Institute for Production and Industrial Information Management

Ontology-based Skills Management

Dipl.-Ing. Lars Dittmann

Lars.Dittmann@pim.uni-essen.de

Abstract[1]

During the last years more and more businesses have realized that knowing their employees competencies is an essential factor in order to stay competitive within the market. A knowledge management system based on ontologies can help a company to build up and manage skill profiles of its employees. For this reason a joint research project currently develops a suite consisting of a process model and a software application. This paper briefly lays out the results of the ongoing research project KOWIEN[2] at the University of Duisburg-Essen.

Keywords

Skills Management System, Ontologies, Process Models

Content

List of figures

1   Introduction

During the last years more and more businesses have realized that knowing their employees skills is an essential factor in order to stay competitive within the market. Northwest Airlines Corp. had to cut 10.000 positions, in the days following Sept. 11, without assessing the loss in company based knowledge affiliated with the layoffs [1]. Another example is the change in demographics. As the age-groups of baby boomers approaching retirement age employers are increasingly concerned about how they are going to replace these skilled employees [2, p. 48].

A knowledge management system based on ontologies can help a company to build up and manage skill profiles of its employees. The use of inference rules within a knowledge based system allows the inquiry of implicit company knowledge. Explicit knowledge about the employees skills can help allocate these skills. That means "known" skills can be deployed at the right time in the right place.

Based on that, ontologies can help to "cure" the linguistic divergences that exist between identical information gathered from different parts of an organization by unifying semantics.

After a brief introduction into ontologies and skills management systems the KOWIEN Project, the KOWIEN Process Model, the KOWIEN Ontologies and the KOWIEN Prototype will be described at their current state.

2   Project KOWIEN

KOWIEN (Kooperatives Wissensmanagement in Engineering-Netzwerken/ Cooperative Knowledge Management in Engineering Networks) is a joint research project in the field of knowledge-based systems. The consortium consists of four business partners, a technology partner and a software development partner (see figure 1). The four business partners (DMT GmbH, Roland Berger GmbH and Temavisio GmbH) will develop the scenarios for the later implementation of the prototype and will evaluate the running system. The technology partner is represented by the Institute for Production and Indus-trial Knowledge Management at the University of Duisburg-Essen in Germany and will conceptualize the system. The work-share of the Comma Soft AG as the development partner focuses on the implementation of the conceptualized system.

Figure 1: KOWIEN Project Consortium

The overall aims of the project are to strengthen the competitiveness of small and me-dium sized companies, to raise the quality of development results and to close the tech-nical gap between theoretical research and practical application in the field of ontolo-gies. The software prototype will support processes for developing new products and services in engineering networks.

As the name refers, skills management deals with the management of knowledge about skills. KOWIEN will conceptualize, develop and evaluate an ontology-based management information system to allocate the skills of employees and even of the organization itself. To achieve this aim all the relevant information sources of an enterprise will be used to build the knowledge base about existing skills.

2.1   Skills Management System

A skills management system can be seen as a part of an organizational memory information system, which gives it the ability to store dispersed and unstructured corporate knowledge, such as corporate competencies characteristics [3].

In general a skills management system (SMS) has to achieve three main objectives [4]:

- It has to support the complete and systematic acquisition of knowledge about skills of members of an enterprise.

- It has to provide the knowledge about skills and the actual owner of the skills.

- It has to apply the available knowledge to serve a purpose.

Normal (e.g. not ontology-based) SMS actually concentrate on the manual definition of skills due to the employees themselves, a simple tree-hierarchy of relations between competencies and focus on the personnel department [5]. This can hardly satisfy basic business demands. For example because of focusing only on managing *existing* skills the strategic human resources development is not supported and often the SMS is not integrated in the existing IT infrastructure. As a result the organization does not benefit from sources of knowledge about its employees skills.

To get acceptance of a SMS, it is essential to gain a high actuality of the administrated knowledge, so the users can rely on the statements the system gives. For this reason it is necessary that the SMS can "look" continuously after its knowledge base and expand it.

