietet die zunehmende IT-Unterstützung von PS derweil einen zentralen Zugangspunkt. Während die IT-Unterstützung einerseits die Nutzung und Vernetzung einer großen Zahl an Parametern im PS erst ermöglicht (Fischer 2006), schafft sie im Umkehrschluss die Vorrausetzung zu deren Auswertung.

Dieses ist der Ansatzpunkt des vorliegenden Beitrages. Es wird zunächst dargestellt, wie Analysegrößen für Entscheidungsdaten in PS allgemein konstruiert werden können und danach am Fallbeispiel einer großzahligen IT-gestützten PS-Veranstaltung aufgezeigt, welchen Mehrwert entsprechende Analysen bieten können. Folgende Forschungsfragen werden gestellt:

1. Wie können Größen zur Analyse von Entscheidungsdaten in PS gestaltet werden?
2. Welche Ansätze für Steuerungsmöglichkeiten ergeben sich aus der Analyse von Entscheidungsdaten in PS und wie können diese umgesetzt werden?

In Abschnitt 2 wird auf die Grundlagen IT-gestützter UPS eingegangen und der vorliegende Anwendungsfall beschrieben. Unter 3 wird ein Modell zur Konstruktion von Analysegrößen für Entscheidungsdaten in PS vorgestellt. Anschließend wird dieses zur Konstruktion entsprechender Größen für den vorliegenden Anwendungsfall genutzt. Unter 4 schließt sich die Evaluation der entwickelten Größen und die Ableitung allgemeiner Potentiale an. Unter 5 erfolgt die Diskussion.

2 Planspiel und Einsatzszenario

UPS stellen einen speziellen Anwendungsfall der PS-Methode für die Domäne der BWL und VWL dar. Die IT-Unterstützung von PS kann nur die Berechnung des Simulationsmodells oder die vollständige Entscheidungsein- und Ergebnisausgabe umfassen. Gegenüber der theoretischen Vermittlung von Lerninhalten können Erfahrungen aus PS durch den höheren Praxisbezug besser auf neue Situationen übertragen werden. Dieses wird dadurch unterstützt, dass das simulierte Modell im Zeitraffer abläuft, so dass die Lernenden innerhalb kurzer Zeit die Konsequenzen ihrer Entscheidungen erkennen können (Trautwein 2011, Baume 2009). Während sich traditionelle Lernmethoden primär auf das deklarative oder prozedurale Wissen konzentrieren, wird angenommen, dass PS durch die Verknüpfung von deklarativem und prozeduralem Wissen auch höhere Wissenslevel wie Analyse, Synthese oder Bewerten (vgl. Lernziel-Taxonomie nach Bloom (Bloom et al. 1972)) vermitteln können (Kriz 2011, Matschiok 1999). Weitere empirische Befunde unterstützen diese Annahme, betonen jedoch auch den noch erheblichen Forschungsbedarf (Tennyson und Jorczak 2008, Sitzmann 2011, Anderson und Lawton 2008).

Andere Untersuchungen konnten eine positive Wirkung auf Bereiche, wie Leadership, Konfliktmanagement und Teamwork zeigen (Whitton und Hynes 2006, Faria 2001, Arias-Aranda und Bustinza-Sánchez 2009). Wie bereits dargestellt, fehlt es in der Literatur hingegen bislang an Betrachtungen, die großzahlig Entscheidungsdaten von PS in ihre Untersuchungen einbeziehen. Vielmehr werden parallele Befragungen durchgeführt oder Testaufgaben ausgegeben, um den Einfluss einzelner Gestaltungsoptionen oder den Lernfortschritt in Erfahrung zu bringen.

Bei dem der Untersuchung zugrundeliegendem UPS handelt es sich um das vollständig IT-basierte TOPSIM – Manufacturing Management in der Cloud Edition der TATA Interactive Systems. Die TeilnehmerInnen greifen für die Entscheidungsein- und die Ergebnisausgabe webbasiert auf das PS zu; in einem BackEnd kann die Spielleitung die Ergebnisdaten einsehen. Der Einsatz erfolgt in einer Pflichtveranstaltung des wirtschaftswissenschaftlichen Grundlagenstudiums mit überwiegend Erstsemestern. Die primäre Zielsetzung stellt die Vermittlung wirtschaftswissenschaftlicher Fachkompetenzen dar. Die Studierenden übernehmen in zufällig zusammengestellten Vierer- bis Fünferteams (= 1 Unternehmen) für sechs Perioden (= sechs Wochen) die Kontrolle über einen Fahrradproduzenten. Jeweils fünf Unternehmen stehen mit identischer Ausgangssituation in Konkurrenz zueinander. Die Entscheidungsbereiche des PS sind Einkauf, Fertigung, Vertrieb, F&E, Personalabteilung und Facility-Management. Eine Großübung und ein Tutorium bieten Unterstützungsmöglichkeiten. Der „kumulierte Erfolgswert" stellt innerhalb des PS die Erfolgsgröße dar. Er setzt sich neben finanzmathematischen Größen aus Qualitätsindikatoren (wie Bekanntheitsgrad oder Produktivität) zusammen.

3 Erstellung von Analysegrößen

Es wird das allgemeine Vorgehen zur Erstellung der Analysegrößen für die Entscheidungsdaten des PS beschrieben. Danach werden konkrete Größen für den vorliegenden PS-Einsatz erstellt.

3.1 Vorgehensmodell

Abbildung 1 verdeutlicht das eigene Vorgehen zur Erstellung der Analysegrößen. Es wird der Anspruch erhoben, dass das Vorgehen auf andere PS-Kontexte übertragbar ist.

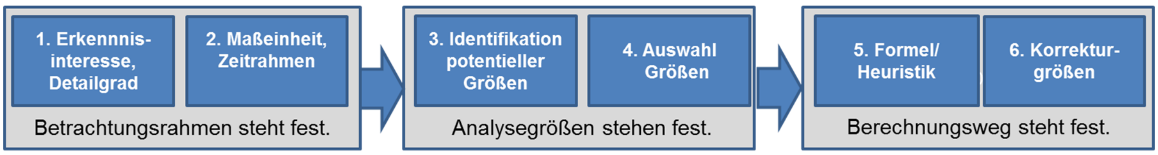

Abbildung 1 - Vorgehen bei der Konstruktion der Fehlergrößen

Die Konstruktion der Analysegrößen erfolgt in drei Blöcken mit jeweils zwei Prozessschritten. Als Ergebnis von Abschnitt 1 steht der Betrachtungsrahmen der Untersuchung fest. In Abschnitt 2 werden die zu erhebenden Analysegrößen festgelegt und in Abschnitt 3 operationalisiert.

Schritt 1 stellt die Zielformulierung dar. Hier ist der Zweck und benötigte Detailgrad der Untersuchung festzulegen. Es ist zwischen einer statischen und dynamischen Betrachtung zu unterscheiden. Wie eingangs erwähnt, ermöglichen statische Grenzen oft nur eine ungenaue

Beschreibung in PS. Allerdings ist die Gestaltung dynamischer Größen aufwendiger, indem weitere Faktoren – wie bspw. die relative Stellung im Markt – einbezogen werden müssen. *Schritt 2* besteht darin, die Maßeinheit für die Analysegrößen und den zeitlichen Betrachtungsrahmen festzulegen. Wenn einzelne Größen in Beziehung zueinander gesetzt werden sollen, ist Wert auf eine gemeinsame Skala zu legen.

In *Schritt 3* werden potentielle Analysegrößen identifiziert. Hierbei können didaktische Ziele aus der Konzeptionsphase eines PS, Praxiserfahrungen oder eine Analyse der einzelnen PS-Inhalte als Quellen dienen. In *Schritt 4* erfolgt die Auswahl der Größen. Der potentielle Erkenntnisgewinn und die Möglichkeiten zur Messung sind hier abzuwägen.

In *Schritt 5* wird die Formel oder Heuristik zur Bestimmung der Größen festgelegt. In *Schritt 6* ist bei Bedarf eine Erweiterung um Korrekturgrößen vorzunehmen. Bei einer dynamischen Betrachtung können diese bspw. die Stellung im Markt abbilden. Ggf. sind zwischen den Analysegrößen Interaktionseffekte (z. B. Opportunitätskosten) zu berücksichtigen.

Unter 3.2 und 3.3 wird das Vorgehensmodell zur Erstellung von Analysegrößen für den vorliegenden Anwendungsfall genutzt und die Anwendung dabei noch einmal verdeutlicht.

3.2 Anwendung des Vorgehensmodells auf den vorliegenden Anwendungsfall: Schritt 1-2

Schritt 1: Anknüpfend an die Zielsetzung der vorliegenden PS-Veranstaltung (vgl. 2) wird das Auftreten und Zusammenspiel von Fehlern auf der Fachkompetenzebene als Erkenntnisinteresse festgelegt. Als Analyseeinheiten sollen Fehlergrößen für die einzelnen Entscheidungsbereiche des PS erstellt werden. Da aufgrund der Breite der Untersuchung nur einzelne Größen je Bereich erfasst werden können, sollen diese möglichst repräsentativ sein und so exakt wie möglich gemessen werden. Es wird sich daher für eine dynamische Betrachtung entschieden.

Schritt 2: Da die Vergleichbarkeit der Fehlergrößen von explizitem Interesse ist, kommt einer gemeinsamen Skala eine hohe Bedeutung zu. Der durch eine nicht optimale Entscheidung vermeidbare monetäre Verlust wird als Skala ausgewählt. Als Vergleichswert wird der kumulierte Erfolgswert herangezogen. Nachteilig anzumerken ist, dass dieser selbst bei Fehlentscheidungen stets Positiveffekte miterfasst. Überhöhte Vertriebsausgaben können bspw. gleichzeitig zu einem steigenden Bekanntheitsgrad führen, was als zukünftiges Potential des Unternehmens den Erfolgswert erhöht. Es ist demnach davon auszugehen, dass sich einzelne Zusammenhänge ggf. abgeschwächt zeigen. Die Fehlergrößen sollen auf eine Periode bezogen werden. Da keine weitere Unterteilung der Perioden im PS stattfindet, bietet diese Einteilung die größtmögliche Präzision. Gleichzeitig stellt sie auch auf zeitlicher Ebene die Vergleichbarkeit der Fehlergrößen sicher.

3.3 Anwendung des Vorgehensmodells auf den vorliegenden Anwendungsfall: Schritt 3-6

Da der Betrachtungsrahmen eine entsprechende Strukturierung vorsieht, werden die Schritte 3-6 abteilungsspezifisch durchlaufen. Für den Personalbereich erfolgt exemplarisch eine detaillierte Darstellung. Die weiteren Fehlergrößen werden aus Platzgründen im Überblick zusammengefasst.

3.3.1 Detaillierte Darstellung am Beispiel des Personalbereichs

Schritt 3: Da aus Praxisbeobachtungen und der Konzeptionsphase des PS keine Fehlergrößen für den Personalbereich abgeleitet werden können, erfolgt die Identifikation in Anlehnung an die zu treffenden Entscheidungsgrößen im PS. Tabelle 1 stellt diese in der Übersicht dar:

Entscheidungsgröße	Einschränkung für Nutzung als Fehlergröße, Anmerkung
MA-Bestand Produktion	Keine
MA-Bestand Vertrieb	Automatische Berücksichtigung der Fluktuation (Eingabe Endbestand MA), als Wirkung auf Kundenzufriedenheit nicht monetär messbar
MA-Bestand F&E	Automatische Berücksichtigung der Fluktuation (Eingabe Endbestand MA), entspräche Beurteilung der Forschungsausgaben
Trainingsausgaben Produktion	Erst ab Periode 3 (nach1/3 des PS) verfügbar, fließt indirekt in die Personalbestandsplanung ein
Trainingsausgaben Vertrieb	
Lohnnebenkosten	

Tabelle 1 - Identifikation Fehlergrößen im Personalbereich

Schritt 4: Die Personalbestandsplanung Produktion wird als Fehlergröße ausgewählt, da sie über die manuelle Einstellung und Entlassung von MitarbeiterInnen (MA) die größten Anforderungen stellt und dabei auch die Notwendigkeit zu einer angemessenen Fluktuations- und Produktivitätsplanung beinhaltet. Damit bietet sie insbes. in der Breite eine bestmögliche Abdeckung des Personalbereichs. Eine monetäre Quantifizierbarkeit ist gegeben (vgl. Schritt 5).

Schritt 5: Gemessen werden sollen die Kosten für Kapazitätsüberlastungen oder für nicht genutzte Einheiten. Dabei sind drei Fälle zu unterscheiden: 1. angemessene Auslastung (95 % -100 %), 2. zu hohe Auslastung (> 100 %), 3. zu niedrige Auslastung (< 95 %). Bei einer angemessenen Auslastung (Fall 2) wird ein Toleranzbereich von 5 % angenommen, da es bei einem vorrübergehenden Nachfragerückgang sinnvoll sein kann, MA mit hoher Produktivität zu halten. Der Toleranzbereich wird eng bemessen, da Praxiserfahrungen zeigen, dass auch in diesen Fällen andere Maßnahmen (z. B. Preissenkung) ökonomisch vorteilhafter sind.

Werden die Produktionskapazitäten überschritten (Fall 2), fallen im PS Kosten für ZeitarbeiterInnen (ZA) an. Das Gehalt von ZA übersteigt das von regulären MA selbst dann, wenn Einstellungs- und Entlassungskosten einbezogen werden. Die Nutzung von ZA ist demnach grundsätzlich nachteilig. Es wird zudem davon ausgegangen, dass bei einer bestehenden Überlastung die MA auch in Folgeperioden zur Wertschöpfung beitragen können, so dass Einstellungs- und Entlassungskosten nicht berücksichtigt werden sollen. Die Fehlergröße für eine Überlastung des Personals wird demnach gemäß folgender Formel berechnet:
*(Gehalt ZA - Gehalt regulärer MA) * (benötigte Anzahl ZA)*.

Unterlastungen (Fall 3) stellen ein nicht genutztes Potential dar. Es ist möglich diese selbst bei Differenzierungsstrategien dauerhaft zu vermeiden, da das Marktvolumen über das gesamte PS deutlich steigt. Die Fehlergröße für eine Unterlastung wird gemäß folgender Formel bestimmt: *(Gehalt regulärer MA) * (Anteil ungenutzter Produktionskapazitäten - 5 %)*.

Schritt 6: Die Formeln erfassen bereits Gehaltsveränderungen. Weitere dynamische Faktoren sind nicht zu berücksichtigen. Das Hinzufügen von Korrekturgrößen ist nicht erforderlich.

3.3.2 Überblick weitere Fehlergrößen

Analog zu dem in 3.2.1 dargestellten Vorgehen wurden auch die weiteren Fehlergrößen operationalisiert. Tabelle 2 gibt einen Überblick über die einzelnen Entscheidungsbereiche und Fehlergrößen. Die Gesamtfehlergröße eines Unternehmensbereichs ergibt sich ggf. in Addition der Teilformeln a bis c (vgl. Spalte 2). In der dritten Spalte sind eine kurze Begründung für die Auswahl der entsprechenden Größe und zentrale Aspekte der Gestaltung genannt.

Bereich	Fehlergrößen	Auswahlbegründung, Gestaltungsaspekte
Personal	Mehrkosten durch... a) Unterlastung Fertigungs-MA b) Überlastung Fertigungs-MA	Implizite Berücksichtigung der Trainingsausgaben und Lohnnebenkosten ermöglicht breiten Querschnitt
Produktion	Mehrkosten durch… a) Unterlastung Maschinenkapazitäten b) Überlastung Maschinenkapazitäten	Implizite Berücksichtigung der Kapazitätsplanung (→ Maschinenkauf) ermöglicht breiten Querschnitt
Einkauf	Maximal mögliche Ersparnis durch… a) Nutzung von Mengenstaffeln, Berücksichtigung von Lager- und Kapitalbindungskosten b) Vermeidung von Einzelbestellungen	- Auswahl zentraler Entscheidungsgröße - Um Vergleichbarkeit zu anderen Größen zu erhalten, Beschränkung auf eine Periode - Beschränkung auf Produkt 1, da Angebot von Produkt 2 erst ab Periode 3 möglich
F & E	Mehrkosten durch Überhöhte Forschungsausgaben Beurteilung entlang Forschungsintensität	- Praxisbeobachtungen ergaben überhöhte F&E Ausgaben als weitereichendes Problem - Einsatz einer Korrekturgröße in Abhängigkeit von technologischer Stellung im Markt
Vertrieb	Mehrkosten durch… Überhöhte Werbeausgaben Beurteilung entlang Werbeintensität	- Analoge Gestaltung zu Forschungsbereich - Einsatz einer Korrekturgröße in Abhängigkeit von rel. Bekanntheit im Markt
Finanzen	Mehrkosten durch… a) Nicht benötigte Kredite b) Überziehungskredite Entgangener Ertrag aus… c) Anlage liquider Mittel	- Abbildung Kassenbestandsrechnung, die nach Praxisbeobachtungen guten Indikator für Verständnis im Finanzbereich darstellt - Überziehungskredite nachteilig: kurzfristige Kredite werden mit gleicher Laufzeit ohne Limit und geringerem Zinssatz eingeräumt
Unternehmens-führung/ Strategie	Konsistente Anwendung von… a) Differenzierungsstrategie (rel. Technologieindex, Preis, rel. Kundenzufriedenheit) b) Kostenfüherschaftsstrategie (Herstellkosten, Preis, Marktanteil)	- Formulierung als monetäre Fehlergröße nicht möglich - Erfüllungsgrad der Strategie auf Basis einer Nutzwertanalyse mit den in Klammern angegebenen Faktoren, erste beiden Faktoren jeweils doppelt gewichtet

Tabelle 2 - Übersicht Fehlergrößen

Hervorzuheben ist, dass in den Bereichen der Forschung und des Vertriebs Korrekturgrößen in Abhängigkeit von der Marktstellung des jeweiligen Unternehmens zum Einsatz kommen. Im Einkauf werden Opportunitätskosten in der Beschaffung sämtlicher Komponenten berücksichtigt. Aufgrund des ggf. deutlich erhöhten Kapitalbedarfs bei Nutzung einer Mengenstaffel sind zudem mögliche Kosten durch die Verteuerung bestehender Kredite einbezogen. Im Bereich der Strategie konnte keine monetäre Fehlergröße identifiziert werden. Daher wurden auf Basis einer Nutzwertanalyse mit jeweils drei Faktoren zwei Positivindikatoren formuliert, die das konsistente Verfolgen einer Differenzierungs- (DFS) oder Kostenführerschaftsstrategie (KFS) abbilden.

Da keine Leistungsbeurteilung erfolgen soll und vielmehr die einzelnen Fehlergrößen und ihre Zusammenhänge von Interesse sind, ist eine Gesamtfehlergröße je Unternehmen nicht erforderlich. Auf die Ermittlung bereichsübergreifender Opportunitätskosten wird daher verzichtet. Für kurz- und mittelfristige strategische Ziele wird ebenfalls von einer Korrektur abgesehen, da diese anhand der Daten nicht unmittelbar abgeleitet werden können und potentiell interpretationsbedürftig bleiben. Durch den Verzicht auf Opportunitätskosten und kurzfristige strategische Effekte sind die konzipierten Fehlergrößen lediglich als Indikatoren zu verstehen.

4 Datenauswertung

Die Datenauswertung beruht auf sämtlichen PS-Daten, die in fünf Durchläufen vom Sommersemester (SoSe) 2012 bis 2014 gesammelt wurden. Da die Daten im Rahmen der Durchführung einer regulären Lehrveranstaltung gesammelt wurden, liegt keine Laborumgebung vor. Die am Konzept vorgenommen Änderungen wurden zentral koordiniert und festgehalten. Dennoch kann nicht ausgeschlossen werden, dass weitere externe Faktoren Einfluss auf die TeilnehmerInnen und ihr Spielverhalten besaßen. Da der PS-Einsatz im Rahmen eines Pflichtmoduls erfolgte, ist von einer hohen Motivation der TeilnehmerInnen auszugehen. Um auf Seiten des PS eine hohe Vergleichbarkeit sicherzustellen, wird die Analyse auf den Zeitraum bis inkl. SoSe 14 begrenzt, da zum Wintersemester (WiSe) 14/15 eine größere Anpassung erfolgte. Lediglich unter 4.3 werden im Zuge der Evaluation einzelner Anpassungen ausgewählte Daten des WiSe 14/15 und SoeSe 15 thematisiert, wobei relevante Anpassungen hervorgehoben werden. Alle Zahlenwerte stellen tatsächliche Spielergebnisse dar.

Der Kernuntersuchung vom SoSe 12 bis SoSe 14 liegen bereinigt 363 Datensätze zu Grunde. Ein Datensatz entspricht einem Team, das das PS über sechs Perioden bestritt. Unvollständige Datensätze bzw. Datensätze von Unternehmen, die vor der letzten Periode insolvent gingen, wurden nicht berücksichtigt. Da diesen Teams bis inkl. Periode 4 ein Neustart ermöglicht wurde, wären diese sonst doppelt vertreten gewesen. 42 Datensätze wurden ausgeschlossen, 36 davon sind als neugestartete Teams an anderer Stelle erfasst. Für die Detailauswertungen in 3.3. wurden nach gleichem Verfahren weitere 222 Datensätze aus dem WiSe 14/15 und SoSe 15 erfasst und Datensätze von drei Teams vollständig ausgeschlossen.

4.1 Wirksamkeit

Um die Wirksamkeit der operationalisierten Fehler zu überprüfen, wird zunächst für die monetären Indikatoren die Korrelation zum Erfolgswert bestimmt (vgl. Abbildung 2).

		Personal	Produktion	Einkauf	Forschung	Vertrieb	Finanzen	DFS	KFS	Erfolgswert
Erfolgswert	Pearson Correlation	-,250**	-,243**	-,104*	,089	-,155**	-,317**	,593**	,047	1
	Sig. (2-tailed)	,000	,000	,048	,091	,003	,000	,000	,374	

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Abbildung 2 - Wirkung monetärer Indikatoren auf Erfolgswert

Es zeigt sich, dass sämtliche Indikatoren erwartungskonform – mit Ausnahme des Bereichs der Forschung – eine signifikant negative Korrelation auf den Erfolgswert aufweisen. Die stärksten Korrelationen ergeben sich für den Personal- und Finanzbereich. Für den Forschungsindikator zeigt sich hingegen eine leicht positive Korrelation. Auf die einzelnen Ausprägungen wird unter 4.2 weiter eingegangen. Um sicherzustellen, dass über die einzelnen Fehlergrößen nicht nur eine Minderheit der TeilnehmerInnen erfasst wird, werden zunächst die absoluten Fehlerhöhen überprüft. Es werden dazu vier Intervalle gebildet, die in Abbildung 3 veranschaulicht sind.

Die Fehlerhöhen werden in Summe für alle Perioden aufgeführt. Demnach entspricht das größte Intervall (> 600.000 €) einem Fehler von im Durchschnitt 100.000 € je Periode. Es zeigt sich, dass die Indikatoren einen repräsentativen Teil der TeilnehmerInnen erfassen. Der Anteil von Teams mit Fehlerwerten liegt bei allen Indikatoren bei mindestens 42,7 %, im Mittelwert sogar bei 81,5 %. Bereits feine Fehlentscheidungen werden demnach erkannt. In den Bereichen Forschung und Vertrieb ist zu berücksichtigen, dass relativ überhöhte Ausgaben erhoben wurden, was die Quote fehlerfreier Teams nahe 50 % erklärt. Mit Ausnahme des Forschungsindikators konnte die Wirksamkeit der monetären Indikatoren damit bestätigt werden.

