THE VCLL: A MULTI-VIEW COMPUTATION INDEPENDENT MODELING LANGUAGE FOR MDA-BASED SOFTWARE DEVELOPMENT

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ABSTRACT

We propose the CIM-modeling language "VCLL", which extends BPMN to four integrated modeling views. The designed modeling language allows creating business processes and its relevant data, business rules and organizational aspects. The VCLL focuses on the development of business applications and provides two entry points into MDA. Our proposed modeling language can be used to describe the behavior of one application (micro view) or it can be used to orchestrate different applications (macro view). Furthermore the VCLL provides a connection to a PreCIM-level, which consists of unstructured information and reveals the relation of model elements with their origin in recorded interviews, forms, documents, etc.

Keywords: Model Driven Architecture (MDA), Computation Independent Modeling (CIM), Model-to-Model (M2M) transformation, Business Process Modeling Notation (BPMN), modeling language definition, Graphical Modeling Framework (GMF)

Introduction

As a consequence of the development towards more and more expressive programming languages the Model Driven Architecture (MDA) increases the level of abstraction to a new state. MDA aims at faster software development by transformation of models into each other. These models are classified by the MDA concept into three levels of abstraction, namely the Computation Independent Model (CIM) level, the Platform Independent Model (PIM) level and the Platform Specific Model (PSM) level (Frankel 2003; OMG 2003).

But most of the existing MDA-approaches (Mellor et al. 2004) focus on PIM- and PSM-level and the M2M-transformation between them. The more conceptual CIM-level is often neglected. Hence, a real life software development project doesn't even start with conceptual modeling on CIM-level but even with more unstructured verbal information about the application's domain.

A major reason for neglecting the CIM-level in MDA-approaches is the lack of a modeling language understandable to end users and at the same time transformable into PIMs. Therefore we introduce a CIM modeling language that is designed to ease the creation of CIMs and the transformation of CIMs into PIMs.

Hence, we present the meta-model based specification of the VIDE CIM Level Language (VCLL) (Seel, Martin 2007) with Meta Object Facility (MOF) (OMG 2005) in section 4. The categorization and thorough analysis of the supported business processes follows the description of the tool support.

Research Methodology

Research in the field of information systems has two major research interests: the discovery and explanation of currently existing phenomena and the development of new methods and recommendations of action for the discovered problems. Corresponding to this division into these two objectives Hevner et al. (Hevner et al. 2004) identify the empirical approach and design science approach as the two possible types of research methodologies.

This contribution develops a solution for a known problem in context of the MDA. Therefore it follows the design science paradigm. Hevner et al. provide seven guidelines for design science research, which determine the necessary parts of this contribution and create a sketch for its structure. The introduction shows the relevance of the research problem (guideline 2). The prototypic implementation of the VCLL in section „tool support" is an artifact (guideline 1) that serves as a proof of concept (guideline 3). As the contribution of the VCLL compared to existing modeling languages is determined by the presented meta-model, the research contribution can be clearly identified (guideline 4). The section "related work" refers to guideline 6, as it presents design as a search process. The research rigor (guideline 5) is addressed by this section and the rigorously structured organization of this paper. Guideline 7 aims at the communication of the research results what is addressed by submitting this paper to the conference.

Related Work

The idea of MDA (Mellor et al. 2004; OMG 2003) is the translation of information models via different steps into finally executable code. According to the definition of MDA the process of creating software starts with information models on CIM level and transforms them into models on PIM level. These models on PIM level are enriched and then transformed into PSM which result in executable source code after the last transformation (Frankel 2003; OMG 2003). By a separation of concerns through creating CIMs and PIMs before PSMs you reach a kind of interdependency from platforms, languages and systems. The transformation starts on a highly abstract level and gets more concrete with each step down. ERP systems which support manufacturing processes are a very good example how to use MDA. Domain experts can be much more included in the software development process to bridge the gap between their requirements and the understanding of them by a software engineer. On the three different levels of MDA different modeling languages are used. Therefore commonly used modeling languages are regarded.

Event-driven Process Chains (EPC) (Keller at al. 1992) allow for creating semi-formal process models. This semi-formal notation is essentially a sequence of the successive events signalizing the important occurrences in the process and functions dealing with the events and further information. It is suitable for a high level design of application systems or organizational structures, but it is not focused on the transformation into an IT system. The disadvantage of this methodology is that though it gives the business users the understandable idea of a business process and its possible paths, but at the same time there is no place for business rules that are standing for the decisions made at important steps in the process model.