2.2   Advantages of Ontologies

The management of a company's knowledge about skills is made difficult mainly because of two problems. Firstly, relevant knowledge may often not be found in an explicit form, e. g. databases, but in documents like project reports and QM handbooks. In addition, it is often included in documents referring to a certain circumstance. This implicit knowledge is not immediately accessible; in particular it cannot be acquired by a

conventional database system. Secondly, the access to knowledge is encumbered with the problem that different actors (parties) use different terms to talk about the same topic. Especially in the case of fulfilling operational tasks based on a strong division of labour, ontologies can help to integrate task relevant knowledge components by bringing the domain knowledge in a uniform structure.

The idea *ontologies* has its origin in the field of artificial intelligence research. The most common definition goes back to GRUBER: an ontology is 'an *explicit specification of a* (shared) *conceptualization'* [6]. An ontology consists of definitions of concepts, attributes, relations and rules.

In the case of explicating gaps, e.g. the knowledge about skills of employees is only implicit contained in documents and not explicitly available for the SMS, an inference engine allows to explicate the implicit knowledge. Using non-deductive inference rules can expand the knowledge base significantly. The user of an ontology-based SMS gets a more valuable answer than he would get by just using a common database query. The inference mechanism takes positive effect on quality, actuality, acceptance and trustworthiness of a SMS [7].

To the knowledge of the author, there are currently two other projects investigating the development of an ontology-based SMS [8, 9]. Both approaches do not use non-deductive inferences rules yet. Therefore it has not been taken advantage of the unique selling proposition of ontologies. Of course, research is done in the field of *not ontology-based* SMS, for an example in a software consultancy company see [12].

3 KOWIEN Process Model

The KOWIEN Process Model is addressed to users within a practical environment. It intends to give advice to users who want to conceptualize, develop and evaluate an ontology-based skills management system. The detailed model [10] has been represented as an event-driven process chain [11]. Actually the KOWIEN Process Model has been extended with concrete tools that help users to apply it successfully. For example a questionnaire has been implemented that allows to evaluate the developed and implemented ontologies.
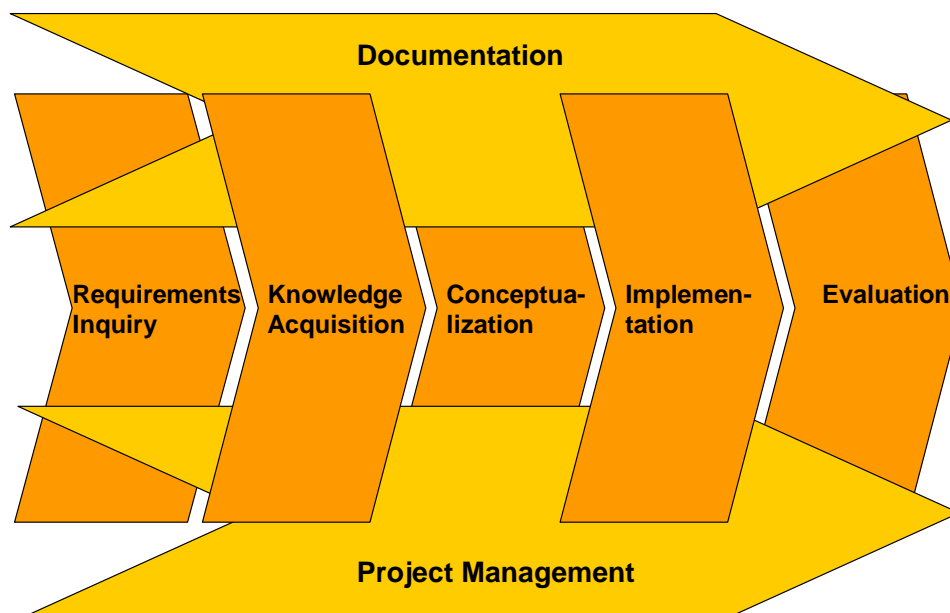
Figure 2: Top Level of the KOWIEN Process Model.

Figure 2 shows the aggregated top level of the model composed of five phases: requirements inquiry, knowledge acquisition, conceptualization, representation, evaluation, documentation and project management.

