NUCLEAR KNOWLEDGE MANAGEMENT: THE GRS REALISATION

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Abstract. The paper describes the setup of a knowledge management system at GRS. A knowledge model has been used as a guideline through the stages of knowledge related activities, including specification of the knowledge goals, knowledge identification, acquisition, development, use, dissemination, preservation, and assessment of the knowledge management system. The activities related to these stages are described. In addition, process-oriented knowledge management as a means to integrate knowledge related activities into everyday work, and semantic technologies for modelling knowledge domains and for improving search for relevant documents are presented.

1. INTRODUCTION

As in many knowledge management initiatives in the nuclear domain, the incentive for the knowledge management activities at GRS came from realizing the problems caused by ageing workforce and the necessity to transfer knowledge to the next generation. Since this challenge is not restricted to single organizations in Germany, but of nationwide importance, a preliminary project was initiated to study knowledge management in an inter-organizational way. In this project, which was conducted by partners from several institutes, the basic methods and tools of knowledge management were studied, and concepts developed for managing the knowledge in a network of organizations. However, at the end of this project, it was decided to start with a less ambitious aim, namely the introduction of knowledge management at GRS as a single organization, keeping in mind future extensions to a nationwide knowledge network.

Now, more than two years later, a synopsis of the efforts in managing knowledge at GRS can be given. For this undertaking, the underlying knowledge model which has been adopted as basis for developing the knowledge management system will be used as a guideline for describing the many facets of knowledge management in a general survey. Then, the tools deployed will be described, followed by two topics with particular relevance for GRS, process-oriented knowledge management and semantic web technologies.

2. THE KNOWLEDGE MODEL

Different approaches and models may be found in the literature. The model GRS has adopted is the one developed by Probst and co-workers. This model is depicted in Fig. 1, and covers all stages of knowledge management. Each stage is related to all others in many ways; to simplify the connection diagram, the idea of knowledge sharing has been introduced as a central point, deviating in this respect from the original model. In the following, the activities performed at GRS relating to these single stages will be presented.

