

# Knowledge Management Challenges in Renewal of R&D Processes in Software Business

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**Abstract** — A software company operates in a dynamic, knowledge intensive business. To stay competitive in such a business, the R&D processes and their development play a significant role. Knowledge management becomes a factor when organizing knowledge work. This paper is based on a qualitative case study conducted in a software company moving to component based production. In addition to theoretical insights, the paper describes the KM challenges involved in this process and suggests solutions to these. Also some managerial implications are proposed.

**Keywords** — knowledge management, software business, R&D process development, component based production, case-study.

## I. INTRODUCTION

### A. Background

Software business is a dynamic industry, where the pressure to continuously develop business processes in order to stay competitive is great. Especially the development of R&D processes plays a key role in software companies, as the productivity of the companies in a technology intensive business is heavily founded on R&D activities.

Software business is also characterized by its knowledge intensity; a software product is based on the combined efforts and expertise of a group of experts. In addition, when developing and producing the software, these experts have to listen to the varying needs of the customers. In fact, a software company operating in the business-to-business markets with multiple products and customers, has to be able to effectively link the expertise of its employees with the requirements and the needs of the customers. Thus, the management of knowledge is particularly important to software companies and needs to be handled with special care, especially when renewing their R&D processes.

### B. Objective and research methods

The objective of this paper is to identify the central

knowledge management (KM) challenges in different phases of the renewal of R&D processes in a software company. Moreover, this paper aims to present possible solutions to these challenges and in this way, the aim is to provide implications for managers dealing with the challenge of R&D process development and renewal.

This paper bases on a qualitative case study of a large software company operating in business-to-business markets. The research was conducted according to the principles of action-oriented research, utilizing qualitative methods [1] in gathering and analyzing the data. Altogether a series of over 30 interviews on various hierarchical levels was made during the time period of January to May 2006. All of the interviews were tape-recorded and typed as detailed interview memos. The interview data was analyzed by grouping and theme building.

We chose to conduct a qualitative case study [2], [3] in order to get an in-depth and holistic insight to the research phenomenon under study. The knowledge management challenges and practices in renewal of R&D processes are explored empirically through qualitative methods in order to conceptualize the phenomenon and to provide theoretical and managerial implications based on the analysis of the case.

### C. Case organization

The case organization is a software company that provides large and complex ICT systems and solutions for its organizational customers. The company is quite dispersed; the operations of the company are based on independent teams, each responsible for their own product development, production and sales. This makes it difficult even for the team leaders to know what the others on an equal level in the organization are working on. Rather often the teams are making the produced software from scratch and too often the teams do overlapping program coding and R&D work. This unnecessary overlap in the R&D processes causes naturally extra costs for the company.

Consequently it is not a surprise, that as a result of a toughening competitive situation, the company is forced to renew its R&D processes and move towards a more

productized way of working. The company aims to root out redundancies from its operations and to improve its productivity. This will require the full utilization of the competence and workings of the teams across the organization. To be able to achieve this goal, improvements in the knowledge flows and closer co-operation between teams through-out the organization are a necessity.

The case organization has decided to tackle this problem by switching to decentralized component based production. A focal element in the new way of working is an entity called component library. The teams will do their day-to-day tasks as before but in addition to this they all, especially the team leaders, must try to identify potential components, i.e. products, subparts or features that could also be used in other teams and environments and entered into the component library. A dynamic, functional cross-team board is set up, that will critically monitor the actions and needs of the teams. From the motion of the team leaders, the board will scrutinize and decide whether a suggested part is suitable to be made as a component.

If accepted as a component the part ends up, in addition to the original product it was developed for, in the library from where every entitled member of the organization can use and reuse it. The component must be well documented according to carefully made specifications in order to be fully usable and even further developed, for and by other teams. However, this transition from a team-oriented way of working to a productized, more holistic R&D processes is a great challenge for the whole organization.

In addition to a change in organizational way of working, the case organization has decided to take an advantage of using a common technology, i.e. programming environment and language. This technology is already in use in few teams, but new to most.