3.1   Successive Phases

The aim of the ontology development is specified in the first step of the KOWIEN Process Model. The *requirements inquiry* defines the area of application. By developing use cases and scenarios, different applications can be described. The requirements need to be identified systematically in order to support the phase of evaluation later on. If a large and complex number of requirements has been identified, it can be reasonable to use a requirements engineering tool to facilitate their management. The inquiry of the users and the analysis of the peripherals can be regarded as completed when the developers or users agree to it.

The phase *knowledge acquisition* denotes that the project team collects all the relevant information that is needed to conceptualize the ontology. Because the activities of acquisition and structuring of knowledge accompany each other, the phases of knowledge acquisition and conceptualization have to be done as an iterative loop. There are different sources that can be used to create a knowledge base. First of all, the employees and their superiors of an organization can be interviewed to acquire knowledge. Another way could be to extract knowledge from electronic documents to ascertain skills. In all cases it is important to pay attention to the fact that knowledge *about* knowledge will be raised.

A model-like account of an ontology will be developed in the phase of *conceptualization*. On the one hand it contains a conceptual system of the domain (terminology) and on the other hand it comprehends rules for interpretation and the use of the concepts. Not only the members of the project team conceptualize, but also the users, who have been interviewed during the phase of knowledge acquisition. As far as possible the conceptualization should not be accompanied by a certain language or technical requirement.

In the phase of *implementation* the formal account of the ontology will be developed. The implementation phase consists of the formal representation of the conceptualization and the integration of the ontology-based application in the system environment. The ontology engineers have to choose an appropriate language considering functionality and capability of the ontology and also the constraints of the given information systems in the enterprise. After representing the ontology the result has to be implemented into an information system (e.g. with a graphical user interface) so that users can fetch knowledge about skills from it. Besides, it is intended that the skills management sys-

tem explicates new knowledge about skills from documents or databases that are already used by an enterprise [7].

Before using the skills management system and the ontology in everyday life the ontology has to be *evaluated* towards requirements conformance and general applicability in the workflow. The process model determines verification (or falsification) and validation.

3.2   Overall Phases

Project management and documentation are backing processes nevertheless they are essential to assure success.

The *documentation phase* embraces all phases (requirements inquiry, know-ledge acquisition, conceptualization, implementation and evaluation) and is very important for modification and reusing of the ontology later on [13, p. 34]. To avoid mistakes the project team has to document important milestones, decisions and results. Furthermore a good documentation is important for users to make the ontology understandable with its inherent definitions. For example the phase will create documents describing knowledge carriers, users and the knowledge acquisition techniques that have been applied. Ontology development tools do help by enabling natural or formal language or graphical account of an ontology or by allowing entering comments or descriptions into source code.

The phase *project management* contains mainly the coordination of the stakeholders, the tracking of the schedule and the budget control.

In the following sections we will show in brief a possible *application* of the KOWIEN Process Model, which is actually in the development stage. The aim is to create a prototype of an ontology-based skills management system by considering the information systems and the using company as given.

4   KOWIEN Ontologies

It is planned to develop domain ontologies for the business partners. These ontologies shall be customized individually either company specific or sectoral. The latter means the classifications in goods or services.

To facilitate the development of these ontologies and to assure the interoperability, the project team has developed a "Common-Sense Ontology" with the topic *skills* [14, 15]. The ontology comprises the necessary concepts, attributes, relations and a set of rules to give detailed descriptions about skills of a firm's employees. After surveying, the consortium decided to use the language F-Logic developed by KIFER, LAUSEN and WU [16] for the stand alone representation of the ontology, mainly because of the closeness to first-order predicate calculus. For implementation and modification the developers used the ontology engineering environment OntoEdit®.[3]

The first customized ontology for the DMT GmbH has been finished recently. While the Common-Sense Ontology and the KOWIEN Process Model have been developed simultaneous, the customized ontology for the DMT GmbH has been developed following the steps of the KOWIEN Process Model. So it became the first implementation and evaluation of the KOWIEN Process Model.

