Role-Driven Knowledge Management Implementation
Lessons Learned

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Abstract: Today, companies have to deeply transform both their product development structure and the structure of their business processes. Knowledge management has shown its efficient applicability in this area. However, implementation of such complex changes in large companies faces many difficulties. The paper presents lessons learned from implementing knowledge management in two collaboration experiences with industrial partners. The role-based knowledge management approach used in these collaboration experiences is described. It relies on the ontological knowledge representation for its sharing and considers the workflows from perspectives of different roles. The major steps of the approach are described. The observations made during the implementation of the approach address problems related to the implementation and generic principles that helped to overcome the problems.

1 INTRODUCTION

Modern market opportunities require companies to introduce new strategic objectives and tools. They have to build strategies that provide maximum flexibility and can optimally respond to changes in their environment (Gunasekaran et al., 2008; Gunasekaran and Ngai, 2005; Christopher and Towill, 2001). In order to cope with these requirements, companies need to deeply transform both their product development structure and the structure of their business processes.

Knowledge management has shown its efficient applicability in this area. It is a complex cooperative network-centric process to support multi-object and multi-disciplinary areas including modelling, design, knowledge representation and acquisition, decision support and supporting environment (Liu et al., 2004).

Due to the modern trends in knowledge-dominated economy from "capital-intensive business environment" to "intelligence-intensive business environment" and from "product push" strategies to a "consumer pull" management companies accumulate large volumes of knowledge usually referred to as corporate knowledge. An efficient approach was required in order to provide a mechanism which allows for decision maker to have required knowledge "at hand" in an appropriate form for making correct and timely decisions, what in turn will make possible for a manufacturing system to quickly react on changes in its environment and to be flexible enough.

A number of efforts have been done in the area of sharing information and processes between applications, people and companies. However knowledge sharing / exchange required more than this. It required information coordination and repository sharing with regard to semantics. This has led to appearance of the Corporate Knowledge Management (CKM) that can be defined as a complex set of relations between people, processes and technology bound together with the cultural norms, like mentoring and knowledge sharing.

However, implementation of such complex changes in large companies faces many difficulties: business process cannot be stopped to switch between old and new workflows; old and new software systems have to be supported at the same time; the range of products, which are already in the markets, has to be maintained in parallel with new products, etc. Another problem is that it is difficult to estimate in advance which solutions and workflow would be efficient and convenient for the employees. Hence, just following existing knowledge management implementation guidelines

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is not possible (e.g. Oluikpe, 2012), and this process has to be and iterative and interactive.

The paper presents lessons learned from implementing knowledge management in two collaboration experiences. The first one is a result of a long-term joint work with Festo AG&Co KG, an industrial company that has more than 300 000 customers in 176 countries supported by more than 52 companies worldwide with more than 250 branch offices and authorised agencies in further 36 countries (Oroszi et al., 2009; Smirnov et al., 2013a). Some early steps of this collaboration related to implementation of the product codification system have been reported in (Smirnov et al., 2011). The other one is a result of project carried out for Ford Motor Company aimed to describing production processes and production facilities (Golm and Smirnov, 2000a; Golm and Smirnov, 2000b).

The paper is structured as follows. Section 2 describes the role-driven approach to knowledge management. Section 3 introduces the implementation of the approach. The lessons learned are concluding the paper.

2 ROLE-BASED KNOWLEDGE MANAGEMENT

Efficient knowledge management assumes deriving and processing not only internal knowledge but also knowledge from various sources including (adapted from Botkin, 1999):

- customer needs, perceptions, and motivations, etc.;
- expertise within and across the supply chain;
- best practices, technology intelligence and forecasting, systemic innovation, etc.;
- products in the marketplace, who is buying them and why, what prices they are selling at;
- what competitors are selling now and what they are planning to sell in the future.