Another modeling concept is UML (OMG 2005a). It gives the IT specialists one of the most substantial tools for modeling the target application systems in different aspects on the different levels of abstraction. At the same time, it is not that well suitable for business users for involving too much knowledge about the technical aspects of the system under construction. It also doesn't provide the mechanisms of dealing with business rules. Though UML can be combined with the Object Constraint Language (OCL) (OMG 2006a) it is in turn too formalized to be used on the requirements level for which the VCLL tool is providing support.

Probably the most extensively used language for modeling of the business processes is the Object Modeling Group (OMG) standard Business Process Modeling Notation (BPMN) (OMG 2006). It can be used on different levels of abstractions, firstly, and can also contain a sufficient amount of technical information, secondly. The technical aspects are needed for the lower level implementation of those processes into for example the Business Process Execution Language (BPEL) (OASIS 2007) (which is a machine readable, textual format without an easy-going way to sketch a process in a graphical way). The disadvantage of BPMN notation is its limitedness to one and only one view, namely the process view that is not always sufficient for the purposes of modeling the systems. It also doesn't provide the extended methodology for data and organization modeling, thus weaving the data and organization constructs into the process view directly.

VIDE CIM Level Language

The VCLL aims at the integration of end users into the software development process, especially data intensive business applications, which demands certain requirements to be regarded. The language has to be as simple and as commonly understandable as possible for “non-IT-oriented” business domain experts. Furthermore the CIM-level language should be able to represent information that allows creating draft UML models on PIM-level. Finally larger business processes can result into more than one monolithic application. Therefore the orchestration of different (sub)-applications should be possible.

In order to create such a modeling language different established languages and notations were explored. For example the Business Process Modeling Notation (BPMN), the Business Process Execution Language (BPEL) OASIS 2007, and the Event driven Process Chain (EPC) Keller at al. 1992 have been analyzed. It turned out that each has its advantages and disadvantages that can be viewed in “related work” section. Based on our research (Seel, Martin 2007), BPMN offers the best starting point for creating the VCLL.

