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Managing Knowledge in Medium Sized Software Companies

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Abstract

The software industry is an ideal case of information production with a high importance of knowledge and information management. This paper distinguishes information and knowledge management and points out the dependencies. It analyses the situation, enablers and restrictions to knowledge management in software companies. In two case studies, a number of obstacles to the introduction of knowledge management such as a lack of awareness, a technical oriented professional code, or time and cost pressure in software development projects are identified and measures towards the introduction of an effective knowledge management system are illustrated. The findings from the case studies are summarized in general problems and possible solutions for knowledge management in medium-sized software companies.

1 Knowledge Management in the Software Industry – a Challenge!

A software enterprise can be defined as an enterprise with more than 50% of its turnover in software and software services. Software, as well as software services, mainly consist of information. Additionally, the corresponding production processes are information and knowledge intensive. As Hoch et. al put it: „Software is nothing but pure knowledge in codified form“[1]. Therefore, the potential of knowledge management (KM) and information management (IM), respectively, is high in software enterprises and the software industry (*figure 1*).

With the development towards an information society, the character of the existing industries will change. As well the industries' shares in the national product will shift towards sector 4, i. e. information rich products and information intensive production processes (“trend” in *figure 1*). Considering this general trend, the software industry can be seen as a reference point for other industries in the future. Experiences from the application of new management concepts such as knowledge or information management in software industry will then be worth rendering.

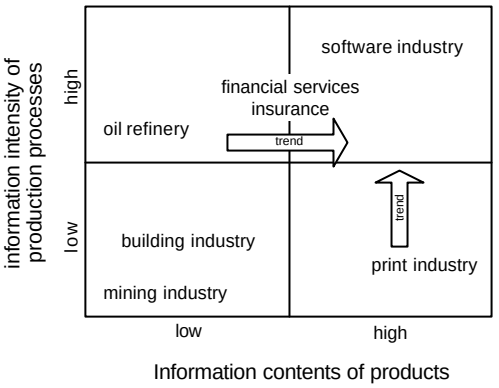

Figure 1: Information intensity of production [2]

Besides its referential character, the software industry has a cross-industrial impact on the national product. Software and software services are investment goods essentially influencing the success of enterprises of different industries. The competitiveness of parts of the economy such as financial services and insurance are highly dependent on software products and services. Through its products, the software industry is an innovating and driving force for several national economies and the European economy as a whole. This is one reason why the software industry has been labeled the “growth industries' growth industry” [3, 4].

Another reason is the software industry's growth in the past. Growth rates of 15% to 20% a year have been typical of the European software market in the 80s. During the recession phase in the beginning of the 90s growth rates fell significantly under 10% in some sectors but recovered in the second half of the 1990s. During this growth phase, numerous new enterprises entered the software market. Consequently, the software industry is now dominated by young enterprises that are still considered small or medium size. In Germany for example, 60% of the software companies have been founded in 1980 or later [5].

As a result the software industry's impact on the economy as an innovating and driving force has to be seen.

From this point of view, the early validation and adoption of promising technologies and management concepts is important; possibly, practical KM solutions and products can be delivered. Another aspect is that software companies are relatively young and small enterprises have grown intensively in the past. Because a rapid evolution of enterprises is often accompanied by problems in management, it may be expected that there are problems and obstacles to the adoption of new concepts such as knowledge and information management that must be overcome.

2 What is "Knowledge Management"?

2.1 Information, Knowledge and Management

Information and knowledge management are often difficult to grasp as the basic terms information and knowledge are not clearly defined or distinguished. Knowledge in a general sense encompasses the mental models, that represent our understanding of the world. It can be understood as "the fact or condition of being aware of something" and it frames "the range of one's (...) understanding" [6]. In an economic context, information is often understood as "useful knowledge", "decision-oriented knowledge" or "additional knowledge in decision making". Such definitions point out the economic value of information, its effect on economic decisions and action. But the characteristics proposed are only of little help in distinguishing knowledge and information. What happens then, if information is already known to the recipient? Is it no longer information? Then, the definition of information depends on a recipient and his state of knowledge at a certain time. Another problem is, when we try to evaluate the impact of information on decisions or economic actions. What economic effects constitute information?

For our analysis, it has proven to be more beneficial and precise to define information from the point of view of information and communication technology (ICT) and computer science. The important characteristic that makes knowledge information is explicitness. That is, information is not bound to the human brain, but represented physically, since physical representations of knowledge are accessible by ICT. In computer science, dedicated formats for processing information electronically and for transferring information are called data and messages, respectively.