## II. THEORETICAL INSIGHTS

### A. Software business characteristics

Software plays nowadays an important role in our modern society [4] as many of our every-life tasks are based on the utilization of software. However, measurements regarding the software industry and its size, importance, and growth rates are not easy to make when it is not always clear what can be labeled part of the software industry and what cannot.

One possible way to better capture the essence of the software industry is to divide the software industry into smaller segments, which helps to understand more clearly the different ways of doing business related to software and the position of the services in relation to them. One rather commonly used way to break down the business is to consider embedded software, professional software services, enterprise solutions, and packaged mass products as involving separate kinds of business, as suggested by Hoch et al. [5].

Embedded software refers to programs integrated as inseparable parts of system products that include also hardware other than standard computing platforms.

Professional software services refer to the work of the software project business (see e.g. [6]) or to tailored software (see e.g. [7]), for which the customer organization is usually charged an hourly rate, not a fixed price for the software products or components provided. Enterprise solutions include software that is produced for the needs of customer organizations, which usually are quite specific, based on general technological solutions and often also on standard application frameworks. Lastly, packaged mass-market software refers to software products that are provided as they are to several customers.

In this segmentation of the software industry, our case organization stands most in the segment of enterprise solutions. This segment consisting of enterprise solutions includes software that is produced for the needs of customer organizations, which usually are quite specific, based on general technological solutions and often also on standard application frameworks. Interestingly, enterprise solutions quite often have characteristics of both the software service business and the more standard software product business. This kind of position at the boundary of the customer-oriented service business and the more brand-driven product business creates challenges also for our case organization.

### B. Organizing software componentization

Because of its special features, software business and production do not fit the traditional hierarchical or functional organizational structures. The different phases, e.g. production and R&D, are almost impossible to separate from each other. Also the development of software is based on the co-operation of multiple parties and even simultaneous with sales. Even in the team-based structure communication and interaction are a problem. They often rely on intermediaries. [8]

The implementation of software componentization and the component library in our case organization is organizationally challenging. The current organizational structure doesn't support the interactions required by componentization. Morisio et al. [9] found in their research on implementing software reuse, that third of reuse cases fail. The main reasons for failure were the lack of processes dedicated to reuse and the adaptation of existing processes. In such a case the processes do not support reuse, i.e. there is no means or time for reuse and componentization. Componentization requires careful planning and adjustments in an organization in order to work.

Also Jacobson et al. [10] emphasize that often componentization projects fail because it is thought to fit the existing structures with little motivation and technical training. The human factor has also often been neglected [9]. In our case organization work has been team- and project-based and there hasn't been time or motivation to make software code also usable for others. It is possible that independent or physically dispersed units even compete with each other (Lynex & Layzell according to [11]) when there is no willingness to share software code. The pressure coming from the customers and financial pressures takes attention away from componentization.

There are two main ways to organize for componentization: decentralized and centralized component based production. The difference between these two ways is the division to component users and creators [10]. In the centralized production these groups are different, specialized people. There is often a dedicated unit for production of components. Instead in the decentralized way of componentization every one can be a creator or user of software components in addition to normal responsibilities. Componentization can also be organized by some mixture of these two. The best way for an organization is dependent on the history and culture of that organization [12]. Still, according to Sherif et al. [12] an important enabler of componentization in any chosen model is the exchange of resources and interaction between the people using and developing reusable software.

In our case organization they have chosen the decentralized component based production. According to Frakes and Kang [13], the strengths of such a model are: a) the initial costs are small, b) the components are being developed for a real customer need and not just for storage c) the development costs of these components will be placed on the project in question. The weaknesses of the decentralized model include: a) the definition and delegation of responsibilities is difficult, b) teams and projects are very different and it is hard for the teams to grasp the total picture and understand the needs of other teams, and c) all the teams will have to be motivated and controlled and this requires a great deal of management resources.

Componentization and the choice of the proper organization model is a balancing act between components that are distant from customer requirements and the risk of not being able to produce components general enough in nature. In both cases the quality of the component could be questionable: can a component made in a hurry to a specific customer need be efficient and applicable in different projects, or can a component made outside a customer project be useful in reality.