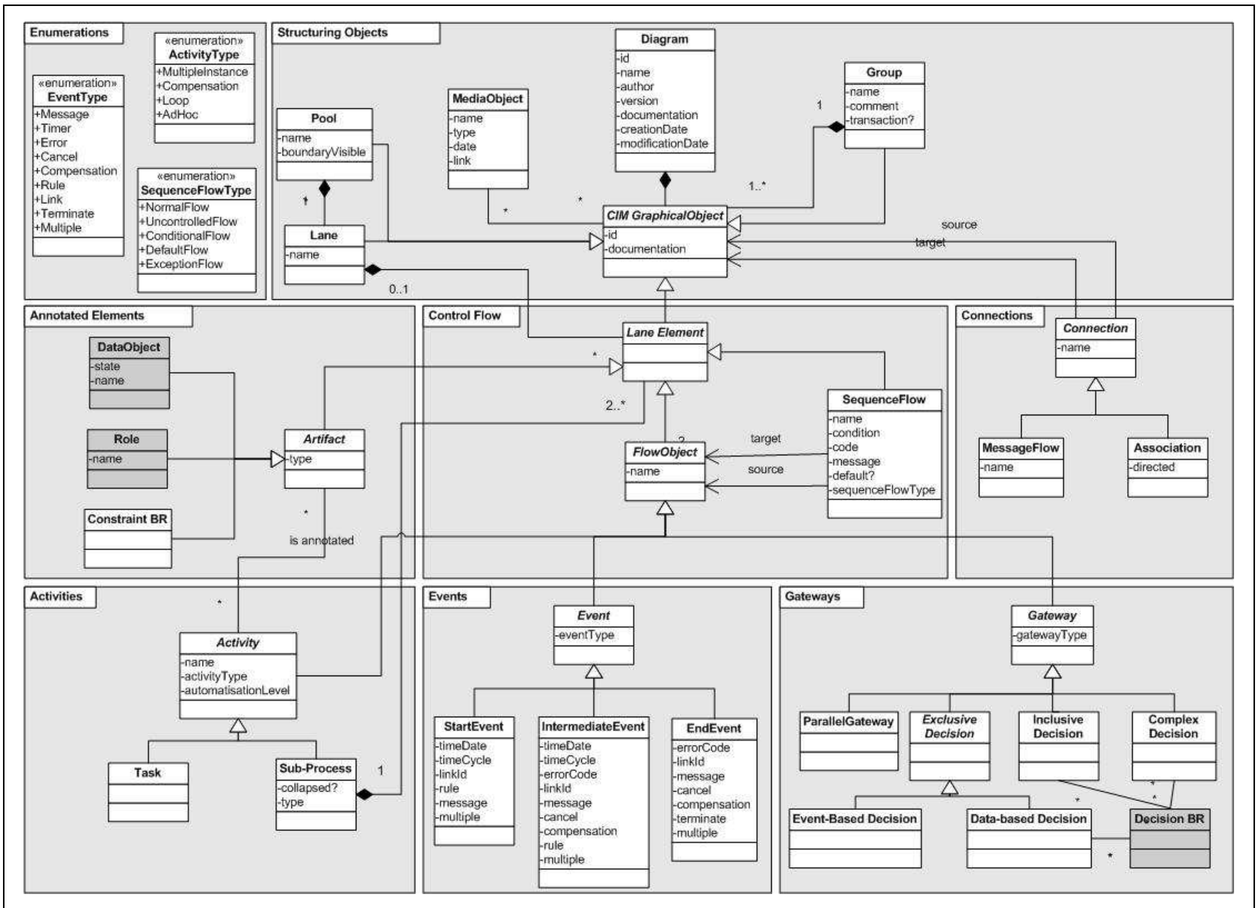

Figure 1. VCLL Meta-model

So, the BPMN meta-model was used as a basis and enriched by different items, partly gathered from other languages as well as newly created. For example, we introduced the concept of business rules, but it showed that, on conceptual design level, we only need decision rules and constraint rules (Scheer, Werth 2005).

Decision business rules are used to describe complex branches of the control flow, e.g. if the decision which activity is the next to execute depends on the combination of several subdecisions. Therefore decision business rules consist of one or more statements. Each statement consists of business variable values and one activity. If the business variables have the values which are described in the statement the activity, which is referred to in the statement, is executed. One decision business rules can consist of one or more statements. The statements have an OR relation between each other. Optional a last row can be added, which contains the keyword “else” as condition. The action which is assigned to this row is executed if no other condition is true.

Constraint business rules can be annotated to any model element on the CIM level and state constraints from a business point of view. For example defining that an order process can be started by a phone call is not possible for new customers. Constraint business rules are constructs which are similar to natural language in order to make them easily accessible for business users. However, to avoid the ambiguity of natural language the parts of constraint business rules are further defined. For this purpose, the use of natural language has to be restricted to the use of standardised statements (Endl 2004). In addition to established approaches like RDF (W3C 2004) or OWL (W3C 2004a), which both focus on semantic-web-technologies, the approach “Semantics of Business Vocabulary and Business Rules Specification” (SBVR), which is defined by the OMG, proves to be a well developed concept for describing business rules in an enterprise-context.

The people addressed by the SBVR-specification are mainly users from the business domain, who should be enabled to formulate rules in a structured but also easy comprehensible manner. There is also a focus on the necessary transformation of the formulated rules into IT-systems. The SBVR defines specifications for the used vocabulary as well as syntactical rules, to allow a structured documentation of business vocabularies, business facts and business rules. Furthermore, the specification describes a XMI-scheme to share business vocabularies and business rules between organizations and IT-systems. The SBVR is designed to be interpretable in predicate logic with a small extension in modal logic. It also defines demands towards the behavior of IT-systems regarding their ability to share vocabularies and rules that complies with the specification (OMG 2005b).

The SBVR-approach uses three perspectives on business rules. The first perspective is derived from the business rules mantra (BRG 2006) and supports a simplified approximation towards a business rule. This perspective should support the communication with people who are not familiar with the approach, e.g. decision makers. The second perspective is the representation. It contains the specifications of SBVR which should be used to formulate vocabularies and rules. The third perspective is the meaning. It contains the underlying semantics of the used vocabularies and rules.