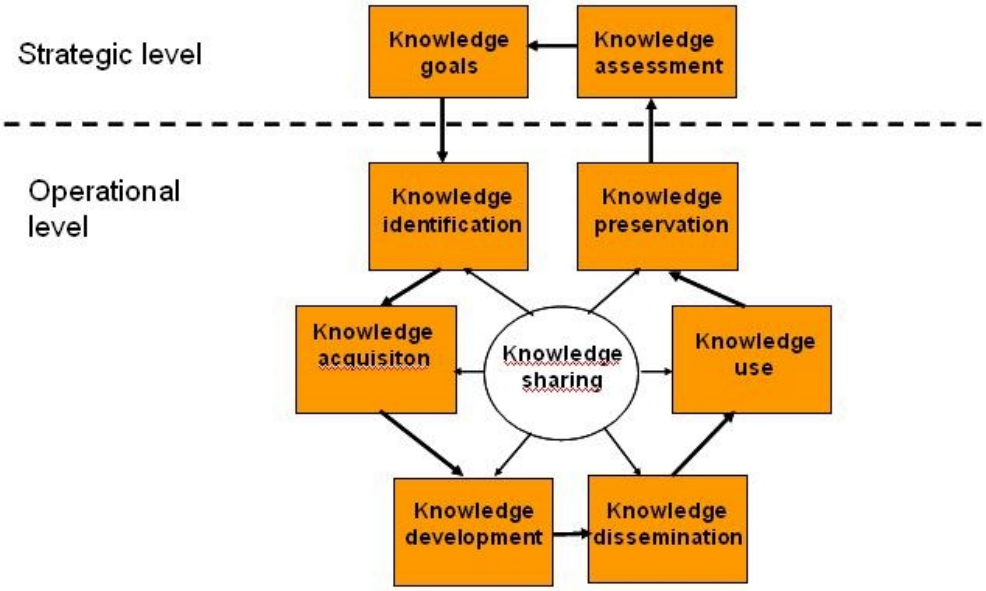

FIG. 1. The Knowledge Management Model

2.1.Knowledge Goals

All models convene that a clear specification of knowledge goals is a necessity, and imperative for the continuous assessment of the evolution of the corporate knowledge management activities. As mentioned before, the first aims of knowledge management are defined by the need to retain knowledge from retiring experts, and transfer it to their successors. This has been supplemented with another goal, which is a precondition for a successful system, namely the integration of knowledge management methods and tools into everyday work. It reflects the conviction that, in the long run, knowledge management methods and tools will have to offer significant advantages for the main work processes; otherwise, acceptance problems will be encountered. Furthermore, the underlying knowledge management principles need not be advertised, thus avoiding the often fruitless fundamental discussions on such topics as impact or usefulness of knowledge management.

The knowledge goals have to be solidly anchored in the organizational culture. To convey the ideals and standards aspired, a Concept Document has been developed and widely distributed. Trying to adhere to these concepts is also a prerequisite to knowledge sharing, which is regarded as the key to successful knowledge management. However, in contrast to what is seen as a problem in most of the literature, sharing of knowledge has always been part of the corporate culture, possibly because of the company's roots in the academic and research environments.

The knowledge management efforts have coincided in time with the activities at GRS to conform to the new ISO 9001:2000 Quality Standard. The strong relations to knowledge management have been used to provide synergies, particularly in the field of business processes, which the new quality standard strongly emphasizes. An example thereof is the assessment stage of the knowledge management model, where a set of key indicators has been developed accounting for requirements from quality as well as knowledge management.

2.2.Knowledge Identification

The distinction between explicit knowledge referring to documented knowledge, and implicit or tacit knowledge, which refers to the knowledge of the experts, is well established by now. In general, documentation in the nuclear field is very comprehensive. The sources of explicit knowledge are manifold, incorporating the document body of the organization (reports, notes,

communication by letters and e-mails) and external documents such as journals, guidelines, technical documentation, to mention just a few. An initial review of the GRS document sources showed that documents reside on personal file shares, common drives, databases, and external sites (e.g. internet), in addition to a large amount of paper documents. In consequence, retrieving documents had proved difficult on many occasions. As in many other organizations, the necessity was perceived to search from a central point all of the document inventories and retrieve relevant information, which led to the implementation of the document management system described later.

As the organization has experienced little personnel fluctuation over many years, the networks operating in particular knowledge domains are well established and stable. This makes it easy for most of the staff to find experts. As the situation begins to change because of the wave of retirements which will meet GRS in the next years, means had to be established to replace this by more formal ways of finding experts, which will be mentioned later on.

2.3.Knowledge Acquisition (Import)

The gaps left by retiring experts will have to be filled by new personnel. The emphasis therefore lies in the personnel policy for the next years. Means have been developed to plan capacities according to retirement, in order to avoid situations which have been met in the past, when a retirement sometimes came somewhat as a surprise. This is accompanied by an improved management of the work load in different organizational units and the valuation of the relative importance of the knowledge domains to the development of the company as a whole, which both help obtaining a clearer picture of development trends and taking early measures.

The necessity to share information and knowledge among organizations in times of diminishing resources is manifest in the establishment of national and international networks. Participating in networks of excellence such as initiatives by the European Commission like Sarnet, the European Network of Excellence for a Sustainable Integration of European Research on Severe Accident Phenomenology, or IAEA, e.g. the Asian Nuclear Safety Network ANSN, is an invaluable source of accessing knowledge at outside organizations. National efforts such as the German Competence Network established by the four major research establishments, which aims at improving the cooperation with universities, coordinating of research programmes and cooperating in international safety standards tackle the problems of engaging young researchers in the nuclear field.