### *C. Knowledge management*

It is difficult to manage knowledge. Reasons for this are e.g. that knowledge is typically invisible, it can not be touched and it is hard to measure [14]. So it is fair to say, that we can not exactly know what there is inside everyone's brains. However there are areas related to knowledge which can be made visible and thus easier to manage. These are a) operations related to knowledge, b) results based on knowledge and c) investments in the creation of knowledge. [14] On the other hand, Nonaka and Takeuchi [15] have stated that every piece of knowledge, despite if it is visible or not, can be managed. Either way, it can be concluded that means to manage knowledge in an organization can be found.

Essential things in knowledge management are administration and goal oriented management of knowledge, skills, competence and communication [16]. To move knowledge and experience in the organization from its origin to places where those are novel can be seen as a

purpose of knowledge management [17]. Also the management of knowledge sharing and application and the improvement of knowledge creation can be seen as the aim of knowledge management [18].

Knowledge management is relatively new operation for organizations. The novelty is one reason for the challenges for organizations to apply systematical knowledge management in practice. Still knowledge management could produce answers for many of the open questions of modern organizations.

Knowledge management comprises of carefully designed operations to maximize organization's performance. These kinds of operations are creation and sharing of internal and external knowledge and experience. [18] Knowledge management can be seen as an inclusive operation where the management of people by different means and instruments is essential. Basically it can be said that the case in knowledge management is the effective diffusion and promotion of the reuse of existing resources [19] for channeling and governing the human capital and intellectual property of an organization [20].

One of the challenging questions for organizations is the difficulty to recognize what knowledge is needed in which situation (Lave 1988, Reeves and Weisberg 1994, Thompson, Gentner and Loevenstein 1998 according to [21]). Also one big problem often is that employees do not know enough about the knowledge already existing in the organization and therefore they cannot look for it or to utilize it in their own work. However the creation of new ideas would be most effective if old knowledge could be attached to new situations and in this way be cultivated and developed [21]-[23]. To be able to utilize existing knowledge in a best possible way for the help of an organization it is wise to execute systematic knowledge management actions.

There are already several studies that say that the support of management has an essential role in the success of knowledge management (see e.g. [24], [25]). Successful creation of knowledge depends on the answerability, justification and both economical and mental support by management [24]. The need for management both in strategic and operational management is undisputable. Managers and leaders are needed. There are different studies that claim that people need to be managed in general (see e.g. Popper and Zakkai 1994 according to [26]).

Katz and Kahn have stated already in 1964 that the need for managers is essentially great during change [26]. Based on this it is reasonable to say that nowadays when the pace of change is fast the need for good leadership is evident. Change requires leadership and leaders need tools to be able to lead in a changing environment. It would be important to find multiple instruments for these leaders to pilot their subordinates to success through change. Some of these instruments can be found in systematic knowledge management.

From knowledge management's point of view one of the challenging questions for managers is the definition of

strategy concerning knowledge management. One of the most common ways to consider knowledge management strategy is to divide it to personalization and codification strategy (see e.g. [27]). The key idea in personalization strategy is the promotion of the communication between people [27]. Personalization strategy is a very people oriented strategy. Effective information and communication systems create the core of codification strategy [27]. Codification strategy is a technology oriented strategy.

Through these strategic approaches, different knowledge management practices can be specified. These practices can be emphasized differently depending on the stage of a transition. In practice both technology and leadership based approaches should be considered.

### III. RESEARCH FINDINGS

As argued above, the renewal of R&D processes and introduction of component based production comprises many challenges to knowledge management. One of the biggest challenges in our case organization is the need to share knowledge not only to make component library work, but also to enable this cultural and organizational change. Luckily, as stated above, there are means to be found in knowledge management.

Due to the confidential and partly heterogeneous nature of the individual interviews, their findings are summarized and presented in a generalized way, which enables us to do the conclusions presented in the chapter four.