Information is a true subset of knowledge. Not all knowledge can be made explicit in an externalization process. As known from research in Artificial Intelligence, experts often have implicit, "compiled" knowledge that they can not explain. In a similar context, POLANY uses the term "tacit knowledge"[7]. Although implicit, knowledge can acquired indirectly by expert work observations, for example. This kind of knowledge transfer is called socialization. Explicit knowledge can be further developed by linking it, reorganizing it or finding a new form of representation. This process is called combination. Internalization is the process of absorbing explicit knowledge and applying it to the solution of concrete problems.

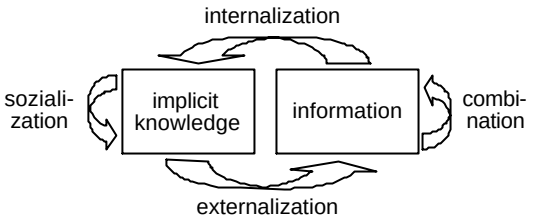

Figure 2: Knowledge-Information-Relationship [8]

Our definitions of knowledge and information have clear consequences on our understanding of IM and KM respectively. The term management describes the leadership function in an enterprise covering planning, controlling, organization and employee guidance. IM comprises all management tasks which relate to the information resources of an enterprises and the information technology used to procure and administer information. Its goal is to provide all organizational units in the enterprise with the information at the time and in the quality needed. Alternatively, KM has a much broader scope. It is concerned not only with information but with all kinds of knowledge – even if implicit and bound to the heads of experts.

By definition IM could be seen as a pure subset of KM, but both disciplines have a different focus. Not all information (e. g. accounting data, bills or administrative documents) are of interest in KM. Rather, KM focuses on the core competencies of an enterprise such as market knowledge, product knowledge, production technologies etc.

2.2 Designing Organizational Learning

KM has been pointed out as an important precondition for and if lacking a strong restriction to effective software development [3]. KM is concerned with establishing organizational learning (OL). OL means developing the knowledge base that is shared by the members of the organization and is used to fulfill the organization's objectives. Possibilities for supporting OL are, for example, technology groups, experience groups, personnel education and training or data and document bases . It becomes obvious from these examples, that OL design is not restricted to information and communication systems (ICS) though these play an important role in KM. In addition to ICS development, KM can be realized by measures in organizational design, leadership and controlling, and organizational culture.

The *organizational culture* covers the values and beliefs shared by employees and management of a company. Culture represents the values which really determine the actions of organization members. The *organizational philosophy* is an idealized mission statement formally defining ethics and identity of an enterprise. The organizational culture cannot directly be designed but it can be influenced by formal philosophy statements and measures to put them into action. KM requires values to be shared that lead to OL – such as cooperation, cross-border communication, and information sharing.

Leadership includes style and principles of personnel guidance. It is well known, that authoritative leadership styles may lead to good results in highly standardized work processes but do not stimulate cooperation and learning.

Controlling traditionally focuses on directly ascertainable measures, preferably financial ones. However, a tight financial oriented project controlling in software development leaves little room for documentation, learning and innovation. Consequently, controlling also has to set incentives for and control non-financial measures in order to stimulate organizational learning.

Organization is an important parameter of KM. On the one hand, the primary structure of departments and units as well as the process structures can be either obstacles to or enablers of organizational learning. For example, well defined development processes are a precondition for comparable project documentation and allow failure analysis ex post. On the other hand, organizational units for KM such as an editorial office or a knowledge coordinator are organizational units dedicated to KM.

Information Systems are a means of KM, especially if they exceed traditional transaction processing on an operational level (administration and disposition systems). Interesting technologies are for example knowledge based reasoning, document management or hypermedia technology. Interesting applications in the context of KM are expert and expertise systems, computer based education and training or customer and market data bases.

In addition to the parameters mentioned, human resource planning and development is an important aspect of KM. But our research does not focus on planning activities. Thus, we have addressed the implementation of KM in daily business.

3 Case Studies

In an action research project, we conducted two case studies concerned with establishing OL in software companies. The objective was to identify the most important steps towards OL, based on the state of OL found in the enterprise. Then, concrete measures for building the KM system were to be defined and ranked. As our cases are taken from the software industry, the focus was on information systems (IS). But as the effectiveness of IS strongly depends on the management framework in general, all aspects of OL, from culture to IS, were addressed [9].