2.4.Knowledge Development

As collaborators are being hired by GRS to compensate for retirements, the significance of education and training is increasing. The internal courses have been restructured by developing three general modules for new staff, and three modules for deepening professional education. The first group of modules contains a synopsis of GRS as and expert organization, the fundamentals of nuclear engineering, radiation protection and waste management, and the basics on project and quality management. The second group concentrates on training on the job, self-study and participation in internal and external advanced training, all under supervision of the technical senior. In addition to these modules, mentoring has been established to provide a contact person to advise and help the novice in occupational questions.

The main field of further developing knowledge is the project work, as GRS is almost entirely financed by projects. As this is a dominant theme, the process-oriented knowledge management will be described in more detail later on.

Communities of practice, i.e. rather informal groups of people with common interests on particular subjects spread throughout the companies, will be encouraged. A first initiative will concern establishing a community of practice in the field of Knowledge Management itself, to

provide an exchange of opinions and discuss the different approaches and needs in the organization.
Collaboration in such communities as well as in teams and projects contributes strongly in sharing and developing knowledge. This is an area where the support by tools will be strengthened in the near future, making use of new technologies such as common team workspaces. This will include also teams consisting not only of GRS staff, but also international cooperation. For the EC Sarnet project mentioned before, such a communication tool has been developed on the basis of commercial portal software for about 25 organizations and 200 participants.

2.5.Knowledge Dissemination

Handling documents is at the core of knowledge dissemination. As in most organizations, documents are stored on personal computers, common file shares, databases, not to mention the vast amount of paper, which complicates information retrieval considerably. The concept of a Corporate Memory tries to integrate all document sources and make them accessible for central search tools. With regard to tacit knowledge, Yellow Pages ("who knows what") help to find experts with specific knowledge. These topics are strongly related to information technology and software tools. As they are fundamental to information management, they will be described later in more detail.
As mentioned before when discussing knowledge goals, the willingness to share knowledge is a matter of corporate culture; in this respect, the experience up to now is be very positive and has not indicated oppositions to sharing knowledge with colleagues in general.

2.6.Knowledge Use

As far as access to knowledge is concerned, it is related on the one hand to the above mentioned means of dissemination of explicit and implicit knowledge, on the other to the rights of retrieving the searched information. Here, often unnecessary restrictions were found due to the fact that the notion of free read access to most (if not all) documents was perceived as alarming to many people. However, in order to achieve more transparency and foster the reuse of information, the principle that everybody should have read access to any document unless there are strong reasons for prohibiting it has been widely accepted by now.
An important aspect of accessing information resources is the notion of subscription and personalization. In contrast to searching for knowledge, a subscription allows to stay up to date to changes in particular information or document repositories. Personalization allows structuring the access to information according to personal preferences and needs.
As mentioned before, the main needs for using knowledge are related to project work. This will be discussed further in the chapter on process-oriented knowledge management.

2.7.Knowledge Preservation

Most of the knowledge activities mentioned in the foregoing paragraphs contribute to the preservation of knowledge. This holds for the corporate memory, which provides the means of archiving documents, as well as for education, training and mentoring or for retirement planning. In addition, the continuity of the project work plays an important role in preserving knowledge by contributing to the definition of best practices and state of art - reports, as will be further discussed in the chapter on process-oriented knowledge management.
One of the central concerns of knowledge management lies in converting the tacit knowledge of the expert into an explicit, i.e. documented knowledge, which is in accordance with the GRS goals of knowledge retention and transfer. In this respect, GRS has started to try out new methods concerned with knowledge representation, which will be delineated in an own chapter.
Closely connected with knowledge preservation is the topic of "forgetting". As the corporate memory grows with time, more and more of the information contained becomes obsolete and

should be marked as such or deleted altogether; at GRS, this problem has not yet been tackled, but it will come up inevitably.

