ONTOLOGY SUPPORT FOR PRODUCT DEVELOPMENT
Successful Application of Ontologies in Product Development

Reiner Anderl, Kai Mecke, Andre Sprenger and Oliver Weitzmann
Department of Computer Integrated Design, Darmstadt Technical University, Darmstadt, Germany

Keywords: Ontology for Industry, Company Data Management, Product Development.

Abstract: Today knowledge management is a very important factor for the success of enterprises. To support knowledge management ontologies have been established. In the product development a lot of knowledge, methods and workflows are used, which have to be protected, managed and distributed. The challenge to manage the diversity of product development knowledge is to combine knowledge management methods and requirements of product development. For this purpose we present functions to support access rights for ontologies, integration of new information, release and storage of information (workflow). Another function to support the efficient work with knowledge is to use templates in order to reduce time and mistakes while integrating information and knowledge in the system. These functions are integrated into the ontology-based product development system (OPDS); the system fulfills the requirements of the product development and used knowledge representation forms.

1 INTRODUCTION

Enterprises are discovering the importance of knowledge and identified knowledge as an important part of the success factor for enterprises (Staab and Studer, 2004). To become a more successful enterprise they have to store, distribute and use their knowledge. Knowledge management becomes significant and enterprises are willing to invest into knowledge management.

The problem of the acquisition of knowledge is that knowledge is bound to humans. If an employee leaves the enterprise, the knowledge will be lost. Especially in the current demographic situation, a lot of the employees knowledge will be lost, when they are going into retirement (Schuett et al., 2007). Thus enterprises try to keep the knowledge in the enterprise and this leads to the necessity of using knowledge management.

According to Probst (Probst et al., 2003) knowledge management is defined as a knowledge process.

We can subdivide the knowledge process into two categories. The first category containing identification, acquisition and development, relies on the human ability to generate and extend knowledge. Computer abilities in this field stayed limited, but become useful in the second category. In the second category it is possible, that the elements of the knowledge process can be supported by computer and new technologies. Knowledge distribution, Knowledge utilization and Knowledge storage belong to this category. The commitment of computers and information technology (IT) contributes that the vast amount of information will be controllable and guarantees the distributed use for everyone, who has access to the information.

A descriptive representation of knowledge in IT is the ontology. Ontologies are abstract models of some aspects of the real world (Gruber, 1993).These models consists of a collection of knowledge concepts, properties and relationship between the knowledge concepts (Kashyap et al., 2008).

Ontologies have been established as important tools to represent knowledge for human and machines in the knowledge management (Staab and Studer, 2004), (Tempich et al., 2006).

Because of the high flexibility of ontologies it is possible to use them in various thinkable contexts to represent a part of real circumstances. Especially complex structures like products and the product development can be represented and supported by ontologies.

For creating ontologies, special-editors are used. These editors are applications, which are developed

Anderl R., Mecke K., Sprenger A. and Weitzmann O. (2009).
ONTOLOGY SUPPORT FOR PRODUCT DEVELOPMENT - Successful Application of Ontologies in Product Development.
In *Proceedings of the International Conference on Knowledge Engineering and Ontology Development*, pages 177-182
DOI: 10.5220/0002298201770182

for designing and manipulating ontologies. They visualize the complex structures of ontologies in clearly presented graphs.

The question is, how enterprises could realize knowledge management and what functions an enterprise would need to do it well. Ontologies are a powerful method to implement knowledge management. Therefore this paper will focus on enterprises in the producing industry and especially in product development.

There are only a few approaches that described conceptual solutions of applications, which expand ontologies with further functions to improve their functionality. These approaches are our starting position and are presented in following paragraphs.

Montoni et al. (Montoni et al., 2004) present an ontology-based Enterprise-Oriented Software Development Environment tool. With the help of Taba Workstation, a software development environment (Montoni et al., 2004), the different software processes will be controlled.

Wu and Chen (Wu et al., 2006) developed an ontology-based Role-based access control model. In the ontology they integrated all information and their relationship, which are necessary for security policy. Especially the expansion of semantic information to the model is an innovative approach.

Using ontologies in industry requires, that an ontology-based application is supported by ontology-lifecycle model. Tran et al. (Tran et al., 2007) developed an information-model for lifecycle management of ontologies. In a second step they presented in (Tran et al., 2007) a generic OIS Architecture with lifecycle supports.