The projects were conducted in three phases. The first phase, *Situation Analysis*, was concerned with the situation within the enterprise. During analysis, the maturity of a knowledge management system was evaluated with respect to the different dimensions identified (see chapter 2.2). The aim of this phase is to identify the state of and the most striking weaknesses in KM as a basis for the development of improvement measures.

The aim of the second phase, *Rough-Cut Design*, was to frame the solution space and to fix edge design parameters. As a result of this phase, the main preconditions in culture, leadership, controlling and organization were to be fixed as the context for information system definition.

In *Information System Definition,* a list of important possible IS projects for KM was to be identified. All project proposals were evaluated by performing a cost / benefit analysis . The benefits were estimated with respect to their contribution to the overall KM system, covering all aspects from culture to organization. A customer and market database, for example, is only be successful, if there are organizational rules for its maintenance and free flows of information to and from sales managers.

Just as we have used these three phases as a structure for the projects conducted we will use them to describe the results of our work in the following sections . Section 3.1 presents the companies under consideration in our case studies and presents the results of *Situation Analysis*. The measures to be taken in *Rough-Cut Design* and *Information Systems Design* are summarized in section 3.3.

3.1 Overview

Both companies investigated in our action research can be characterized as medium-sized since the number of employees is less than 100. Nevertheless, the companies are quite different. They operate in entirely different markets with different qualifications. One company is independent, the other bound in a conglomerate structure.

Because the case studies will point out some internal details and problems of the companies they will be presented anonymously.

3.1.1 The Digital Image Processing Company

The first company will be referred to as DIPC (digital image processing company), according to its products and markets. The DIPC was founded in Germany in 1976 as a GmbH & Co. In the beginning DIPC's main business was the application of video technology in employee education and training. In the 1980s, video technology was more and more accompanied by computer technology, first to control video systems and later in digitizing images to allow interactive picture sequences. In the end of the 1980s, DIPC, in the light of the emerging market, changed its business purpose from education and training to digital image processing in quality assurance. In the beginning, DIPC only developed lab solutions. Step by step, these were extended to real-time applications for inline control of industrial production processes.

Since the beginning of the 1990s the DIPC exclusively offers hardware-software-systems for analytical and preventive quality assurance in industry (computer aided quality assurance, CAQ). The DIPC has about 20 employees, in production mainly electronic engineers, physicists and computer scientists. Nearly all employees are between 25 to 35 years old and have had only little professional experience before they joined DIPS.

In the years 1996-1998, turnover was about 1.5 to two million EURO. The core competence of DIPC is the development of software for digital image processing. Accordingly, 70% of the total turnover can be assigned to software and services. The DIPC is a software company by definition (see section 1), but it can be more precisely identified as a systems provider since it delivers integrated software-hardware-solutions.

3.1.2 The Electronic Publication and Media Company

The second company is called EPMC (electronic publication and media company) here. EPMC has its roots in two former enterprises. One of these had done its business in the printing sector with electronic typesetting and printing machines while the other had been one of the first companies using CD-Rom as storage medium. As the synergy of printing and CD-media became obvious, EPMC has been founded as a fusion of these two enterprises 11 years ago.

EPMC is now primarily involved in publication systems, i. e. systems allowing to store, process and prepare information for presentation on different media, especially paper, micro-fiche, CD-Rom or Intra-/Internet. Other products are electronic commerce platforms and applications.

The EPMC has about 70 employees and up to 30 independent contractors depending on demand. Employees in software development and sales are mainly computer scientists, mathematicians, business computing experts, economists and some engineers. Ages range from 25 to 45 years and there is a large number of employees who have experiences from other jobs.

Between 1996-1998 turnover developed from just 10 Million to 15 Million EURO. EPMC can bee seen as a software company with some business in the printing sector.

3.2 Situation Analysis

In order to perform a situational analysis, it is necessary to begin with the core competencies of the enterprise. Core competencies are analyzed from a knowledge management point of view by identifying the relationship between knowledge assets and core competencies. Then, the companies' state of organizational learning in the core knowledge areas is analyzed. This is done with respect to each dimension of OL.