2.8.Knowledge Assessment

As the knowledge management system becomes operational, it has to be assessed with regard to its original aims and the efficiency of its performance. The qualification of GRS according to the ISO 9001:2000 standard had requested the definition of key indicators. Since some of these key indicators are strongly related to knowledge management, it was decided to unify the indicators in one common set instead of defining two, which would produce much overhead. The key indicators will be regularly updated, and their trend evaluated with regard to the objectives of knowledge management.

3. TOOL SUPPORT

Information and communication technologies are defined as "enabling technologies" for knowledge management. The progress in those technologies has been one of the driving forces in developing knowledge management. Irrespective of the often diverse importance on assigns to them, tools they are essential and may be decisive in the acceptance of knowledge management in an organization.

3.1.Portal

One of the lessons learned since the internet has changed information processing concerns the use of a unique tool for accessing information: it is the web browser. It is good practice to use the same mechanisms for the distribution of information in intranets. A portal provides a central point for accessing information from different, distributed sources. At GRS, the SharePoint Portal Server was adopted as the portal server. It integrates document management, a mapping of the fields of activity at GRS, news and information on forthcoming events, access to information systems, Yellow Pages, Quality Management, Organization Handbook, Library and more. A second portal has been set up dedicated entirely to project work (see the chapter on project-oriented knowledge management).

The portal is based on the first version of SharePoint. The next version is already available, which offers many improvements in the area of collaboration and communication and will be adopted soon.

3.2.Document Management

The document management system provides a structured repository for documents and controls the access to documents. Accessing a document in the document management system starts with borrowing it from the library ("check out"). After check out, no other author can borrow it for editing (he may look through a copy) unless it has been returned by the author that checked it out ("check in"). Each document or document library may be granted access rights by the owner or the administrator of the system. These rights may be grouped in Windows fashion, or assigned individually.

3.3.Integration of data bases

Much of the information at GRS has been traditionally kept in Lotus Notes databases. Porting the contents of these databases to a central document repository is prohibitive because of the large document amount and undesirable since those databases are widely used and efficient. Therefore, it was required that the portal should be able to index those databases such that their content might appear when performing a full text search. This has proved quite successful. A particular database is the personnel database, which has been expanded to contain information on skills to realize a Yellow Pages directory for the GRS. Other databases such as the Technical Documentation on Oracle have not been connected to the portal yet.

3.4.Indexing and information retrieval

Modern indexers can set up an index of multiple information sources and various document formats for a huge amount of documents. They crawl remote information repositories, such as

databases or file shares, without requiring the documents to be moved to a central document management system.

Information retrieval may rely on the index for free text search, on searching for meta-information (additional information such as author, date, keywords, relevant technical topic, project to which it belongs etc.), or on more advanced means described in the chapter on knowledge representation. The free text search is cheap in the respect that no expenses are needed for classification or for the maintenance of metadata. However, a plain free text search will present the results in an arbitrary ranking, which is not the desired result when too many hits are produces. Using Boolean operators leads to narrowing down the number of hits, but even so, finding the relevant documents may be difficult as the number of documents grow. The rankings of the search engines popular in the internet are often quite effective, but the methods employed for ranking (which are a treasured secret of the internet search engine developers) are not necessarily efficient within the scope of an organization. Automatic classification is undergoing fast progress and may be of assistance in highly structured domains, test have shown that for our purposes, those techniques are not yet applicable.

4. PROCESS-ORIENTED KNOWLEDGE MANAGEMENT

Process-oriented knowledge management aims at analyzing and supporting the business processes encountered in an organization. This holds in particular for workflows, which may range from fully standardized to more flexible ones. The main idea of process-oriented knowledge management is to capture the knowledge at the location when and at the time where it is produced, and to make it available when and where it is needed.

Summarizing briefly, the starting point usually is a model of the process in form of a workflow, thus representing the functionality of the process. Each single step is then analyzed according to the knowledge needed to perform the step, and to the knowledge produced in this step, which in turn might provide the input to one a later step (Fig. 2). The analysis of the information needed may result in e.g. a specification on where this information may be found, on designation of experts which may have relevant experience, in description of comparable cases, or in defining ways to search for the information (e.g. keywords). For the knowledge obtained by performing the step, guidelines may be produced on where to store the technical information (e.g. locations in the document management systems), the experience in performing the step (e.g. Lessons Learned database), the experts involved, and more.