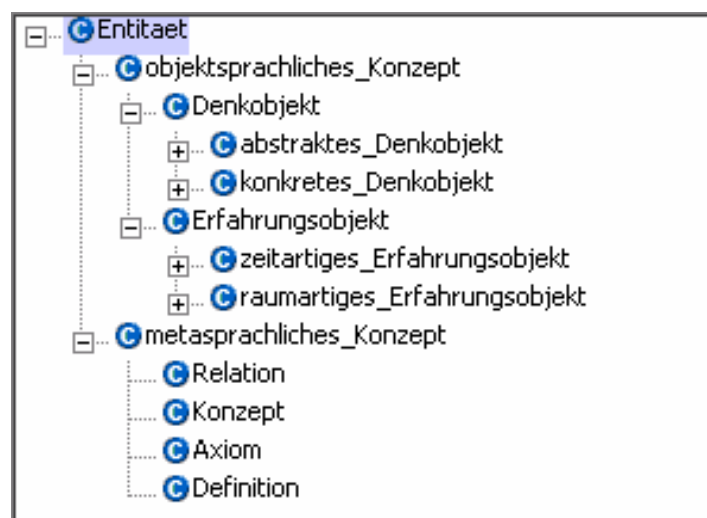Figure 3 shows the upper level of the KOWIEN Common-Sense Ontology with German concepts (Screenshot OntoEdit®).

Figure 3: Upper Level KOWIEN Common-Sense Ontology (in German).

---

[3] For further information about OntoEdit® and the Ontoprise® GmbH visit the web: http://www.ontoprise.com.

5   KOWIEN Prototype

5.1   System Architecture of the Prototype

The software development partner will use his infonea®-Suite[4] as a basis to develop the KOWIEN prototype (figure 4).
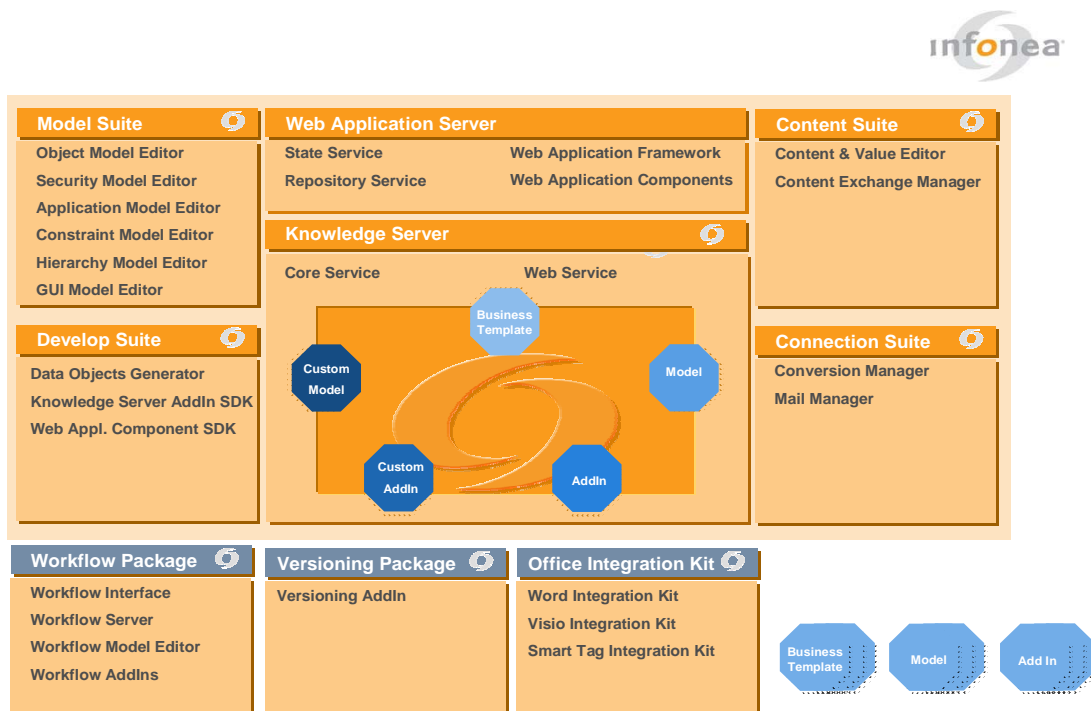

Figure 4: The System Architecture of infonea®.