In this contribution will be discussed which elements are necessary in regard of developing knowledge management system, which applies all industry requests. In the second chapter the requests will be defined. In chapter three the concept regarding the defined requests will be proposed.

2 INDUSTRY REQUESTS

For a successful introduction of semantic technologies in the industry, a number of requirements have to be met. Existing workflows of product development have to be supported and additional requests regarding security, collaboration and social networks considered.

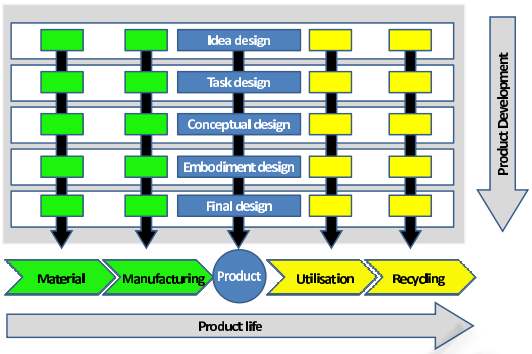

Figure 1: Product development and Product Life (Birkhofer et al., 2009).

2.1 Product Development

Product development is the process, which is necessary to get a product from an idea to a salable solution. This process is subdivided in several succeeding processes. The single processes are shown in figure 1. To support the product development process the VDI-guideline 2222 has defined tasks for these processes (VDI, 1997). The product development process is also documented by several authors (Spur and Krause, 1997) and (Pahl et al., 2003).

The product development is part of the Product Lifecycle. This process describes the whole life of products from planning to disposal. It is divided in the major categories of a product life: plan, design, build, support, and dispose. (Grieves, 2006)

The key to success of enterprises is the reduction of time consumption of the phases of Product Lifecycle plan, design and build. For this purpose the methods Simultaneous Engineering, parallelizing processes to decrease time and Concurrent Design, subdividing construction space and working simultaneous at each space are developed.

Product Data Management (PDM). Product data management is part of the product data technology and it is used for the processing of product data (Grabowski et al., 1998). In the product lifecycle product data management (PDM) supports the management of product data and controlling of product data flows.

2.2 Practical Requests

Distributed Product Development. The development of a product at multiple research centers around the globe is a special challenge for every company dealing with complex products. In case of the integration of a subcontractor or supplier and the consideration of variants of the product the challenge in-

creases significantly. Several concepts, like "'follow the sun"', "'Function sharing"' and Module sharing have been developed.

All approaches rely on common distributed data, which is presented to the participating developers in an intuitive manner. Ontologies have the basic possibility to make everyone understand the relation between concepts. As a web technology, the distribution of information in an intranet, analog to the World Wide Web, is easy.

Styling, Design and Management. Styling deals with shapes, impressions and appearances of a product in early phases of the product development process. Contrary to this, the design process from the engineering side considers technical requirements, functions and construction space, an abstract approach considering a high granularity of the product (Klug, 2007).

A common knowledge base is a necessary step for interdisciplinary product development. An important support of this step is graphical, intuitive presentation of relevant information and relations which can be provided by ontologies. The development process, supported by graphical mapping techniques ("Design-mapping") is described in (Malzacher et al., 2008).

Intellectual Property Protection. Impressive occurrences of plagiarism have sensitized the industry to protect intellectual property as a key factor to stay one step ahead of competitors (Nitterhouse, 2003).

Industry espionage has increased over the last decades. Therefore access control to information is needed, ensuring that it is available at the right place, to the right person at the right time (iViP Association, 2008).

There are two basic strategies for intellectual property protection information hiding and information filtering.

The idea of securing electronic business documents is an increasing necessity nowadays. (Alkassar et al., 2007).

2.3 Need for Action

From the compact overview of industry requirements the need for action can be derived. Even though ontologies can easily satisfy some of these requirements, such as being a web technology, some requests lead to unsolved problems.

The storage of distributed information is not a challenge for a web technology. The unique and unified identification of ontology elements in the web and the vast possibilities of interconnection of distributed ontologies can be a strong support for global collaboration in product development.

The emerging structures in interdisciplinary product development can be reduced to graph structures. With additional rules of an appropriate expressivity level, these structures can be represented by ontologies as a uniform datamodel.