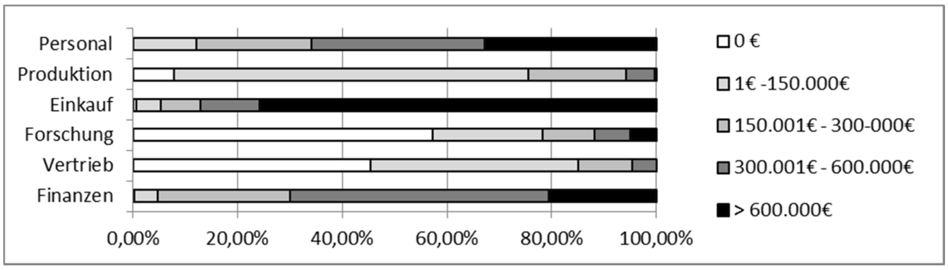

Abbildung 3 - Verteilung absoluter Fehlerhöhen

Bemerkenswert ist, dass es mit den Bereichen Personal, Einkauf und Finanzen drei Bereiche gibt, in denen kaum ein Team über die sechs Perioden fehlerfrei blieb. Hervorzuheben ist ferner der Bereich des Einkaufs, in dem die deutlich größten Fehlersummen zu beobachten sind.

Bei den Indikatoren für das Verfolgen einer Unternehmensstrategie ergeben sich wie erwartet positive Korrelationen zum Erfolgswert. Allerdings fällt die Korrelation für den Bereich der KFS nicht signifikant aus. Der Umstand, dass der Technologieindex als zukünftiges Potential des Unternehmens stark gewichtet in den Erfolgswert einfließt und im Rahmen einer KFS nur eine untergeordnete Rolle spielt, kann hier zumindest anteilig als Erklärung dienen. Zudem zeigt sich eine ungleiche Verteilung der Strategien als Grundproblem der Untersuchung: Ausgehend von einer Strategieausprägung von mindestens einem Punkt im Durchschnitt (= mittlere Ausprägung) zeigt sich, dass 46,0 % der Unternehmen eine DFS und nur 8,5 % eine KFS aufweisen.

4.2 Einzelübersicht Zusammenhänge der Indikatoren

Abbildung 4 stellt die Zusammenhänge der einzelnen monetären Fehlergrößen dar. Aus Platzgründen wird sich in der weiteren Darstellung auf zentrale Ergebnisse beschränkt.

		Personal	Produktion	Einkauf	Forschung	Vertrieb	Finanzen	DFS	KFS	Erfolgswert
Personal	Pearson Correlation	1	,334**	,124*	,012	,161**	,185**	,028	-,217**	-,250**
	Sig. (2-tailed)		,000	,019	,826	,002	,000	,596	,000	,000
Produktion	Pearson Correlation	,334**	1	,035	-,073	,081	,260**	-,125*	-,072	-,243**
	Sig. (2-tailed)	,000		,509	,166	,125	,000	,017	,172	,000
Einkauf	Pearson Correlation	,124*	,035	1	-,025	-,051	-,035	,028	-,619**	-,104*
	Sig. (2-tailed)	,019	,509		,636	,329	,502	,591	,000	,048
Forschung	Pearson Correlation	,012	-,073	-,025	1	,057	-,043	,364**	-,091	,089
	Sig. (2-tailed)	,826	,166	,636		,276	,411	,000	,085	,091
Vertrieb	Pearson Correlation	,161**	,081	-,051	,057	1	,090	-,013	-,075	-,155**
	Sig. (2-tailed)	,002	,125	,329	,276		,088	,810	,154	,003
Finanzen	Pearson Correlation	,185**	,260**	-,035	-,043	,090	1	-,143**	-,025	-,317**
	Sig. (2-tailed)	,000	,000	,502	,411	,088		,006	,631	,000
DFS	Pearson Correlation	,028	-,125*	,028	,364**	-,013	-,143**	1	-,252**	,593**
	Sig. (2-tailed)	,596	,017	,591	,000	,810	,006		,000	,000
KFS	Pearson Correlation	-,217**	-,072	-,619**	-,091	-,075	-,025	-,252**	1	,047
	Sig. (2-tailed)	,000	,172	,000	,085	,154	,631	,000		,374
Erfolgswert	Pearson Correlation	-,250**	-,243**	-,104*	,089	-,155**	-,317**	,593**	,047	1
	Sig. (2-tailed)	,000	,000	,048	,091	,003	,000	,000	,374	

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Abbildung 4 – Korrelationen Fehlerindikatoren

Die Indikatoren der Personal- und Produktionsauslastung korrelieren erwartungskonform eng miteinander. Interessant ist, dass die Fehlergröße der Personalplanung – abgesehen vom Bereich der Forschung – signifikant mit allen weiteren Größen korreliert. Eine Erklärung könnte in der Annahme eines gemeinsamen Konstrukts aus Fähigkeit zur periodenübergreifenden Planung und der Bereitschaft liegen, entsprechende Berechnungen vorzunehmen. Dieses wäre an anderer Stelle weiter zu untersuchen.

Bemerkenswert ist die geringe Korrelation des Fehlerindikators im Einkauf mit anderen monetären Fehlerindikatoren, obwohl dieser Bereich wie dargestellt die mit Abstand höchsten Fehlerwerte aufweist. Mögliche Korrelationen abschwächen könnte allerdings der Umstand, dass erfolgreiche wie wenig erfolgreiche Teams z. T. hohe Fehlergrößen aufweisen (vgl. Abbildung 3). Dieses könnte auch die vergleichsweise geringe Korrelation mit dem Erfolgswert erklären.

Bei den Indikatoren für Forschung und Vertrieb ist die gegenseitige fehlende Korrelation auffällig, da beide analog zueinander konstruiert wurden und jeweils auf überhöhte Budgetentscheidungen abzielen. Bei einer Analyse der Fehlerhöhen je Periode verstärkt sich dieser Eindruck: Während nach der dritten Periode im Vertriebsbereich ein Absinken überhöhter Ausgaben und damit ein Lerneffekt sichtbar wird, steigen die Ausgaben im Bereich der Forschung kontinuierlich weiter an. Dieses bestätigt Praxisbeobachtungen, nach denen z. T. ganze Märkte aufgrund zu hoher Investitionen in die Verlustzone gerieten. Die Gründe wären an anderer Stelle detaillierter zu analysieren. Ansatzpunkte könnten in der spielerischen Komponente des PS (= Ziel, den Mitspieler zu übertrumpfen), der Durchführung im ersten Semester (= isolierte Betrachtung, Versuch dominante Strategie zu übernehmen), einer grundsätzlichen Präferenz der DFS (Teams geben häufig die Orientierung an Premiummarken an) oder Informationen aus Vorsemestern (Studierende übernehmen z. T. unreflektiert vermeintlich erfolgreiche Strategien aus Vorsemestern) liegen. Der Mangel an Reflektion der überhöhten Forschungsausgaben insgesamt stellt derweil die wahrscheinlichste Erklärung für die eingeschränkte Funktionalität des relativ zum Marktgeschehen konstruierten F&E Indikators dar.

Beim Zerlegen des Indikators im Personal- bzw. im Produktionsbereich entfallen 60,7 % bzw. 56,0 % der Fehlerhöhen auf eine Unterlastung und 30,3 % bzw. 34 % auf eine Überlastung. Da Überlastungen im PS kostenintensiver als Unterlastungen sind, deutet dieses auf eine defensive Planung der TeilnehmerInnen hin. Unterstützt wird dieser Befund bei einer Zerlegung der Fehlergrößen im Finanzbereich. Hier entfallen 24,7 % auf einen vermeidbaren Überziehungskredit, 28,2 % auf Zinsen für nicht benötigte Kredite, aber 47,1 % auf nicht genutzte Zinserträge durch die Anlage überschüssiger liquider Mittel. Eine mögliche Erklärung könnte auch hier in der Probandengruppe der Erstsemester liegen.

Das Verfolgen einer konsistenen Strategie wirkt sich wie erwartet insgesamt positiv auf die weiteren Fehlerindikatoren aus. Während sich für eine KFS durchgängig Negativkorrelationen zu anderen Fehlergrößen zeigen, sind für DFS die Fehlergrößen in den Bereichen Personal und Einkauf geringfügig und für den Bereich der Forschung signifikant erhöht. Bei erfolgreichen KFS scheint demnach eine exaktere Ressourcenplanung in diesen Bereichen zu erfolgen. Dieses ist plausibel, indem KFS i. d. R. mit einem höheren Rechenaufwand verbunden sind: Mengenstaffeln müssen genutzt, Maschinen- und Personalkapazitäten erhöht werden und bei Absatzschwankungen entstehen potenziell größere Fehl- oder Lagermengen. Dieser höhere Schwierigkeitsgrad könnte auch die niedrige Anzahl erfolgreicher KFS-Umsetzungen erklären.

4.3 Steuerungsmöglichkeiten

Im Folgenden wird anhand von zwei Beispielen dargestellt, wie die Analyse von Entscheidungsdaten konkret zur Verbesserung von PS-Veranstaltungen beitragen kann.

Über die Strategieindikatoren wurde erfasst, ob die Teams ihre Entscheidungen konsistent gemäß einer Strategie ausrichten. Wie dargestellt, zeigte sich ein deutlicher Mangel an erfolgreichen KFS und eine deutliche Dominanz der DFS. Dieses beeinträchtigt die Dynamik des Marktgeschehens, wenn im Extremfall alle Unternehmen identisch am Markt positioniert sind. In der Analyse des Forschungsindikators wurde analog deutlich, dass sich zahlreiche Teams überhöhte Forschungsausgaben erlauben.

Diese Befunde bestätigen Praxisbeobachtungen, die bereits im SoSe 12 eine Dominanz der DFS konstatierten. Daher wurden bereits ab dem WiSe 12/13 Anpassungen vorgenommen, um die Nutzung der KFS zu fördern. Da die Ergebnisse der Datenauswertung zu diesem Zeitpunkt nicht vorlagen, erfolgten die Anpassungen unstrukturiert entlang inhaltlicher Wirkungszusammenhänge: Die Wirkung der Forschungsausgaben wurde abgeschwächt und Forschungsresultate somit indirekt verteuert, um die Nutzung anderer Instrumente zur Abgrenzung – wie den Preis – zu fördern. Parallel wurden erfolgreiche KFS in der Großübung thematisiert, um deren Akzeptanz zu erhöhen. Ferner wurden die Gehälter für Forschungs-MA erhöht, um die Forschungsresultate nun auch sichtbar zu verteuern. Außerdem wurde der Basispreis angehoben, um allgemein ein größeres Potential für Preissenkungen und höhere Gewinnmargen auch bei niedrigpreisigen Strategien zu ermöglichen. Die Analyse der Entscheidungsdaten ermöglicht nun rückwirkend die Evaluation dieser Anpassungen: Es zeigt sich, dass die Zahl erfolgreicher KFS-Umsetzungen nicht wie gewünscht erhöht werden konnte. Mit Ausnahme des WiSe 12/13 (4,3 %) wurde die KFS nahezu stabil von lediglich 9,8 % bis 11,2 % der Studierenden erfolgreich umgesetzt.

Gleichzeitig lieferte die strukturierte Analyse der Entscheidungsdaten einen neuen Ansatz zur Anpassung des PS. Aufbauend auf der beidseitig signifikanten Korrelation zwischen den Indikatoren im Einkaufsbereich und der KFS wurde das Ziel formuliert, über die Förderung der Nutzung von Mengenstaffeln auch die Nutzung der KFS zu erhöhen. Der Preisvorteil und die Grenzen zur Nutzung der Mengenstaffeln wurden daher zum SoSe 15 angehoben, um den Anreiz und Vorteil für Unternehmen mit hohen Absatzvolumina zu vergrößern. Eine erste Auswertung des aktuellen Semesters legt nahe, dass die Anpassung erfolgreich war: Die Zahl erfolgreicher KFS stieg auf 14,9 %. Die Anpassung zeigte demnach einen höheren Effekt als alle vorigen zusammen. Es wird deutlich, wie die strukturierte Analyse von Wirkungszusammenhängen genutzt werden kann, um die Parametrisierung von Planspielen zu verbessern.

Das zweite Beispiel verdeutlicht, wie die Analyse aktueller Entscheidungsdaten im Vergleich mit Referenzdaten genutzt werden kann, um das PS selbst zu verbessern: Die Analyse der Forschungsausgaben zeigte vom WiSe 13/14 auf das SoSe 14 einen sprunghaften Anstieg von 23 % der überhöhten Ausgaben auf den mit Abstand höchsten Wert seit Beginn der Messung. Auch die absoluten Ausgaben stiegen deutlich an. Gleichzeitig ergaben sich durch andere Indikatoren keine Anhaltspunkte für eine Änderung im grundsätzlichen Spielverhalten der TeilnehmerInnen. Der Anteil an Teams mit KFS nahm sogar leicht zu. Auch Änderungen in der Parametrisierung oder in der Begleitung durch Großübung und Tutorium konnten den Anstieg nicht erklären. Der Blick richtete sich daher auf eine Anpassung an der PS-Oberfläche. Hier waren Freitexteingaben durch Schiebregler ersetzt worden, um die Usability für mobile Endgeräte zu erhöhen. Der Maximalwert des Reglers war deutlich oberhalb des sinnvollen Bereichs gewählt worden, um keine Anhaltspunkte für eine zielführende Lösung zu bieten. Obwohl dieses aktiv kommuniziert worden war, ergab eine Analyse der einzelnen Eingaben, dass zahlreiche Teams offenbar trotzdem zumindest eine mittlere Position des Reglers (= bereits überhöhter Wert) oder sogar Stellung nahe des Maximalwerts (= stark überhöhter Wert) genutzt hatten. Die Gestaltung des Reglers schien damit Einfluss auf die Budgetentscheidung der Teams zu entfalten. Bereits zum SoSe 15 wurden die Schiebregler daraufhin durch den PS-Anbieter wieder entfernt. Erste Auswertungen für das SoSe 15 zeigen, dass die absoluten Forschungsausgaben tatsächlich wieder auf ihr vorheriges Niveau zurückgingen.

Die dargestellten Beispiele verdeutlichen, wie die Analyse der Entscheidungsdaten zur Verbesserung des Gesamtkonzepts von PS-Veranstaltungen beitragen kann. In der Evaluation getroffener Anpassungen, dem Aufdecken von Wirkungszusammenhängen zwischen Entscheidungsbereichen und der Verfügbarkeit durchgängiger Referenzdaten werden der Spielleitung Unterstützungswerkzeuge bereitgestellt, um deutlich zielgerichtetere und präzisere Anpassungen am PS vorzunehmen als in der Vergangenheit.

Allein der Aspekt einer validen Evaluation darf in seiner Wirkung nicht unterschätzt werden, da er nicht auf das Planspiel selbst beschränkt ist und bspw. auch Veränderungen in der Betreuung einschließt. Eine Anpassung der Großübung im WiSe 12/13 sowie der Tutorien zum SoSe 13 zur Reduktion von Verständnisschwächen im Finanzbereich konnte so bspw. anhand deutlich sinkender Fehlergrößen als erfolgreich bestätigt werden. Gleichzeitig zeigte sich, dass die Anpassung des Tutoriums größeren Einfluss auf das Absinken der Fehlerhöhen besaß. Eine wichtige Stärke der dargestellten Methode liegt zudem darin, dass im Perioden- und Semesterquerschnitt trennscharf zwischen punktuell auftretenden Fehlern und dauerhaften Verständnislücken unterschieden werden kann. Dieses ist wie eingangs erwähnt eine Grundvorrausetzung für wirkungsvolle Unterstützungsmaßnahmen im PS-Kontext, da das Lernen aus Fehlern immanenter Bestandteil der Methode selbst ist.

5 Diskussion

In Hinblick auf Forschungsfrage 1 wurde in Abschnitt 3 ein allgemeines Verfahren zur Konzeption von Analysegrößen für Entscheidungsdaten in PS vorgestellt. Dieses wurde zur Erstellung der Fehlerindikatoren für den in Abschnitt 2 beschriebenen Anwendungsfall einer großzahligen IT-gestützten Planspielveranstaltung genutzt. Um der Dynamik des PS gerecht zu werden, wurden die Indikatoren z. T. mit Korrekturgrößen ausgestattet. In Abschnitt 4 konnten fünf der sechs operationalisierten monetären Fehlerindikatoren als wirksam beurteilt werden.

In Bezug auf Forschungsfrage 2 wurde unter 4.3 an zwei konkreten Beispielen aufgezeigt, wie die Analyse von Entscheidungsdaten über die Evaluation vorheriger Anpassungen, das Aufdecken von Wirkungszusammenhängen sowie die Verfügbarkeit von Referenzdaten die Verbesserung des Gesamtkonzepts von PS unterstützen kann. Weiterer Vorteil der vorgestellten Methode ist, dass sie die wichtige Unterscheidung zwischen punktuell und nachhaltig auftretenden Fehlern erlaubt.

Perspektivisch könnte die vorgestellte Analyse Anpassungen direkt während des PS ermöglichen. DozentInnen könnten relevante Fehler frühzeitig erkennen und zielgerichtet thematisieren. Darüber hinaus könnten zur Durchführung erhobene Daten eine adaptive Hilfe oder automatisierte Niveauanpassung des PS entlang zuvor definierter Regeln ermöglichen.

Für die Forschung könnten die gewonnen Daten bspw. im Bereich der Psychologie oder Verhaltensforschung genutzt werden. Die auffällige Dominanz der Differenzierungs- über die Kostenführerschaftsstrategie oder der Einfluss der Schiebregler auf die Forschungsausgaben könnten hier bspw. Ansatzpunkte darstellen. Auch für andere Forschungsbereiche könnten entsprechende Analysen von Interesse sein. Eine erste Analyse von Kontextfaktoren in Wechselwirkung mit den Fehlerindikatoren zeigte bspw. signifikante Unterschiede in der Höhe einzelner Fehlergrößen zwischen männlichen und weiblichen Studierenden.

Eine Grenze der vorgenommenen Analyse bleibt, dass bereichsübergreifende Opportunitätskosten und kurzfristige strategische Ziele nicht berücksichtigt wurden. Eine weitere Limitation besteht in der Auswahl der Fehlergrößen sowie der Bemessung der Korrekturgrößen und Toleranzbereiche. Auch wenn diese stets begründet erfolgten, verbleibt hier ein subjektiver Einfluss. Am Beispiel des Forschungsindikators zeigt sich die Schwierigkeit, einen Indikator zu operationalisieren, der dynamisch die Marktsituation und gleichzeitig ggf. ein irrationales Verhalten des gesamten Marktes berücksichtigen muss. Hier wäre der vorliegende Indikator ggf. wiederum um statische Konstrukte zu erweitern. In Bezug auf die semesterübergreifende Vergleichbarkeit der PS-Daten ist anzumerken, dass diese im Rahmen einer realen Lehrveranstaltung gesammelt wurden und nicht erfasste externe Einflussfaktoren nicht völlig ausgeschlossen werden können.

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Gestaltung einer nachhaltigen Online-Lernumgebung für Elektromobilität – Erfolgsfaktoren und Unterstützungsmöglichkeiten

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Abstract

Trotz zahlreicher Bemühungen von Politik und Wirtschaft konnte die angestrebte Marktdurchdringung mit Elektrofahrzeugen bisher nicht erreicht werden. Als ein wesentliches Hemmnis gilt der unzureichende Wissensstand in der Bevölkerung zu den verschiedenen Themen der Elektromobilität. Der methodisch geführte Aufbau einer umfassenden Wissensbasis kann diesem Defizit entgegenwirken. Dabei scheint der partizipative Kontext einer Online-Lernumgebung besonders geeignet für den Wissensaufbau zu neuen Technologien zu sein. Im Beitrag werden Erfolgsfaktoren identifiziert, auf deren Grundlage ein Konzept für eine solche Lernumgebung geschaffen wird. Dies beinhaltet auch den Einsatz von Analytics-Verfahren, um den Aufbau und den Betrieb der Wissensplattform zu begleiten und neue Erkenntnisse über Stakeholder der Elektromobilität zu gewinnen. Es wird zudem aufgezeigt, wie das Konzept auf der Plattform eMobilisten im Rahmen des BMBF-geförderten Projektes CODIFeY angewandt wird.

1 Einleitung

Bis zum Jahr 2020 soll sich Deutschland zu einem internationalen Leitmarkt für Elektromobilität entwickeln (Nationale Plattform Elektromobilität 2014). Trotz der steigenden Zahlen gemeldeter Elektrofahrzeuge (Statista 2015) geht die Marktdurchdringung weitaus langsamer vonstatten als angestrebt. Den Vorteilen der Elektrifizierung des Straßenverkehrs stehen Hemmnisse entgegen. Im Hinblick auf flexible Mobilitätsbedürfnisse wird bei Elektrofahrzeugen häufig eine Reihe von Einschränkungen (Reichweite, Transportkapazität, Kosten) subjektiv wahrgenommen. Ein weiteres starkes Hemmnis stellt die Verlustwahrnehmung dar, die sich auf antizipierte Bedürfnisse wie spontane Urlaubsfahrten bezieht (Peters und Dütschke 2011). Trotz einer insgesamt positiven Einstellung gegenüber der neuen Technologie (Statista 2012) bestehen erhebliche Unsicherheiten und Wissenslücken. So schätzen laut ECAR-Studie zur Akzeptanz der Elektromobilität (Bongard 2014) nur 25% der Befragten ihr Wissen zur Elektromobilität als „hoch“ oder „sehr hoch“ ein. Um eine zielführende Marktdurchdringung in Bezug auf die deutsche Energiewende und im Speziellen die Elektromobilität zu gewährleisten, gilt es, vorherrschende Hemmnisse zu überwinden und potentielle Nutzer mit dem notwendigen Wissen zu versorgen. Kenntnisse über die Wirkungsweisen und Möglichkeiten neuer Technologien können deren Wahrnehmung bezüglich Kosten, Risiken und Nutzen nachhaltig verändern (Huijts et al. 2012). Weiterhin kann Wissensaufbau einen positiven Beitrag zum Image von Elektromobilität leisten. So zeigen Srinivasan und Ratchford (1991) einen negativen Zusammenhang zwischen subjektivem Produktwissen und wahrgenommenem Risiko beim Autokauf. Dem folgend trägt gezielter Wissensaufbau dazu bei, die subjektiv wahrgenommenen Risiken der Elektromobilität zu senken und somit Unsicherheiten abzubauen. Ferner lässt sich durch den Aufbau von Wissen der Informationsaustausch zwischen verschiedenen Marktteilnehmern verbessern. Gerade im Bereich hochkomplexer Technologien, sind der Austausch von Wissen und die Vernetzung zwischen verschiedenen Akteuren relevant, da implizites Wissen bei der Etablierung von Marktstrukturen von großer Bedeutung ist (Sauer und Thielmann 2014). Peters et al. (2011) vermuten, dass u. a. Informationen über Nutzungskonzepte, Finanzierung und Alltagserfahrungen die letzten Hürden auf dem Weg zum Kauf eines Elektrofahrzeuges beseitigen können.

Die Aufklärung der Bevölkerung über Möglichkeiten und Facetten der Elektromobilität stellt eine wichtige Voraussetzung für ihre nachhaltige Etablierung dar (Fraunhofer-Institut IAO 2014). Durch den gezielten Einsatz von E-Learning als eine Möglichkeit der Vermittlung von Wissen zu Themen der Elektromobilität können Unsicherheiten in der Bevölkerung abgebaut werden. Um eine große Zahl von Nutzern für diesen Wissensaufbau zu gewinnen, muss die Lernumgebung möglichst attraktiv gestaltet und auf die Bedürfnisse und Interessen der Lernenden abgestimmt werden. Dies lässt durch den Einsatz von Analyseverfahren, so genannter Learning Analytics (LA), gewährleisten, welche Lernaktivitäten auswerten, und so den Wissensaufbau unterstützen und das Lernerlebnis der Nutzer verbessern. Wir fokussieren in diesem Beitrag auf die Gestaltung einer E-Learning Umgebung und beantworten die Fragen: (1) Welche Erfolgsfaktoren spielen bei der Implementierung einer Online-Lernumgebung für Elektromobilität eine Rolle und (2) Wie können diese durch den Einsatz von LA unterstützt werden. An dieser Problematik knüpft auch das vom BMBF geförderte Verbundprojekt CODIFeY – Community-basierte Dienstleistungs-Innovation für e-Mobility an, in dessen Kontext der vorliegende Beitrag eingebettet ist. Teil des Projektes ist der Aufbau einer Community-basierten Lernumgebung für Elektromobilität.