Knowledge management in a global companies requires interoperability at both technical and semantic levels. The interoperability at the technical level is addressed in a number of research efforts. It is usually represented by such approaches as e.g., SOA (Service-Oriented Architecture) (SOA, 2014) and is based on the appropriate standards like WSDL and SOAP (Web services explained, 2014). The semantic level of interoperability in the production network is also paid significant attention. As an example (probably the most widely known), the Semantic Web initiative is worth mentioning (Semantic Web, 2014). The Semantic Web relies on application of ontologies for knowledge and terminology description.

The approach used in the presented work (Smirnov, Levashova and Shilov, 2009) relies on the ontological knowledge representation for its sharing. The ontology describes common entities of the company's knowledge and relationships between them. Besides, the dynamic nature of the company requires considering the current situation in order to provide for actual knowledge or information. For this purpose, the idea of contexts is used. Context represents additional information that helps to identify specifics of the current transaction. It defines a narrow domain that the user of the knowledge management platform works with. One more important aspect covered by the approach is the competence profiling. Profiles contain such information as the network member's capabilities and capacities, terminological specifics, preferred ways of interaction, etc.

The overall conceptual model of the knowledge management platform would be formed as follows. The approach is based on the idea that knowledge of the company can be represented by two levels for the purposes of its processing in information systems. The knowledge of the first level (structural knowledge) is described by a common ontology. The ontology forms the core of the platform. In order for the ontology to be of reasonable size it includes only most generic common entities. Ontologies provide a common way of knowledge representation for its further processing. They have shown their usability for this type of tasks (e.g., Bradfield et al., 2007; Chan and Yu, 2007; Patil et al., 2005). The common ontology is used to solve the problem of knowledge heterogeneity and enables interoperability between heterogeneous information sources due to provision of their common semantics and terminology (Uschold and Grüninger, 1996). It describes all the products (produced and to be produced), their features (existing and possible), production processes and production equipment. This ontology is used in a number of different workflows. The tools are interoperable due to the usage of the common ontology and database. Knowledge map connects the ontology with different knowledge sources of the company.

Knowledge represented by the second level is an instantiation of the first level knowledge.

For modern decision support systems, personalized support is important. Usually, it is based on application of the profiling technology. Each user (human or an information system) works on a particular problem or scenario represented via a context that may be characterised by a particular customer order, its time, requirements, etc.

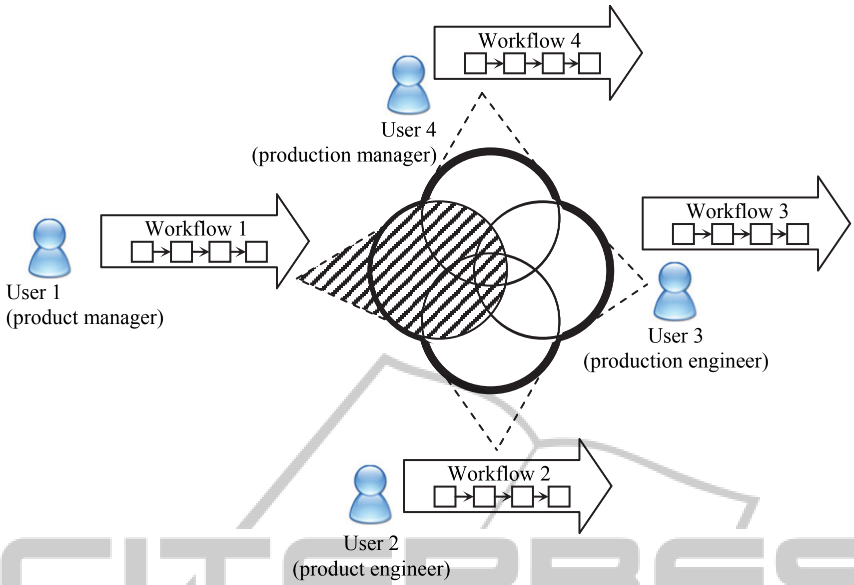

Figure 1: Role-based perspectives of the common ontology.

