Supporting Awareness and Reflection in Companies to Move towards Industry 4.0

Miloš Kravčík, Carsten Ullrich, Christoph Igel

[1] Educational Technology Lab, DFKI GmbH, Berlin, Germany
Milos.Kravcik@dfki.de

Abstract. Transfer to Industry 4.0 is a big challenge nowadays. At the level of an individual company it requires to identify the current situation as well as the target status in a foreseeable future. This awareness and reflection needs to be followed by an action plan for overcoming the existing gap. The problem is being addressed by the ADAPTION project, dealing with migration to Cyber Physical Production Systems. Considering the technical, organizational and personal aspects, the consortium aims to identify relevant measures that lead to the development of the progress model and the maturity model. This work is in progress and includes a lot of consultations with companies. Based on the formalized models, requirements for a software tool will be specified and the tool will be developed, in order to support process steering and progress monitoring in individual companies. Finally, the system will be evaluated, using the Technology Acceptance Model. We expect the ADAPTION approach will support awareness and reflection in companies as well as to help them to take right actions in order to move towards their specific requirements of Industry 4.0.

Keywords: Industry 4.0, Awareness, Reflection, Action.

1 Introduction

Networking of intelligent machines and products transforms current production systems to *Cyber Physical Production Systems* (CPPS). Consequently, the existing centrally and hierarchically organized structures in medium-sized production enterprises will be increasingly decentralized in the future. There is a paradigm shift from the prevailing resource-oriented planning to a product-oriented planning. By fast changing customer requests the requested product provides the framework for the planning. The intelligent product to be produced will be able to request the necessary production resources autonomously. This trend of automation and data exchange in manufacturing technologies is called *Industry 4.0*. It impacts the organizational processes as well as the role of the employee.

For an individual company such transition towards Industry 4.0 requires to identify the existing gap between the current situation and the target status in a foreseeable future. This awareness and reflection needs to be followed by an action plan for overcoming the existing gap. The organizational and technical changes imply updated and dynamic competence profiles of employees, requiring qualification through new learning formats directly at the workplace.

The ADAPTION project addresses this problem of company migration to CPPS. It is a work in progress. Considering the technical, organizational and personal aspects, the consortium aims to identify relevant measures that lead to the development of the process model and the maturity model. Based on these models a software tool will be implemented, which should support not only awareness and reflection of companies regarding their current and target status, but also their decisions on the next actions by providing suitable options.

In the following we first outline the theoretical background. Afterwards we introduce the ADAPTION approach, describe its models, and present first requirements for the software tool. Finally, we conclude the paper.

2 Theoretical Background

The classical automation pyramid is being continuously replaced by networked, decentralized, self-organizing services, which bring about a radical change not only in the production but also in the preparation of the work [1]. It is a paradigm shift from a resource-oriented planning (what can be produced from the available resources?) to a production-oriented logic (what will be needed when, where and in which quantity to produce certain commodities?) [2]. The intelligent product can autonomously search for the best possible production way, taking into account given and weighted target criteria (like cost, target date) by knowing exactly the requirements for the company's own production as well as the availability and scope of production resources.

However, the paradigm shift is accompanied by a strong change in the three design areas of the socio-technical production system: technology, organization and personnel (T-O-P) [3, 4]. The increasing complexity and the higher degree of automation of the technical systems also change the organizational processes of the work preparation and production. Therefore, it will have a considerable impact on the work and qualification profiles of the employees.

A further field of action is aimed at the future work organization and division of functions between technical and human systems in Industry 4.0. The key question in this context is: What tasks do technology and employees have to assume during the work process and what control functions do they have? The introduction of CPPS calls for increased communication skills, an increased degree of self-organization, as well as new abstraction and problem solving competences [5]. In the work system of the future, people and machines will be increasingly networked so that manual activities with automated work processes must be synchronized [6]. In previous research projects, the impact of CPS and Industry 4.0 on machine operators was often considered (for example, APPsist [7], DigiLernPro [8]).

Awareness and reflection in workplace learning has been investigated by several research teams. Based on the experience in the MIRROR project a theory of reflective learning at work was developed, addressing also the issues of process drivers and emotions in reflection [9]. In the BOOST project managers could identify the knowledge gaps in their company, assign these to employees and recommend them learning resources in order to fill the gaps in [10], which was an attempt to proceed from reflection to action, which can be facilitated by various services.

Assistance and knowledge services are defined as software components that provide specific types of support: assistance services assist in solving a current problem, while knowledge services support the transfer of knowledge, it means the achievement of individual medium- and long-term development goals [11]. The current state of the art is represented by service architectures whose functionality results from the interplay of a large number of services. Each of the services thereby implements a specific, independent functionality and makes these available for other services. One of the most advanced service architectures has been developed in the APPsist project for Industry 4.0 [7].