In Abschnitt 2 werden die Grundlagen des Community-basierten E-Learnings und der LA dargelegt. Anschließend wird das Projekt CODIFeY kurz vorgestellt und die diesem Beitrag zugrundeliegende Forschungsmethodik erläutert (Abschnitt 3). Die Herleitung der relevanten Erfolgsfaktoren und die Implikationen für die Implementierung von LA werden in Abschnitt 4 dargelegt, bevor eine Diskussion der Ergebnisse in Abschnitt 5 erfolgt. Den Schluss bilden eine Zusammenfassung und ein Ausblick auf die weiteren Entwicklungen des Wissensaufbaus im Projekt (Abschnitt 6).

2 Grundlagen

Um Empfehlungen für die Gestaltung einer E-Learning-Komponente für den Wissensaufbau zu neuen Technologien (am Beispiel Elektromobilität) hinsichtlich Lernumgebung und technischer Unterstützung (LA) abzuleiten, werden im folgenden Abschnitt die Grundlagen vermittelt.

2.1 Wissensaufbau im Umfeld einer Online Community

Aufgrund des Trends zu lebenslangem Lernen und die Zunahme medien-gestützter Lehransätze haben partizipative Lernumgebungen in den letzten Jahren zunehmend an Bedeutung gewonnen (Treeck et al. 2013). Die Öffnung des Lernprozesses durch die Schaffung einer Online Community gibt Nutzern die Möglichkeit, miteinander in Kontakt zu treten, gemeinsam zu lernen, Kompetenzen zu entwickeln oder auch selbst Inhalte zu erstellen (Bernhardt und Kirchner 2007). Dieser Ansatz ist besonders für den Wissensaufbau zu Elektromobilität geeignet, da sich ein breites Publikum unabhängig von Ort und Zeit über neue Technologien informieren kann, Erfahrungen systematisch dokumentiert und Informationsbewertungen angeboten werden. Zudem erleichtern Online Communities den Austausch von Wissen und Erfahrungen zwischen den Lernenden sowie zwischen Lernenden und Lehrenden. Die Akquise der Teilnehmer aus verschiedenen gesellschaftlichen Gruppen und darüber hinaus aus dem privatwirtschaftlichen Sektor ist dabei eine Herausforderung, welcher über individuelle, zielgruppenspezifische Wertbeiträge begegnet werden kann. Mit der Einführung von E-Learning sind allerdings oft weitreichende Erwartungen verbunden, die in Ernüchterung münden: „Die didaktische Innovationskraft der elektronischen Medien wird überschätzt und zugleich das Beharrungsvermögen der ‚alten Didaktik' unterschätzt" (Kremer et al. 2008, 1). Umso wichtiger ist es, die E-Learning Community nicht nur didaktisch ansprechend, sondern auch benutzerfreundlich zu gestalten, um Nutzer akquirieren und halten zu können und nachhaltiges Lernen anzustoßen. Es ergeben sich daher vielfältige Anforderungen, die mit der Gestaltung von innovativen E-Learning-Plattformen verbunden sind. In Anlehnung an Seufert und Meier (2013) lassen sich sechs Felder definieren, die sich um die zwei Pole „Kompetenzentwicklung Elektromobilität" und „Gestaltung von lern- und innovationsförderlichen Rahmenbedingungen" verteilen. Die Diskussion und die Ableitung von Erfolgsfaktoren aus den einzelnen Polen im Kontext von Online Communities erfolgt in den Abschnitten 4.1 und 4.2.

2.2 Learning Analytics

Die Unterstützung von Lernprozessen mittels computergestützter Analyseverfahren hat in den letzten Jahren an Bedeutung gewonnen. So werden LA im Horizon Report 2014 als wichtige Zukunftstechnologie für die Entwicklung der Lehre aufgeführt (Johnson 2014). Als Hauptursachen identifizieren Baker und Siemens (2014) die deutliche Erhöhung der zur Verfügung stehenden analysierbaren Lerndaten, standardisierte Datenformate, zunehmende Rechenleistung sowie die Entwicklung komplexer Analysewerkzeuge für große Datenmengen (Big Data). Laut Definition der 1st International Conference on Learning Analytics (vgl. u. a. Buckingham und Ferguson 2011; Chatti et al. 2012), umfassen LA „the measurement, collection, analysis, and reporting of data about learners and their contexts, for the purposes of understanding and optimizing learning and the environments in which it occurs" (https://tekri.athabascau.ca/analytics/). Neben LA beschäftigt sich auch der Forschungsbereich des Educational Data Mining (EDM) mit Datenanalysen im Bildungskontext. Dieser nutzt Methoden des Data Mining zur Identifikation von Mustern in großen Mengen von Lerndaten (Romero 2009). Die International Educational Data Mining Society definiert EDM als "an emerging discipline, concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings which they learn in" (http://www.educationaldatamining.org/). LA und EDM unterscheiden sich hinsichtlich ihrer akademischen Wurzeln und der eingesetzten Methoden, weisen jedoch viele Gemeinsamkeiten auf. Beide Ansätze nutzen datenintensive Analysemethoden zur Auswertung von Lerndaten und verfolgen das Ziel, Lernprozesse zu verbessern und das Verhalten von Lernenden zu ergründen (Siemens und Baker 2012). Im

Folgenden wird daher auf eine weiterführende Differenzierung verzichtet und LA als umfassender Begriff verstanden, welcher die Methoden des EDM mit einschließt. Im Kontext von Community-basiertem Lernen rücken neben den eigentlichen Lernprozessen auch soziale Aspekte in den Fokus von LA (Buckingham und Ferguson 2011). Untersuchungsgegenstand sind hier die Beziehungen und die Kommunikation der Akteure untereinander. So können durch die Auswertung von Netzwerkstrukturen und Diskussionen zusätzliche Erkenntnisse über die Interessen und Bedürfnisse von Lernenden gewonnen werden (Fournier et al. 2011). Die Implementierung von LA im Projektkontext wird in Abschnitt 4.3 dargelegt.

3 Projektkontext und Forschungsmethodik

Im Rahmen des Verbundprojektes CODIFeY wurde die Online-Plattform eMobilisten (https://www.emobilisten.de) entwickelt, mit deren Hilfe das Zusammenspiel von Wissensaufbau und Dienstleistungsinnovation zu neuen Technologien (am Beispiel Elektromobilität) ergründet werden soll. Daher verfolgt das Projekt zwei zentrale Zielstellungen. Der (1) systematische Aufbau von Wissen zur Elektromobilität mittels einer E-Learning-Komponente ermöglicht Plattformnutzern, Informationen zu verschiedenen Aspekten der Elektromobilität abzurufen und ihr Wissen zu erweitern. Weiterhin können Nutzer ihre Expertise auf dem Gebiet der Elektromobilität einbringen, indem sie selbst Lernkurse erstellen und mit der Community teilen. Das zweite Ziel ist die (2) kollaborative Entwicklung von Dienstleistungen zur Elektromobilität mit den Community-Mitgliedern im Sinne von Open Innovation. Die Plattformnutzer können hier Vorschläge zu spezifischen Ideenaufrufen (z. B.: Wie sieht die optimale Bezahl-App für das Laden von Elektroautos aus?) einbringen, kommentieren und bewerten. Diese Beiträge werden anschließend ausgewertet und in Workshops zu marktreifen Elektromobilitäts-Dienstleistungen weiterentwickelt. Wissensaufbau und Dienstleistungsinnovation agieren nicht isoliert, sondern unterstützen und befördern sich wechselseitig. Dieses Zusammenspiel soll durch die Analyse von Nutzeraktivitäten und Inhalten angeregt werden (Community Analytics). Dieser Beitrag fokussiert auf die Gestaltung des Wissensaufbaus auf der Online-Plattform eMobilisten und dem folgend auf die unterstützende Analyse von Lerndaten und –prozessen (LA).

Ausgehend von den eingangs genannten Forschungsfragen wird der gestaltungsorientierte Forschungsansatz des Design Science Research (Hevner et al. 2004) angewandt. Nach einer Darstellung der Relevanz des Themas und der Dringlichkeit des Problems (im Abschnitt 1) werden die Anforderungen an das zu schaffende Artefakt (Konzept einer nachhaltigen Lernumgebung als Teil einer Online Community zu Elektromobilität) in Abschnitt 4 umfassend hergeleitet. Auf dieser Grundlage erfolgt die Konkretisierung des Artefakts in Abschnitt 5. Dieses soll im Anschluss einer multi-methodischen Evaluation unterzogen werden. Im Mittelpunkt steht die Anwendung und Verprobung des Konzeptes im Rahmen des CODIFeY-Projektes auf der Plattform eMobilisten. Die Implementierung der LA soll ebenfalls zur Überprüfung von Teilen des Konzepts genutzt werden.

4 Erfolgsfaktoren für die Wissensvermittlung in Online Communities

Um Empfehlungen zum Wissensaufbau in Online Communities abzuleiten und Herausforderungen zu identifizieren, werden im Folgenden Implikationen für die nachhaltige Wissensvermittlung und die Implementierung von Erfolgsfaktoren erörtert. Erfolgsfaktoren sind in diesem Zusammenhang Kriterien, die den Aufbau langfristig abrufbaren Wissens in Online Communities gewährleisten.

Die nachfolgenden Ausführungen beziehen sich exemplarisch auf die Plattform eMobilisten, auf welcher Wissen zu Themen der Elektromobilität aufgebaut wird.

4.1 Kompetenzentwicklung im Kontext Elektromobilität

Um den Wissensaufbau für die eMobilisten-Plattform zu unterstützen, müssen nutzerseitig Kompetenzen zur Elektromobilität aufgebaut werden. Nachfolgend werden die Anforderungen an diese Kompetenzen, abgeleitet aus dem Modell von Seufert und Meinert (2013), diskutiert (vgl. Bild 1).

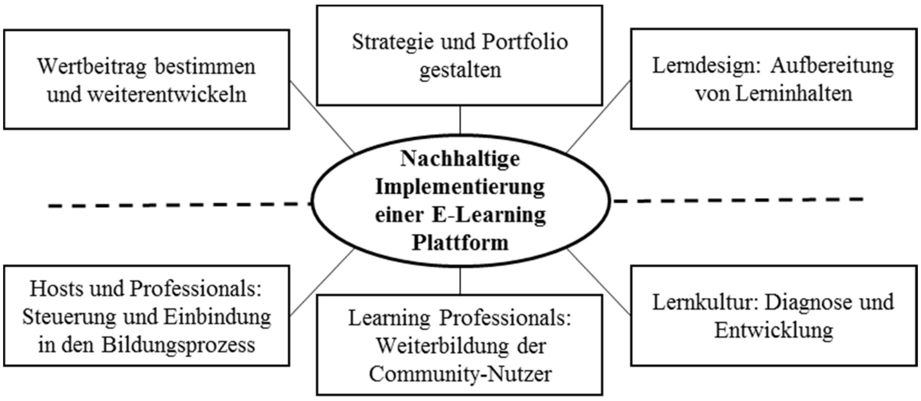

Bild 1: Struktur einer E-Learning-Plattform in Anlehnung an (Seufert und Meier 2013)

Wertbeitrag bestimmen und weiterentwickeln: Die nachhaltige Einführung einer Online Community für Elektromobilität erfordert, dass ein aus Nutzersicht erkennbarer Wertbeitrag mit der Teilnahme verbunden ist. Mit der Bewegung von „E-Learning 1.0“, dem klassisch offerierten Content eines Lehrenden auf einer Plattform (Bernhardt und Kirchner 2007), hin zu „E-Learning 2.0“, der Anpassung herkömmlicher Learning-Management-Systeme auf die „Digital Natives“, rücken nicht nur andere Lehr-/Lern-Szenarien in den Vordergrund (z. B. User-generated Content oder Mobiles Lernen), sondern auch andere Werttreiber (Arnold et al. 2011). So können Aspekte wie die Vereinheitlichung von Lerninhalten oder die schnelle Kontaktaufnahme zu Professionals oder Hosts (Plattformbetreibern) an Relevanz verlieren und Kriterien wie die Entwicklung einer neuen Lernkultur mit mehr Selbstbestimmung auf Seiten der Lernenden in den Vordergrund rücken (Seufert und Meier 2013). In diesem Zusammenhang sind Professionals derjenige Personenkreis, welcher bereits über tiefgründiges Wissen zur Energiewende oder Elektromobilität verfügt. Der Wertbeitrag der Plattform besteht mit Bezug auf das Projekt CODIFeY im Wissensvorsprung und Informationsgewinn der Nutzer durch Partizipation und dem Netzwerk der Teilnehmer.

Strategie und Portfolio: Technologieunterstützte Lehr-/Lernaktivitäten können in verschiedenen Kontexten stehen. So können diese Bausteine ein Element formal organisierter Kurse sein, oder informell in sich selbst initiierte Professional Communities bilden (Seufert und Meier 2013). Dieser transferorientierte Ansatz verschiedener Lehr-/Lernkonzepte wird durch die eMobilisten-Plattform umgesetzt. So stehen standardisierten Kursen moderierte Reflexionsprozesse gegenüber, welche sich z.B. in Action-Learning-Projekten, Gamification-Ansätzen oder der Pflege eines Kompetenz-portfolios ausdrücken. Das Bildungsmanagement der Community Hosts hat die Aufgabe, Lernprozesse auf individueller Ebene zu initiieren, zu implementieren, zu begleiten und zu evaluieren (Diettrich und Vonken 2009). Die Art und der Grad der Partizipation der verschiedenen Teilnehmer untergliedern sich in standardisierte Weiterbildungskurse, transferorientierte

Bildungsmaßnahmen, moderierte Reflexionsprozesse und Professional Communities. Diese veränderte Lernarchitektur (Detecon International GmbH 2006) findet im Kontext der eMobilisten-Plattform Anwendung. Neben standardisierten Kursen werden informelle Lernangebote in der Community angeboten. Durch ihren ganzheitlichen Ansatz wird so ein weiterer Erfolgsfaktor für den Aufbau langfristig abrufbaren Wissens zur Elektromobilität offeriert.

Lerndesign: Im Rahmen formal organisierter Lehr-/Lernprozesse stellen Lern- und Entwicklungsziele den Ausgangspunkt für das didaktische Design, die zu vermittelnden Inhalte und deren Abfolge dar (Seufert und Meier 2013). Darauf aufbauend müssen Tätigkeiten und Lehrprozesse geplant werden, wobei die Frage nach den Lehr-/Lernaktivitäten bezüglich der Entwicklungsziele im Vordergrund steht. Als geeignete Werkzeuge stehen bspw. Texte, Grafiken, Tonspuren, Videos und Videokonferenzen zur Verfügung. Auch im Kontext von informellem, selbstgesteuertem Lernen geht es nicht prioritär um das Ausreizen technischer Infrastrukturen. So wird das Gros der Lehrbausteine in Form transferorientierter Bildungsmaßnahmen angeboten. Diese Maßnahmen können in Form von Web-basierten Trainings stattfinden, welche den Kern des E-Learnings bilden und dem Lernenden eine räumliche, zeitliche und inhaltliche Flexibilisierung seines Lernprozesses offerieren. Charakteristisch sind Onlinekurse, Informationsangebote oder Lehrsequenzen, die mit Anschauungsmaterial, Übungsfragen und Verweisen auf weitere Informationsquellen versehen werden. Diese bilden das Kernstück der Plattform eMobilisten. Die Erfolgsfaktoren der Online Community beschränken sich nicht auf Aspekte der technisch-organisatorischen Unterstützung, sondern umfassen auch den Nutzen, die beteiligten Personen, geprüfte Lehrbausteine und die Moderation durch die Hosts und Professionals der Elektromobilität.

4.2 Gestaltung lern- und innovationsförderlicher Rahmenbedingungen

Um die nachhaltige Etablierung der Wissensaufbau-Komponente zu gewährleisten, werden in diesem Teilabschnitt lern- und innovationsförderliche Rahmenbedingungen aus dem Modell von Seufert und Meier (2013) adaptiert und diskutiert (vgl. Bild 1).

Hosts und Professionals: Als Ergänzung zu den durch die Hosts offerierten Lernbausteinen sollten Meinungsführer und Professionals aktiv in den transferorientierten Reflexionsprozess eingebunden werden (Seufert et al. 2013). Um einen hohen Mitgliederbindungsgrad aufrecht zu erhalten, werden die von den Professionals erstellten Lernbausteine von den Hosts lektoriert, da das Angebot qualitativ unzureichender Inhalte eine starke Barriere für eine nachhaltige Lernkultur darstellt (Diesner und Seufert 2010). Eine ähnlich förderliche Rolle nehmen Professionals der Elektromobilität ein. Sie sind einflussreiche Vorbilder in einer Community und beeinflussen andere Personen mehr als sie selbst von anderen beeinflusst werden. Empirische Studien belegen einen hohen Einfluss von Professionals auf die Nachhaltigkeit von Bildungsmaßnahmen (Kauffeld 2006). Professionals sind ebenfalls entscheidende Promotoren für die Akzeptanz und erfolgreiche Verankerung der offerierten Lernformen. Eine unterstützende Lehrführung ist folglich einer der zentralen Erfolgsfaktoren für die Akzeptanz von Bildungsinnovationen durch Lehrpersonen (Hall und Bacon 2001).

Learning Professionals: Das in 2013 veröffentlichte Kompetenzmodell für Learning Professionals von Rothwell et al. (2013) unterscheidet zwischen Basiskompetenzen und Vertiefungskompetenzen und nimmt Abschied von einem Set wohldefinierter Rollenausprägungen. Es hat sich gezeigt, dass die tatsächlichen Ausprägungen der Rollen im Bereich der Kompetenzentwicklung in Communities weitaus vielfältiger verteilt sind und insbesondere mit den Entwicklungen im Bereich Social Media neue Spezialisten hervorbringt. Die Annahme von Rollen steht dem Nutzer der Online Community frei, ob durch passives Lernen, aktives Gestalten eigener Lehrbausteine oder durch Informationsaustausch innerhalb der Community. Die erfolgreiche und nachhaltige Nutzung solcher neuer Angebote erfordert Sachkompetenzen im Umgang mit neuen Lernmedien, Sozialkompetenzen wie die Fähigkeit zur Vernetzung und kooperativen Zusammenarbeit mit anderen Lernenden, sowie Selbstkompetenzen wie Fähigkeiten zur Selbstorganisation, -steuerung und -bestimmung (Zürcher 2007). Häufig ist die Startphase neuer didaktischer Konzepte nicht so erfolgreich wie erwartet, da zunächst die erforderlichen Lernkompetenzen gestärkt werden müssen (Jenert et al. 2011). Die Möglichkeit zur direkten Kommunikation zwischen Host und Learning Professionals muss gegeben sein, um potentiellem Missmanagement entgegenzuwirken und Erfolge sicherzustellen. In der eMobilisten-Community wird dies durch einen Feedbackbaustein am Ende eines jeden Lernkurses gesichert und durch ein klassisches Q&A-Forum zum Informationsaustausch unterstützt. Zusätzlich zu den offerierten Entfaltungsmöglichkeiten der Learning Professionals wird über die eMobilisten-Community ein Anreizsystem in Form von Wettbewerben und geldwerten Leistungen (z. B. in Form von Fahrsicherheitstrainings) angeboten.

Lernkultur: Die nachhaltige Einführung einer Online Community als Ort des Lernens und Austauschens zur Elektromobilität erfordert eine ausreichende Passung mit der bestehenden Lernkultur bezüglich E-Learning, bzw. muss einen ausreichend starken Impuls zur Änderung der Lernkultur liefern. Eine Analyse der Lernkultur ist daher ein wichtiger Erfolgsfaktor für die nachhaltige Etablierung der Community als Bildungsinitiative. Im Rahmen der vom Schweizer Zentrum für Innovation in der Lehre (scil) entwickelten Lernkulturanalyse (Seufert et al. 2007) werden fünf Aspekte von Lernkultur ermittelt. Diese fassen die in den Abschnitten 4.1 und 4.2 dargelegten Erfolgsfaktoren für die nachhaltige Gestaltung der Lernumgebung zur Elektromobilität wie folgt zusammen:

- Lernen einen Wert zuweisen: Wie werden Lernaktivitäten evaluiert und wie wird der Wert von Lernen aufgezeigt und kommuniziert (vgl. *Wertbeitrag bestimmen und weiterentwickeln*)?
- Lernen vielfältig gestalten: Welche Formen formellen und informellen Lernens sind bereits etabliert und werden präferiert (vgl. *Strategie und Portfolio und Lerndesign*)?
- Mitglieder befähigen: Wie und in welchem Umfang wird eigenverantwortliches Lernen gefördert und gefordert (vgl. *Lerndesign*)?
- Hosts/Professionals einbinden: Wie und in welchem Umfang wird lernförderliche Führungsarbeit praktiziert (vgl. *Host, Professionals* und *Learning Professionals*)?
- Lernen ermöglichen: Welche organisatorischen Rahmenbedingungen fördern (informelles) Lernen (vgl. *Learning Professionals*)?

Die Durchführung einer solchen Lernkulturanalyse kann Auskunft über den Status Quo in einer Community geben. Darüber hinaus liefern die Ergebnisse Anhaltspunkte für ein lernkulturkonformes Design von Lehr-/Lernangeboten. Ziel dieses Zugangs ist es somit, das komplexe Zusammenspiel einer Vielzahl lernbezogener Einflüsse in einer Bildungscommunity aus der Wahrnehmung von Lernenden (sowie aus der Perspektive von Hosts und Professionals) zu analysieren, um didaktische Leitvorstellungen effektiv umsetzen zu können (Gebhardt und Jenert 2013). Die Lernkultur innerhalb der eMobilisten-Community kann mit Hilfe von LA analysiert werden. Im Folgenden wird dargelegt, wie die genannten Erfolgsfaktoren mit Hilfe von LA unterstützt werden und welche Faktoren bei der Implementierung zu beachten sind.

4.3 Learning Analytics zur Unterstützung des Wissensaufbaus

Die in den Abschnitten 4.1 und 4.2 ermittelten Erfolgsfaktoren für das Lernen in Online Communities sollen durch den Einsatz von LA unterstützt werden. Weiterhin sollen durch die Auswertung des Nutzungsverhaltens auf der Plattform Erkenntnisse zu Motivation und Bedürfnissen von Elektromobilitätsinteressierten gewonnen werden. Um einen systematischen Aufbau von LA auf der Online-Plattform eMobilisten zu gewährleisten, wird das Learning Analytics Reference Model von Chatti et al. (2012) als Ausgangspunkt für die Überlegungen verwendet. Das Rahmenwerk besteht aus den vier Dimensionen *Daten und Lernumgebung*, *Stakeholder*, *Ziele* und *Methoden*, welche jeweils Einfluss auf die Umsetzung von LA haben. Diese werden im Folgenden kurz vorgestellt und Implikationen im Projektkontext abgeleitet.