Infonea® is a software-architecture for knowledge communication. Furthermore it represents a platform for intra- and internet applications. Different objects can be modeled for customers, e.g. employees, themes, expertises, projects, products or processes. Properties can be allocated to so called *knowledge objects*. These knowledge objects can be bound to one another and to different information sources like documents in a DMS or project data in Lotus Notes®. In the way of the specifically modeled objects, infonea® allows the connections to nearly any information sources. There are several additional features that are not important for our research topic in this paper and so they will not be explained here. The infonea® suite includes four Sub-Suites, two server ap-

---

[4] For further information about infonea® and the Comma Soft AG visit their webpage: http://www.comma-soft.com.

plications and three supporting packages. We will briefly describe the constituents for our needs.

The model suite provides different editors to model objects, constraints and the graphical user interface.

The knowledge server harbours the knowledge base in the form of the custom model and the meta model.

The web application server with its web application framework provides the possibility for users to actually access database knowledge just by using their web browsers.

5.2   Main Components of the Ontology-based Skills Management System

The framework of the ontology-based skills management system is shown in figure 5. As already mentioned, the prototype will use the infonea® suite as a basis. Adding browser, web server, inference engine, ontology and knowledge base the ontology-based system is complete.
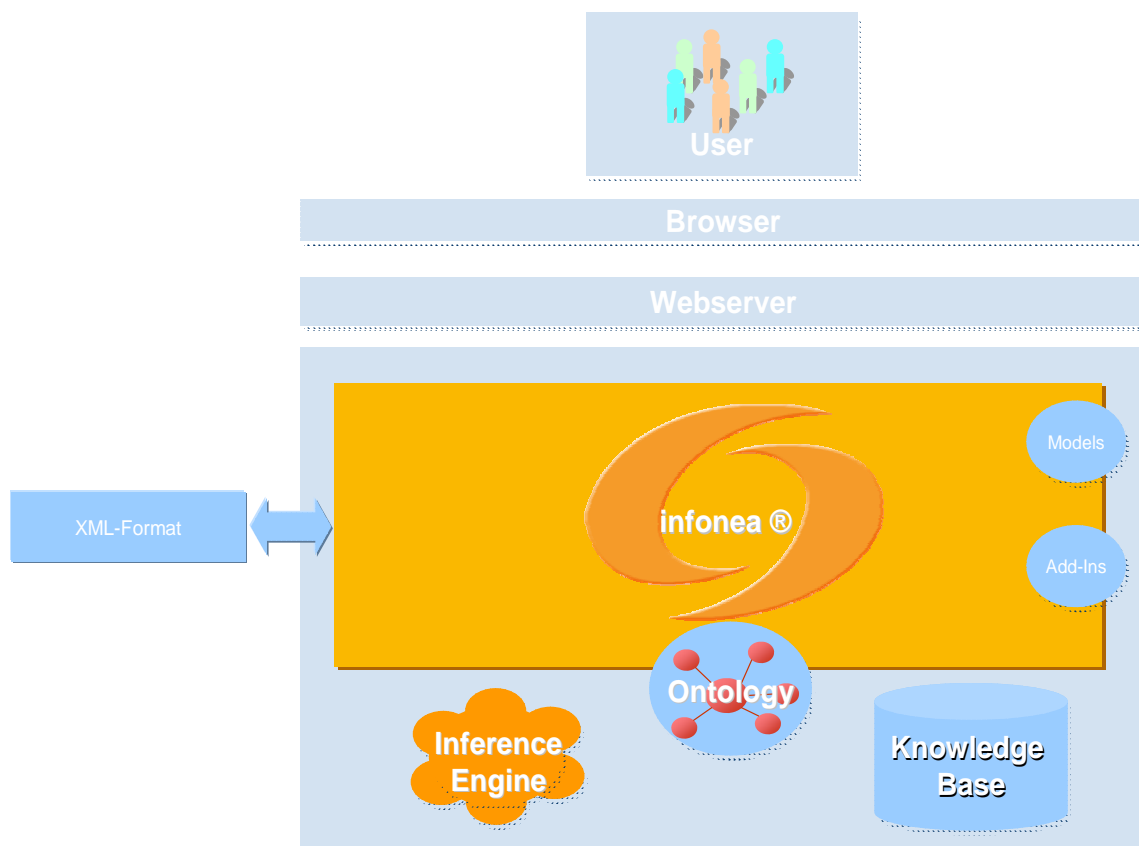

Figure 5: Framework of the Ontology-based Skills Management System.

