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Knowledge Management

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Synonyms

Knowledge-based methods; Knowledge engineering

Definition

Knowledge management (KM) can be defined as the approaches (methods, procedures, tools, etc.) for handling the registrations (writings) in order to allow their interoperability (the IEEE Glossary defines interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" (IEEE 1990)) (use as a single piece of knowledge or combined with other elements). Knowledge engineering must implement the different cultural mediations to construct representations made to allow the interpretation (adapted from Bachimont 2004).

Thus knowledge management integrates different strategies, practices, and tools in the organization to identify, capture, formalize, and share knowledge, experience, or know-how, either for human expertise or for organizational practices. Such knowledge increases in a continuous interaction with the environment at all levels of the organization. Knowledge management is, for the company, a lever support for innovation both in products, processes and services and in the organization (Nonaka et al. 2000). Knowledge management adds value to the processes of design and production while improving operational processes and innovation with the ultimate goal of enabling the company to inherently learn (Bakema 1999).

Knowledge management approaches are developed in knowledge-based environments. They provide a set of methods, formalisms to manipulate the piece of knowledge, depending on its initial form. The knowledge-based environments (KBE) define the specifications and the content of the knowledge-based systems (KBS). A knowledge-based system can be defined as a computerized system that uses knowledge about some domain in order to deliver a solution concerning a problem (Fasth 2000).

It is necessary to formalize and structure the initial knowledge in a knowledge base, before using it in a knowledge-based system. Knowledge management and knowledge-based engineering give different solutions as to how to develop this software.

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Theory and Application

History

Knowledge-Based Systems

The first generation of knowledge-based systems was expert systems using a set of facts and rules (Ulengin and Topcu 1997). This kind of system is composed of essentially two components: a knowledge base (KB) and an inference engine. It applies specific domain or domain-specific knowledge to problem-specific data to generate problem-specific conclusions. The next KBS generation was the case-based systems. These systems use previous solutions to problems as a guide to solving new problems. Knowledge-based systems are widely acknowledged to be the key for enhancing productivity in industry, but the major bottleneck of their construction is knowledge acquisition, i.e., the process of capturing expertise before implementation in a system (Chan 2000). Some methodologies assist the developers in defining and modeling the problem in question, such as Structured Analysis and Generation of Expert Systems (STAGES) and Knowledge Acquisition Documentation System (KADS) (an acronym that has been redefined many times, e.g., Knowledge Acquisition Documentation System and Knowledge-based system Analysis and Design Support). Moreover, these approaches get enriched in order to take into account the project management, organizational analysis, knowledge acquisition, conceptual modeling, user interaction, system integration, and design (Breuker and Wielinga 1987; Buchanan et al. 1983). Consequently, knowledge modeling in engineering must be based on a rich and structured representation of this knowledge and an adequate way of user interaction for modeling and using this knowledge (Klein 2000). Due to the complexity of engineering knowledge, knowledge modeling in engineering is a complex task.

Knowledge-Based Environment

KBE has been defined as being an engineering methodology in which knowledge about the product, e.g., the techniques used to design, analyze, and manufacture a product, is stored in a special product model. The product model represents the engineering intent behind the geometric design. The KBE product model can also use information outside its product model environment such as databases and external company programs. KBE has been defined as "a computer system that stores and processes knowledge related to and based upon a constructed and computerized product model" (Fasth 2000). The encoding of design knowledge from domain experts into computer codes that can generate complex geometric data has demonstrated significant savings in manpower and time resources for routine design problems and has also provided a high degree of design integration and automation in well-defined and complex design tasks. The MOKA methodology has been proposed to address methodological issues during KBE systems development for our case study.

The modeling approach in KBE has to structure the engineering knowledge. In terms of developing KBE applications, this structuring process involves the configuration of the objects that model the engineering design environment and the rules that control the behavior of the objects (Sainter et al. 2000). Current KBE systems are based upon a combination of the production rules and the object-oriented knowledge representation. Both elements together offer an automated way to introduce design requirements, model design constraints, and provide a product description.

Knowledge Structuring

The balance between information structuring and use flexibility is not a new problem. Partial solutions have been already used, for instance, indexes, summary, keywords, or tables of content.

For a desynchronized and now numeric transfer of expertise, the degradation of knowledge in data necessitates new navigation tools to correct the lack of context for interpretation. The multiuser approach of collaborative platforms or networks requires a common language between experts, to confirm relevance, authority, and confidence in resources and the information therein. These terms can be defined as follows:

- Validity = relevance + authority + confidence

- Relevance = corresponds to my interest
- Authority =
  - Has been assessed by a mediator I am confident in
  - Recognized by a large community
  - Could be assumed as proof
- Confidence =
  - Seems interesting to me
  - Is something I personally trust

These concepts should help users to assess in real time the validity of the observed knowledge network. The use of these terms appears progressively in different tools. The following list is composed of similar language-synchronization and document-navigation tools illustrating the evolution of indexing tools towards a naturally valid and dynamic system:

- Terminology: list of terms
- Glossary: list of definitions
- Taxonomy: structured list of definitions (like trees)
- Thesaurus: semantic and structured groups of definitions organized in networks
- Ontology: objective networks of defined concepts

Theory

Knowledge management actors can be divided in three main research groups as illustrated in the figure below.