3.2.1 Core Competencies

Generally speaking, both companies have their core competencies in

(1) their capability to solve problems within the domain by means of software,
(2) the efficient re-use of domain specific software, experiences with software platforms (operating systems, server platforms) and hardware,
(3) their capability to handle complex projects in time, resources and cost,
(4) the effective use of CASE- and project management tools,
(5) a clear understanding of market and customer requirements,
(6) precise offer calculation based on cognizant of competitor's products and prices,
(7) the ability to recognize trends early and adopt promising IT-solutions (platforms, tools) from the market.

In DIPC, competences No. 1, 2, 3 were judged most important, competences 5, 6, 7 were only judged important. In contrast to DIPC, the EPMC'S products are less domain specific, so that competencies 2, 3, 5 were ranked very high while 1, 4, 6 and 7 were ranked high.

3.2.2 Knowledge Analysis

Since competencies 1,2, 3, and 5 were seen as most important in at least one of the companies, we provide an overview about the results of the knowledge analysis in these points.

Domain Problem Solving

Domain Problem Solving requires a clear understanding of the application domain procedures and methods to

solve domain problems. This has been recognized clearly in scientific study, since there are strong efforts in the development of domain reference models and patterns [10]. Nevertheless, domain knowledge can only be taken from literature in foundations. Even internal project documentation – that is seldom available – gives only limited insights into a domain. Real domain professional or expert problem solving is based on pattern recognition and intuition [11]. In other words, domain expertise is mainly bound to the heads of the system analysts. Beyond this, problem solution is a creative process and strongly depends on the experience and intellectual capabilities of the experts.

Product Re-Use

Product capabilities include all knowledge about the software and hardware components that have already been used and applied in former projects. In literature, there are dedicated recommendations on the documentation and organization of self manufactured software components for reuse. Nevertheless, in our cases, only little effort was exerted in this regard . Experiences in the application of hardware and software platforms were not well documented. Information about products and platforms were only available from the engineers who had developed or intensively used them.

Project Management

The discussion of project management is often reduced to methodological issues such as process models, planning techniques and scheduling algorithms. But in our research it became obvious that efficient project management depends much more on project experiences and social intelligence. Management methods are relatively easy to document and were partly documented in our cases. Both enterprises had software development process models and rudimentary specification of deliverables at their disposal. But experiences were neither documented in case descriptions nor in lessons learnt.

Customer and Market

Market and Customer knowledge is a clear understanding of the trends in the customer markets, the customer's economic situation, products, services and production technology. On an individual level, knowledge about persons to turn to and about individual relations is necessary. Such knowledge can be kept in market expertise, client profiles and event histories.

3.2.3 Conditions for Organizational Learning

Culture

Both enterprises lacked a clear cut definition of their organizational philosophy as a basis of shared values. In both cases, values were substantially defined by the products and domain; the challenge was seen in building high tech solutions. Accordingly, the professional code of ethics mainly focused on technological issues. At EPMC some economic and administrative issues were included too. Accordingly, DIPC "know how" in domain problem solving was very good. EPMC had experts for products and domains as well as for customers and market.

The technical professional code was accompanied by an idiosyncratic expert behavior and "head monopolies". Knowledge was partly understood as a means of power instead of a resource to be shared freely. Experts did not actively distribute new valuable information to other colleagues. Information was only shared as a result of explicit inquiries, often in the context of concrete project problems. But such inquiries were seen more as disturbing the work process than as necessary for professional cooperation. Free information exchange is partly possible during coffee breaks but, especially at DIPC, is mostly restricted to acute technical questions.

In both enterprises KM was more a "matter of intent" rather than actively embraced. Values such as cross-border communication, free information exchange and cooperation in order to learn and gain more competence were not commonly shared. Instead, communication was project driven and often reduced to operational problems.

Leadership and Controlling

Leadership and controlling differed substantially in both enterprises. EPMC built on strong economic control and a tight, cost sensitive project management. Leadership style was principally authoritative and participation was restricted to technical questions. But there was intensive communication between managers and employees in order to meet the concerns of developers. A general leadership guideline was to "recognize potentials in employees and situations, to further and appreciate good performance, critique constructively and redress deplorable state of affairs decidedly". Other guidelines advised project managers to set measurable goals, check goal attainment and evaluate employees. Goals were to be discussed with employees and should give way to own decisions. Nevertheless, there was a strong cost and performance orientation that neglects OL issues. Efforts besides direct project fulfillment such as reflecting on work done, drawing conclusions, and discussing lessons learnt were not in the scope of objectives.