3 ADAPTION Approach

The core of the ADAPTION project[1] is the development of a maturity-based migration model for production companies in order to facilitate their transition towards Industry 4.0. This requires a holistic approach, which, in addition to technical aspects, also takes into account the associated impact on the organization and the employees. This should enable an iterative implementation of suitable measures and actions. Affected groups of employees, which will be involved in the process of change, will be provided with access to relevant knowledge related to required new skills.

This is work in progress and consultations with companies are regularly going on. Based on these the progress and maturity models will be conceptualized and formalized. This will help to specify the requirements for the software tool as well as to design and implement it, in order to support process steering and progress monitoring in individual companies. Finally, the system will be evaluated, using the Technology Acceptance Model.

The development to the CPPS must be closely coordinated with the particular needs and abilities of the respective companies and is carried out on different individual migration paths. The individual maturity levels of the companies in the areas concerned are to be identified. Taking into account the interactions between these dimensions, the optimum degree of maturity as well as the corresponding migration paths need to be determined. For this purpose, suitable methods and tools must be developed within ADAPTION.

This is an innovative approach, as previous research activities primarily addressed the dimensions of technology and organization, but did not support any systematic migration. The maturity-based migration concepts are implemented with the involvement of the employees and taking into account the entire company. The organizational and technical changes result in updated and dynamic activity profiles, requiring qualification through new learning formats directly at the workplaces, e.g. through assistance and knowledge services integrated into intelligent machines and facilities.

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[1] http://www.adaption-projekt.de

4 ADAPTION Models

In order to support companies in their transfer to the CPPS, a *progress model* is required, which based on the existing gap shows possible maturity-dependent migration paths. The progress model starts with an Industry 4.0 audit, which assesses an existing production area with regard to T-O-P. The relevant interactions are taken into account. For example, the technical introduction of a manufacturing execution system requires a change in the planning methodology (Organization) and the training of the production controllers (Personnel). The audit guidelines will include a self-assessment tool, which consists of a list of questions and criteria.

The audit is based on a *maturity model*, with which different development stages in the target direction can be presented. For instance, the technology area includes categories like Digital connectivity of machines, Man-machine interface, while the personnel field is represented also by qualifications, like Social-communicative competence. The model includes assessment guidelines for the dimensions of technology, organization and personnel. Migration paths mark possible developments between maturity levels (manifestations) and take into account the compatibility of the individual maturity grades in the individual dimensions. For the respective levels of the maturity model, load balances containing adopter-specific requirements, are to be created.

In order to support the practical usage of the maturity and progress models in companies, they will be implemented in a *software application*. It allows a distributed and collaborative capture of the current and target status by responsible employees and the company management, and determines accordingly possible migration paths necessary for the transition, which reflect the specific situation of the company, depending on its degree of maturity. The intelligent adaptive and interactive visualization of the paths supports the performance of the necessary actions. After a systematic requirement analysis, both models are first conceptually developed in several steps and finally implemented in software.

5 ADAPTION Requirements

The collection of requirements for the software tool is a long term process, requiring consultations with companies, in order to follow the general objective of providing IT-based support for migration of a company towards Industry 4.0. Compared to a paper guide, it should offer more accurate support, better understanding through visualizations, easier update and extension of the model, as well as analysis of the data collected by the tool. Based on the needs analysis the progress and migration models will be formalized, which will inform specification of requirements, according to which a software application will be implemented.

The basic process consists of several phases. First, the responsible actors describe the actual status of the company. Then the target status is identified. Based on this information and the encoded knowledge the application should visualize the gaps and dependencies, as well as suggest the steps leading to the target status. Thus in the progress model a key requirement is to drive through the process consisting of several phases as well as to provide awareness about the current position and status.

The maturity model is crucial, as it specifies how to describe the actual and the target states (strategic objective), considering the categories and concrete criteria that are relevant for the company. The criteria should provide a complete image of the company and each of them has to be clearly explained, in order to avoid misunderstandings. Moreover, in each case distinguishing levels of achievement must be specified, which will identify the limiting and supporting factors. The corresponding visualization should clarify the priorities and dependencies. The application must explain which actions have to be taken to overcome the existing gap between the current and target states.

As different actors may have different responsibilities in a company, the application has to take into account the particular role of the person and for this purpose filter just the relevant categories. Afterwards it should support a productive negotiation among the actors.

6 Conclusion

The ADAPTION approach should support awareness and reflection in companies on their current status and objectives related to Industry 4.0. Based on this gap concrete actions will be recommended for the selected migration path. Currently the progress and maturity models are still being finalized, but as soon as this phase is over, the software requirements will be completed. Then the system can be implemented and evaluated in realistic settings. This will be an iterative process, which should not only lead to a better awareness and reflection in companies regarding their readiness to migrate towards Industry 4.0, but also drive the necessary actions in the right way. To summarize, the ADAPTION system will offer suitable ways for companies, in order to solve their problems independently. The focus is on industrial application scenarios in work planning and production control, as well as the further development of the competencies of affected occupational groups. Therefore, also training opportunities on how to deal with new devices in an understandable language need to be provided to employees.

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