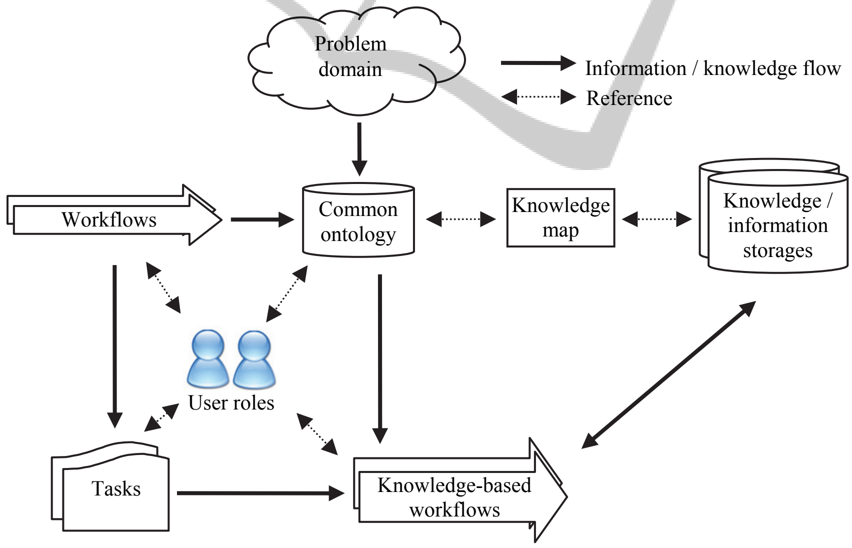

Figure 2: Approach illustration.

The second idea of the approach is to consider the workflows from perspectives of different roles.

Research efforts in the area of information logistics show information and knowledge needs of a particular emploee depend on his/her tasks and responsibilities (Lundqvist, 2007). This is also confirmed in other works, e.g.: “Information demand depends on the role and tasks an entity has within a larger organization. If the role and/or the tasks change, so too will the demand" (Persson and Stirna, 2009).

Role-based approaches have shown their efficiency in such adjacent areas as ontology modelling (Fox et al., 1995), competence modelling (Tarasov and Sandkuhl, 2011), etc.

Based on the experiences from two industrial case studies, the following perspectives have been identified: product manager & product engineer (from the first case study), and production manager and production engineer (from the second case study). Each of them works with his/her part of the common ontology, with the ontology parts overlapping (Figure 1).

The approach assumes the following steps for knowledge management implementation (Figure 2):

1. Structural information about workflows and the problem domain is collected and described in the common ontology.
2. User roles are identified and their relevant parts of the common ontology are defined.
3. Tasks assigned to the identified roles are defined.
4. Knowledge required for performing identified tasks is defined.
5. Based on the identified roles, tasks and knowledge, new knowledge-based workflows are defined.
6. Corresponding role-based knowledge support of the workflows is provided based on the usage of the common ontology and knowledge / information storages.

This process repeats for each particular role, with some knowledge being reused between roles.

The next section describes the implementation of the developed approach.

3 IMPLEMENTATION

The first step of the approach implementation is creation of the ontology. This operation was done automatically based on existing documents and defined rules of the model building. The resulting ontology consists of more than 1000 classes organized into a four level taxonomy, which is based on the VDMA (Verband Deutscher Maschinen – und Anlagenbau, German Engineering Federation) classification (VDMA, 2014). Taxonomical relationships support inheritance that makes it possible to define more common attributes for higher level classes and inherit them for lower level subclasses. The same taxonomy is used in the company's PDM and ERP systems.

For each product family (class) a set of properties (attributes) is defined, and for each property, its possible values and their codes are defined as well. The lexicon of properties is ontology-wide, and as a result, the values can be reused for different families.

Then, based on the developed ontology, the complex product modelling design and system has been implemented. Complex product description consists of two major parts: product components and rules. Complex product components can be the following: simple products, other complex products, and application data. The set of characteristics of the complex product is a union of characteristics of its components. The rules of the complex products are union of the rules of its components plus extra rules. Application data is an auxiliary component, which is used for introduction of some additional characteristics and requirements to the product (for example, operating temperatures, certification, electrical connection, etc.). They affect availability and compatibility of certain components and features via defined rules.