DIPC in contrast had no clear leadership guidelines. Project managers' only orientation were project deadlines. Developers were given objectives, not always clearly defined, and fulfillment was left to self coordination. Management by objectives allows for cooperation, invention and learning but strongly depends on employees' personal profiles. Unfortunately, strong individualism an-

chored in culture was a strong restriction for collective learning at DIPC.

Organization

The DIPC had a flat organizational structure with only top management and project management levels. Besides this formal structure, there were informal expert groups working in the technical key subjects of image processing, software technology and imaging environment.

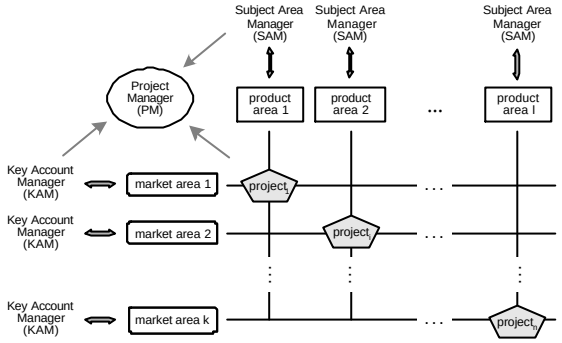

Figure 3: Organization structure of EPMC

The EPMC was organized in a matrix structure as presented in figure 3. The primary organizational dimensions are customers/market and products/technologies. Key Account Managers (KAM) take the view of the market and customer and Subject Area Managers (SAM) orientate themselves towards solutions and products. Project management staff as well as developers are members of the subject area divisions. In project initialization it is necessary that KAM, SAM and project managers (PM) balance customer requirements and technical feasibility.

Both companies were basically project centered. In software development there were clear definitions of processes, but these were only roughly put into action in daily practice. Projects were documented in physical files structured according to the software development process. However, these files were only structured rudimentarily in project phases. Deliverables from within the phases differed substantially. As a consequence, project deliverables (products and pre-products) were difficult to reuse, project experiences difficult to compare and lessons learnt difficult to transfer form one project to another.

Information Systems

Surprisingly, both enterprises already experimented with Intranet solutions as a platform for internal documentation and information exchange. Both solutions were just implemented in fragments and acceptance by users was very low. Reasons given were:

a bad user interface,
lack of transparent structure,
outdated information,
irrelevant information that did not meet employees' needs or address employees' problems.

Other systems for OL already in use were:

e-mail for internal and external communication and exchange,
Internet for external data procurement,
customer databases,
document management systems for storage and administration of documents such as offers, requirements definitions, design documents, user manuals, organizational directives.

Customer databases and document management systems were only implemented in parts. While the customer database at DIPC was not much more than an address book, at EPMC a rudimentary contact and interaction history was available. Document management was restricted to a clear file structure defining where to put and find documents. The Internet was used extensively in both cases to collect market and technical information.

3.3 Problems and Measures towards an Organizational Learning

The measures to be taken were triggered by the most striking problems the enterprises had with respect to OL.

3.3.1 Culture

One general measure to promote KM was to anchor KM-values strategically and to express them in the organizational philosophy. One problem at this strategic level was the definition of benefits expected from investments. Although a question such as "What is the ROI of KM?" is difficult to answer, management could be convinced, that KM is a strategically important investment because it supports the development of core competences.

After having anchored KM and OL in the organizational philosophy, concrete measures were taken to put values into action. These were on an organizational, leadership and control level but also had a strong impact on the culture. They are described in the following sections.

3.3.2 Leadership and Controlling

Regarding leadership, neither an authoritative (EPMC) nor a laissez faire style (DIPC) proved to be effective for KM. In principle, a participative leadership style is well suited for KM as it leaves room for creativity and self determined learning. Nevertheless, it requires strongly shared goals in KM and responsible and self reflecting employees. If employees are not accustomed to self determined cooperative work, a concentrated leadership style may be more effective.

In the EPMC case, it was necessary to enrich control criteria in time and cost with product quality and know how acquired. Furthermore, it is necessary to give way to self determined learning, discussion, documentation and communication the results. Objectives should be defined cooperatively to direct learning efforts in the right direction and to increase motivation. In the DIPC case, lacking order within project execution was the main obstacle to KM. First attempts to improve OL by helping project teams to reflect their work did not have the desired effects. Results could only be achieved in a roundabout way by first introducing a very concentrated leadership style and controlling. Control criteria introduced were timeliness, cost, product quality and reusability.