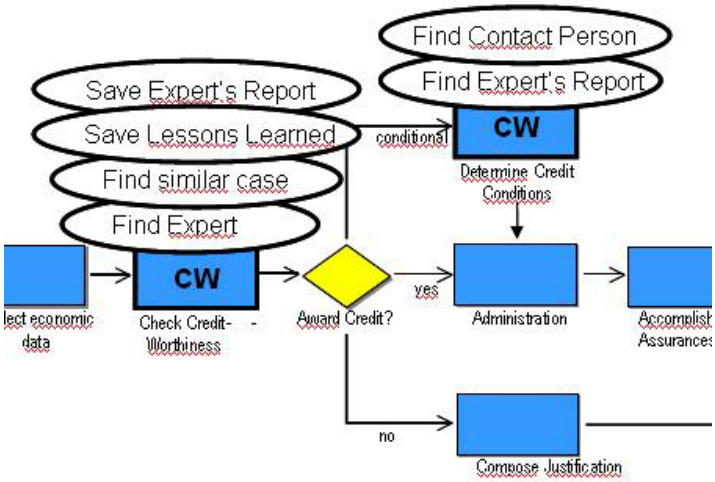

FIG. 2. A part of a workflow indicating knowledge-related activities

As outlined before, projects are the fundament of GRS everyday work. A project may be regarded as a particular case of a business process; however, it will be in general less structured than other business processes. To provide a starting point for the activities at GRS,

a very simple process model has been defined, which covers many of the projects. At the beginning of a project, a description of the state-of-art is requested. At the end of the project or at important milestones in larger projects, the state-of-art description should be augmented by the results obtained in the project. In addition, a Lessons Learned report should be provided, as well as contributions to Best Practices (or setting up an initial document on Best Practices if they do not already exist) if the project is part of a more comprehensive field of work.

With regard to all documents related to the project, they should be kept in a specific portal denoted as "project portal". At the start of the project, the project controller will set up a project folder in the document management system of the project portal containing two identically structured subfolders, one for internal use, a second one with qualified content. The internal folder is delivered to the project leader and his team, and used as a repository for every document concerning the project. The folder with qualified documents is managed by the project controller, and will contain the "official" and quality-assured documentation, parts of which will be accessible by the customer (the project sponsor). The subfolders themselves are organized in a subfolder structure containing documents relevant to contracts, correspondence, project management, reports etc.

Since this program started quite recently, not much experience on this type of managing knowledge is yet available. However, the notion of a project repository central for all project documents is appealing; other measures have a strong impact on the accustomed way projects are carried out, and may be more controversial.

5. KNOWLEDGE REPRESENTATION AND KNOWLEDGE MAPPING

The reasons for engaging in knowledge mapping and knowledge representation techniques were twofold: first, knowledge representation offers the methodology for capturing expert knowledge, and second, it helps solving the problem of improving document retrieval.

5.1.Capturing expert knowledge

In a preliminary project, methods for capturing expert knowledge were looked at, and a test was performed interviewing an expert who would leave GRS soon. This and corresponding experience in the literature showed that, one the one hand, posing the right questions is an art. It is doubtful if non-experts are able to extract the relevant knowledge, since this might require a deep understanding of the expert's domain of knowledge. On the other hand, the presentation of the extracted knowledge is difficult. Publishing the experience in form of a report is not a satisfactory solution, a presentation which offers the information in a way readily accessible when the need for this information appears would be much preferable. What was clearly needed was first an efficient way of interviewing the expert, and secondly, a suitable representation of the knowledge domain.