At the second step, the major roles, whose workflows were addressed by knowledge management implementation, have been identified. As it was mentioned earlier, the roles are product manager, product engineer, production manager, and production engineer.

Then, at steps 3 and 4, their tasks and needs are analysed. The product manager works with customers and their needs. Usually, the parameters and terminology the customer operates with differ from those, operated by product engineers. For this reason, a mapping between the customer needs and internal product requirements is needed. Based on these requirements new products, product modifications or new product systems can be engineered for future production.

For the goal of production process description the approach distinguishes between virtual and real modules. In accordance with the approach, the virtual modules are used for grouping technological operations from the production engineer’s point of view. The real modules represent actual production equipment (machines) at the level of production manager.

At steps 5 and 6 the knowledge-based workflows are defined and corresponding supporting tools are built.

A system (called DESO) has been developed for a structured storage of the knowledge about data domain, and for its further processing. Depending on the particular tasks it can be supplemented by other components (tools) intended for solution of specific problems using the knowledge, contained in the common storage. In the time being the tools for the enterprise production program planning (Goal), for the production modules designing (Module), and for the industrial resources distribution and planning (Goal and Module) have been developed.

The system supporting the levels of production engineer and production manager was originally focused on the early stages of planning procedure of investment calculation and determination for the

(a) derivation of production scenarios, (b) determination of investment cost, (c) assignment of locations and (d) estimation of product variable cost. The system aims at providing a knowledge platform enabling manufacturing enterprises to achieve reduced lead time and reduced cost based on customer requirements through customer satisfaction by means of improved availability, communication and quality of product information. It follows a decentralized method for intelligent knowledge and solutions access. Configuring process incorporates the following features: order-free selection, limits of resources, optimization (minimization or maximization), default values, freedom to make changes in global production network model.

This system distinguishes between virtual and real modules. In accordance with the approach, the virtual modules are used for grouping technological operations from the production engineer's point of view. The real modules stand for the real equipment used for the actual production. The production engineer sets correspondences between the technological operations of virtual modules and machines of real modules.

It also includes a tool for sequences of operations for a part production, possible alternatives of production distribution etc. This tool supports inheriting subordinate objects, what allows creating of complex hierarchical systems of objects, and using templates automating the user's work.

The main entities of the approach implementation and identified roles are presented in Figure 3. The figure also identifies tools implemented in the first case study.

The developed so far integrated knowledge management workflow for the first case study (addressing roles of product engineer and product manager) is presented in Figure 4 and is described in detail in (Smirnov et al., 2013b). At the first stage, the major product ontology is filled with generic classifications of products and their components. This is done via two tools (NOC and CONCode) since recently developed order code scheme differs from that used before. However, since multiple customers are used to operate with the old classification it has to be maintained.

At the next stage, the product managers and product engineers design new products and solutions based on existing products and components (the CONSys tool). If a new product or component is needed, its implementation can be requested from the order code structure team. Together with new products and solutions, the appropriate rules and conditions are designed as well (e.g., acceptable load, size, compatibility constraints, etc.).

When the configuration model is finished it is proposed to the customers so that they could configure required products and solutions themselves or with assistance of product managers (the CONFig tool).

4 LESSONS LEARNED

During the work on the mentioned case studies the following observations related to knowledge management implementation in companies have been made:

- Engineers and managers are concentrated on their work and cannot pay enough attention to additional tasks related to trying new knowledge-based workflows. This was in a higher degree applicable to the product managers and product engineers. At the levels of production engineers and production managers, this issue was less obvious, because the "experimental" knowledge-based production planning could be done in parallel with the actual one.
- A potential target knowledge management group has to be formed. It has to consist of people volunteering to assist in implementing knowledge management in the company. These people have to be experts in their roles and in several other roles, which would re-use some of the knowledge of this role. They will be involved into the processes of building the initial common ontology and implementing knowledge-based workflows for their role and several other roles thus slowly involving other roles into the process of knowledge management implementation.
- Role-based approach makes it possible to implement knowledge management incrementally, with initiative coming from employees. E.g., an experimental knowledge-based support of one workflow could be implemented for one user role letting the users estimate its efficiency and convenience. Then, workflows reusing some of the knowledge of the experimental workflow can be added, etc. Representatives of other roles seeing the improvements of the implemented knowledge-based workflows also wish to join and actively participate in the identification of the knowledge needed for their workflows and further turning their workflows into the knowledge-based ones.

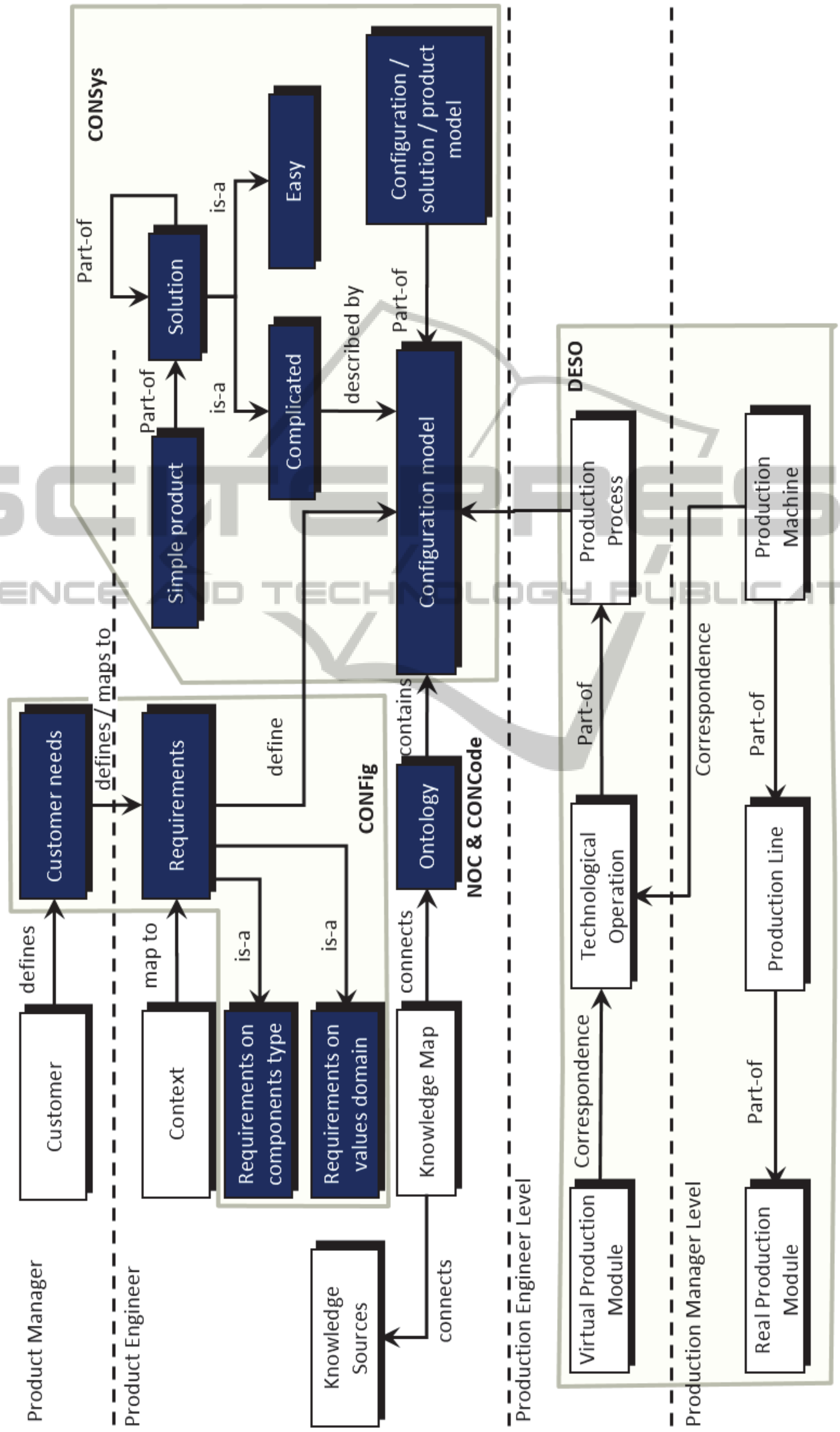

Figure 3: Role-driven knowledge management implementation.

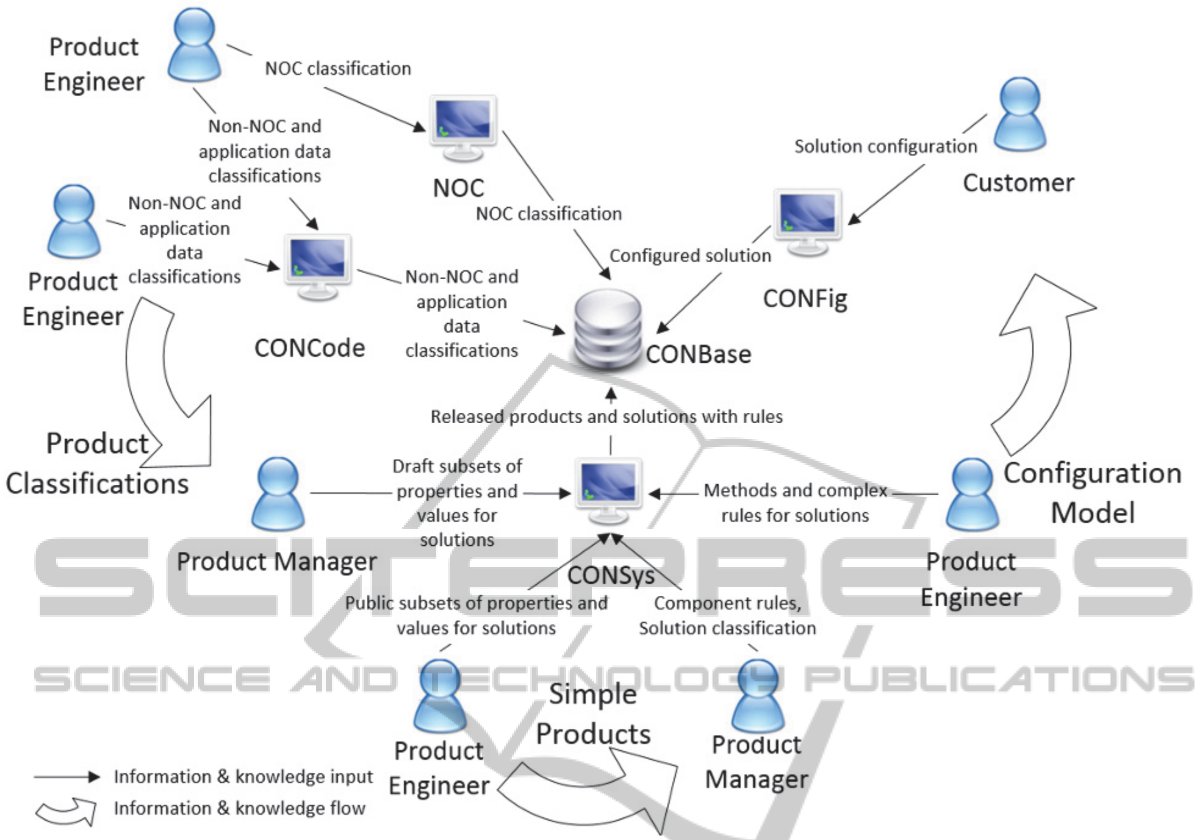

Figure 4: Integrated knowledge-based workflow.

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