Die erste Dimension betrifft die (1) *Lernumgebung* und die in dieser anfallenden *Daten*. Wissensaufbau kann sowohl auf zentralisierten Plattformen als auch auf im Web verteilten Systemen stattfinden. Dies hat Einfluss auf die Verfügbarkeit und Struktur der entstehenden Lerndaten (Chatti et al. 2012). Die Lernprozesse auf der eMobilisten-Plattform erfolgen auf einer zentralen Lernplattform, von der die Daten standardisiert an einen Lerndatenspeicher weitergeleitet werden. Jedoch ist der Wissensaufbau, wie in Abschnitt 3 geschildert, nur eine Komponente der Plattform. Ferner sind für die Analysen auch Daten aus den Dienstleistungsinnovationszyklen und allgemeine Nutzerdaten (z. B. demografische Nutzerdaten) einzubeziehen, um ein ganzheitliches Bild der Aktivitäten auf eMobilisten zeichnen zu können. Neben diesen internen Daten sollen auch externe Datenquellen (z. B. Social Media, Open Data) einbezogen werden, um die Qualität der Analysen zu erhöhen.

Die Bereitstellung von bedarfsgerechten und leicht verständlichen Informationen für verschiedene Anspruchs- und Zielgruppen zählt zu den Hauptaufgaben von LA. Die zweite Dimension betrachtet die Rollen und Bedürfnisse dieser (2) *Stakeholder*. Allgemein kann zwischen Hosts (Plattformbetreibern) und Professionals bzw. Learning Professionals unterschieden werden. Das Hauptinteresse der Hosts liegt zum einen auf Informationen, die als Performance-Indikatoren für die Plattform und deren Inhalte verwendet werden können (z. B. Nutzerzahlen, Popularität von Lernkursen, Feedback). Diese Informationen werden genutzt, um die Plattform kontinuierlich zu verbessern und weiterzuentwickeln. Zum anderen sollen durch die Beobachtung des Nutzerverhaltens Erkenntnisse zu Typen, Verhaltensmustern und Bedürfnissen von Elektromobilitätsinteressierten gewonnen werden. Die Ansprüche der Lernenden beziehen sich hingegen vor allem auf den verantwortungsvollen Umgang mit personenbezogenen Daten und die Verbesserung des eigenen Lernerlebnisses (Greller und Drachsler 2012).

In Abhängigkeit von den identifizierten Erfolgsfaktoren und den Ansprüchen der Stakeholder ergeben sich verschiedene (3) *Ziele* für den Einsatz von LA auf der eMobilisten-Plattform. Durch die Analyse von Beiträgen und Aktivitäten können Aspekte der Elektromobilität herausgestellt werden, welche aus Sicht der Nutzer bzw. individueller Nutzergruppen von besonderem Interesse sind. Diese Informationen werden genutzt, um bedarfsgerechte Kurse zu designen und so ein werthaltiges Lernangebot zu offerieren. Unterstützt wird dies zusätzlich durch die Auswertung von Nutzerfeedback zu den Lernkursen. Ein weiteres Ziel von LA besteht in der Auswertung des Lernverhaltens auf der Plattform. Ein zentraler Erfolgsfaktor für die nachhaltige Wissensvermittlung stellt die Befähigung der Learning Professionals zum eigenverantwortlichen Lernen dar. Zur Unterstützung eines erfolgreichen Wissenstransfers werden Lernwege und –ausstiegspunkte (Drop Outs) der Nutzer analysiert. Auf diese Weise werden Probleme in Lernprozessen frühzeitig erkannt und Anpassungen des Designs und der didaktischen Gestaltung der Kurse ermöglicht. Neben der Analyse von Lernprozessen und -erfolgen können die Ziele von LA in Hinblick auf den kollaborativen Charakter der Plattform um eine soziale Komponente ergänzt werden (Buckingham Shum und Ferguson 2011). Dem folgend besteht eine weitere Aufgabe in der Erfassung und Auswertung von Kooperation und Kommunikation zwischen Nutzern innerhalb der Community. Um Professionals in die Gestaltung der Lernumgebung einzubeziehen, müssen diese zunächst aus der Menge der Plattformnutzer bestimmt werden. Daraus ergibt sich für LA das Ziel, Lead User und Meinungsführer in der Community zu identifizieren, welche dann durch gezielte Ansprache zur Mitgestaltung der Lernumgebung aktiviert werden sollen.

Die vierte Dimension betrifft die letztendlich die Umsetzung von LA mittels verschiedener (4) *Methoden*. Um den divergenten Ansprüchen der Stakeholder gerecht zu werden und die Implementierung der Erfolgsfaktoren zu unterstützen, kommt eine Kombination verschiedener Methoden zur Anwendung. Durch den Einsatz von Web Analytics werden deskriptive Indikatoren wie Zugriffshäufigkeiten, Verweildauern und Ausstiegspunkte erfasst. Nutzergenerierte Inhalte und Beiträge werden mittels Verfahren des Data Mining bzw. Text Mining ausgewertet. Zur Einbeziehung der sozialen Strukturen innerhalb der Community wird die Soziale Netzwerkanalyse genutzt. Mit dieser Methode können nicht nur Beziehungen zwischen einzelnen Community-Mitgliedern sondern auch zwischen Lerninhalten und Beiträgen untersucht werden (Cambridge und Perez-Lopez 2012). Die durchgeführten Analysen werden unter Verwendung von Visualisierungstools aufbereitet und den Hosts in Form von Reports zur Verfügung gestellt.

5 Diskussion der Ergebnisse

Bezüglich dieser Gestaltung einer nachhaltigen Lernumgebung zur Elektromobilität konnten fünf Erfolgsfaktoren identifiziert werden, welche sukzessiv den Einfluss technischer und personeller Aspekte auf die Lernprozesse auf der eMobilisten-Plattform abbilden. Bild 2 visualisiert die Zusammenhänge zwischen Erfolgsfaktoren, LA und der Lernumgebung.

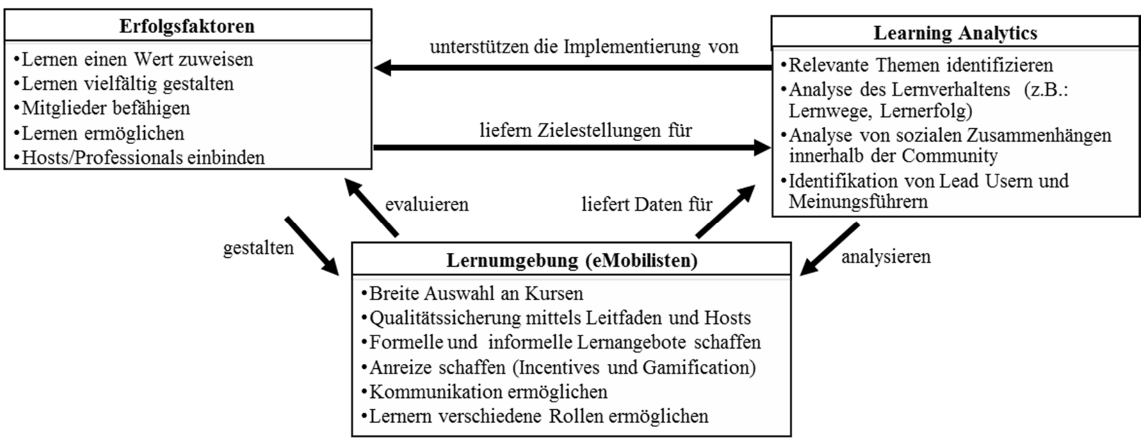

Bild 2: Zusammenhang von Erfolgsfaktoren, Learning Analytics und Lernumgebung

Die Lernumgebung auf der Plattform eMobilisten wurde unter Berücksichtigung der identifizierten Erfolgsfaktoren entwickelt. Den Nutzern steht eine breite Auswahl von Lernkursen zu verschiedenen Aspekten der Elektromobilität zur Verfügung. Den Nutzern werden verschiedene Lernangebote offeriert. Vom passiven Rezipieren bis zum aktiven Gestalten von Kursen können Nutzer eine Vielzahl von Rollen einnehmen. Ein Leitfaden für die Erstellung von Lernkursen und die aktive Unterstützung durch die Community Hosts trägt zur Qualitätssicherung der Wissensinhalte bei. Um Anreize zur Beteiligung zu setzen, werden regelmäßig die aktivsten Plattformnutzer bestimmt. Diese erhalten für ihr Engagement geldwerte Leistungen mit Bezug zur Elektromobilität (z. B. Fahrsicherheitstrainings oder Probefahrten). Die Kommunikation innerhalb der Community wird durch ein Q&A-Forum und die Möglichkeit direkter Kommunikation zwischen den Nutzern gefördert.

Die Erkenntnisse aus dem Betrieb der Plattform werden, wie in Abschnitt 3 beschrieben, verwendet, um die Gültigkeit der identifizierten Erfolgsfaktoren zu überprüfen und ggf. weitere hinzuzufügen. Die Aktivitäten und erstellten Inhalte auf der eMobilisten-Plattform bilden die Datenbasis für die Auswertungen der LA, deren Zielstellungen sich wiederum aus den Erfolgsfaktoren herleiten. Neben der Identifikation von relevanten Inhalten und Lead Usern unterstützen die LA den Wissensaufbau auf der Plattform durch die Analyse von individuellen Lernprozessen und sozialen Zusammenhängen auf der Plattform. Die kontinuierliche Bereitstellung von Informationen zu den Geschehnissen auf eMobilisten durch LA wird genutzt, um Maßnahmen zur Verbesserung von Prozessen und Design der Plattform abzuleiten und so die nachhaltige Implementierung der Erfolgsfaktoren zu unterstützen.

6 Zusammenfassung und Ausblick

Es wurde untersucht, welche Erfolgsfaktoren beim Aufbau einer Online-Lernumgebung zur Elektromobilität eine Rolle spielen und wie diese durch den Einsatz von LA unterstützt werden können, um eine nutzergerechte und nachhaltige Wissensvermittlung zu gewährleisten. Aus den gewonnenen Erkenntnissen wurden Maßnahmen abgeleitet, welche auf der Online-Plattform eMobilisten implementiert und auf die praktische Anwendbarkeit geprüft werden. Die initial geschaffene Wissensbasis auf der Plattform soll zukünftig in Kooperation mit den Nutzern kontinuierlich erweitert und an deren Bedürfnissen ausgerichtet werden. Zudem wird eine engere Verknüpfung zwischen Wissensaufbau und Dienstleistungsentwicklung innerhalb der Community angestrebt. So sollen bspw. Innovationsherausforderungen mit Hilfe von Lernkursen visualisiert und genauer erklärt und Ideenaufrufe zu innovativen Lernkursen gestartet werden. Auch darüber hinaus bietet die Plattform eMobilisten reichhaltige Möglichkeiten, Akteure der Elektromobilität zu verbinden und die Gesellschaft für Elektromobilität zu aktivieren.

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Learning Analytics für eine verbesserte Lernbegleitung in kollaborativen formellen E-Learning-Angeboten

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Abstract

Dieser Beitrag ist Teil einer umfassenden Aktionsforschung zur Learning Analytics. Die Autoren stellen am praktischen Beispiel die Relevanz konkreter Informationen über kollaborative Lerneraktivitäten für eine erfolgreiche Lernprozessbegleitung durch E-Tutoren heraus. Sie zeigen Lösungen auf, welche Lernplattformen verwendet und wie diese bereitgestellt werden können, um die Aktivitäten von E-Tutoren in der Rolle des Lernprozessbegleiters zu unterstützen. Hierbei erwiesen sich in der Vergangenheit die von den Lernenden genutzten verteilten, externen Web 2.0-Plattformen als Hürde, da die Nachvollziehbarkeit ihrer jeweiligen Aktivitäten nicht gegeben war. Durch Interviews mit Teilnehmenden, E-Tutoren und Dozenten eines formellen E-Learning-Angebotes wurden die Ursachen für die Wahl externer Plattformen ermittelt und Lösungen erarbeitet, die sowohl die Funktionalität der Lernplattform, als auch den Datenschutz und Aufwand berücksichtigen. Hiermit soll eine Auswertung mit Learning Analytics ermöglicht werden.

1 Einleitung & Motivation

In formellen E-Learning-Angeboten haben Lehrende die Aufgabe, Lernende zu unterstützen und dadurch die Erreichung der Lernziele zu fördern (Jank & Meyer 2006). Dies kann durch E-Tutoren in der Rolle des Lernprozessbegleiters erfolgen, der bei inhaltlichen, technischen, sozialen und organisatorischen Fragen und Problemen unterstützen soll (Gretsch et al. 2010). Da eine gute Lernbegleitung u.a. die Gefahr einer Überforderung bei den Lernenden reduzieren (ebd.) sowie positive Auswirkungen auf deren Motivation (Ojstersek 2007), die Bewältigung von Schwierigkeiten und den Transfer der gelernten Inhalte nehmen kann (Geyken et al. 1998), gilt sie als Erfolgskriterium E-Learning-basierter Lernangebote (Schulmeister 2001). Sie setzt jedoch voraus, dass von den E-Tutoren der Stand der Lernzielerreichung und dabei auftretende Probleme bei den Lernenden schnell erkannt und daraus adäquate Interventionsmaßnahmen abgeleitet werden können. Dies erfordert eine kontinuierliche Beobachtung und Einschätzung der Lernprozesse.

Die Beobachtung und Einschätzung durch E-Tutoren ist in stark vom Medieneinsatz geprägten Lernangeboten an Voraussetzungen gebunden. Zum einen bedarf es einer umfassenden Datenbasis hinsichtlich der Lerneraktivitäten, d.h. die digitalen Spuren Einzelner und von Lernergruppen müssen, auch bei der kombinierten Nutzung verschiedener Tools, abrufbar sein. Zum anderen gilt es Indikatoren zu identifizieren, anhand derer eine lernzieladäquate oder verbesserungswürdige Lernprozessentwicklung zu erkennen ist. Beide Faktoren sind dabei voneinander abhängig und stellen Anforderungen an die Funktionalitäten und Daten der zu verwendenden Lernplattform. Diese Anforderungen sind Gegenstand des vorliegenden Beitrages. Da sie von konkreten Lernzielen abhängen, erfolgt die Betrachtung anhand eines seit vielen Jahren etablierten E-Learning-Szenarios. Dieses stellt das kollaborative Lernen und Arbeiten von Studierenden in den Mittelpunkt.

2 Forschungsdesign

Dieser Beitrag dient dem übergeordneten Forschungsziel, in formellen E-Learning-Angeboten eine erfolgreiche Lernprozessbetreuung unter Einsatz von Learning Analytics sicherzustellen. Er klärt anhand eines konkreten, kollaborativ geprägten Szenarios, welche Funktionalitäten eine adäquat gestaltete Lernplattform bieten sollte. Weiterhin werden Hosting-Möglichkeiten aufgezeigt, um Daten zu Lerneraktivitäten erheben, aufbereiten und visualisieren zu können. Der Beitrag adressiert folgende Forschungsfragen (FF):

FF1: Welche Prozessmerkmale von E-Collaboration sind für die Lernbegleitung relevant?

FF2: Welche Funktionalitäten bieten state-of-the-art E-Collaboration-Werkzeuge?

FF3: Wie bewerten die Teilnehmer die aktuell eingesetzte Kollaborationsplattform?

FF4: Welche Anforderungen existieren seitens der Lernbegleiter an die Lernplattform?

FF5: Wie können Lernplattformen bereitgestellt werden, um Learning Analytics zu ermöglichen?

FF1 und FF2 wurden mit Erkenntnissen aus der Literatur beantwortet. Die Beantwortung von FF3 und FF4 erfolgte mit Hilfe von 12 teilstrukturierten Einzelinterviews mit Studierenden und E-Tutoren sowie einem Gruppeninterview mit 3 Dozenten. Alle Probanden stammten aus der betrachteten kollaborativen Lehrveranstaltung. Die Interviews dauerten zwischen 30 und 75 Min. und fanden spätestens einen Monat nach Ende der Veranstaltung statt. Inhaltlich fokussierten sie auf den Ablauf der Gruppenarbeit in der Lehrveranstaltung, den dabei genutzten Tools und deren Verbesserungsmöglichkeiten. Die Interviews wurden transkribiert und anhand der quantitativen Inhaltsanalyse ausgewertet, bei der eine deduktiv-induktive Kodierung hinsichtlich genutzter Werkzeuge und gewünschter Funktionalitäten erfolgte. Sinneinheiten des Gesagten wurden als Kodiereinheit zugrunde gelegt und konnten einzelne Wörter bis zu mehreren, zusammenhängenden Absätzen umfassen. Mehrfachnennungen und -kodierungen innerhalb eines Interviews entstanden aufgrund von Nachfragen zur Konkretisierung oder eigener Relevanzen. Die Kodierungen wurden anschließend einer Häufigkeitsanalyse unterzogen, um die genutzten Werkzeuge und den damit einhergehenden Handlungsbedarf zu priorisieren (Bortz & Döring 2006). Entsprechend Nakapan, Gu, Gul, & Williams (2009) wurden nach der ersten Auswertung der Interviews die Anforderungen der Lernbegleiter mit denen der Studierenden abgeglichen, um anschließend Lösungsalternativen zu konzipieren und damit FF5 zu beantworten.

Die Autoren gehen nachfolgend zuerst auf die betrachtete Lehrveranstaltung und das im Mittelpunkt stehende Lernziel ein. Weiterhin wird das in der Veranstaltung bereits etablierte Lernbegleitungskonzept vorgestellt (Abschnitt 3). Im Anschluss werden mögliche E-Collaboration-Werkzeuge gelistet und die in der Veranstaltung genutzte Lernplattform eingeordnet. Die bislang auf dieser Plattform bereitgestellten Werkzeuge werden zuerst mit den aktuellen Anforderungen der Studierenden und anschließend mit denen der E-Tutoren verglichen (Abschnitt 4). Gleichzeitig werden Ursachen identifiziert, die die Nutzung dritter Plattformen begründen und davon ausgehend Lösungsalternativen vorgestellt, die die Anforderungen der Zielgruppen mit dem Ziel der Datenverfügbarkeit für die Lernbegleitung erfüllen (Abschnitt 5).

3 Betrachtetes E-Learning-Angebot

Bei der in diesem Beitrag fokussierten Lehrveranstaltung handelt es sich um ein Virtual Collaborative Learning (VCL)-Projekt. In diesem Setting lösen Kleingruppen mit vier bis sechs Studierenden über mehrere Wochen komplexe, realitätsnahe Problemstellungen. Diese werden in Form von Fallstudien bereitgestellt und unter Einsatz internetbasierter Informations- und Kommunikationstechnologien bearbeitet (Balázs 2005). Seit 2004 finden neben nationalen Kooperationen, bspw. mit der HTW Dresden, FU Berlin und Ruhr-Universität Bochum, auch internationale VCL-Projekte mit Partnern u.a. aus China, Finnland, Lettland, Litauen, Polen, Russland, den USA, der Türkei (Schoop, Michel, Miluniec, Kriksciuniene, & Brundzaite 2005; Bukvova, Lehr, Lieske, Weber, & Schoop 2010) und Jordanien statt. Die Lernziele orientieren sich an den höher komplexen kognitiven Prozessen des Analysierens, Bewertens und Erstellens von konkretem bis hin zu abstraktem Wissen (Anderson et al. 2000). Daraus resultieren höhere Anforderungen an die Bewertung, die sich nicht nur auf das Abfragen von Faktenwissen konzentrieren kann, sondern auch die Lösungskonstruktion inkl. ihrer Abhängigkeiten und Kontexte einbeziehen sollte (ebd.). Die Studierenden lernen im Rahmen einer VCL-Veranstaltung:

- komplexe Aufgabenstellungen zu analysieren,
- Teilaufgaben für die gesamte Gruppe und einzelne Gruppenmitglieder abzuleiten,
- selbstständig lösungsrelevante Informationen zu suchen,
- Informationen sinnvoll zu integrieren,
- Lösungsmöglichkeiten zu erarbeiten, zu bewerten und in der Gruppe begründete Entscheidung zu treffen und
- Lösungsvorschläge bzw. Entscheidungen zu präsentieren und zu verteidigen.

Nahezu alle benannten Lernziele stellen Facetten der E-Collaboration dar. Die Besonderheit dieser Lehrveranstaltung liegt u.a. darin, dass kollaboratives Lernen und Arbeiten unter Einsatz von Informations- und Kommunikationstechnologien nicht nur ein übergeordnetes Lernziel im Sinne einer zu entwickelnden Kompetenz, sondern gleichzeitig der Weg zur Erreichung aller anderen Lernziele ist. Es ist daher als zentral anzusehen und soll im Folgenden näher betrachtet werden.

FF1: Welche Prozessmerkmale von E-Collaboration sind für die Lernbegleitung relevant?

Kollaboratives Lernen unterliegt kaum externen Strukturvorgaben (Perrez, Huber, & Geißler 2006; Carell 2006) und stellt die Lernenden neben der Bewältigung von Fachinhalten vor die Aufgabe, selbstständig Ziele festlegen und ihre Vorgehensweise planen, steuern und kontrollieren zu müssen (Geyken et al. 1998). Es wechseln sich gemeinsame und individuelle Arbeitsphasen ab (Carell 2006b). Deren ausbalancierte Verteilung wird von Rummel & Spada (2005) sogar als Erfolgskriterium für Kollaboration benannt. Entscheidend dabei ist, dass sich die Beteiligten immer wieder zusammenfinden, um einzelne Teilergebnisse zu besprechen, zusammen zu führen und zu überarbeiten. Sie müssen eine gemeinsame Vorstellung von einem zu bearbeitenden Problem entwickeln und dieses lösen (Clark & Brennan 1991; Roschelle & Teasley 1995; Carell 2006b). Die Aufgabenteilung erfolgt horizontal, d.h. die einzelnen Aktivitäten sind stark miteinander verflochten und die jeweils entwickelten Ergebnisse werden von einer zur nächsten Person weiter gegeben, dort einbezogen und weiter entwickelt (Dillenbourg 1999).

Während Roschelle & Teasley (1995) Kollaboration als eine ausschließlich synchron ablaufende, koordinierte Aktivität sehen, schließt das Verständnis in dem benannten VCL-Szenario auch asynchron ablaufende Aktivitäten mit ein (Jödicke et al. 2012). Entscheidend dabei ist, dass entsprechend den Ausführungen von Dillenbourg (1999) während der gemeinsamen Arbeit eine Verflechtung von Interaktionen und Begründungen erfolgt. Das bedeutet, dass die Lernenden sich bei der Entwicklung der Lösung gegenseitig beeinflussen, indem sie ihren jeweiligen Standpunkt einbringen, gegenüber anderen vertreten und begründen sowie am Ende zu einer gemeinsamen Lösung kommen (Dillenbourg 1999). Dieser Prozess, d.h. das Abwägen von Argumenten, Ansichten und Meinungen sowie das logische Begründen und Verteidigen führt zum einen bei den Beteiligten zum Aufbau neuer Wissensstrukturen und kognitiver Fähigkeiten (Ko-Konstruktion zweiter Ordnung). Zum anderen kann am Ende ein Ergebnis entstehen, welches über das Leistungsvermögen der einzelnen Beteiligten hinaus geht (Carell 2006b).

Um die Ziele von Kollaboration zu erreichen, erfordert es Training, Erfahrung und Unterstützung sowie den sinnhaften Einsatz von Web 2.0-Werkzeugen und Kommunikationskanälen (Pauleen & Yoong 2001). Die für kollaboratives Lernen notwendigen Fähigkeiten sind jedoch nicht bei allen Lernenden gleichermaßen vorhanden (Geyken et al. 1998; Dittler & Jechle 2004). Erfahrungen aus der Praxis zeigen, dass kollaborative E-Learning-Arrangements durch hohe Abbruchraten, geringe Lerneraktivitäten sowie eine oberflächliche Auseinandersetzung mit dem Lerngegenstand gekennzeichnet sein können (Carell 2006b). Vollständig unbetreut, können sie hinsichtlich ihrer Zielerreichung eingeschränkt und der Lernfortschritt der Teilnehmenden gefährdet sein (Kerres et al. 2008). Es wird daher empfohlen, eine gezielte Unterstützung in das Lernszenario einzubinden, im Rahmen derer die Aktivitäten des selbstgesteuerten und gemeinsamen Lernens angeregt, unterstützt und ggf. gelenkt werden (ebd.) ohne dabei den Freiraum der Lernenden zu stark einzuschränken (Balázs 2005; Hoberg & Gohlke 2011). In dem geschilderten VCL-Szenario erfolgt diese Unterstützung durch den Einsatz von speziell geschulten E-Tutoren.