In the renewal process in the case organization two stages of proceeding can be identified: *the design and preparation phase* and *the consolidation phase*. The design and preparations phase is the responsibility of the management or project team. This phase includes the preliminary assessment of the available, thus possible technologies; the analysis of the current processes; the remodeling of practices; division of responsibilities; a preliminary allocation of resources and finally the technological decisions. In the consolidation phase the planned practices are put into action and anchored into the organization. According to the study the management and project team should also be tightly involved in this phase to monitor the process and to support the correct actions. These two phases ensure the proper implementation of new practices and technologies.

Next this paper identifies the central knowledge management challenges in our case organization and also proposes solutions for their settlement. The challenges and solutions are divided into *technology-oriented* and *people-oriented*, because these are the two generally acknowledged main elements in knowledge management.

#### A. KM challenges

The main source of knowledge management challenges and uncertainty in the renewal of R&D processes in our case organization is the great diversity of the teams in their initial situation. It complicates greatly both the design and preparation phase and the consolidation face. The teams have different organizational backgrounds, different

technologies in use, different products and customers and also very different compositions. In addition to this they can be quite separated from each other even physically.

Table one introduces the challenges for knowledge management in the renewal of R&D processes in the case organization.

TABLE 1  
KM CHALLENGES IN DIFFERENT PHASES OF THE RENEWAL PROCESS

	<b>Design and preparation phase</b>	<b>Consolidation phase</b>
<i>Technology oriented challenges</i>	<ul style="list-style-type: none"> <li>· Different kinds of teams and demands</li> <li>· Usability and exploitability of the component library</li> <li>· How to find a viable technology for the future</li> <li>· Architectural design</li> </ul>	<ul style="list-style-type: none"> <li>· Lack of competence for a new chosen technology</li> <li>· Attitude problems towards a new technology</li> <li>· Difficulty to integrate to mature products</li> <li>· Component interfaces that are general enough</li> </ul>
<i>People oriented challenges</i>	<ul style="list-style-type: none"> <li>· Information doesn't flow between teams</li> <li>· Prejudices for different technologies</li> <li>· Fear and/or uncertainty caused by not-knowing the future</li> </ul>	<ul style="list-style-type: none"> <li>· Different kinds of teams and demands</li> <li>· Attitude problems towards change</li> <li>· Lack of time for training and experimenting</li> </ul>

The technological challenges are knowledge management challenges as the case organization sells knowledge intensive products and services and the technology also affects the information flows and communications by being either the content of communication or means to it.

The heterogeneous nature of the teams in the case organization makes it challenging for the case organization to find a right technological solution that could fit all the teams. The same fact, the different state and nature of the teams, makes it difficult and trying task to find a technology to support the existing software products produced and maintained by the teams. This is also a factor, which made it rather difficult to find the right explicit descriptions of the challenges for the table.

As for the people oriented challenges the information flows, communications, are one key to the successful outcome. Other challenges seem less threatening if the organizational communications can be properly dealt with. With good communication the other areas may be elucidated and the uncertainties lifted. To put it simply, if the people know what's going on, they are less concerned and more confident and trusting for a better future.

#### B. KM solutions

The possible KM solutions provided by knowledge management are diverse. The interesting feature of knowledge management practices is that the effects of the actions taken are multiple and sometimes even difficult to point out. This is why the solutions for KM challenges introduced in table two cannot all be matched to a certain challenge introduced in table one. The purpose is that by applying these, the organization creates the right

circumstances for the challenges not to turn into risks or weaknesses in the renewal process.

TABLE 2  
SOLUTIONS TO KM CHALLENGES IN DIFFERENT PHASES OF THE RENEWAL PROCESS

	Design and preparation phase	Consolidation phase
<i>Technology oriented solutions</i>	<ul style="list-style-type: none"> <li>· Appoint a team responsible of the component library</li> <li>· An expert pool must find a "right" technology to adapt for component based production</li> <li>· Training of the new chosen technology</li> </ul>	<ul style="list-style-type: none"> <li>· Intranet as a communication channel</li> <li>· The new technology must be agile enough to accommodate the needs of the teams</li> <li>· Clear architectural design and structure</li> </ul>
<i>People oriented solutions</i>	<ul style="list-style-type: none"> <li>· Consultant</li> <li>· A member of senior staff must announce the need for change</li> <li>· The board of controllers should consist of extensive and valued expertise from within the organization</li> <li>· Pilot cases to act as an example</li> <li>· Training for the chosen approach</li> </ul>	<ul style="list-style-type: none"> <li>· Informative meetings with teams</li> <li>· Job rotation</li> <li>· Regular team leader meetings</li> <li>· A team member visits the meetings of other teams</li> <li>· Successful cases to act as an example</li> </ul>