The lack of a suitable specification of semantics in enterprise models leads to inconsistent interpretations and uses of knowledge. Reasoned by (Grueninger et al., 2000) it is necessary to establish a uniform data model.

The protection of intellectual property is a central challenge for the use of ontologies in product development. Basically knowledge in ontologies is accessible to every user. Data, which are referenced by the ontology, is protected by access control mechanism of an additional datasource or data system. The basic idea of information for everyone is useful for the application in the World Wide Web, but not in a company environment of research and development, where data leakages can be fatal for the product success.

Contemporary ontologies-editors are not suitable for the use of knowledge-management in enterprises. Therefore, an enhanced ontology-editor/access system has to be developed, which increases the usability for enterprises.

3 CONCEPT

We defined a system called Ontology-based Product Development System (OPDS). This sketched system is able to support every phase of the product development process. It allows retrieving information about the design, the decisions and the know-how of a product. Especially know-how from manufacturing, utilization, recycling etc. like uncertainties (e.g. dimension tolerance, production accuracy etc.) can be relevant factors of designing of high-quality products. So the information from later phases of the product lifecycle can be stored in the system, design engineers get the information and consider this by the design process. This system is distinguished from PDM-Systems, because the use of ontologies for representing knowledge and especially the representing of knowledge is not possible for PDM-Systems today.

To manage these requirements it is necessary to integrate new functions in the ontology-editor, in order to become an Ontology-based Product Development System.

In the following sections the different functions and templates will be explained.

3.1 Functions of OPDS

The requirements of enterprises towards an application to manage their knowledge are to save and to protect their knowledge, so that the application has to control the access and also to control and to support the enterprise workflows.

Based on the requirements the application must have different functions, which are

- the elementmanagement,
- the rightsmanagement,
- the workflowmanagement and
- the datamanagement.

The functions will be explained in the following sections.

3.1.1 Elementmanagement

Ontologies' main function is to store and to manage knowledge and information. To reuse and retrieve knowledge and information it is necessary to build a uniform described element model. The component of this element model is attributes to identify and classify the elements. This information is stored in metadata.

Identification attributes have to be interpretable by application and user. An attribute consists of an identification number and of a human interpretable name. This name is subject to a naming convention, which is given by the enterprise restrictions.

Through the classification of elements the belonging is given, the element is extended by codification, which includes the organizational structure of the enterprise. The codification is a part of the classification attributes.

The elementmanagement supports the organisation of the knowledge management and the users to retrieve data.

3.1.2 Rightsmanagement

Standard ontologies provide information to all users. Everyone has access to get this information. Therefore a restriction of access is necessary in form of a rightsmanagement, so that only authorized users have to access to the information. The rightsmanagement includes user management, aggregation to groups, controlling the access to information amd controlling the access to functions.

To control the rightsmanagement a system module called role-based access control (RBAC) will be integrated. A concept to implement an ontology-based RBAC is mentioned by (Wu et al., 2006).

In the following paragraphs the elements of the rightsmanagement will be described in detail.

User Management, Groups, Roles and Rights The access to the system is only for authorized users. The authorization process requires a restriction of the user. In conjunction with the account, the user belongs to special groups and roles. This helps to organize the user into groups and roles and which different rights to access the different information they have.

A user will be a part of a special ontology, which includes all information about users, their groups, their roles and further information about the person. The Access Control Module uses the user-ontology to check, if the user is allowed to access the application.

The module distinguishes between the two basic roles of the system: user and administrator.

Controlling the Access to Information. The pieces of information of the ontology are the central elements and have to be protected by the system. Through the protection code, which is part of the metadata, the information about the kind of access rights a user has got is stored.

Controlling the Access to Functions. Analog to the access to information it is also necessary to control the access to functions. To support the product development process and to organize the system the OPDS have to provide functions, which supports e.g. several workflows.

Not every user should have the possibility to use every function, because he has not got the competence to decide the circumstances. The restriction of access to function is a protection against misuse.

3.1.3 Workflowmanagement

In the product development there are a lot of workflows like releases, change, versioning etc., which are supported by the OPDS to get consistency. Even information and knowledge are subjected to changes, releases and versioning.