4 Herausforderungen für eine effektive Lernbegleitung

In VCL-Veranstaltungen liegt es in der Verantwortung von E-Tutoren, evtl. auftretende Lernprobleme bei den Teilnehmenden zu identifizieren, Handlungsbedarf abzuleiten und entsprechend zu intervenieren. Sie werden bspw. aktiv, wenn die für Kollaboration notwendige Interaktion in der Gruppe nicht anläuft oder zum Erliegen kommt. Es ist ihre Aufgabe, die Gründe für die fehlende Interaktion zu ermitteln, evtl. zugrunde liegende Probleme zu identifizieren und gemeinsam mit der Gruppe zu lösen. Dies setzt jedoch voraus, dass die Aktivitäten Einzelner nachvollzogen und Brüche erkannt werden. Es ist nötig zu überblicken, welcher Teilnehmer was zu welcher Zeit gemacht hat, wann er wie mit den anderen Gruppenmitgliedern interagiert hat und wie sich seine Ergebnisse in die Gruppenarbeit einfügen. Darüber hinaus ist es u.a. wichtig zu sehen, welche Ziele sich die Gruppe gesetzt hat, welche Schritte, Fristen und Zuständigkeiten zur Erreichung der Ziele abgeleitet und eingehalten wurden und über welchen Bearbeitungsverlauf das finale Gruppenergebnis entstanden ist. Neben diesem proaktiven Vorgehen besteht die Aufgabe von E-Tutoren auch darin, auf Fragen seitens der Lernenden zu reagieren. Die von ihnen zu bearbeitenden Belange können technischen, zwischenmenschlichen, fachlichen oder organisatorischen Ursprungs sein. Um dies realisieren zu können, haben sie sich über die gesamten individuellen und gruppenspezifischen Aktivitäten zu informieren und die Aktivitäten der Teilnehmenden kontinuierlich zu beobachten. Eine optimale lernzielförderliche Unterstützung der Lernenden ist in Veranstaltungen mit sehr hoher Teilnehmerzahl bei begrenzten Ressourcen jedoch nur schwer zu realisieren.

Anwendungen im Bereich der Learning Analytics können diesem Problem ggf. entgegenwirken. Learning Analytics ist zu verstehen als "Sammlung und Auswertung von Daten, um diese in lernunterstützende Aktionen zu übertragen" (Chatti, Dyckhoff, Schroeder, & Thüs 2012, S.22). Mit Hilfe von IT-gestützten Assistenzsystemen sollen Lernprozesse verfolgt und verbessert werden. Ziel ist die Steigerung des Lernerfolgs durch eine bessere Erreichung der Lernziele (Siemens et al. 2011; Papamitsiou & Economides 2014). So können bspw. über die Datenauswertung Informationen über die Lernleistung der Teilnehmenden gewonnen (Greller & Drachsler 2012) und dadurch menschliche Entscheidungen hinsichtlich didaktischer Interventionen vorbereitet werden (Siemens & Baker 2012).

Nachdem zahlreiche Analysemethoden aus dem Educational Data Mining überführt (Papamitsiou & Economides 2014) und darauf aufbauend Analysewerkzeuge entwickelt wurden (Ferguson 2012), stellt sich insbesondere bei umfassenden virtuellen Lehrveranstaltungen die Frage nach einem vollständigen Datenzugriff. Die hierfür konzipierten speziellen Formate zur Speicherung und zum Datenaustausch (Verbert et al. 2012; Niemann et al. 2013; Fortenbacher et al. 2014) bilden die Grundlage, um einen systemischen Überblick zu erhalten. Allerdings beschränken sich die Analysen bislang auf einzelne Lernmanagementsysteme. Erschwerend kommt hinzu, dass zahlreiche Lerneraktivitäten außerhalb der bereitgestellten Plattform stattfinden. Greller & Drachsler (2012) weisen darauf hin, dass der Bedarf zur integrierten Betrachtung von Dateien aus (bereitgestellten) geschlossenen Plattformen (u.a. Fortenbacher et al. 2013; Harrer 2013; Mazza & Milani 2004) bzw. (externen) offenen Plattformen von Drittanbietern (u.a. Evans 2015; Joksimovic, Gasevic, & Hatala 2014; Santos, Verbert, Govaerts, & Duval 2013; Tromp & Pechenizkiy 2013) besteht, um lernerorientierte und personalisierte Aussagen treffen zu können. Ein systemischer Ansatz existiert bislang noch nicht (Greller & Drachsler 2012). Die Verbesserung und Unterstützung der E-Tutoren-Rolle bedarf somit nicht nur einer speziellen Vorbereitung der eingesetzten Personen (Gretsch et al. 2010), sondern ist auch plattformseitig mit Anforderungen verbunden. Dabei gilt es in einem ersten Schritt, diese Anforderungen zu identifizieren. Die Ergebnisse dieses Prozesses in Bezug auf das Beispielszenario werden im folgenden Abschnitt dargestellt.

4.1 Anforderungen an die Lernplattform

In einem VCL-Projekt ist die Lernplattform das Werkzeug zur Bearbeitung der Aufgabenstellung, sodass vom Dozenten kontextabhängig die erforderlichen Werkzeuge auszuwählen (Bennett et al. 2012) und in einer Web 2.0-Plattform zu integrieren sind (Nakapan et al. 2009). Diese Plattform ermöglicht Netzwerkeffekte, die sich mit zunehmender Beteiligung verstärken (O'Reilly 2005) und den Erfolg der E-Collaboration sicherstellen.

Hierbei müssen die Anforderungen der Zielgruppen berücksichtigt werden, denn ohne Akzeptanz und aktive Nutzung würde die E-Collaboration scheitern (Michaelides et al. 2012). Die Studierenden haben aufgrund ihrer täglichen Nutzung von Social Software Ansprüche an die

Funktionalität entwickelt. Vergleichbare Ansprüche stellen auch die späteren Arbeitgeber, sodass möglichst praxisrelevante und -nahe Plattformen in der Lehre verwendet werden sollten.

FF2: Was bieten state-of-the-art E-Collaboration-Werkzeuge?

Die aktuell verfügbaren Werkzeuge zur Unterstützung von E-Collaboration wurden im Internet umfangreich beschrieben (vgl. Wikipedia 2015). Sie werden nachfolgend nach ihrem vorrangigen Zweck der Kommunikation und Kollaboration sowie ihren funktionalen Anforderungen unterschieden. Alle Werkzeuge und Funktionalitäten sind in Tabelle 1 in den Spalten F aufgeführt.

Werkzeuge zur Kommunikation		
F	**A**	**I**
Instant Messenger[1]	+	57
Web-Conference[1]		29
Email[1]	+	6
Application Sharing[1]	+	1
Videokonferenz[1]	+	
Synchrone Konferenzen[1]	+	
Telefonie[1]		
Data Conference[1]		
E-Meeting System[1]		
Fax[1]		

Werkzeuge zur Kollaboration		
F	**A**	**I**
Dokumentenmanagement[1]	+	74
Projekt Management[1]	+	17
Foren[1]	+	17
Blogs[1]		15
Annotation/ Comments[1]	+	15
Umfragen[1]		10
Rating[1]		5
Profile		5
Kalender[1]	+	4
Wikis[1]		2
Schlagworte[1]		1
Lesezeichen[1]		1
Suche[1]	+	1
Prozesse[1]	+	
Whiteboards[1]	+	
Business Intelligence[1]		
Charting[1]		
Listen[1]		
Zeiterfassung[1]		
Social Software[1]		
XML Formulare[1]		
Web Publishing[1]		

Funktionalitäten der Werkzeuge		
F	**A**	**I**
Office Suite[1]		38
Mobil[5]		29
Aktivitäten/ Historie[4]	+	17
Benachrichtigungen[3]		16
Layout[2]		13
Navigation[2]		11
Gruppenchat[5]		10
Gruppenseiten[1]	+	8
Ordnerstruktur im DMS[5]		7
Direktablage Protokolle[5]		7
Mobile/Desktop App[5]		5
Statusanzeige[4]	+	3
Empfehlungen[3]		1
Direktantwort in Email[5]		1
Umfrage mit Mehrfachantworten[5]		1
Chat mit Anhängen[5]		1
Hyperlinks[2]		1
Entwicklerbereiche[1]		
Taxonomies[3]		
Folksonomies[3]		
Content Syndication[2]		

Tab. 1: E-Collaboration-Werkzeuge nach McAfee, 2006 (1); Michaelides et al., 2012 (2); Wikipedia, 2015 (3)

Bezugnehmend auf das fokussierte Lehr-Lern-Arrangement wurden von Balázs (2005) bereits spezifische Funktionen gefordert. Nach Abgleich wurden die hier gelisteten Funktionen um zwei weitere Aspekte (4) ergänzt. Die ursprünglich für die Lernplattform formulierten Anforderungen sind in den Spalten „A“ mit „+“ markiert. Aus den Interviews wurden weitere Werkzeuge und Funktionalitäten hinzugefügt (5), die Häufigkeiten der Codes in den Spalten „I“ dargestellt und die Liste davon ausgehend absteigend geordnet. Da die Interviews ebenso die Verbesserungspotenziale der Plattform thematisierten, deutet die Häufigkeit der Nennung von Werkzeugen auf eine starke Diskrepanz zwischen Erwartung und vorgefundener Situation hin.

4.2 Bisherige Lösung

Als Lernplattform wird die Social Software-Suite ELGG (www.elgg.org) zur Verfügung gestellt. ELGG verfügt in der Basisinstallation über die Web 2.0-Tools Forum, Blog, Microblogs, Wiki, Messaging, Profile, Bookmarks, Groups, Likes, TagClouds, FileSharing und eine Suchfunktion. Über PlugIns wurden ein Chat, Aufgaben, Kalender, Mentions und ein Aktivitäts-Addon installiert.

Der Funktionalitätsumfang gewährleistet die Lösung der Aufgabenstellung durch die Teilnehmer und sollte den E-Tutoren als Informationsgrundlage zur Lernbegleitung sowie den Dozenten zur formativen Bewertung der Lernenden dienen. In mehreren Veranstaltungen wurde jedoch festgestellt, dass weder die Lernbegleitung noch die formative Lernerbewertung optimal realisiert werden konnten, da die Studierenden auf externe Plattformen auswichen. Es stellt sich die nachfolgend untersuchte Frage, weshalb dies geschieht und welche Anforderungen seitens ELGG derzeit nicht erfüllt werden.

FF3: Wie bewerten die Teilnehmer die aktuell eingesetzte Kollaborationsplattform?

Die studentischen Teilnehmer schilderten in den Interviews eine schlechte Server-Performanz sowie eine ungenügende Bereitstellung von Werkzeugen und einer mobilen Schnittstelle. So forderten sie bspw. einen Gruppenchat auf der Plattform sowie eine Einbindung von mobilen Endgeräten in diesen. Gleichzeitig wurden eine Videokonferenzlösung und eine in das Dokumentenmanagement eingebundene Real-Time Office Suite gewünscht. Bisher wurden externe Plattformen zugelassen, auch wenn die Aktivitäten dort nicht unmittelbar durch E-Tutoren verfolgbar waren, was bei den Teilnehmern zu erhöhtem „work around" in Form zusätzlicher Dokumentationen (bspw. Protokolle für die Kommunikation außerhalb der Plattform; Kommentare zur Abstimmung; manuelle Benachrichtigungen) führte.

Die plattformseitigen Nachteile veranlassten die Studierenden bisher zur Nutzung dritter, selbstgewählter Plattformen. Hierzu gehörten:

- Facebook, WhatsApp und Skype für bilaterale und gruppenweite Chats,
- DropBox, Google Drive und OneDrive zum Austausch der Dokumente,
- Doodle zur Terminabstimmung und
- Skype bzw. Google HangOut für Videokonferenzen.

Es zeigte sich jedoch auch, dass die Vielzahl der verwendeten Plattformen zum Verlust des Überblicks führte und einige Teilnehmer sich nicht über den Einsatzzweck und die umfangreichen Funktionalitäten der Werkzeuge bewusst waren (Skype als ausschließliches Chat-Werkzeug). Als eines der größten Probleme offenbarte sich ebenso die Einigung auf eine gemeinsame Plattform.

FF4: Welche Anforderungen existieren seitens der Lernbegleiter an die Lernplattform?

Für den E-Tutor konnten aus den Interviews zwei gegensätzliche Verhaltensweisen von Lernenden identifiziert werden, die sie vor Herausforderungen stellten. Einige Gruppen agierten auf externen Plattformen, sodass die Arbeitsprozesse teils vollständig im Verborgenen blieben und die eigentlich hierfür bereitgestellte Plattform nur zum Hochladen der Ergebnisse genutzt wurde. Eine Intervention war somit nicht zeitnah möglich, sondern erst, wenn Protokolle hochgeladen, die Lösungen fertiggestellt, Gruppenprozesse erfragt oder die Teilnehmer aktiv wurden. Ein detaillierter Einblick in die extern genutzten Plattformen würde hier die Informationsbasis für die E-Tutoren verbessern. Andere Gruppen nutzten die bereitgestellte Plattform so umfangreich, dass sich das Nachverfolgen der Beiträge (Lesen, Verknüpfen, Kommentieren) sehr aufwändig und zeitintensiv gestaltete. Eine zeitnahe, proaktive Intervention konnte auch hier nicht gewährleistet werden. In diesem Fall stellen selektive Benachrichtigungen und Auflistungen von Aktivitäten eine Anforderung an die Plattform dar. Ein besonderes Problem bei dieser Alternative liegt jedoch im Umgang mit Konflikten. So gaben einige Studierende an, dass sie aus Angst vor Sanktionen die gruppeninternen Konflikte auf externen, für den Lernbegleiter unbekannten Plattformen austragen. Es fehlt derzeit eine Lösung, um dies zu verhindern oder zumindest zu erkennen.

Beide geschilderten Umstände führten dazu, dass eine lernzielförderliche Lernbegleitung aufgrund technischer Probleme derzeit nicht umfassend stattfinden kann. Zur formativen Lernerbewertung müssen möglichst umfangreiche Lerneraktivitäten eingeschätzt werden. Im Gegensatz zum Bewertungsprozess müssen die E-Tutoren die Lerneraktivitäten jedoch in Echtzeit verfolgen, sie interpretieren und bei Handlungsbedarf intervenieren. Die bisherige Lösung ist hierfür nicht geeignet, da die manuelle Erfassung und Interpretation zu aufwändig ist. Eine teilautomatisierte Datenaggregation und -analyse ist erforderlich. Der nachfolgende Abschnitt leitet vor diesem Hintergrund eine Verbesserung der bestehenden Lernplattform ab und thematisiert nötige Schritte zur Umsetzung.

5 Lösungsvorschlag

FF5: Wie können Lernplattformen bereitgestellt werden, um Learning Analytics zu ermöglichen?

Das als Ergebnis dieser Untersuchung entwickelte Konzept ist in Bild 1 visualisiert und stellt eine vierstufige Architektur dar. Es integriert im Gegensatz zur bisherigen Architektur zwei weitere Ebenen, die zur Informationsaufbereitung für die Lernbegleiter fungieren. Aus einem heute schon existierenden Beobachtungsbogen der Lernbegleiter werden Anforderungen an die Analysen abgeleitet. Diese greifen auf eine zentrale Datenbasis zu, die durch Konnektoren mit den Lernplattformen verbunden ist. Aus den dezentralen Lernplattformen werden die Daten in ein plattformunabhängiges Format transformiert (Beuster et al. 2012). Mit dem generalisierten Datenmodell für Learning Analytics (gDMLA) ist dieses unabhängige Format verfügbar. Es ist bereits an das Lernprozess Monitoring Analysewerkzeug (LeMo) angebunden, dessen Analysen auf 80 potenziell relevanten didaktischen Fragen basieren (Beuster et al. 2012). Die an dieser Stelle analysierten Daten dienen als Interpretationsgrundlage für die Lernbegleiter (Hansen et al. 2015).

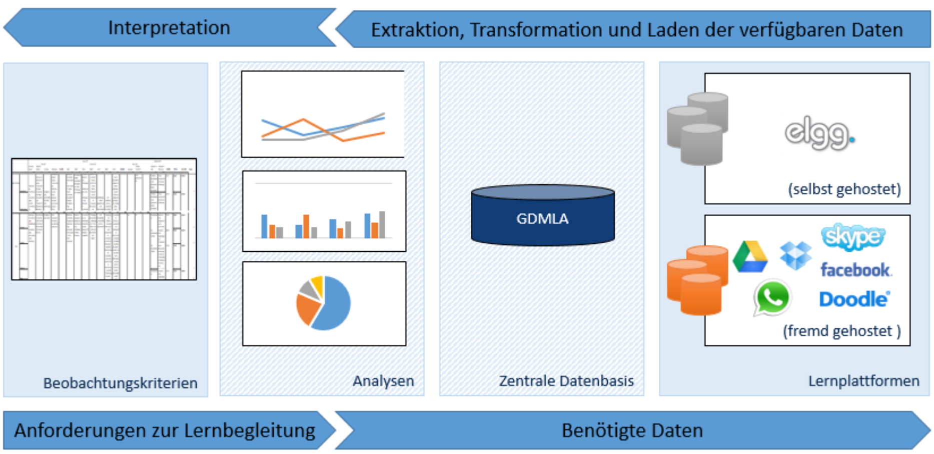

Bild 1: Architekturkonzept für Lernbegleiter-orientierte Learning Analytics

Die bei „Lernplattformen" aufgezeigten Anbieter fanden bislang Verwendung. Im Zentrum des neuen Konzeptes für die Lehrveranstaltung steht die Plattform ELGG. Diese verfügt nun durch die Erweiterung durch PlugIns über die grundlegenden – hauptsächlich asynchronen – Funktionalitäten, insbesondere einen Gruppenchat, ein Abstimmungstool und ein Dashboard. Diese Funktionen sind zum Lösen der Aufgabe weiterhin ausreichend, sodass mit der Erweiterung eine datenschutzkonforme und komfortablere Lösung als das Ausweichen auf (unsichere) Fremdanbieter gefunden wurde.

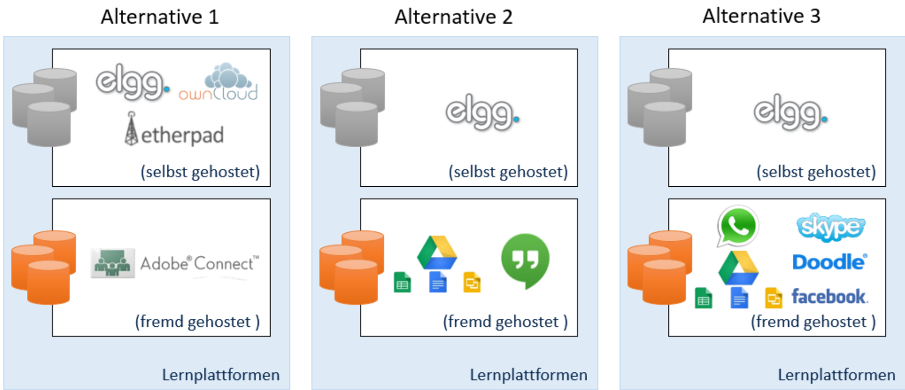

Bild 2: Lösungsalternativen für Lernplattformen

Als Konsequenz aus den Interviewergebnissen wird die Nutzung von ELGG obligatorisch und dient ausschließlich als Grundlage der kollaborativen Arbeit. Nur die hier verfolgbaren Aktivitäten werden für die Bewertung der Studierendenleistung herangezogen. Aufgrund der Nachfrage nach „komfortableren" Werkzeugen werden in den folgenden Abschnitten Lösungsalternativen vorgestellt, die eine zusätzliche, optionale Plattformnutzung ermöglichen. Die in Bild 2 aufgezeigten Lösungsalternativen zeigen mögliche Kombinationen der Lernplattformen (rechte Spalte in Bild 1) und werden nachfolgend ausführlicher erläutert.

5.1 Alternative 1: Selbst gehostet

Durch Bereitstellung von etherpad als real-time Editor und ownCloud als Dateispeicherlösung mit sowohl Web-Frontend wie auch Client App kann neben ELGG ein Großteil selbst gehostet werden. Als Videokonferenz Software dient Adobe Connect im Rahmen der DFN Lizenzierung. Fehlende Datenschnittstellen zu Adobe Connect erfordern jedoch strukturierte Protokolle mit Angaben zum Zeitpunkt, Dauer, Teilnehmer, Agenda, Verlauf und getroffenen Entscheidungen.

Diese Kombination wurde bereits einmalig erprobt. Hierbei war ein deutlicher Rückgang bei der Nutzung externer Plattformen zu verzeichnen. Nachteilig stellten sich jedoch die fehlende Integration eines real-time Editors in ownCloud und ebenso ein hoher Bandbreitenbedarf von Adobe Connect heraus, sodass weiterhin Google Apps und Skype zum Einsatz kamen. Der hohe Administrationsaufwand war ebenso negativ zu beurteilen.

5.2 Alternative 2: Selbst gehostet und eine externe Plattform

Google bietet Bildungseinrichtungen die kostenfreie, professionelle Nutzung von Google Apps (https://www.google.de/edu/) an. Hierbei können das Office Paket, Google Drive als Dateispeicher mit real-time Editor und Google Hangout für Videokonferenzen genutzt werden.

Diese Lösung reduziert den Aufwand gegenüber Alternative 1 erheblich. Es verbleibt ausschließlich das Hosten von ELGG und das Einrichten von Google Apps. Die Bereitstellung aller gewünschten Funktionen auf einer externen Plattform sowie die Nutzung von APIs zur Datenintegration sind von Vorteil. Selbst wenn diese Lösung aus Sicht des Datenschutzes kritisch einzustufen ist, würden Studierende Google Apps in jedem Fall nutzen, um die gewünschten Funktionalitäten zu erhalten.

5.3 Alternative 3: Selbst gehostet und verschiedene externe Plattformen

Sollten die Studierenden möglichst uneingeschränkt arbeiten können, bietet sich an, die bisher genutzten Plattformen weiterhin zu erlauben. Im Unterschied zur bisherigen Situation sollten nun jedoch externe Plattformen über APIs angebunden werden. Da der Datenzugriff teilweise nur für Gruppenmitglieder möglich ist, muss ein Account für den begleitenden E-Tutor auf allen Plattformen angelegt und den studentischen Arbeitsgruppen hinzugefügt werden.

Mit dieser Möglichkeit verbleibt den Studierenden ein freies und gewohntes Nutzen der privaten Plattformen. Gleichzeitig können Sie die Medienkompetenz aus ihrem Privatbereich in die Universität einbringen und die gewonnenen Erkenntnisse aus der Lehre wieder in das Privatleben transferieren. Wie auch Alternative 2 reduziert es den Hosting-Aufwand, jedoch mit gesteigertem Aufwand zur Schnittstellenerstellung zu den Plattformen. Hinsichtlich des Datenschutzes gelten die gleichen Anmerkungen wie bei Lösung 2.

6 Zusammenfassung & Fazit

Im Rahmen dieser Arbeit wurden die Herausforderungen einer lernzielförderlichen Lernbegleitung in kollaborativen formellen E-Learning-Angeboten thematisiert. Als derzeit größtes Hindernis stellte sich die fehlende Informationsverfügbarkeit bei der Nutzung externer Plattformen heraus, die eine effiziente und zeitnahe Lernbegleitung nicht erlaubt. Die Ergebnisse der Interviews von Teilnehmern und E-Tutoren der letzten kollaborativen Lehrveranstaltung wiesen auf spezifische Bedürfnisse der Befragten hin. Aus diesen Anforderungen wurde eine Lösung konzipiert, die aktuell umgesetzt wird und auf deren Basis durch die Anbindung verschiedener Web 2.0-Werkzeuge an eine zentrale Datenbank und die Auswertung der hierin befindlichen Daten eine verbesserte Lernbegleitung möglich werden soll.