- Actors from science organizations and change. They theorize on the concept of knowledge, its states, and its dynamics. They are in connection with the philosophy point of view of the knowledge. They guide the methodologies to carry out the steps of knowledge management.
- Actors from science and technology of information and communication. They develop computing environments in order to model, capitalize, and manipulate knowledge. It opens the field of artificial intelligence and decision support systems. They work for the evolution of tools and languages that support the automation of knowledge and its transcripts.
- Actors from engineering sciences. They work in the formalization and integration of business expertise to optimize a business process or integrate it into a business environment. They are developing and deploying knowledge-based environments and synthesize theoretical propositions pragmatically, tools and technologies available, and operational requirements in the areas of engineering (Fig. 1).

Knowledge Concept in Knowledge Management

Wiig and Alavi (Wiig 1997; Alavi and Leidner 2001) give an introduction to the main concepts of knowledge management. We propose a short summary of the different conceptual positions. For more details, refer to each author proposal:

- Grundstein (2002) focuses on the methodology of capitalization and knowledge management (Model for Global Knowledge Management within the Enterprise: MGKME).
- Ermine (2003) accepts the capitalization and knowledge management by integrating internal and external environment as well as flows that connect them.
- Nonaka and Takeuchi (Nonaka et al. 2000; Nonaka and Takeuchi 1995) are interested in the dynamics of accumulation and creation of knowledge for innovation (SECI model).
- Zacklad and Grundstein (2001) are working on technology cooperation for innovation and organizational change.
- Dieng-Kuntz et al. (2000) addresses issues of corporate memory.
- Wainwright and Beckett (Wainwright 2001; Beckett et al. 2000) interested in aspects of enterprise knowledge through research on industrial performance measures.
- Amidon (2003) presents the control of knowledge through participatory innovation networks of experts.

Firestone (2000) introduces the knowledge life cycle with three specific phases: production, validation, and structuring. These steps give the procedure for the development of knowledge bases. These bases are the prerequisite for the development of software capable of handling theses imbedded knowledge.

Application

During the settling and the use of a knowledge-based system, the expertise or knowledge goes from the expert mind to an informatics' environment before being restituted (presented) to a user. The knowledge management system has to minimize the loss of meaning between the initial expert knowledge proposal and the user interpretation. A knowledge-based environment has to support three levels of processing:

1. Capture and reproduce optimally the meaning contained in the digital information
2. Automatically process, share, manipulate, and enhance the trail of knowledge
3. Connect and monitor as part of expert networks

Three main technologies address these issues: the semantic web, ontology, and tools specific to knowledge management.

Semantic Web Tools

The semantic web or Web 2.0 has not yet clearly defined the contours of its field of activity and impact. Its tools are global and not formalized. The major contribution is the integration of intelligent agents able to understand and integrate various information resources (based on ontological approaches). On the other hand, based on Web technologies, they provide the ability for users (users) to share, critique, comment, aggregate, and reference information available. Examples include:

- Blogosphere
- Wiki encyclopedia
- Folksonomies
- RSS feed

Ontology Approaches

The introduction of ontology in the world of engineering creates ambiguity with philosophy. What could be called information system (IS) ontology corresponds in philosophy to conceptualization. The difference lies in the fact that philosophy seeks a perfect objectivity in ontology, whereas engineering reaches an intersubjectivity that becomes the local objectivity of a community. Local agreements enable multiexperts to reach consensus and smooth misunderstandings and concept gaps.

Ontology gives a metalevel for the global model in a given domain (models of the concepts and their interrelations).

Research on ontology and attempts to use it as a knowledge reference in knowledge management has led to three main research categories.

- Consensual vision between different stakeholders: it is often difficult to make people agree on common words with common definitions. Definitions are slightly different from one expert to another, but it is often enough to stop convergence. The quest for a real objectivity in a particular expert domain is unrealistic. An unusable extensive aggregation of points of view may result from this approach.
- Model comparison in computer science: some methodologies or tools try to allow comparison between different models (Amidon 1997). Ontology is then required to align the models. Even if it may be easier because of formalisms used, it then comes back to the previous difficulty which is to define the common analysis reference.
- Decision-making or case-based reasoning: information concerning previous experiences is extracted from a marked-up corpus. Ontology is used as an indexing tag library at a high semantic level. Here again, the difficulty consists in the construction of the initial common understanding. The analyzed corpus may be formed by very different sources (Internet) and the difficulty consists in rebuilding enough contexts to assess information validity. Classical modeling references (static, humanly mastered) usually try to solve this issue when a breakthrough in dynamic and fuzzy approaches is required. Different algorithm strategies already perform well (e.g., Google, the social-bookmarking service Delicious).