Through the distributed work, which is required by Simultaneous Engineering and Concurrent Design, the OPDS is suited to control the exchange workflow and to start workflows automatically(Schuschel and Weske, 2003).

A general function of workflowmanagement is the management of information, which has been stored in OPDS. Further functions for workflowmanagement are constrained by the requirements of the enterprise.

Besides the automated control of workflows, the knowledge about these workflows is also represented in workflow ontology. Doing so, the staff understand the flow between the processes.

In following paragraphs the three basic functions for the management of knowledge and information will be explained.

Inspection Procedures. To guaranty the consistency of the ontologies, inspection procedures like change-management and releasemanagement are necessary. These inspection procedures consist of a set of rules. The modified structures are checked against these rules, before they get the release to be published for usage.

State Change. The knowledge is subjected to persistent change, new experiences lead to new knowledge, which has to be stored in the ontology. Before new knowledge will be used, it has to be checked by authorized staff, which has the competence to decide (Tempich et al., 2006).

Versioning. A permanent Knowledge acquisition is a factor of success. One part of Knowledge acquisition can be the modification of information. By the modification of information a new version of information with a version number to distinguish will be stored in the ontology. The versioning supports the integration of the new information in the existing ontology, therefore there is a versioning assistant necessary, which tracks the relations of the old version and give the choice to integrate the new version with existing relations.

3.1.4 Datamanagement

The use of Ontologies leads to a lot of data and information. To store this data and information a database is preferred. Because databases enable a structured storage and scalability, fast access and save transactions.

This character of databases permits a central management of data. Another reason for using database is the factor of safety; through the encapsulation it is not possible to access the database without the middleware.

3.2 Templates

A Template is a standard pattern, which includes abstract information about repeating data constructs. The benefit of templates is that they are implemented once and they can be used for several similar cases.

Templates will support and improve the implementation, the unification and the recognition of similar structures. The users only have to complete the data content and have not build up a new structure.

With template features are being integrated in OPDS, it is possible to generate templates for specified problems. The templates are independent from application versions.

To support, for example, projectmanagement the basics structures of a project will be represent in a template, so that a user only have to complete the specified project data. This reduces the time to initialize new projects and minimizes the probability to make mistakes.

3.3 Model of OPDS

Based on the representation of knowledge in form of ontologies a model for a system to control knowledge management in enterprises was developed.

Through the presentation in form of a graphical user interface the user/administrator can access the OPDS.

Before he can enter the ontology, he has to log in and the RBAC checks if he is authorized. The RBAC belongs to the workflowmanagement, which as well controls the workflows Versioning, Change Management and Inspection Procedures.

Authorized user have the possibility to create templates, therefore they can use extracted structures from the ontology and for further knowledge acquisition.

4 CONCLUSIONS

In this paper we discussed, that knowledge management is an important factor for enterprises to become successful in developing new concepts. The integration of knowledge management is a challenge for enterprises.

To support knowledge management, ontologies have been established as form of representation. Especially in the product development the complexity of knowledge, information, methods and workflows, which are necessary to be protected and to be managed, requires the commitment of IT and knowledge representation forms.

To fulfill these tasks and requirements we developed an Ontology-based Product Development System (OPDS). The OPDS has several functions to control permission to ontologies (RBAC) and manipulation of the ontologies. Furthermore OPDS supports the enterprise workflows to assure the technical and the content consistency.

To make work with ontologies easier and to guarantee the consistent description, templates will use master to provide the integration of information.

The commitment of OPDS in enterprises leads to faster access to information and knowledge; therefore

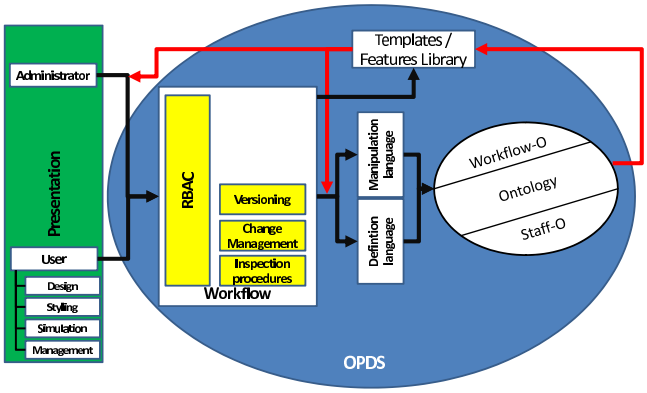

Figure 2: Model overview of complete system.

products can be developed faster.