The system architecture contains interfaces to security systems, mail systems, file converters and XML data. Therefore it is possible to build a distributed system.

The most important component of the KOWIEN prototype is the *ontology* (figure 5). The project KOWIEN plans the configuration of an ontology for every business partner in the project accounting the scenarios of product engineering and service engineering. Additionally to the representation of concepts, relationships and properties, the ontology will represent rules of integrity and inference. The inference rules allow explicating implicit factual knowledge about the skills of the employees. In the *knowledge base* the knowledge about the skills of the organization and the employees will be hosted. The *inference engine* will serve to explicate the implicit knowledge. For this purpose the inference engine will access the ontology and the knowledge base. Deduced knowledge will be saved in the knowledge base. The *web server* adopts the communication between the browser and the infonea® application. Using XML the data between external applications and the knowledge management system can be exchanged. Figure 6 shows a screenshot of the present starting page of the KOWIEN Prototype.
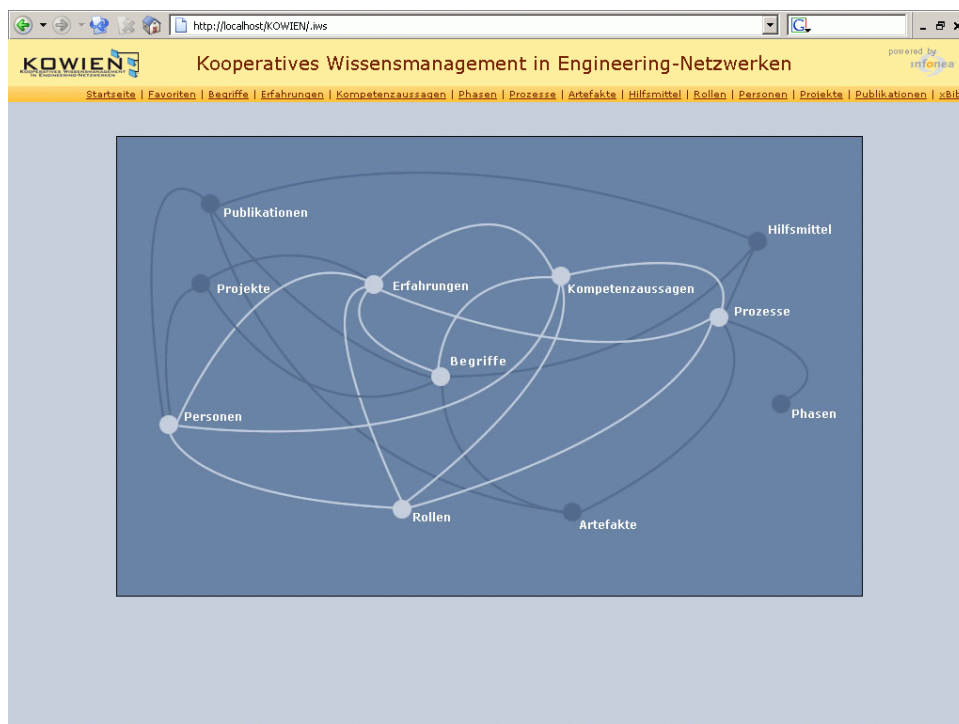

Figure 6: Screenshot Starting Page KOWIEN Prototype (in German).

5.3   Possibilities of Queries

There are two ways of querying the knowledge base, either directly or by using the inference engine. Using the inference engine will result in a higher quality of the outcome in both actuality and reliability.