Today, intense efforts can be witnessed towards knowledge representation, which are rooted in the vision of the next generation of the internet, the Semantic Web, as proposed by Tim Berners-Lee, the inventor of the WWW. The underlying idea is to convey meaning to the huge amount of data found in the internet, and to make it thereby available to different purposes and contexts. The ground for this endeavour is the specific field of "Knowledge Representation", in particular the structuring of knowledge in domain models in form of ontologies. Ontologies provide a knowledge network, with hierarchies of concepts (taxonomies), characteristic properties assigned to concepts, and relations between the concepts.

5.2.Improving information retrieval

The portal includes a map of the activity fields of GRS. Initially, it was considered that all pertinent documents should be associated with this area, such that information on the area would be found quickly. The metadata for the documents in the repository include an entry to

indicate the appropriate field. Documents outside the document management system may be linked to the field. After some time, some of the fields were crowded with all documents which had any connection to the field of work, other areas still remained completely free, which is quite unsatisfactory. At the same time, as the document repository rapidly grows, the number of hits when searching the repository also increases, but there are increasingly objections to the quality of the hits by the users. This has led to redefining the strategy for the mapping of knowledge: The activity fields should contain the important, high-quality documents relevant to the field; more documents will be found by performing a search; the search however should be improved. This provides the link to knowledge representation methods: the "controlled vocabulary" of the concepts and properties defined in ontologies provides the means to use correct search terms also for non-experts in the fields, thus leading to better search results.

5.3."Containment" Ontology

To test the potential of knowledge representation methods, a workshop was held gathering four experts in the containment area, one of short before his retirement. This was held to be much superior to single interviews, since the experts could discuss on the relevance of topics, and define a common vocabulary ("controlled" vocabulary) providing the correct terms used in this knowledge domain. The group was enlarged by knowledge management staff, with a little knowledge in ontology construction. The result of the group was a first draft of an ontology for the containment domain, which covers all topics relevant to GRS. In a second step, one of the experts expanded the ontology in the specific field of fission products and aerosols, enriching the concepts with properties such as links to the relevant documents in the area, thus following the strategy outlined above to include the important documents directly in the knowledge fields.

The ontology was realized by the "Semantic Miner" tool by Ontoprise (Fig. 3). The tool offers an editor for constructing ontologies, visualization and navigation of the ontology. The concept terms may be used as search keywords, combined by Boolean logic, enriched by synonyms and translations in several languages, or expanded to include sub-concepts. The tool will be further developed to enable queries on the ontology, which provide answers by drawing inferences.

FIG. 3. A view on the prototype Containment ontology

First feedback was positive by newcomers to the field, stating that the navigation and the documents contained are very helpful when aiming to achieve a good view on the whole knowledge domain. The potential for either a rather flat modelling of knowledge areas as well as deeper structures for capturing rather detailed knowledge has been recognized, and should be extended to other knowledge areas.

6. CONCLUSION

For realizing knowledge management at GRS, a knowledge model was adopted containing the different stages of specification of the knowledge goals, knowledge identification, acquisition, development, use, dissemination, preservation, and assessment of the knowledge system. The activities in these phases have been described. The technology enabling the implementation of the knowledge management system has been addressed, focusing on a company-wide portal as a central access point to all information sources.

This has laid the basis for the deployment of methods which aim to achieve the goal of retaining and transferring knowledge, as well as deploying the system for everyday work. In particular, the implementation of process-oriented knowledge management, which is modelled on the project work of GRS, has been presented. The experience from these first steps has shown that methods for capturing the expert's knowledge as well as improved search were needed. This is being accounted for by testing the potential of semantic methods for representing knowledge and enhancing the accuracy of search results.

Summarizing, the foundations for knowledge management with regard to methods and tools have been laid. This however is just the first step towards a sustained knowledge management in the company. Still, efforts will have to be undertaken to increase the acceptance of the staff, integrate the tools even closer into everyday work, and establish knowledge management as part of the corporate culture.

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