Product quality was evaluated in quality reviews by experts. The value of knowledge acquired was measured indirectly by measuring the reuse of ideas, software engineering documents (analyses, specifications, design) and products (code). The underlying assumption is, that the more knowledge is reused, the more its value is. Therefore a framework has been developed, which allows storing and retrieving knowledge as well as counting (re)use frequency. This framework includes an evaluation in so called "knowledge points". Each time knowledge is reused, the importance of its practical application in a concrete project is evaluated by the user. Knowledge points are summed up during a period and accounted for by commission payments.

3.3.3 Organization

The primary organizational structure in both companies already reflected the core competencies. One organizational dimension focused on technical and product key competencies. At DIPC, this dimension was implemented in practice teams, at EPMC it was the subject area structure. A second dimension focused on market and customer knowledge, i. e. Sales Managers (DIPC) and Key Account Managers (EPMC), respectively. Within these two dimensions projects were conducted as a temporary organizational form.

Learning and knowledge development especially takes place in project work. The problem is, that after project settlement this knowledge is often not stored and made available for future reference. Thus, it was important to deploy efficient information flows from projects to the permanent organizational units [12].

A fundamental step was the redefinition of the project manager's role. Besides resource and time management, PMs were bound to knowledge management objectives. In order to redefine the PM's role three measures concerning PM's responsibility were proposed.

First, the PM's responsibility for project documentation was enlarged. Documentation objectives were expanded from documenting project fulfillment to the reusability of project deliverables in other projects. Consequently, the scope of project documentation was also enlarged. Documentation must not only include software documents, i. e. requirements definitions, design documents, code, user and system documentation, etc., but also results of domain analysis and installation reports.

Second, PMs should report new knowledge about the domain, customer and ideas for product improvements and innovations to the product and market management, respectively. These organizational units are the practice leaders and sales management at DIPC and the SAMs and KAMs at EPMC. This kind of knowledge is not bound to a concrete project.

A third concern was the development of project management knowledge. The challenge was to learn teleologically from projects, reflect experiences systematically, and bring lessons learnt in to a broader discussion. A precondition for systematical learning in projects is to have clear process structures as they make projects repeatable and enable transferring lessons learnt from one project to another. Since the processes at DIPC and EPMC were only defined and accepted on a very abstract level, structures had to be refined with project managers and employees.

Furthermore, the PM has to report upon the qualifications employees gain in project work. This is necessary to derive information about the "know how" available and developing further within the projects.

All three measures proposed lead to new information flows as depicted in *figure 4*.

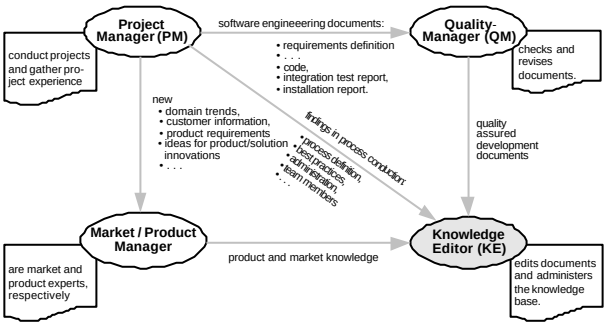

Figure 4: OL structure

Figure 4 points out two more roles involved in the OL process, the Quality Manager (QM) and the Knowledge Editor (KE).

The QM is not a totally new role but changes to a more holistic one with much responsibility. The status quo in our cases was that QMs judged software documentation completeness (are all documents available?) and document quality with very rough and superficial criteria (formal structure, layout, comments wording, etc.). In knowledge

management, a much broader understanding of quality is necessary. Main quality criteria should be reusability and adaptability; documents should be correct (true), complete, unambiguous, well structured and conform to documentation standards, concise, easy to read, and simple to understand [13].

The KE collects knowledge from PMs, product/market managers and from the QM. He/she is responsible for editing knowledge and storing it in a knowledge base. Knowledge base administration and revision of the knowledge is within his obligation as well. The knowledge base should be accessible for all organizational units. Knowledge access as well as representation must reflect customer requirements.

All organizational units depicted in *figure 4* must be coordinated according to the strategic aims of the enterprise in KM. This is the Knowledge Manager's job. The Knowledge Manager is more a role than necessarily an organizational unit. He/she must be a member of the top management that keeps the discussion on core competences of the enterprise alive and derives aims for OL from it. He must have the authority to decide about the enterprise wide guidelines with respect to OL and direct all knowledge management activities.