Querying the knowledge base directly without using the inference engine means a fast performance at a lower quality. Therefore to use of the inference engine will be optional for the user. That means normally the user queries directly. Only in the case of not getting a satisfying answer with a direct query he uses the inference engine in order to obtain a higher quality.

6   Future Research

The KOWIEN Process Model is currently revised by the project partners. After this it is planned to expand it to take reference models into consideration. A reference model already disposes about knowledge in a certain domain. So the users get information that make it much easier to develop the needed ontologies. Currently a top level ontology exists as a prototype that represents the domain of skills in an enterprise in general. A more specific one has been build recently representing the domain of skills of one business partner.

In the case of the KOWIEN Prototype the representation of the ontology will be split: The concepts, relationships, properties and parts of the rules will be represented in the infonea® data model. The remaining rules will be represented in F-Logic (especially the non deductive ones). The part of the ontology that is represented in infonea® can be exported as a XML-document.

In spring 2004 the implementation of the KOWIEN Prototype will be completed. After this it undergoes an evaluation phase. Additionally, a web based training module that allows learners to develop their own ontologies without knowing beforehand what the concept "Ontologies" means will be developed. The first module has just been completed recently.

At the end of year 2004 the project will be finished.

7   References

[1] Goodridge, E.: Right Skills, Right Place. InformationWeek 11/12/2001 Issue 863, p. 99.

[2] Raphael, T.: HRMS Gets Easier, Better for Smaller Companies. Workforce, Feb. 2002, Vol. 81, Issue 2, pp. 46-49.

[3] Vasconcelos, J.; Gouveia, F.; Kimble, C.: An Organizational Memory Information System using Ontologies. Proceedings of the Third Conference of the Associacao Portuguesa de Sistemas de Informacao, University of Coimbra, Portugal 2002.

[4] Sure, Y.; Maedche, A.; Staab, S.: Leveraging Corporate Skill Knowledge – From ProPer to OntoProPer. Lausen, G.; Oberweis, A.; Schlageter, G. (eds.): Proceedings of the Third International Conference on Practical Aspects of Knowledge Management, Basel, Switzerland 2000, pp. 221-229.

[5] Maedche, A.: Skillmanagement der nächsten Generation. Lecture: AK Wissensmanagement 2002/06/01, Karlsruhe, Germany 2000.

[6] Gruber, T. R.: A Translation Approach to Portable Ontology Specifications. In: Knowledge Acquisition 1993, Vol. 5, No. 2, pp. 199-220.

[7] Dittmann, L.; Peters, M. L.; Zelewski, S.: Mitarbeitermotivation und Kompetenzmanagementsysteme. In: Reimer, U.; Abecker, A.; Staab, S.; Stumme, G. (eds.): WM2003: Professionelles Wissensmanagement - Erfahrungen und Visionen, Beiträge zur 2. Konferenz, 02.-04.04.2003 in Luzern, Bonn 2003, pp. 9-16.

[8] Lau, T.; Sure, Y.: Introducing Ontology-based Skills Management at a large Insurance Company. Glinz, M.; Müller-Luschnat, G. (eds.): Modellierung 2002, Modellierung in der Praxis – Modellierung für die Praxis, Arbeitstagung der GI, Proceedings LNI 12 GI 2002, Tutzing, Germany 2002, pp. 123-134.

[9] Vasconcelos, J.; Kimble, C.; Gouveia, F.; Kudenko, D.: A Group Memory System for Corporate Knowledge Management: An Ontological Approach. Proceedings of the First European Conference on Knowledge Management, Bled School of Management, Slovinia 2000, pp. 91-99.

[10] Apke, S.; Dittmann, L.: Generisches Vorgehensmodell KOWIEN, Projektbericht 4/2003, KOWIEN Project, Institute for Production and Industrial Information Management, University of Duisburg-Essen, Essen 2003.

[11] Scheer, A.-W.: Aris: Business Process Modelling, 3rd Edition, Springer Press 2000.