Figure 1 shows the graphical meta-model of the proposed CIM language. Beyond the business rule view we added three other views, namely a process, a data and an organizational view. The most extensively represented process view integrates the other views and consists of eight parts. Structuring objects are the top-level class the model contains. The control flow section introduces lane elements, which are connected to each other by flow objects. The connections section has two further types of connections between objects in a model. The annotated elements part of the meta-model shows model objects that are used to enrich activity objects with relevant information. The activity section tells which elements are representing actions in a model. The events section describes different types of events which tell what kind of triggers could be used in a model. Gateways explain how decisions of different types could be integrated into a VIDE CIM model. The enumerations section is the last section and it gives an overview of the complex types used in three different classes. Data, organizational and business rules views introduce interfaces to three further business process analysis scopes.

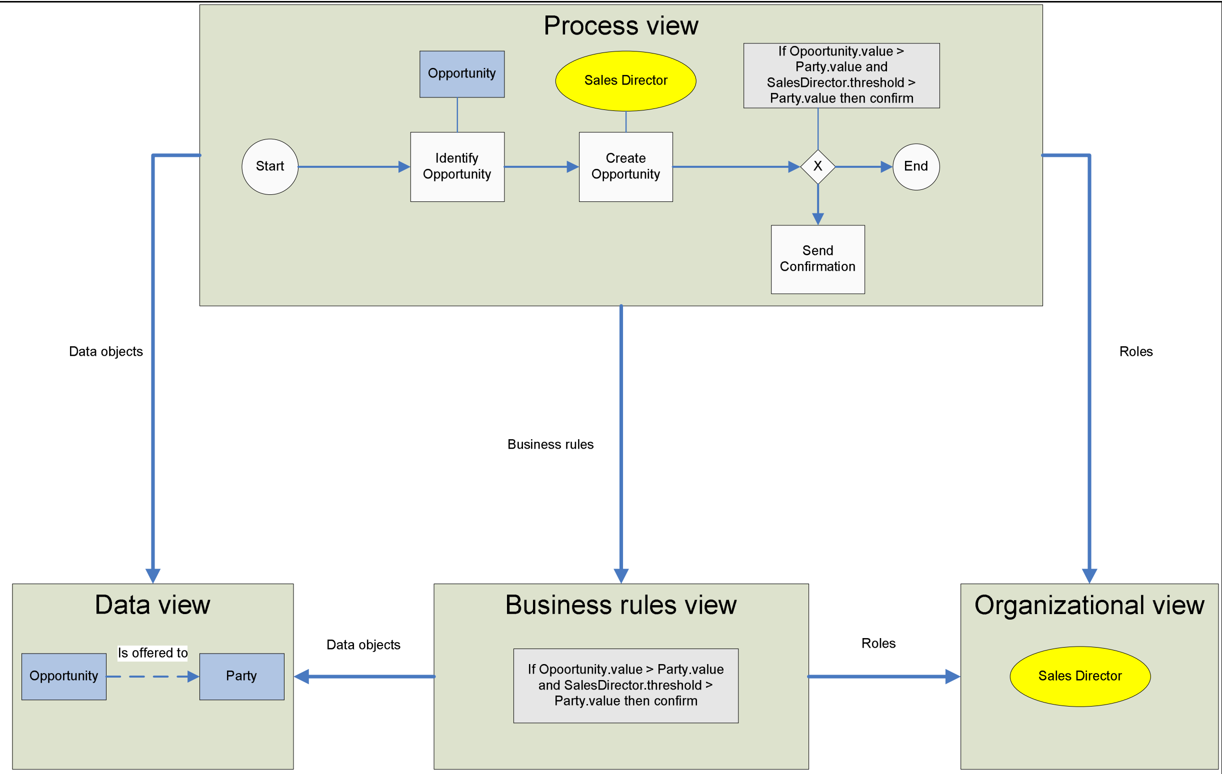

Figure 2. VCLL Architecture

In Figure 2 you can see a simple example of the different views and their interconnection. Inside the data view there are two entities ‘opportunity’ and ‘party’, which are connected by a simply expressed association ‘is offered to’. Then there is a business rule defining a branching condition and at least inside the organizational view a role ‘sales director’. On top of the picture the process view shows the business logic as a flow of different functions. After the start event a function ‘Identify opportunity’ is executed, doing some work on a data object ‘Opportunity’ which is imported from the data view. Then the function ‘Create opportunity’ follows which is accomplished by a person who has the role ‘Sales director’. After that, at the branch construct, it will be decided whether to stop the process in case of a negative condition or to go on with the opportunity process and ‘Send a confirmation’. The shown information can then be used either focusing on the micro view, i.e. the definition of concrete PIM function or service, or on the macro view, i.e. controlling the calls of functions or services by a workflow system. For more information concerning the PIM transformation see Martin et al. 2008.