Hinsichtlich der Validität der Anforderungen an eine lernerorientierte Plattform sollten neben den Anforderungen der Teilnehmer auch andere Einflussfaktoren, wie bspw. die Aufgabenstellung, Fallbeispiele oder die Lernziele berücksichtigt werden. Abhängig von diesen Faktoren können sich Informationsbedarfe und die mittels Learning Analytics bereitzustellenden Datenauswertungen ändern. Vor der Übertragung auf andere Lernarrangements sollte die Passfähigkeit daher überprüft werden.

Als nächste Forschungsaufgaben stehen teilnehmerseitige Akzeptanzuntersuchungen der drei aufgezeigten Architektur-Alternativen, die Überprüfung der Nutzbarkeit der Lösung durch die E-Tutoren in Form detaillierter Einsatzanalysen an sowie die Konkretisierung der notwendigen Daten für eine (teil)automatisierte Informationsbereitstellung.

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Mass Customization im Lernservice Engineering: Realisierung durch einen webbasierten Baukasten für die Gründungslehre

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Abstract

In der industriellen Fertigung verspricht das „Mass Customization" eine Verbindung von individualisierter und standardisierter Leistungserstellung. Daran angelehnt sollen Serviceplattformen ähnliche Ziele im Service Engineering erfüllen. Auch bei der Erstellung von Lernservices werden auf dieser Grundlage Kostenvorteile und Qualitätssteigerungen vermutet. Eine als informationstechnisch umgesetzte Lernserviceplattform, welche die empirische Überprüfung solcher Aussagen erlaubt, existiert bislang nicht. Mit der Entrepreneurship Lehr- und Austauschplattform (ELAP) wird in dieser gestaltungsorientierten Forschungsarbeit ein Vorschlag zur Lösung dieses Problems unterbreitet und im Feld der Entrepreneurship Education erstmalig getestet. Die prototypische Artefaktgestaltung und mehrere Tests in Workshops, Interviews und heuristischen Evaluationen legen die Nutzbarkeit der Plattform dar. Mit der ELAP lassen sich Lernszenarien strukturiert entwickeln und Lehr-/Lernkomponenten zwischen Lehrenden austauschen.

1 Einführung

Modularisierung als Voraussetzung der „Mass Customization" sind Kernthemen des Service Engineering. Sie werden als eine Lösungsmöglichkeit zur Auflösung bzw. Minderung des Zielkonfliktes zwischen Standardisierung und Adaptivität betrachtet. Innerhalb dieser Diskussion werden Serviceplattformen als Konzept dargelegt, die das „Mass Customization" industrieller Fertigung auf die Erstellung von IT-basierten Dienstleistungen übertragen. Technologiegestützte Lehre – in Anlehnung an Weber (2008) nachfolgend Lernservice genannt – stellt eine IT-basierte Dienstleistung dar, welche konzeptionell bereits von Gersch und Weber (2007) auf dessen Eignung zur Bildung von Serviceplattformen geprüft wurde. Eine mittels Informationssystemen unterstützte Umsetzung dieser Konzepte blieb bislang jedoch aus. Mithin konnten weder die Anwendbarkeit noch die Effekte einer Serviceplattform auf die Lehre empirisch geprüft werden. Daher soll in der vorliegenden Arbeit ein IT-Artefakt geschaffen werden, welches diese Überprüfung ermöglichen kann.

Diese Arbeit folgt einem gestaltungsorientierten Forschungsansatz, welcher der Entwicklung von Artefakten und damit der Lösung eines spezifischen Problems dient (Becker and Pfeiffer 2006). Das Problem muss dafür relevant und die Artefaktgestaltung rigoros (bzw. stringent) sein (Winter and Baskerville 2010). Das informationstechnische Artefakt ist ein Webservice, welcher die Gestaltung von Lernszenarien in Form einer Serviceplattform ermöglicht: die Entrepreneurship Lehr- und Austauschplattform (ELAP). Entsprechend des Vorgehens zur Durchführung gestaltungsorientierter Arbeiten von Peffers et al. (2007) wird im Folgenden zunächst das Problem identifiziert (Abschnitt 2) und der Prozess der Artefaktgestaltung dargelegt (Abschnitt 3.2). Anschließend werden die Kernfunktionen der ELAP in Abschnitt 4.1 demonstriert. Dafür wird sie auf das Feld der Entrepreneurship Education an der Universität 1 und Universität 2 angewendet. Nach einer Evaluation der Rigorosität der Artefaktgestaltung und des Ergebnisses sowie der Relevanz des zugrundeliegenden Problems in Abschnitt 4.2 erfolgt schließlich eine Zusammenfassung und Würdigung der Erkenntnisse in Abschnitt 5.

2 Modularisierung im Lernservice Engineering

2.1 Modularisierung im Service Engineering

Der Wertschöpfungsprozess einer Dienstleistung lässt sich über drei Leistungsdimensionen beschreiben: Leistungspotenzial, Leistungserstellungsprozess und Leistungsergebnis (Engelhardt et al. 1993; Fließ and Kleinaltenkamp 2004; Kleinaltenkamp et al. 2009). Leistungspotenziale definieren sich über die Fähigkeit und Bereitschaft eines Dienstleistungsanbieters, Aktivitäten auszuführen. Es umfasst damit sowohl die Vorbereitung als auch die Verfügbarmachung interner Ressourcen. Mit der Aktivierung dieser Potenziale wird der Leistungserstellungsprozess initiiert. In diesem interagieren die intern bereit gestellten Potenzialfaktoren mit Ressourcen, die in Form von externen Faktoren von Seiten der Nachfrager, Kunden bzw. Nutzer eingebracht werden (Lusch and Vargo 2014; Lusch and Nambisan 2015). Dies resultiert schließlich in der Erstellung von Leistungsbündeln. Diese drei Leistungsdimensionen lassen sich auf alle Dienstleistungen und somit explizit auch auf Lernservices, welche eine spezielle Form der IT-basierten Dienstleistungen darstellen, anwenden (Lehr 2012).

IT-basierte Dienstleistungen werden zu einem wesentlichen Teil durch Informationssysteme ermöglicht, welche als Potenzialfaktoren eingebracht werden oder den Leistungserstellungsprozess begleiten sollen. Vor dem Hintergrund von Effektivitäts- und Effizienzerwägungen ist die kundenindividuelle Bereitstellung solcher Dienstleistungen regelmäßig nicht möglich. Anstatt dessen wird eine Standardisierung von Bestandteilen der Dienstleistung vorgeschlagen, mit dessen Hilfe Verbundvorteile oder Skaleneffekte ermöglicht werden sollen (Böhmann and Krcmar 2005). Daraus resultiert ein Zielkonflikt zwischen der Adaptivität und Standardisierung einer Dienstleistung, welche durch modularisierte Dienstleistungsarchitekturen gelöst werden kann (Burr 2002). Zu diesem Zweck werden IT-basierte Dienstleistungen in quasi-unabhängige Module geteilt, welche lose gekoppelt und zielgruppenspezifisch arrangiert werden können (Böhmann and Krcmar 2005). Dafür müssen Teile der Dienstleistung, in Form von Modulen und ggf. deren Schnittstellen, standardisiert werden können (Burr 2002). Die entstehende Service Architektur setzt sich somit aus drei Elementen zusammen: Modulen, Schnittstellen und Tests (Baldwin and Clark 2003). Die Architektur enthält demnach eine Beschreibung der wertschöpfenden Funktionen solcher Module und definiert die über Schnittstellen zu erfolgende Interaktion. Teststandards gewährleisten die Konformität der Module auf Basis festgelegter Gestaltungsrichtlinien und prüfen deren

Ergebnisbeitrag. Die von Böhmann et al. (Böhmann et al. 2008) vorgestellte und durch Langer (Langer 2013) erweiterte SCORE-Methode stellt ein Vorgehen zur systematischen Modularisierung bestehender IT-basierter Dienstleistungen dar.

Module, auf denen mehrere Dienstleistungen aufbauen und die selbst eine Kombination verschiedener Subsysteme, Strukturen und Schnittstellen darstellen, können zu einer Serviceplattform entwickelt werden (Stauss 2006). Diese Plattformen sollen das Konzept der "Mass Customization" aus der industriellen Produktfertigung auf die Dienstleistungserstellung übertragen. In Anlehnung an Burr (2002) schlägt auch Stauss (2006) eine Standardisierung nach Leistungsergebnis, Leistungserstellungsprozess, Potenzialfaktoren und externen Faktoren vor. Aus dieser Einteilung leitet er vier Serviceplattformtypen ab:

1. Bei der Standardisierung von **Leistungsergebnissen** werden unterschiedliche Versionen einer Leistung angeboten. Dabei ist jedoch die mitunter eingeschränkte Standardisierung von (autonomen) Nutzungs- und Interaktionsprozessen zu berücksichtigen, welche vor dem Hintergrund der Value Co-Creation durch externe Faktoren (Vargo et al. 2008; Grönroos 2011) einen Einfluss auf das Leistungsergebnis nehmen und im „Mass Customization“ definitionsgemäß einen großen Einfluss ausüben (Piller 2007).
2. Die Standardisierung von Aktivitäten – etwa über Vorgehensmodelle – kann die Effizienz und Effektivität von **Leistungserstellungsprozessen** erhöhen.
3. Wird die Diversität der **Potenzialfaktoren** und somit der intern bereit gestellten Ressourcen eingeschränkt, wird von Potenzialstandardisierung gesprochen.
4. Analog kann auch der **externe Faktor** in eingeschränktem Maße standardisiert werden. Dafür werden Nachfrager beispielsweise nach bestimmten Eigenschaften vorselektiert und/oder ihre Einflussmöglichkeiten im Leistungserstellungsprozess auf vordefinierte Varianten begrenzt. Auf Basis dieser nunmehr vorausgesetzten Eigenschaften können daraufhin differenzierte oder fokussierte Potenzialfaktoren bereitgestellt oder unterstützende Prozesse modelliert und angeboten werden.

2.2 Die Serviceplattform im Lernservice Engineering

Folgt man den Darstellungen von Weber (2008), beschreibt das Lernservice Engineering die „zielorientierte Entwicklung und Bereitstellung von Prinzipien, Methoden und Werkzeugen [...]" (S. 195) für die IT-basierte Dienstleistung Lehre. Lernarrangements werden mit ihrer Hilfe und unter Berücksichtigung ökonomischer Prinzipien, wie Effizienz und Effektivität, systematisch gestaltet und durchgeführt (Gabriel et al. 2010; Fink et al. 2013).

In konzeptionelle Vorarbeiten zur Serviceplattform im Lernservice Engineering wird zwischen Lernszenario, Lernphasen, Lernarrangement und Lehr-/ Lernkomponenten unterschieden (Gersch and Weber 2007; Gabriel et al. 2007; Weber and Abuhamdieh 2011). Lernszenarien werden als abstrahierte Veranstaltungstypen beschrieben, welche Lehr-/Lernkomponenten in Lernphasen und auf Grundlage einer Serviceplattform arrangieren. Diese Serviceplattform umfasst mitunter mehrere Anwendungsgebiete und kann sich an verschiedene Zielgruppen richten. Sie legt Gestaltungsrichtlinien sowie Schnittstellen für Lehr- und Lernkomponenten fest. Um die Konzeption von Lernszenarien von ihrer Realisation zu trennen, wird der Begriff des Lernarrangements eingeführt. Dieser stellt die konkrete Realisierung eines Lernszenarios bei einer bestimmten Zielgruppe und unter mitunter variierenden Kontextfaktoren dar. Die Überleitung eines Lernszenarios in ein Lernarrangement vollzieht sich über das didaktische Design (Weber 2008) und unter Berücksichtigung der jeweiligen epistemologischen Annahmen (Knight et al. 2014). Es umfasst die Gestaltung von Lernprozess, Lernzeit, Lernort, beteiligter Personen sowie eingesetzter Lehr- / Lernkomponenten (siehe Abbildung 1). Der Leistungserstellungsprozess eines Lernservices lässt sich somit in zwei Phasen oder sogar Teildienstleistungen unterteilen. Zunächst stellt ein Anbieter Lernservicemodule auf einer Serviceplattform zur Verfügung, welche im B2B-Austausch von einem anderen Anbieter zur Erstellung eigener Lernszenarien genutzt werden kann. Anschließend realisiert ein Anbieter, auf Grundlage des gebildeten Lernszenarios, das Lernarrangement bei den Lernenden (B2C).

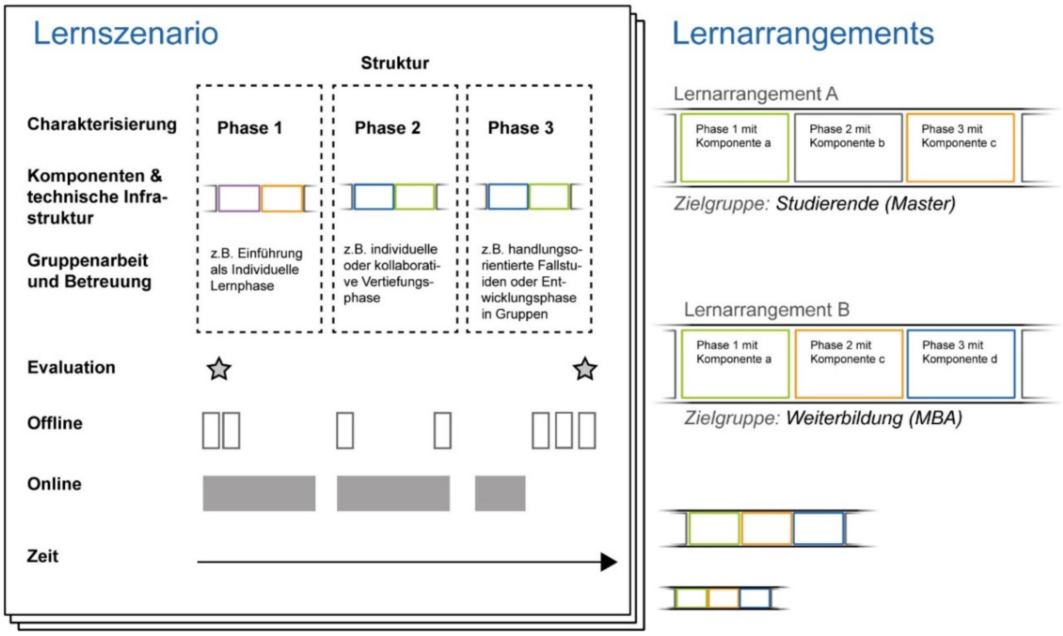

Abbildung 1: Darstellung eines Lernszenarios in Anlehnung an Rothe (2016)

Betrachtet man primär die erste Phase der Lernservicegestaltung, findet eine Einschränkung von Lernserviceanbietern, die Lernszenarien gestalten wollen, regelmäßig nicht statt. Die Ausgestaltung des Leistungserstellungsprozesses wird ebenfalls nicht vorgegeben. In Form einer breiten Variation möglicher Lernszenarien – vom 30-minütigen Kurzinput, über den zweistündigen Workshop oder virtuellem Seminar, bis hin zur traditionellen Vorlesungs-/Übungskombination – kann die Serviceplattform die Erstellung einer Vielzahl möglicher Leistungsergebnisse unterstützen. Die Darstellungen von Weber und Abuhamdieh (2011) weisen daher maßgeblich auf eine Potenzialstandardisierung hin, welche auffällige Kongruenzen zu Standardisierungsbemühungen der Lehr-/Lernforschung im Rahmen der Pedagogical Patterns (Bergin et al. 2012) aufweisen.

Die konzeptionellen Überlegungen zur Ausgestaltung einer Lernserviceplattform und ihrer Auswirkung auf die Lernservicegestaltung in der ersten Phase konnten bislang jedoch vorwiegend argumentativ reflektiert werden. Vor dem Hintergrund des aufstrebenden Feldes der Open Educational Resources (OER) entstehen zwar verschiedene Informationssysteme, die sich dem Austausch von Lehr- und Lernkomponenten widmen (z.B. www.oercommons.org oder www.oerplatform.org). Eine Plattform, welche die Integration von Lehr-/Lernkomponenten in Lernphasen bzw. zu ganzen Lernszenarien ermöglicht, ist den Autoren jedoch bisher nicht bekannt. Auf der Ebene von Plattformlösungen bleibt die von Gersch und Weber (2007) initial vermutete Anwendbarkeit eines „Mass Customization von Lehrangeboten“ (S. 22) daher bislang auch empirisch unbestätigt. Daher lässt sich folgende Forschungsfrage definieren:

"Wie kann das Konzept der Serviceplattform im Lernservice Engineering durch ein webbasiertes Informationssystem realisiert werden?"

Diese Serviceplattform muss dabei (1) die Standardisierung von Potenzialfaktoren zulassen, welche die Grundlage für die Modularisierung des Lernservices darstellt. Ferner soll sie (2) Lernszenarien strukturieren, um eine Ableitung diverser didaktischer Designs vorzubereiten. Das Problem soll durch eine spezielle Lernserviceplattform im folgenden Abschnitt gestaltungsorientiert adressiert werden. Dafür wird ein Artefakt geschaffen, welches am explorativen Beispiel der Entrepreneurship Education eine Lösung demonstriert.

3 Gestaltung einer Serviceplattform für die Entrepreneurship Education

3.1 Entrepreneurship Education

Nachfolgend wird die Gestaltung der Entrepreneurship Lehr- und Austauschplattform (ELAP) beschrieben. Gefördert durch das Bundesministerium für Wirtschaft und Energie sowie der Europäischen Union entstand diese Plattform im Rahmen eines durch das so genannte „EXIST IV Programm“ geförderten Projektes. Es dient u.a. der Stärkung und nachhaltigen Verankerung der Entrepreneurship Education (EE) an der Universität 1 und Universität 2. Durch die EE sollen an den Universitäten unternehmerische Fähigkeiten von Studierenden, Promovierenden und Mitarbeitern sowie ihre Einstellung zum Unternehmerischen Handeln positiv entwickelt und nicht zuletzt der Forschungstransfer befördert werden (Pittaway and Cope 2007). Dieser Kontext erscheint als Feld zum Aufbau einer ersten Lernserviceplattform als geeignet, weil in ihm fachbereichsübergreifende Methoden- und Fachkompetenzen vermittelt und somit eine breite Zielgruppe in verschiedenen Lehr- und Lernszenarien adressiert werden.

3.2 Prototypische Gestaltung der ELAP

Abbildung 2 stellt den Verlauf der prototypischen Entwicklung der ELAP dar. Ein Workshop mit elf Teilnehmern initiierte die konzeptionelle Entwicklung. In ihm wurden Anforderungen durch verschiedene Zielgruppen der EE aufgenommen. Es beteiligten sich Mitarbeiter und Professoren der Humanmedizin, Biologie/Chemie/Pharmazie, Mathematik und Informatik, Wirtschaftswissenschaft, Gründungsunterstützung und der Weiterbildungseinheiten von Universität 1 und Universität 2. Innerhalb des Workshops wurden drei Personas (als typische Nutzercharaktere) und mögliche Nutzungsszenarien entwickelt. Auf dieser Basis konnte anschließend ein Lasten- und Pflichtenheft definiert werden. Das daraufhin abgestimmte Ziel des Entwicklungsprojektes beschreibt die Erstellung einer institutionenübergreifenden Lernserviceplattform, welche den Austausch von Lehr- und Lernkomponenten ermöglicht und deren Integration in etablierte sowie neue Lernszenarien erlaubt. Zielgruppe der Plattform sind Lehrende der Universität 1 und Universität 2. Die ELAP ist explizit als (B2B-)Serviceplattform kreiert, welche den Austausch zwischen Lehrenden ermöglicht und der (Weiter-)Entwicklung von Lernszenarien dient. Folglich richtet es sich nicht an Lernende und substituiert somit nicht die klassischen Lernmanagementsysteme, wie Moodle oder Blackboard.

Die Erstellung vollzog sich über drei implementierte Prototypen. Zunächst wurden papierbasierte Prototypen (Paper Prototypes) auf Basis des Pflichtenheftes erstellt und im Entwicklungsteam abgestimmt. Der **erste** implementierte **Prototyp** entstand daraufhin auf Basis des Python-

Frameworks Django. Zur Überprüfung der Nutzbarkeit dieser Plattform wurde eine heuristische Evaluation durchgeführt. In dieser heuristischen Evaluation nach Nielsen und Molich (1990) analysierten fünf projektunabhängige Evaluatoren die existierende Softwareoberfläche und das Interaktionskonzept. Sie ordneten die entdeckten Probleme einem vordefinierten Set an Heuristiken aus den Bereichen kognitiver Psychologie, Human-Computer-Interaction, Design und Kulturwissenschaft zu und priorisierten diese nach dem subjektiv wahrgenommenen Schweregrad (Shneiderman 1992; Nielsen 1994; Tognazzini 2014). Infolgedessen wurde das Interaktionsdesign der ersten Interaktionsschritte mit dem Webservice, der Such- und der Filterfunktion von Lehr- / Lernkomponenten überarbeitet.

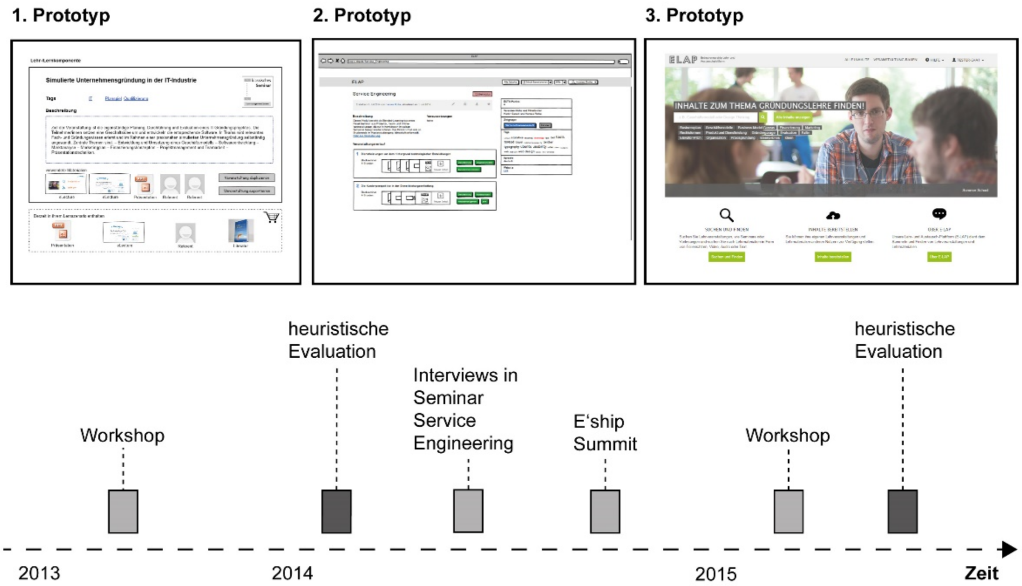

Abbildung 2: Gestaltungs- und Evaluationsprozess der Entrepreneurship Lehr- und Austauschplattform (ELAP)

Der daraufhin angepasste **zweite Prototyp** wurde mit verschiedenen Testnutzern, aus der Biologie/Chemie/Pharmazie, Wirtschaftswissenschaft, Humanmedizin und Gründungsberatung erprobt. Ihr Feedback wurde um Interviews mit weiteren Lehrenden ergänzt. Im Ergebnis sollte die Konzeption von Lernszenarien stärker strukturiert und vereinfacht werden. Diese Lernszenarien werden infolgedessen in Lehreinheiten unterteilt, welche sich am Konzept der Lernphasen orientieren und denen die Lehr- / Lernkomponenten zugeordnet werden können.