REFERENCES

Alkassar, A., Husseiki, R., Stble, C., and Hartmann, M. (2007). *ISSE/SECURE 2007 Securing Electronic Business Processes*. Vieweg.

Birkhofer, H., Kloberdanz, H., Mathias, J., and Engelhardt, R. (2009). Integrated product and process development based on robust design methodology. *Proceedings of the International conference on engineering design ICED 2009*.

Grabowski, H., Anderl, R., and Polly, A. (1998). *Integriertes Produktmodell. Entwicklungen zur Normung von CIM*. Beuth-Verlag.

Grieves, M. (2006). *Product Lifecycle Management*. McGraw-Hill.

Gruber, T. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition. Academic Press Inc.*, 5(2).

Grueninger, M., Atefi, K., and Fox, M. S. (2000). Ontologies to support process integration in enterprise engineering. *Computational & Mathematical Organization Theory*, 6(4).

iViP Association, P. (2008). Secure product creation processes (sp2). Technical report.

Kashyap, V., Bussler, C., and Moran, M. (2008). *The Semantic Web - Semantics for Data and Services on the Web*. Springer-Verlag.

Klug, L. (2007). *Methodischer Einsatz von parametrischen Prototypen in der Produktentwicklung*. PhD thesis, Techn. Univ. Darmstadt.

Malzacher, J., Rambo, J., Geis, C., and Richter, M. (2008). Designmapping: Ein arbeitsmittel fr die kollaborative produktentwicklung zwischen ingenieuren und designern. In Hentsch/Kranke/Wlfel:, editor, *Industriedesign und Ingenieurwissenschaften*. 2. Symposium Technisches Design Dresden 2008.

Montoni, M., Santos, G., Villela, K., Rodrigo Miranda, A. R. R., Travassos, G. H., Figueiredo, S., and Mafra, S. (2004). Knowledge management in an enterprise-oriented software development environment. *PAKM 2004, LNAI 3336*, pages 117–128.

Nitterhouse, D. (2003). Plagiarism - not just an ”academic” problem. *Teaching Business Ethics*, 7(3):215–227.

Pahl, B., Beitz, W., Feldhusen, J., and Grote, K. (2003). *Konstruktionslehre - Grundlagen erfolgreicher Produktentwicklung - Methoden und Anwendungen. 5. Auflage*. Springer-Verlag, Berlin, Heidelberg.

Probst, G., Raub, S., and Romhardt, K. (2003). *Wissen managen: Wie Unternehmen ihre wertvollste Ressource optimal nutzen*. Gabler-Verlag, Wiesbaden.

Schuett, P., Bentele, M., and Weber, M., editors (2007). *Positionspapier: Wichtige Trends im Wissensmanagement 2007 bis 2011*, Berlin. BITKOM Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V.

Schuschel, H. and Weske, M. (2003). *Lecture Notes in Computer Science*, chapter Integrated Workflow Planning and Coordination, pages 771–781. Springer-Verlag.

Spur, G. and Krause, F.-L. (1997). *Das virtuelle Produkt: Management der CAD-Technik*. Carl Hanser.

Staab, S. and Studer, R., editors (2004). *Handbook on Ontologies*. Springer-Verlag.

Tempich, C., Pinto, H., and Staab, S. (2006). Ontology engineering revisited: An iterative case study. *LNCS*, 4011:110–124.

Tran, T., Haase, P., Lewen, H., scar Muoz-Garca, Gmez-Prez, A., and Studer, R. (2007). Lifecycle-support in architectures for ontology-based information systems. *ISWC/ASWC 2007, LNCS 4825*, pages 508–522.

VDI, editor (1997). *VDI-Richtlinie 2222 Blatt 1: Konstruktionsmethodik - Methodisches Entwickeln von Lsungsprinzipien*. VDI-Verlag GmbH, Dsseldorf.

Wu, D., Chen, X., Lin, J., and Zhu, M. (2006). Ontology-based rbac specification for interoperation in distributed environment. *Lecture Notes in Computer Science*, 4185:179–190.