As the VCLL is compatible to BPMN 2.0, VCLL models can be used to generate XPDL documents that define the orchestration of different applications. So, VCLL models can be imported by all XPDL compatible workflow management systems. Furthermore a software tool has been developed that supports the import of unstructured requirements information (see Kanyaru et al. 2008), the creation of VCLL models and the export into draft UML models on PIM-level or XPDL files.

Business Process Support by VCLL

Classification of business processes

Business processes can be classified by different criteria. An important criterion for the use and especially the economic benefit of a software support for business processes is their repetition rate. The repetition rate as criterion for the classification of business processes is proposed by several authors (Derszteler 2000; Giaglis 2001; Leymann, Roller 2000; Maurer 1996; Picot, Reichwald 1985; Rathgeb 1994; Reijers 2003; Schmidt 2002). Despite this criterion being very common the values that describe the repetition rate differ between different authors. In order to categorise different possible values we distinguish between three categories of repetition rate: singular, sometimes, frequently. Singular business process only execute once. These are business processes which are individual for each customer or are research and development processes which are not standardized. Business processes that are executed sometimes are not processes that occur in the daily business but occur more than once. An example would be the creation of a balance sheet once a year. The last category contains business processes that occur frequently. These are processes from daily business, which can include variants, but are standardized and documented.

A second criterion for the classification of business processes is their degree of structure. The degree of structure as classification criterion is used by several authors, e.g. (Aalst 1999; Deiters et al. 1996; Derszteler 2000; Maurer 1996; Picot, Reichwald 1985; Schmidt 2002; Sheth et al. 1997). The distinction between different degrees of structure is stated differently. Becker et al. 2002 differentiate between ad-hoc processes and structures, pre-defined activities but ad-hoc processes, and pre-defined processes. By ad-hoc processes they mean business processes that are not structured, planned and documented. Their run-time behavior is defined not until their execution. The second category consists of planned activities, which can be aggregated to a business processes at runtime. The third category consists of planned, managed and standardized business processes, where each activity as well as the whole process is known at its build-time. The other references mentioned above describe the first category as hastily formed or unstructured. The second category is not mentioned in all references. The third one is described as structured or formally defined. In order to get an intuitive formulation the categories are described as unstructured, semi-structured and (fully) structured. Unstructured refers to business processes where the activities and the control flow of the business process is not defined at their build-time. The opposite are structured business processes. Business processes are classified as semi-structured if their activities or their control flow are partly defined at build-time.

The next criterion is the alignment of business processes to strategic levels (Heilmann 1994, Zhou, Chen 2003). Traditionally in economics three different levels are defined: the strategic, the tactical and the operational level. Strategic business processes serve the purpose of long-time planning and definition of goals. These business processes usually require creativity and are not standardized. In order to realize strategic goals the strategic business processes are refined into tactical business processes. They usually have a mid-time range. These tactical business processes are refined again into operational business processes. The operational business processes are executed in every-day work. The creation of business value is done by this type of processes.

The next criterion is the stability or *frequency of changes* of the business processes (Aalst, Hee 2002, Maurer 1996). Some business processes are have to be adapted frequently, e.g. for each project. Other are changed rarely and other are very stable. The last category e.g. describes business processes that are predefined by laws, which won't be changed for a long time.

Another attribute of business processes is their granularity (Becker et al. 1999; Sheth et al. 1997). The can be modeled in a very detailed manner, so that the activities of the processes can be further refined in a reasonable manner. Compounded business processes have parts that are detailed but other parts that can be refined by a detailed process. The highest granularity is aggregated business processes. They are often depicted as value chains. They show the relation and order of groups of process steps, e. g. that the marketing activities are done before the sales activities.

Additionally several authors classify business processes by the value they create (Leymann, Roller 2000). Authors distinguish between business processes of low and of high business value. Business processes that create a low value are mostly administrative and support processes. They are necessary in order to create goods or services but do not create saleable products. Business processes with a high value creation are customer-oriented core processes.

Furthermore business processes can be classified by their scope as intra- or inter-organizational (Becker et al. 2002 Hauser 1996). Intra-organizational business processes take place within one enterprise. All organizational units, hardware and software systems that take part in the processes belong to the same enterprise. Inter-organizational business processes take place between two or more different enterprises. This type of business processes requires interfaces between the application systems that are used in different enterprises. Judicial aspects have to be considered and security aspects have to be taken into account.