3.3.4 Information Systems

In our cases, we proposed a number of different IS for KM. The systems with the most anticipated benefits were:

An *Organizational Memory System (OMS)*: Intranet documentation of all business processes and platform for exchange of experiences and discussion of lessons learnt.
A Project Document Retrieval System (PDRS): With the rising amount of project documentation and the efforts towards reusability an effective retrieval became necessary.
A Customer and *Marketing Information System (CMIS)*: A customer database linked to customer histories and customer and market profiles.
A *Human Resource Information System (HRIS):* a very powerful "know how" database. It covers knowledge profiles for all employees and links them to core competencies.

All systems were planned to be integrated through a common interface called *Knowledge Map Interface (KMI)*. For the implementation of the presentation interface we choose Internet technology because it provides rich hypertext- and hypermedia facilities as well as communication features. Thus, the KMI can be comparable to an Internet portal that provides a common access to different information resource. The KMI was coupled with general services such as:

intelligent search across all applications,
a knowledge navigator that offers help and guided tours through the knowledge landscape and
a knowledge evaluator, that counts knowledge accesses and evaluates them in "knowledge points" (see section 3.3.2)

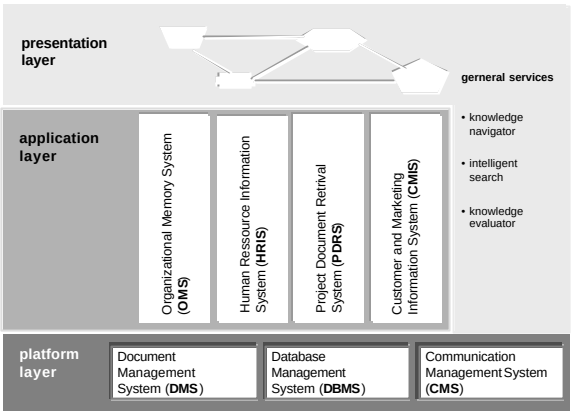

Figure 5: Integrated KM system architecture

Figure 5 depicts the architecture proposed. The *platform layer* provides the basic functionality for the IKMS. In our research, database management, document management and communication / workflow management appeared to be the most important platforms with respect to the needs of medium sized software company.

The *application layer* makes use of platform layer services and enables dedicated knowledge services to become available. The services proposed are provided by the OMS, PDRS and CMIS mentioned above. For EPMC, because of its size and the number of freelancers involved, we was also recommend to integrate a powerful "know who" database, i. e. the HRIS.

The main challenge on the *presentation layer* is to find meaningful interpretations and representations for the knowledge provided by the applications. We choose the knowledge landscape as central metaphor. The knowledge KMI describes this landscape in the area's markets, customers, products, platforms, problem solving techniques and tools. At EPMC, the map links these knowledge areas to "heads", i. e. employees' knowledge profiles.

4 Conclusions

KM in medium sized software companies strongly depends on the business and the size of the enterprise. Nevertheless, there are some general observations and recommendations.

First, there is broad acceptance for IS projects in software companies, but IS benefits are limited if the organiza-

tional, cultural and controlling parameters are not set accordingly. From our experience, it is much more difficult to analyze and change the culture and structure of an organization than to develop an IS. Consequently, introducing KM must be seen rather as careful organizational development than merely as development of IS.

Another important finding is that though IS acceptance was very high in software companies, IS were only scarcely used for KM in our cases. The most striking objections to the existing systems were that they did not offer information that were requested or information were out of date. Another objection to current IS applied for KM was the lack of user friendliness. Especially in broad knowledge bases, it is important to offer guidance for example through metaphors or electronic assistants.

Some of these problems are addressed by the integrated KM system architecture. The architecture makes a clear distinction between functionality and presentation. It proposes a set of information systems that are enablers of KM. Moreover, the architecture defines a common Interface (portal) to access these systems and proposes mechanisms for assisting the user when moving through the knowledge landscape of the enterprise.

The recommendations given and the architecture proposed are not only of interest to software companies but can also be applied, sometimes only in a limited manner, to other companies. The software industry is indeed an excellent example for the application of new insights in KM. It is an information intensive industry, open to innovations and itself a driver to innovations in other sectors.

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