[12] Dingsøyr, T.; Røyrvik, E.: Skills Management as Knowledge Technology in a Software Consultancy Company, Learning Software Organizations Workshop, 12.-13. September, Kaiserslautern, Germany 2001, Springer Press, Lecture Notes in Computer Science, Vol. 2176, pp. 96-107.

[13] Fernández, M.; Gómez-Pérez, A.; Juristo, N.: METHONTOLOGY: From Ontological Art Towards Ontological Engineering. Farquhar, A.; Gruninger, M. (eds.): Ontological Engineering, Papers from the 1997 AAAI Symposium, Technical Report SS-97-06, Stanford, California, USA 1997.

[14] Alan, Y.: Konstruktion der KOWIEN-Ontologie. Projektbericht 2/2003, KOWIEN Project, Institute for Production and Industrial Information Management, University of Duisburg-Essen, Essen 2003.

[15] Alan, Y.: Modifikation der KOWIEN-Ontologie. Projektbericht 5/2003, KOWIEN Project, Institute for Production and Industrial Information Management, University of Duisburg-Essen, Essen 2003.

[16] Kifer, M.; Lausen, G.; Wu, J.: Logical foundations of object-oriented and frame-based languages. Journal of the ACM 1995, Vol. 42, No. 4, pp. 741-843.

8   Appendix

List of published project reports (mainly in German) in reversed chronological order:

- Alparslan, A.: Evaluation des KOWIEN-Vorgehensmodells, Projektbericht 1/2004, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2004.

- Dittmann, L.: Towards Ontology-based Skills Management. Projektbericht 8/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Engelmann, K.; Alan, Y.: KOWIEN Fallstudie - Gebert GmbH. Projektbericht 7/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Alan, Y.; Alparslan, A.; Dittmann, L.: Werkzeuge zur Sicherstellung der Adaptibilität des KOWIEN-Vorgehensmodells. Projektbericht 6/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Alan, Y.: Modifikation der KOWIEN-Ontologie. Projektbericht 5/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Apke, S.; Dittmann, L.: Generisches Vorgehensmodell KOWIEN Version 1.0. Projektbericht 4/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Alan, Y.: Ontologiebasierte Wissensräume. Projektbericht 3/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Alan, Y.: Konstruktion der KOWIEN-Ontologie. Projektbericht 2/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Apke, S.; Dittmann, L.: Analyse von Vorgehensmodellen aus dem Software, Knowledge und Ontologies Engineering. Projektbericht 1/2003, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen (Campus Essen), Essen 2003.

- Zug, S.; Klumpp, M.; Krol, B.: Wissensmanagement im Gesundheitswesen, Arbeitsbericht Nr. 16, Institut für Produktion und Industrielles Informationsmanagement, Universität Duisburg-Essen (Campus Essen), Essen 2003.

- Alan, Y.: Evaluation der KOWIEN-Zwischenergebnisse. Projektbericht 7/2002, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002.

- Alparslan, A.: Wissensanalyse und Wissensstrukturierung. Projektbericht 6/2002, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002.

- Alan, Y.; Bäumgen, C.: Anforderungen an den KOWIEN-Prototypen. Projektbericht 5/2002, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002.

- Dittmann, L.: Zwecke und Sprachen des Wissensmanagements zum Managen von Kompetenzen. Projektbericht 4/2002, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002.

- Zelewski, St.: Wissensmanagement mit Ontologien – eine einführende Darstellung, Arbeitsbericht Nr. 15, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002. [Langfassung zum u.a. Beitrag „Organisierte Erfahrung – Wissensmanagement mit Ontologien" in: Essener Unikate, Nr. 18, Essen 2002, S. 63-73.]

- Dittmann, L.: Sprachen zur Repräsentation von Wissen. - eine untersuchende Darstellung - Projektbericht 3/2002, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002.

- Alan, Y.: Methoden zur Akquisition von Wissen über Kompetenzen. Projektbericht 2/2002, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002.

- Alparslan, A.: Ablauforganisation des Wissensmanagements. Projektbericht 1/2002, Projekt KOWIEN, Institut für Produktion und Industrielles Informationsmanagement, Universität Essen, Essen 2002.

For further regular and irregular publications please visit the website:

http://kowien.uni-essen.de.