In addition, the use of persistent data of a business process can be different (Kalenborn 2000; Picot, Reichwald 1985). Business processes can just check information or transform a defined input into an output. This type of business process is very rare. They don't use any persistent data. The second type of business processes uses persistent data but does not create or change it. The largest group of business processes use, create and change persistent data.

A very important criterion for the classification of business processes is the level of automation (Derungs 1996, Sheth et al. 1997). Three levels are distinguished manual, semi-manual and automated. Manual business processes are executed by employees without using application systems, e. g. service or consulting processes. Semi-automated business processes are executed by humans but supported by application systems, e. g. an employee enters the personal data of a customer in an application and the system checks the consistency of data. Automated processes run without human interaction. They are performed completely by application systems, e. g. bookings on bank accounts from one bank to another, which run as batch job every night.

Two other attributes that classify business processes are the number of process participants (Sheth et al. 1997) and the number of parallel instances (Mentzas 1999). The number of processes participants is classified into two categories: high and low. The number of parallel instances can be one, which means there is no parallelism. It can be also be some or many. Some means a small number of instances below ten.

Another attribute of a business processes is data-driven, referring to the data that is involved in the business process. It is the necessity of using transactions, which can either be required or not. If it is required the business process has to ensure that it will be completed successfully or comes back to the starting state again, e. g. the transfer of money from one bank account to another, has to be done completely and shouldn't stop after withdrawing the money from the first account and before in-payment to the second account.

The attributes for the classification of business processes and their possible values are summarized in as morphological box in Table 1.

Table 1: Morphological box for business process classification

Attribute	Value		
repetition rate	singular	sometimes	frequently
degree of structure	unstructured	semi-structured	structured
alignment	strategic	tactical	operational
frequency of changes	never	sometimes	often
granularity	detailed	compounded	aggregated
value creation	low		high
process scope	intra-organizational		inter-organizational

usage of persistent information	none	low	high
level of automation	manual	semi-automated	automated
# of process participants	low	high	
# parallel instances	one	some	many
transaction necessity	required	not required	

Criteria of Business processes supported by VCLL

After criteria for the classification of business processes have been presented, this section classifies the business processes that are supported by VCLL. For this purpose, for each category defined above, the supported business processes are classified.

For the repetition rate, VCLL is able to support all types of business processes. But in addition to other software development methodologies the software development is too expensive for a process which is only executed once in the same way. Therefore a software development project is only reasonable if there is a trade-off between the resources spent in software development and the benefit the developed software creates. As VCLL is aimed particularly at rapid software development, the software development is going to become less expensive and therefore more reasonable for business processes that are only executed sometimes.

Concerning the second criterion, only defined parts of a business process can be implemented. Therefore structured business processes are supported by VCLL. Semi-structured business processes can be treated with the VCLL methodology in two ways. If the control flow of the business process is completely available then it could be used for the orchestration of VCLL applications based on a workflow management system. Otherwise the structured and detailed activities can be implemented using the CIM-to-PIM transformation wizard that VCLL offers. Unstructured or ad-hoc business processes are not supported by VCLL as the logic of the business processes is too vague to create an executable description.

Regarding the strategic alignment of business processes VCLL could support all three levels. But an implementation for the support of creative decisions which have to be taken in strategic or tactical business processes are difficult to describe as business processes and to implement in software. Therefore VCLL supports especially the implementation of everyday business processes with relation to internal or external customers, which are located at the operational level.

Similar to the repetition rate the frequency of changes has an economic impact on the software development process. Business processes which are unchanged or rarely changed just need to be implemented once and can stay unchanged. Unfortunately changing business models, shorter product lifecycles and new competitors in markets increase the need to change business processes and shorten the time in which they remain unchanged. Therefore the software that supports business processes has to be changed more often as well. As VCLL starts its MDA approach at the CIM level and keeps the relation between CIM and PIM objects the implementation of changes is relatively fast, because changes in business processes can be propagated to the PIM level. Therefore VCLL supports frequently changed and unchanged business processes as well. But it’s not economic reasonable to implement business processes that are changed faster than it took to implement them.