Each of these uses may imply different architectures and interfaces.

Specific Tools Developed for Knowledge Management

There are two types of tools:

- Tools developed specifically matched to specific methodologies for knowledge management (formalisms and tools are designed to support the process of modeling, structuring, and exploitation of knowledge)
- Tools developed to support some of the steps of knowledge engineering

The following gives a (very small) number of examples of solutions. Many more are available, so the following is nowhere complete:

1. Tools that want to *list the knowledge of the organization* in order to build a corporate memory or mapping of expertise:
   - REX (Retour d'EXperience – means Feedback): capitalizing on knowledge obtained during the implementation of the activities of an organization, represented textually to a user query in natural language. Two phases: first build a collection of knowledge elements in a set of procedures. Second phase, include the collection in a document management system called the memory of experience that draws connections between user requests and documents.

2. Approaches that *develop models for the control and sharing* the complexity of the repository and knowledge sharing within organizations:
   - MKSM (Methodology for Knowledge Management System) capitalization of knowledge in a perspective of knowledge management in an organization. Evolves in MASK method (Method for Analyzing and Structuring Knowledge). This method involves three phases: the study domain definition, the cycle of modeling, and the architecture. The cycle of modeling represents and structure knowledge through domain, activities, and tasks models. The architecture articulates modeling MKSM with the operational part of the project on strategic, tactical, and risk analysis.
   - CYGMA (Cycle de vie et Gestion des Métiers et des Applications – means Life Cycle Management and the Trades and Applications): creating knowledge bases specific for a domain. The method proposes six categories of knowledge (singular, terminological, structural, behavioral, strategic, and operational) on which it builds breviaries knowledge for the domain and the knowledge bases computable by the algorithms of deductive reasoning. The breviary is composed of a business glossary, a semantic booklet, a booklet of rules, and an operating manual. This method has the advantage of distinguishing between different types of business knowledge present in the company.

3. Computer applications to *automate the activities and provide decision systems*:
   - CommonKADS (Knowledge Acquisition and Design System): modeling the knowledge of an expert group in order to structure a knowledge based. It scans the entire cycle, since the process of acquiring knowledge, its transformation into a collection of knowledge, and the development of a complete system. This methodology has several constitutional principles, including:
     - Separate the conceptualization phase of its integration expertise.
     - Consolidate the knowledge according to their homogeneity and their objectives.
     - Get, build, and use blocks or generic models of knowledge.
     - Preserve concept maps obtained when deploying the application.
   - MOKA (Methodology and Tools Oriented to Knowledge Engineering Applications): modeling and representation of knowledge of engineering. The method describes the rules, processes, and modeling techniques and the definition of the steps required to build a system engineering knowledge base. As KADS, since it covers the identification phase of knowledge to the phase of commissioning of the final application with an emphasis on structuring and

formalization. The method uses MML formalism, adapted from UML (MOKA Modeling Language), and is divided into two phases before reaching the final application:

- Informal phase: structure the knowledge base in text form for verification and validation by the expert. The informal model is used to structure various blocks of knowledge in the ICARE model.
- Formalization phase: builds a formal model to facilitate the use and integration of knowledge in the application, with a structure that is understandable and computable by the machine. It defines an object-oriented model for the product and process design, the features needed to describe geometric objects, and concepts of artificial intelligence to represent the knowledge associated with design activities.

Cross-References

▶ Decision Making
▶ Design
▶ Knowledge Based System

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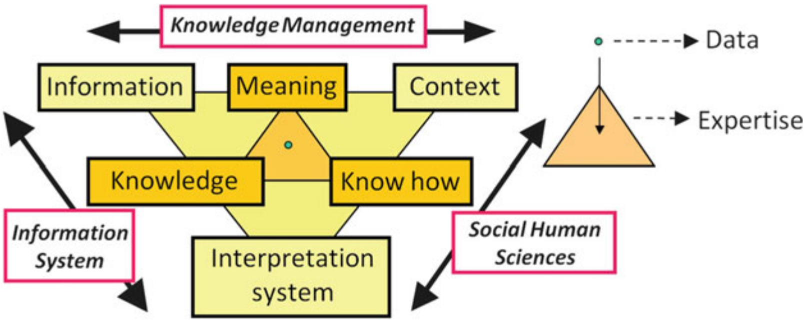

Knowledge Management, Fig. 1 Research domain in connection with KM and their main interest topics

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