Nach Erprobung neu erstellter, papierbasierter Prototypen für diese Funktion wurde ein **dritter Prototyp** implementiert. Die Tests wurden durch Studierendenteams unterstützt, welche im Sommersemester 2014 im Kurs Service Engineering eigene papierbasierte Prototypen erstellten. Diese validierten sie durch insgesamt achtzehn Interviews in acht Fachbereichen und drei Universitäten. Parallel dazu wurde das Austauschkonzept der ELAP auf der Entrepreneurship Konferenz – Entrepreneurship Summit 2014 – mit Experten der Gründerlehre und -beratung diskutiert.

Als Reaktion auf das Feedback wurde das Interaktionsdesign grundlegend überarbeitet und auf eine clientseitige Interaktion mittels Asynchronous Javascript and XML (AJAX) umgestellt. Zu diesem Zweck wird das Angular.js-Framework eingesetzt, welche mittels REST-Schnittstelle mit dem auf Django basierendem Backend der Plattform interagiert. Nachdem der dritte Prototyp in einem

Workshop mit 29 Teilnehmern im März 2015 vorgestellt und diskutiert wurde, erfolgt ein erneuter Test der Nutzbarkeit über eine heuristische Evaluation. Diese richtete sich nun explizit an die (Weiter-)Entwicklung von Lernszenarien.

4 Funktionen und Erfahrungen aus der Nutzung der Plattform

4.1 Demonstration der Kernfunktionen

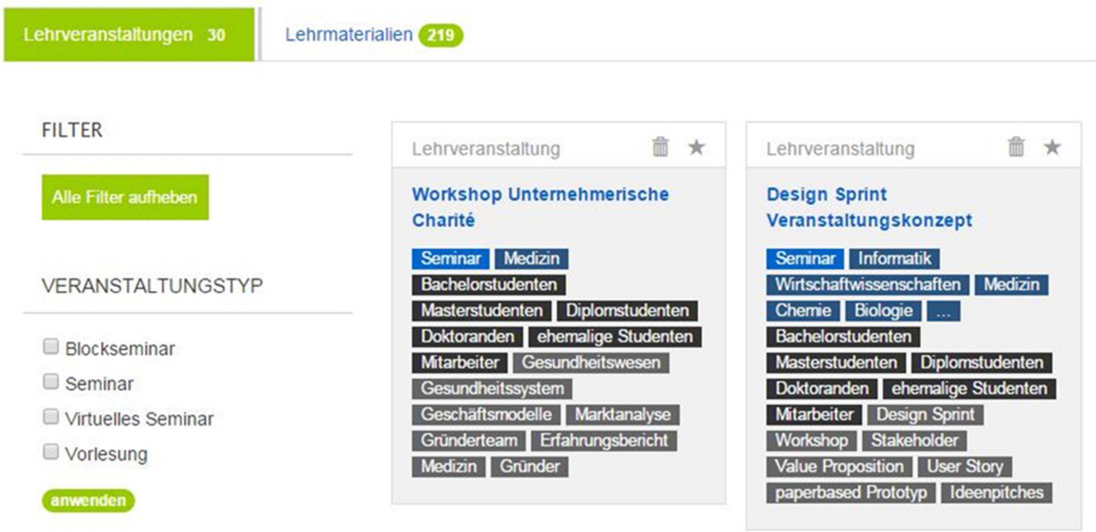

Abbildung 3: Such- und Filterfunktion für Lernszenarien und Lehr- / Lernkomponenten

Alle angelegten Lernszenarien sowie hochgeladenen bzw. eingebetteten Lehr-/Lernkomponenten lassen sich über die in Abbildung 3 dargestellte Such- und Filterfunktion auffinden und in Merklisten organisieren. Die Verschlagwortung der Lernszenarien gibt dabei einerseits die Zielgruppe und andererseits die Themenschwerpunkte wieder. Obwohl Lernobjektstandards, wie LOM oder SCORM, bereits eine Vielfalt möglicher Systematisierungen für Lehr-/Lernkomponenten anbieten, wird davon an der Schnittstelle zum Nutzer der Plattform abgewichen. Die vorab und im Verlauf der Erstellung geführten Interviews wiesen mehrfach darauf hin, eine allgemein verständliche Sprache zu wählen. Zum einen lässt sich dies darüber begründen, dass keine zu hohen technischen Vorerfahrungen bei den betreffenden Professoren und Mitarbeitern, an die sich die Plattform wendet, vorausgesetzt werden sollte. Darüber hinaus variiert der Sprachgebrauch zwischen den Fachbereichen mitunter deutlich. Daher wird lediglich zwischen Text, Video, Audio und Software unterschieden, welchen die Lehr-/Lernkomponenten zugeordnet werden müssen. Durch die vorliegenden Standards bestimmter Datenformate für Videos oder Präsentationsfolien und technischer Schnittstellen werden auch extern gehostete Materialien, etwa von Youtube, Vimeo oder Slideshare, integriert. Dabei wird auch die Lizenzierung der Materialien auf möglichst einfachem Wege adressiert. So können die Lehrenden aus einer überschaubaren Anzahl verschiedener Lizenzen, welche mindestens die Wiederverwendung an einzelnen Institutionen oder öffentlich gestatten, wählen.

Im Backend der Plattform werden die gespeicherten Metadaten einzelner Lehr-/Lernkomponenten und die Struktur der Lernszenarien in eine Modellierung nach SCORM übertragen. Ein Zip-Archiv, welches die Lehr-/Lernkomponenten inklusive Metadaten enthält, ermöglicht auf Basis einer im

XML-Format hinterlegten Struktur des Lernszenarios die Übertragung in das Lernmanagementsystem Blackboard.

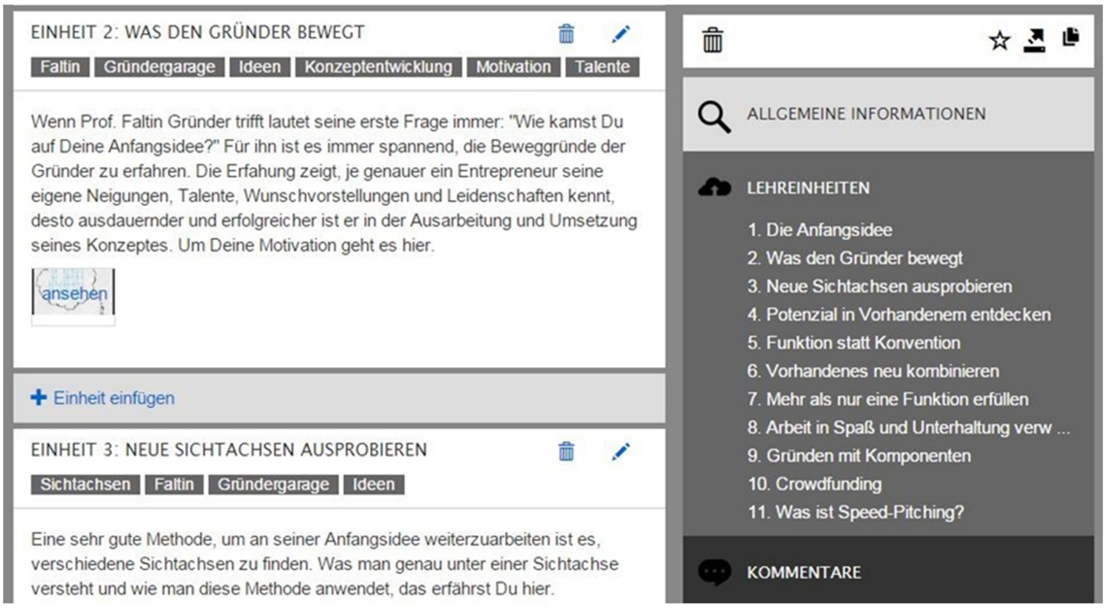

Abbildung 4: Gestaltung von Lernszenarien über separat beschriebene Einheiten

Die Konzeption neuer Lernszenarien kann auf zwei Wegen geschehen (nachfolgend fett markiert). Die **komplette Neukonzeption** („Veranstaltung bauen“) eines Lernszenarios folgt einem Vorgehen in fünf Schritten, wobei der letzte Schritt noch einmal gegliedert und iterativ durchlaufen wird. Zunächst (1) werden verpflichtende Metadaten zum Lernszenario hinterlegt. Diese beinhalten Titel, Urheber, Zielgruppenangaben, einen Veranstaltungstypus, welcher sich an den Grundformen der Lehre orientiert (siehe etwa Schulmeister 2002; Gierke et al. 2003), sowie einen kurzen Beschreibungstext. Anschließend (2) erfolgen optionale Angaben zu ECTS-Punkten, Sprache und zum Webauftritt und (3) etwaigen Voraussetzungen. In Schritt (4) werden Sehrechte für die Veranstaltung vergeben und Nutzer ausgewählt, welche das betreffende Lernszenario ebenfalls bearbeiten dürfen. Schließlich werden (5) die Lernphasen angelegt. Für jede Lernphase – aus Vereinfachungsgründen „Lehreinheit“ genannt – lassen sich Titel, Methodenbeschreibungen und Schlagwörter anlegen. Ferner werden ihnen die Lehr-/Lernkomponenten zugeordnet. Abbildung 4 gibt zwei dieser „Lehreinheiten“ innerhalb der ELAP exemplarisch wieder. Alternativ steht auch der **Remix von Lernszenarien** zur Verfügung. Dafür wird ein komplettes Lernszenario dupliziert und zum Editieren bereitgestellt. Infolgedessen konnte etwa ein Lehrender ein Lernszenario aus dem Bereich des Innovationsmanagements, welches sich primär an Wirtschaftsinformatiker richtet, kopieren und für die Zielgruppe der Humanmediziner anpassen. Dafür mussten lediglich einzelne Lehreinheiten angepasst bzw. ausgetauscht werden. Allgemeine Lehr-/Lernkomponenten, etwa zur Marktanalyse, Rechtsformen oder zur Geschäftsmodellinnovation, konnten wiederverwendet und methodisch analog eingesetzt werden.

4.2 Evaluation der ELAP als Instanzierung einer Serviceplattform

Methoden zur Evaluation gestaltungsorientierter Forschungsarbeiten lassen sich nach ex ante und ex post Methoden unterscheiden (Pries-Heje et al. 2008). Sie dienen der Darlegung von Relevanz und Rigorosität. Ein Problem ist als relevant anzunehmen, soweit es grundsätzlich abstraktionsfähig ist und für eine Anspruchsgruppe aktuellen oder zukünftigen Nutzen verspricht (Österle et al. 2010). Relevante Lösungen müssen innovativ, kreativ und/oder wichtig für ein Forschungsfeld sein (Nunamaker et al. 1991; Hevner et al. 2004). Die Rigorosität bemisst sich an vorab festgelegten Zielen sowie einer nachvollziehbaren und korrekten Methodenanwendung und Argumentation (Hevner et al. 2004; Becker 2010). Die Gestaltungsziele bestanden darin, (1) eine Modularisierung des Lernservices durch Standardisierung zu ermöglichen und (2) eine Ableitung verschiedener didaktischer Designs aus den beschriebenen Lernszenarien zuzulassen.

Zur Evaluation der ELAP wurde *ex ante* die Relevanz des Problemfeldes, wie in Abschnitt 2 dargelegt, argumentativ hergeleitet und durch einen initialen Workshop mit verschiedenen Stakeholdern der EE im empirischen Feld validiert (Sonnenberg and vom Brocke 2012). Hauptgrund für die erkannte Relevanz im Feld stellt eine dezentrale strategische Entwicklung der EE an den beteiligten Universitäten des EXIST IV Projektes dar. Diese sind – als Folge diverser strategischer Grundsatzentscheidungen – unter anderem auf den Aufbau von Skalierungseffekten ohne zentralisierte Gründungsprofessur und der Förderung eines auf die EE bezogenen Erfahrungsaustausches zwischen Vertretern verschiedener Fachbereiche angewiesen.

Die *ex post* Evaluation erfolgte durch (heuristische) Tests der drei erstellten Prototypen mit Test- und Lead Usern an unterschiedlichen Fachbereichen der beiden beteiligten Hochschulen, Interviews mit Lehrenden einer anderen Hochschule durch Studierendenteams und einer Demonstration des zweiten Prototypen vor Gründern, Gründungslehrenden und -beratern auf dem Entrepreneurship Summit. Die Plattform sollte die adressierte Zielgruppe EE-interessierter Lehrender in die Lage versetzen, Lehr-/Lernkomponenten auszutauschen und Lernszenarien zu gestalten. Der iterative Gestaltungsprozess der ELAP, wie er in Abschnitt 3 dargelegt wird, leistet zur Darlegung der Rigorosität der Artefaktgestaltung bereits einen wichtigen Beitrag (Hevner et al. 2004).

Zusammenfassend ist zu erkennen, dass die ELAP die Faktoren, Lehr-/Lernkomponente und Lernszenario, vorstrukturiert erfasst und somit standardisiert. Der erste Gestaltungsparameter scheint mithin erfüllt. In der Anwendung zeigt sich jedoch, dass ein Großteil zusätzlicher Informationen, wie etwa Vermittlungsmethoden bestimmter Lehr-/Lernkomponenten oder Abläufe innerhalb einer „Lehreinheit“ unstrukturiert erfasst werden. Dies senkt die Transparenz des Lernszenarios insbesondere bei sehr aktiven Plattformnutzern. Damit werden bei der Erfassung des Lernszenarios jedoch nicht nur inhaltliche Schwerpunkte beschrieben, sondern auch methodische Hinweise gegeben. Infolgedessen ist die Diversität zu entwickelnder Lernarrangements aus diesen Lernszenarien begrenzt, da sie bestimmte didaktische Designs präjudizieren. Die Trennung zwischen Lernszenario und Lernarrangement wird in der praktischen Anwendung aufgeweicht, da der Abstraktionsgrad der beschriebenen Lernszenarien gesenkt wird. Zudem erscheint es erwähnenswert, dass einzelne Interviewteilnehmer diese methodischen Hinweise als besonders hilfreich empfanden. Aus diesem Grund wurde das „Duplizieren“ von Lernszenarien ermöglicht. Damit können Lehrende ein Lernszenario an ihre eigenen Bedürfnisse anpassen, ohne das Original zu verändern.

Aufgrund des vorgegeben Interaktionsdesigns der Plattform wird zusätzlich das Vorgehen zur Erfassung beider Faktoren vereinheitlicht. Mithin findet auch eine eingeschränkte Standardisierung des Leistungserstellungsprozesses statt. Obwohl die Plattform zum gegenwärtigen Zeitpunkt lediglich von einer Gruppe von sieben Lead Usern mit 21 registrierten Nutzern verwendet werden soll, wurden bereits 23 Lernszenarien (weiter-) entwickelt und 175 Lehr-/Lernkomponenten (73 Videos, 101 Textdokumente und Foliensätze sowie eine Software) hinzugefügt.

5 Fazit

5.1 Zusammenfassung

Obwohl Serviceplattformen für die Dienstleistung Lehre bereits seit längerem diskutiert werden (Gersch and Weber 2007; Gabriel et al. 2007; Weber and Abuhamdieh 2011), fand eine empirische Erprobung einer plattformgestützten „Mass Customization" in diesem Bereich – insbesondere mangels fehlender konsequenter Umsetzung/Implementierung – bislang nicht statt. Die vorliegende, gestaltungsorientierte Arbeit adressiert dieses Problem, indem sie eine Lernserviceplattform als Web Service gestaltet. Die explorative Anwendung am Einzelfall der Universität 1 und Universität 2 weist auf die Nützlichkeit von Serviceplattformen in der Hochschullehre hin. Auf der Entrepreneurship Lehr- und Austauschplattform (ELAP) können Lehr-/Lernkomponenten strukturiert erfasst, zentral bereitgestellt und in Lernszenarien integriert werden. Die Plattform unterstützt damit den Aufbau, die Weiterentwicklung und den Remix von Lernszenarien sowie den Austausch von Lehr-/Lernkomponenten. Die Entwicklung von Lernservices wird dabei insbesondere durch eine Standardisierung von Potenzialfaktoren sowie partiell des Leistungserstellungsprozesses unterstützt.

5.2 Implikationen und weitere Forschung

Die Anwendung der ELAP in der Entrepreneurship Education weist zunächst auf eine grundsätzliche Anwendbarkeit des Serviceplattform-Konzepts zur Realisierung einer „Mass Customization" in der Hochschullehre hin. Die empirischen Erkenntnisse im Rahmen einer ersten Evaluation lassen sich jedoch lediglich auf diesen engen Anwendungsfall und die exemplarische Erprobung an zwei großen Universitäten begrenzen. Um generalisierbare Aussagen treffen zu können, sollten weitere Fälle herangezogen werden.Ferner gilt es in kommenden Arbeiten, die jetzt realisierte Serviceplattform zu erweitern bzw. auszudifferenzieren und im Hinblick auf mögliche Varianten zu testen. Dies bezieht sich zum Beispiel auf den Grad der Standardisierung und insbesondere der strukturierten Erfassung von Lernphasen in der ELAP sowie eine Erweiterung der unterstützten didaktischen Methoden. In der praktischen Anwendung erscheint es schwierig, den Abstraktionsgrad eines Lernszenarios und damit die Anwendbarkeit auf verschiedene didaktische Designs aufrecht zu erhalten. Fraglich ist, ob eine weitere Standardisierung der erfassten Lernszenarios dies erleichtern könnte. Darüber hinaus bieten die jetzt erhebbaren Daten interessante Auswertungsmöglichkeiten („Academic / Learning Analytics") sowie eine mögliche Grundlage für den Aufbau eines Empfehlungssystems für Lehrende. Dieses unterstützt nicht nur die Auswahl geeigneter Lehr-/Lernkomponenten zu bestimmten Themen, sondern sollte darüber hinaus bei Strukturentscheidungen eines Lernszenarios, wie etwa empfehlenswerte Methoden oder die Reihenfolge bestimmter Lernphasen, unterstützen.

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Design for Collaborative Contextualization of Open Educational Resources

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Abstract

The paper presents an evaluation of a prototype design for collaborative adaptation of open educational resources (OER) in e-Learning platforms. Interactive mock-ups are designed for the process of adapting OER collaboratively. The overall research question is: Which functional design allows for a meaningful navigation through collaborative contextualization processes? The analysis focuses on the time (when users like to add peers), which informational needs are required to select peers, and which functions are missing more generally in the prototype. Results provide insights how a well-planned design can increase the use of adaptation tools and how to overcome the important barrier of systems complexity. Findings suggest that participants like to contact peers before having selected the resource and by sending a link or a mail. They do not need to see much information to select their collaboration partner. Furthermore, aspects which need to be added are icons that facilitate identifying collaboration spaces. Based on the results and user feedback, design principles and their adaptation are discussed in this paper.

1 Introduction

The goal of this paper is to advance understanding of collaborative development and adaptation processes of digital learning resources and its implications for user interface design. Contextualization is a well-known activity in e-Learning and the development of open educational and knowledge resources and stands for the creation and adaptation of cultural sensitive digital knowledge resources for others as well as for personal learning means, preferences or devices. Associated strategies such as 'localization' and 'modularization' are applied and discussed in practice and research (Dunn & Marinetti2002). Contextualization shall mitigate difficulties given the emerging, global use of educational resources. It was found that the resources are culturally shaped and thus access to knowledge is not opened as intended. OER convey customs of original author's contexts what may disrupt the learning experience. Several studies have elaborated on barriers in this respect, both in private and educational domains (Pirkkalainen & Pawlowski 2014) as well as in public sector contexts (Eidson 2009).

Apart from barrier studies, strategies for contextualization have been developed from instructional (Edmundson 2007; Henderson 2007; Dunn & Marinetti 2002) and technical perspectives (Richter & Pawlowski 2007). While they provide an overview what aspects are to consider in the development of e-Learning resources, they do not formulate design principles (Tapanes 2011; Pawlowski & Richter 2010). For designers who are interested in developing appropriate interfaces, the strategies provide no guidance. Design choices cannot be guided by design principles, indicating how to enable learners to navigate through contextualization processes online. What are principles that guide to design usable contextualization screens?

This study will answer the questions by defining and evaluating mock-up designs. The outcome will be a set of generalizable principles and design implications for collaborative context-ualization. The study contributes to close the gap between practical design and theoretical contextualization strategies. In the following, the relevance of collaborative contextualization design is discussed. Subsequently, a set of design principles is defined and applied. Then, the evaluation method is presented. Last but not least, results and implications are discussed.

2 Background

2.1 Approaching culture contextualization

Culture contextualization is a cyclical process of creating and adapting culture sensitive OER for making them suitable for local uses and means (cf. Dunn & Marinetti 2002:2). Several models clarify *what* needs to be created / adapted, but differ in foci and approach. Focusing on learning resources Anand (2005:2f.) suggests to focus on linguistic (textual artefacts), substantive (rules, abbreviations) and cultural aspects (such as customs) in the contents. Adapting terms, icons and examples, however, is just as important as the concept behind. Henderson (2007) criticizes that without a conceptual model, resources are not becoming sensitive to multiple cultures but prone to tokenism and stereotyping. A suitable concept would emphasize standpoint epistemologies, gender, minority, workplace culture and eclectic pedagogical paradigms among others (Henderson 2007:136). As a result, not only the content of a resource but its format, method and learning structure may be subject to contextualization.

Apart from adapting contents, several studies have developed contextualization models which address the re-use of resources (Rensing et al. 2005). Another model suggests steps which users take to adapt OER; they cover the search, re-use validation, adaptation and re-publishing among others (Pawlowski & Richter 2010). But do models represent adequately how users accomplish contextualization; and how can design interface support the process? For developers, the model provides hints, which functional references must be provided in screens. Otherwise, design principles for contextualization are not developed, especially not for collaborative scenarios. Only a few design heuristics for e-Learning have evolved that may provide guidance. *Which functional design allows for a meaningful collaborative contextualization* is thus the overall research question of the study.

2.2 Formulating design principles for culture contextualization

In the domain of e-Learning several authors have defined design principles to improve the learning experience. Hetsevich (2014) has translated Nielsen's usability design principles (1994) into concrete design guidelines for e-Learning websites. The heuristic to leave user control and freedom in the navigation (no.3) resulted in the design of different navigation tools to navigate back and forth in the interfaces (cf. Hetsevich 2014). Lane (2010) addresses a similar aspect, the 'agency of users' in open e-Learning platforms and indicates to be more open which contents can be published and why. Another principle is the heuristic to keep consistency (no.4) by arguing to apply consistent fonts and layouts (cf. Hetsevich 2014). A third example is the translation of the heuristic help and documenting uses of e-Learning platforms (no.10) (Nielsen 1994). Hetsevich (2014) decides to provide tutorials and manuals that are short, simple and informative for learners. Furthermore, the search through the platform and resources must be easy, including the match of wordings (Hetsevich 2014).

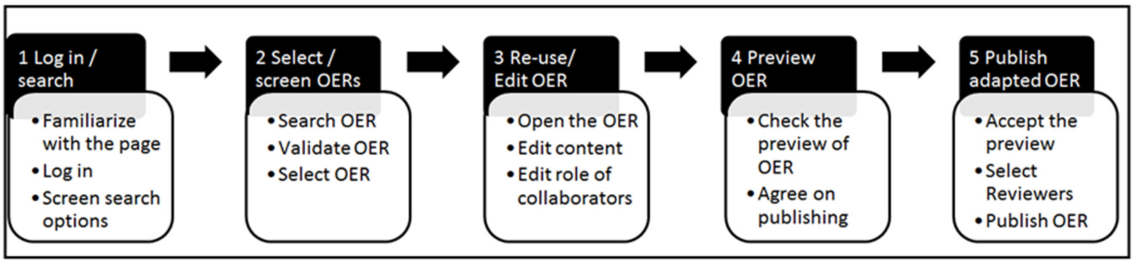
Generally, orientation can be gathered by such design heuristics. Often, however, heuristics are too general to guide design activities (Nielsen 1995). Abstract principles may be advanced by providing illustrating examples from practice. Following Shneiderman (2002) and Galitz (2007) abstract principles have to be specified not at last for the use of words and icons (I), the layout (II), in-/output of the system (III) and required training (IV). Aiming to advance the current state of literature about contextualization design, an initial specification of design principles is provided in Table 1. The first column defines the label and origin of principles. The second column indicates how they are translated into the screen design.