Regarding the granularity of business processes, two types are supported. Detailed business processes, which cannot be further refined from a business perspective, can be transformed into PIM models. Compounded business processes can be used for orchestration. The activities which can be further refined are regarded as black boxes and an appropriate application is invoked by the WfMS.

The value creation also addresses economic issues. From an implementation point of view business processes with a low value creation as well as processes with a high value creation can be implemented with VCLL. But the benefit that arises from an implementation of a business processes with a low value creation can be less than the effort for the implementation. Therefore VCLL especially supports business processes with a high value creation.

The process scope that VCLL regards is on intra-organizational business processes. The modeling languages VCLL uses on CIM and PIM level don’t consider special information such as the description of interfaces or mechanisms for information hiding between different enterprises. Because of the fact modeling of inter-organizational business processes and software is an own field of research (Röhricht, Schlögel 2001; Schulz, Orlowska 2001; Schulz 2002), this kind of models are not in the scope of the project and the methodology being developed.

Concerning the usage of persistent information, VCLL is designed to handle persistent data. Most business applications use, create or manipulate data. Therefore the VIDE CIM level language has its own DATA view in order to describe data objects and their usage in the business process. PIM level language elements for data definition and queries on databases have been introduced. Therefore VCLL can handle all three types of business process in regard to their usage of persistent data.

The level of automation that business processes possess is crucial for their implementability. VCLL supports business processes that are fully automated. They can be described at CIM and PIM level and/or be orchestrated in the sense of the VCLL approach. Semi-automated business processes can be described on the CIM level, because the CIM modeling language also allows the description of activities that are executed manually. However, on the PIM level, manual activities cannot be described. Therefore in semi-automated business processes the whole business process is described at the CIM level but only the automated part is transferred to PIM level. Manual business processes can be described on the CIM level in VCLL, but are not implemented.

Regarding the number of participants and parallel instances that VCLL can support a limitation is only given by the target platform on PSM level. If the PSM level supports multiple instances and is able to handle a large number of users VCLL can be used for this kind of system.

Regarding the last classification criterion, the need of a business process for transaction support, VCLL partly supports transactions. As VCLL is based on databases, the transaction concepts of databases can be used. Therefore a transaction support for data is realized. But transaction support for the process steps itself is only partly possible. The VIDE CIM level language offers the concept of compensation. This does not allow a roll-back to be done, but defines actions that have to be undertaken in order to undo an activity. As the description of compensations on CIM level are done in the same way as the description of normal business processes they can be implemented at the PIM level as well. Therefore VCLL offers a full transaction concept for data and compensations for business process activities. An overview of the type of business processes that are supported by VCLL gives the following table:

Table 2: Classification of business processes supported by VCLL

Attribute	Value		
repetition rate	singular	sometimes	frequently
degree of structure	unstructured	semi-structured	structured
alignment	strategic	tactical	operational
frequency of changes	never	sometimes	often
granularity	detailed	compounded	aggregated
value creation	low	high	
process scope	intra-organizational	inter-organizational	
usage of persistent information	none	low	high
level of automation	manual	semi-automated	automated
# of process participants	low	high	
# parallel instances	one	some	many
transaction necessity	required	not required	

In general VCLL supports all types of executable business processes. The only requirement is that the business processes can be described by a set of actions, a control flow between them, and data objects the activities are working on. The type of business processes which are supported optimally are business processes which just display, create or change data. These actions are typically for administrative processes, such as booking a flight or the administration of a warehouse.

Other domains, such as real-time or embedded systems, are not in the focus of VCLL. Furthermore VCLL is not designed to depict very complex algorithms, such as those used in Artificial Intelligence systems, because these kind of systems require a large number of loops, branches and case differentiation which are difficult to describe in the control flow of the VIDE CIM level language.

Conclusions and Outlook

The MDA approach is an effective way to create software systems to support business processes. But therefore a proper CIM-level language is needed. Thus the meta-model based definition of the VCLL and its four views is presented. The VCLL allows describing business processes, data, organizational structures and business rules in a way that is understandable for end users. Furthermore a VCLL modeling tool based on the framework GMF is presented. It supports the creation and linkage of models in all four views of the VCLL and the semi-automated transformation from CIM to PIM.

Further research is required in the area of CIM creation starting with non-formalized and unstructured information. Additionally OMG's MDA Guide (OMG 2003) should be enhanced by more elaborated sections for CIM-level modeling and CIM to PIM transformation in order to fill the existing gap in the relation between these levels.

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