It is obvious that the solutions come from the commitment of the management and proper resources. There are no quick fixes, but the change must be gradually implemented in to the organization. To overcome the resistant of the personnel communication must be handled with especial care.

#### IV. CONCLUSIONS AND MANAGERIAL IMPLICATIONS

This paper discusses the knowledge management procedures in a case company as well as conclusions drawn from the literature. The chosen viewpoint is that of process development. Also the KM challenges in this case and their possible solutions were analyzed with some depth.

Renewing one's R&D-processes presents a major change and challenge for the whole organization. We still firmly believe that knowledge management practices and tools will facilitate and ease the change in organizational ways of working. Some of these methods are listed above in table two.

Already at this point it is fair to say that leading the change systematically is critical in this kind of an endeavor. The individual teams in the case organization all have their own business as usual -modes and now they must change them. All teams need to adjust their functions at least mentally, some even more drastically, and even change the technology that is being used. Some must learn and adapt to an altogether new technology and way of working. Leading and leadership in this kind of undertaking and setting are crucial for the successful outcome. Thus extra attention must be given to these functions.

Still the whole operation in the case organization is more than a try-out for a certain period of time and so it is also meant to be. The ultimate goal is a permanent change in the ways of working. This brings along the fact that a procedural change such as in the case organization may well take time up to two to three years or even be continuous, a sort of on-going change of things. This may well justify the discarding the term *project*, as a project has its start and ending.

What are required now, are short-term successes. The organization and its members need strengthening in their resolve to overcome the difficulties, and they also need a counterforce to the human resistance to change. Thus try-out or pilot cases are needed to show the employees that this kind of new way of working is possible and also functional. These successes should be promoted on the company level (i.e. via intranet) but it could also be wise to bring the message down to individual teams and groups within the case organization. In this way the opinions and notions could be better taken into account as well as a better and more caring picture of the process management may be given to the employees.

As important all the prior tasks and themes are, it would also be wise to assemble a body of experts to monitor and guide the operations. There was such an organ during the initial phases and stages of the project, but there was polarized opinion of its future. We feel that some such control is needed or even vital for a successful ending and for the new fashion to actually become the usual way of working. This is also due to the fact that this kind of change needs promotion through well-executed organization wide communication. Promotion is more likely to be taken care of and be functional if done by dedicated personnel, even if their main tasks would lie elsewhere. Obvious fact suggests that a known person of the organizational high command should be set to be a leading figure in the change. Also a way for this promotion could be to set a team leaders' meeting that could be (at least occasionally) visited by a member of the top management and they could in turn promote the message to the members of their own teams. In these middle level meetings also various training needs could be discussed.

As for the more technological side to the whole change, it should be considered that the chosen technology is, and must be, agile enough to enable the continuance of the work of the individual teams. The teams and their products are of so much variance that it may represent unexpected challenges or even difficulties to find such a technology. The other alternative is to make compromises in the way the new chosen technology is implemented and during how long a transitional period of time.

Thus the managerial implications of such a reform are significant. Qualifications and features required from a leader in this kind of situation are not necessarily easy to meet. To master the human side of the whole change process may be one thing and even a bit much to ask but there is also the organizational side to be considered. Are some organizational changes necessary, and if so, which

ones? There are questions that are still partly unanswered or the answers are still obscure. The answers to these questions must come from the management of the case organization drawn from the strategy and the organizational everyday life. Our current view of the case company is much like a snapshot, it describes the situation in a certain moment in time. However lightheartedly we may point out some factors to change and improve, the organizational reality is to be remembered. To answer these questions as well as to study how the change has set in would make an interesting part two in this research.

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