As presented in the table, a set of design principles is defined and discussed. To elaborate whether the resulting design choices enable collaborative contextualization, results have to be tested and improved on behalf of user feedback. Given that contextualization is a comprehensive process, the focus needs to be tailored as well. To begin with, the first contextualization steps can be addressed. They include the steps searching, selection of resources and collaboration partners. Correspondingly, the overall research question can be split into a set of three operational questions: (1) What is the time point of choosing collaboration partners? (2) What informational needs are required to validate the selection of peers? (3) Which functions are missing in the evolving design? These aspects will allow tailoring user feedback to certain aspects.

3 Methodology and study context

The study is associated to the project EnhAnced Government LEarning (www.eagle-learning.eu). EAGLE aims at developing an open source platform for the exchange of experiences and OER for training means in the public sector, accompanied by a set of change management guidelines and a pedagogical strategy supporting introduction of online knowledge exchange and learning. The study provides insight on early design sketches. Moreover, they are focused on the contextualization of resources which represents neither the centre nor the whole scope of activities in the EAGLE platform. Yet, the results will inform later design choices as discussed in the last section of the paper.

To enable a test of early sketches and get design principles into screens, a set of interactive mock-ups was designed. The approach followed is LUCID (Logical User-Centered Interactive Design Approach; in Shneiderman 2002; Kreitzberg 2008), suiting the user-centred design perspective (Abras et al. 2004:19; Lowdermilk 2013) of authors. Correspondingly to LUCID, a Goals, Operators, Methods and Selection Rules analysis (GOMS), job-task, context, and needs analysis (incl. scenario development) was made to inform the initial design. The results of analysis suggest to develop five screens including the following contextualization steps as shown in Graphic 1.



Graphic 1: How contextualization steps correspond to mockups

Guidance to prepare mock-ups and scenarios is drawn from Galitz (2007) and Benyon (2010) as well as Goodman & Kuniavsky (2012). Technical tools used are pencil (pencil.evolus.vn) and Umlet (umlet.com).The resulting mock-ups are presented in the results section (which facilitates following design principles and their evaluation). **The evaluation of mock-ups** follows a concurrent mixed-method approach (Creswell & Plano-Clark 2011) to include standardized as well as in-depth evaluation techniques that complement each other. To have a representative set of target users of the project, sampling goals were to balance gender, age, and experience levels (in contextualization) of people working in the public sector. To test the usability of the mock-ups, the VisAWI-questionnaire was chosen and taken over from Moshagen and Thielsch (2010;2014b). Being interested to evaluate the navigation (i.e. particular design choices), led to add further questions (orienting on Reeves & Hedberg 2003:148). To supplement questionnaire results, three qualitative data gathering techniques were conducted. Firstly, observations were made during user test. Secondly, users were asked to think aloud (and explain their thoughts and challenging design aspects) while navigating through the set of mock-ups. Thirdly, semi-structured interviews are made in small focus groups to qualify questionnaire responses (Merton & Kendall 1946; Kitzinger 1994; Cohen et al. 2011). The interviews are guided by non-reactive tools such as the semi-structured guidelines and by reactive tools such as stimulus prompts and provocative statements (cf. Merton & Kendall 1946). All materials can be provided on demand. **The approach to analyse questionnaires** was oriented on Moshagen & Thielsch (2014a). Based on the questionnaire results, most negative, positive and surprising responses were noted (as “action points”) to tailor the analysis of qualitative data. Subsequently, audio records and notes were analysed. Apart from action points, particular focus was to answer the three operational research questions. Finally, results from both methods were synthesized and related back to design principles. Hence, the analysis can be summarized as an exploratory sequential mixed method approach (Creswell & Plano-Clark 2011), which is reflected in the following report of results.

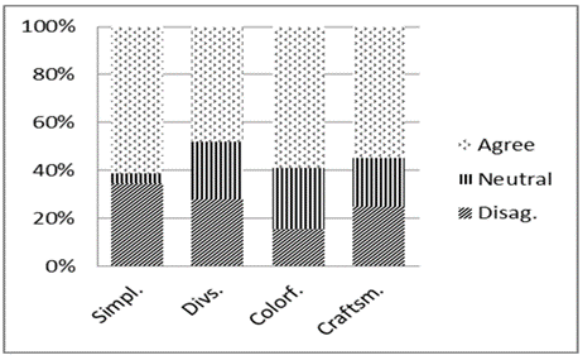
4 Report of results

4.1 Sample of participants

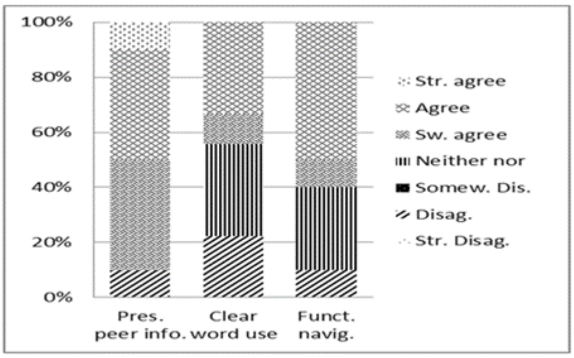
Six women and four men participated in the mock-up evaluation. The age of people ranges between forty and twenty-three, the average age is 29.4 years. Except for one person, participants are employed and work in the public sector (higher education). The time of being employed ranged from a half year to almost eight years. Three participants indicated to never have contextualized OER before (one male and two females). Two participants (two males) indicated that they regularly adapt OERs and are expert in the fields. Other participants were more or less familiar with contextualization. Apart from the employment background of participants, the sampling of involved participants is appropriate. The generalizability of results will be addressed in the discussion section.

4.2 Analysis of Usability / Aesthetic Factors

The overall rating of the usability and aesthetic-factors of the interface design tends to be rather positive (see Graphic 2- note the scale accumulates responses, expressed in percentages). Concerning the factor **simplicity**, about 60% of participants agree (somewhat simply or strongly agree) that the layout is lofty, easy to grasp, well-structured and coherent. Agreement to the factor **diversity** appears to be less positive. About 48% somewhat, strongly or simply agree that the design and layout is appealingly diverse. Coming to the factor **colourfulness**, the assessment shows that about 46% somewhat, strongly or simply agree that the colourfulness is positive. Furthermore, only about 15% of participants disagree that colours are negative in the design. Last but not least, the responses to the **craftsmanship** indicate that about 45% of participants agree that the layout and design is well made, compared to 25% participants who disagreed (simple, strongly or somewhat disagree).



Graphic 2: Overall Evaluation



Graphic 3: Evaluating Navigation

Apart from the VisAWI-report, participants were asked to answer additional questions concerning the **navigation** (see Graphic 3). Aggregating positive (strongly, simple, somewhat agreement) and negative (strongly, simple, somewhat disagreement) responses, nine of ten participants agree the presentation of peer information is clear, followed by the responses that the overall navigation is functional (six of ten). In contrast, the wording of buttons appears to be unclear; three people did not decide, one did not respond and two participants disagree that the use of words is clear.

So far results suggest that action points address the **density** of the page, **choice of colours,** inventiveness, **diversity**, as well as **actuality** of the layout. Additionally**,** the role of li**nguistic terms** needs to be further evaluated. While the questionnaire results do not answer how to go about and improve the design, the results of qualitative data will provide additional hints.

4.3 Qualitative analysis of mock-up design

Results of the audio records and observation notes will be presented in the following. In a first step, a descriptive report of the findings will be provided. Findings informing the action points and navigation (highlighted in bold) will be described for each mock-up screen (1-5). In a second step, a brief aggregation of responses to the main research questions will be provided. In a third step, implications for the design (and principles) will be defined.

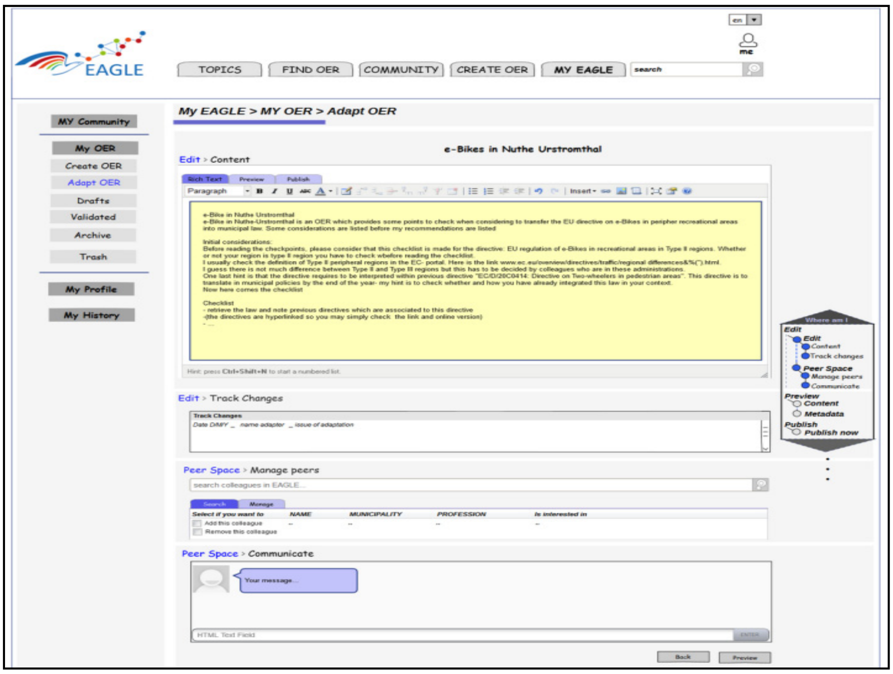
4.3.1 Descriptive results: observing users navigation through contextualization

Screen (1) Log in: Most participants needed time to familiarize with the first screen which shows several buttons and attention capturing information (such as the link 'what is an OER'). A central picture, which did not matter at all for the testing, captured attention as well and indeed, disrupted the process. Hence, a locale to improve **density** of the page can be allocated for the forthcoming design. The assumption that density is critical in the first screen can further be supported as users were looking for the log-in sign but could not find it: "*…where is the log-in*" (participant 3). Concerning the **use of words**, questions concerning abbreviations such as "OER" were posed. This hint will inform the section 'required training' (IV) of design principles. In the first screen, other action points (diversity, actuality, colours) were not addressed. Concerning the **navigation**, the most intuitive clicks can be allocated to the "search", "topic" and "find OER" button, as well as on the "play" button of the picture. In fewer cases, participants wanted to login in a first step and search OER afterwards. Only in one case, a participant wanted to look for collaboration partners and click "MyEagle" or the "community" button first. These results suggest that overall, users looked at the higher part of the interface first and oriented on the main navigation buttons.

Screen (2) Search OER: Given the programming of the search process, participants scrolled over the exposed OERs on the second screen. Those who evaluated presented information were very positive about seeing the "author", "last date of adaptation" and the "document type" of the resource. Users stayed only a short amount of time on this screen, wherefore neither design aspects nor action points were addressed. Concerning the **navigation**, the most intuitive clicks were directed to the OER content. Only few participants clicked the button "use this OER", a drop down menu which allows discriminating between "opening" and "seeing" the OER or opening a dedicated "adaptation space" (a point to be discussed later). Concerning **informational needs,** users were further interested to see whether this OER has an adaptation history. Hence, whether it was the latest OER or whether (parts of) the OER were re-used is of interest.

Screen (3) Adaptation space: Participants identified that the resource can be adapted 'here' in the third screen given the editor surrounding the OER text. A problem was that the laptop displayed information small wherefore it was mentioned often: "*…this is very small*" (participant 1). This feedback provides a valuable hint where to improve density of the interface. Concerning the **navigation**, most intuitive clicks were the buttons "preview", and "communicate with peers". The navigational device on the right hand was perceived and used by two novices. The third novice did not like the navigational device, while others found it non-disturbing when being asked. If the navigational device is not needed, a locale for improving density and simplicity of the layout can be defined. In screen 3, people further hesitated and screened all navigation bars for an option to ***add*** peers (to collaborate during contextualization). Not all participants identified the "*peer space"* button (and link) as the surrogate for this option. On the one hand, the action point **choice of linguistic terms** leads to a difficulty for users. On the other hand, **simplicity** of the layout may have to be improved in this respect. When opening the section '*peer space'* people were seldom clicking the *search* button to search and add peers. Output tables appeared to be overloaded since participants were looking only for name, surname and department to identify peers. Apart from informational needs, a surprising note was that participants were looking for icons to “add” friends or to “share” the OER. Here, the action point **linguistic terms** can be substantiated. Also, **actuality** and **diversity** of the layout may be improved regarding the use of icons. Interestingly, participants were looking for other options to inform their collaboration partner, namely by sending a mail, link or an invitation. This informs which **functional needs** are currently missing in the design. Last but not least, participants neither used (found) the ‘*manage’* button nor asked for options to restrict editing rights of collaboration partners. In focused interviews, however, participants supported that such options are important, but the current layout would not point them out intelligibly. In this context, negative results in the questionnaire regarding **simplicity** may be substantiated.

Screen (4&5) Preview and publishing space. After taking their time on the adaptation screen, users scrolled past the preview and publishing space without major considerations. Here, metadata for OER are presented by icons. Participants addressed seldom or outlined: “… *all these do not tell me anything but I don’t know this platform yet- I guess it will work out*” (participant 2). In this respect, a point to note for ‘required training’ (IV) of design principles can be allocated. Concerning the navigation, people both used the top navigation as well as the lower navigation to go back and forth between contextualization steps.



Graphic 4: Mockup screen (3)

4.3.2 Responses to the research questions

In the following, an answer to the research questions is sketched: (1) when users like to add collaborative peers in the process; (2) which informational needs users require to validate the selection of collaborative peers; and (3) which functions need to be added to allow collaborators to exchange their knowledge (how and/or what to adapt)?

(1) Concerning the **point of collaboration**, the test has shown that users like to contact peers before having reviewed the resource, after having selected the resource, by invitation, and sending a link

or mail. Users like to be informed when their peer has been informed about the invitation. Users require managing the editing rights of their collaborative peers. They wait for typical icons and wordings of social platforms such as “invite, share, send to” as well as “add“. Last but not least, users require seeing collaboration functions directly up front, since collaboration is their central point of concern. (2) Concerning **informational needs**, the test clearly pointed out, that the current design provides too much information. Users perceive an informational overload. It would be sufficient when showing name, surname only. (3) Concerning the third question, **functions which need to be added** to allow collaborative exchange of knowledge resources are icons for identifying the share functions and for identifying the collaboration space. Kind of media needed are chats, screen-shots, links, video, audio, notifications of changes, app mobiles. Last but not least, signs to differentiate between adapting and viewing spaces of OER should be considered.

So far, results of the questionnaires, audio records and observation notes have been presented. Missing so far is the consideration how findings allow improving and adapting the design and chosen principles in the table. The following section addresses this point.

4.3.3 Implications for the forthcoming design

The following table shows an *excerpt* of chosen design principles and their translation into screens (the full table can be provided on demand). The last column specifies problematic translations and indicates how to change forthcoming design.

Specific design principles	Argumentation of design choice	Implications
I. Use of words and icons		
A. **Consistency** o Keep consistency in design and textual devices (e.g. Hetsevich 2014) B. **Wording** o Use linguistically clear elements (e.g. Hetsevich 2014) C. **Usability** o Language is appropriate to increase usability (e.g. Nielsen 1994)	Consistency achieved by: consistent fonts, colour (shades of blue, light yellow, light red). Navigation is on the top, wordings in pages labels /fonts /buttons reflect results of GOMS cf. Galitz 2007:139; Oracle 2010). The use of words and textual learning contents needs to be low. The platform is used across countries so several languages are configured. As linguistically unambiguous terms are chosen f.e.: “peer space”, “manage” or “communicate”, “trace”, “editing”, “preview” and “publish”.	→**Linguistic terms:** use more icons and familiar wordings. F.e. ***icons*** for: share, log in, save, search; ***words***: share, invite, add, colleague, collaborate / chat. → Orient on **mobile phones** and social platforms design.
II. The layout		
D. **Capabilities** o Capabilities are easy to grasp (cf. Galitz 2007:47) o Ongoing representation of objects and actions o Fast, incremental, revisable operations, related effects are immediately visible on the screen or object (cf. Shneiderman 2002:149). E. **Usability** o Users are informed, enjoy control, capabilities allow recognition (Nielsen 1994)	Capabilities are highlighted by bolding (are bolded, colored cf. Galitz 2007:164,338). Capabilities of the page are displayed by buttons and links, they are exposed by the navigation. Most objects can be clicked, such as the ‘sign in’ icon, search, and so forth. The cursor changes its appearance by mouse-over, i.e. clickable fields are highlighted by visual cues (cf. Galitz 2007:338f.) Wordings, buttons etc. enable users to recognize functions instead of recalling how functions proceed. The status in the process of the contextualization process is displayed by process bars.	→**Display status more clearly**: when ***saving*** the contents; ***adding*** colleagues; ***distributing rights*** to colleagues; tracing ***editing changes***. →**Simplicity of screen structure**: open (and highlight) main capabilities (f.e. adding peers) headmost or central in the screen.

III. In/output of the system		
F. **Input/ interaction sequence** o Visible objects can be clicked (buttons instead of syntax) (cf. Galitz 2007) o An appropriate spirit (emotional effect) is drawn; intentional and viewer effects are aligned o User, tasks, job and product shall be attuned appropriately (cf. Galitz 2007:47) G. **Usability** o flexible interaction design given user characteristics (Nielsen 1994)	The design shall be playful yet convey a sense of seriousness for self- and guided learning activities. To make self-dependent learning joyful, user control is provided by letting people decide whether or not to collaborate & in which navigational paths. Tasks in the process (contextualization) and job-work were aligned in scenarios. They informed the interface & interaction sequence in return. The navigation has two layers, represents contextualization steps, follows the site structure, offers visual cues; linked text and labels match (cf. Galitz 2007:345; Serif 2012). Metadata input is guided by LOM, (expected) experience level of users and is limited to low, appropriate range.	→ **Highlight input options:** e.g. search bar for searching peers, log-in sign. → Configure **additional navigation bar** (right handed) as a customizable menu, depending on user characteristics (experience level)
IV. Required training		
H. **Meaning of words must be clear** o Abbreviations such as OER, where to find hints, use of navigation, familiarization with the interface	An additional navigation bar guides users in adaptation screen. (Navigation bar in the right handed side). Users may need to be advised about the meaning of acronyms such as OER.	→ Let people **explore the main interface** before starting the test. → **Meaning of LOM** needs to be clarified, → Explain **steps of contextualization**

Table 1: Design principles and implications from results

5 Discussion

So far, the results of the study have allowed answering the research questions. Few points are to discuss, beginning with the **quality of results**. The results stem from a sound, qualitative research approach to answer: when users like to add peers, which information they need and which functions they aspire in a collaborative contextualization process. The evaluation was conducted with ten participants. It is a small number and limits the generalizability of the results; statistical tests provide no meaningful outputs in this respect. Audio records further indicate that results may be biased by interviewer effects: Participants asked whether interviewers are designers of mock-ups at the same time. Subsequently, interviewers noted in some cases that participants hesitated to evaluate the questionnaire. The depth of qualitative data, however, allows supporting as well as extending the insight of quantitative data. On behalf of the rich responses it was achieved to substantiate questionnaire results, both with regard to action points and responses to the three operational questions. Overall, the quality of results is thus appropriate to discuss the findings and draw further conclusions for e-Learning and Lern-Service Engineering research.

Considering the scenario, that tutors and learners have to select a learning environment for their purposes, **recommendations in Table 1 can support the evaluation**. For example, findings suggest that additional navigational menus should be designed according to the experience level of users. Tutors could check the level of expertise of their scholars and compare provisions of learning environments respectively. Considering the scenario, that tutors are developing their own learning environment, results of the study facilitate designing contextualization. For example, results suggest placing layout structures centrally in the screen. In this respect, the principle 'focus & emphasis' (Galitz 2007:162-165) can be supported and should be taken into account in the design of learning services. Apart from tutors, learners can take the findings into account and check whether a given e-Learning service provides suitable information to identify their peers. Based on the results of the study, the versioning history of a resource would be of interest, for example.

Last but not least, to the systematic learn-service engineering, results of the study further emphasize the role of linguistic terms. Users were looking for particular wordings, cues and related icons. In this respect, a clear link between design and contextualization strategies can be found. The role of terminology is mutually emphasized so systematic engineering may benefit from synthesizing strategies from both approaches. Apart from these implications, further emphasis can be placed upon the role of social networks for innovative learn-service engineering. Users' wordings resemble terms commonly used in social network platforms (such as "add", "invite"). Aiming to develop a functional collaborative contextualization process should bear this hint in mind to innovate learning environments.

Apart from considering implications for e-Learning scenarios, the results presented in table one can be used to further integrate future e-Learning concepts: The role of mobile phones needs to be explained a bit more in this point. Looking specifically at **interaction design for mobiles**, we need to ask how much we know about the mobile digital environment, how much we know about using mobiles whilst being on the move vis-à-vis the knowledge of static computing. Maybe functional design depends on the daytime and location since phones are frequently checked close to getting up or going to sleep, even at Friday and Saturday nights (Perlow 2012). The use of mobile technologies must be understood as no longer a psychological phenomenon but now a sociological one; defining job-task and requirements for design may thus benefit from research on sociology of mobilities (e.g. Nyiri 2007; Urry 2007) in the future. Additional design principles may thus have to be specified and added to table 1.

Apart from design for mobile learning, **pedagogical design implications** are not yet addressed in this study. Pedagogical designs depend on the understanding of learning and on the culture and context where this learning process pretends to be fostered. Moreover, the appropriation of any artefacts (technologies, digital resources, tools) it is shaped by the culture and history of the individual user. Hence, how re-design is able to analyse and acknowledge original pedagogical design needs to be further discussed. More generally, a salient question is whether the pedagogical design of an OER should be explicitly highlighted during contextualization processes. In an age where educational innovations are demanded at all levels and sectors, it would be of importance to investigate if this information would allow users to question their own pedagogy and explore new ones, fostering this way the required educational innovations. Following this line, it should be considered which pedagogical dimension should be added to design principles, since a contextualization process could result in a re-conceptualization of the educational resource itself.

6 Conclusion

The study has elaborated which functional design allows for collaborative contextualization. The systematic analysis of requirements, design principles and their translation into mock-ups laid a foundation for user evaluations. Based on a mixed-method evaluation, user feedback has allowed discussing appropriateness of design choices. Empirical results suggest that users are looking for linguistic terms which resemble social platforms. Concerning contextualization steps, users like to add collaborators not only after they have selected the resource. Moreover, they would like to send the resource among others by mail and invitation to peers. Apart from insight on contextualization, implications for design principles are defined. Results suggest that general orientation can be gained by e-Learning heuristics. Overall, the results can guide designers who are interested in developing interfaces for collaborative contextualization. In the future, design strategies and contextualization models need to be extended to become more useful for practice. Two future research topics emerging from results are the role of mobile and pedagogical principles for interaction design. Implications for design are valuable and inform discussions of development choices in the project EAGLE so far. An interface validation and assessment of subsequent design choices will be addressed in the future. Generally, however, it will be salient to assess the design principles in other context and further elaborate on their generalizability.

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