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Information Technology for Knowledge Management

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Abstract: Knowledge has been lately recognized as one of the most important assets of organizations. Can information technology help the growth and the sustainment of organizational knowledge? The answer is yes, if care is taken to remember that IT here is just a part of the story (corporate culture and work practices being equally relevant) and that the information technologies best suited for this purpose should be expressly designed with knowledge management in view. This special issue of the Journal of Universal Computer Science contains a selection of papers from the First Conference on Practical Applications of Knowledge Management. Each paper describes a specific type of information technology suitable for the support of different aspects of knowledge management.

Key Words: knowledge management, information technology, knowledge life-cycle, knowledge work processes, corporate memories, information filtering

Category: A.1, H.4.m, I.2.1, K.m

1 Knowledge Management

Managers, consultants, IT professionals and customers believe that they have finally discovered what makes organizations work: knowledge—that invisible force that propels the most successful companies to stock market values which far exceed the visible assets of their financial balance sheet. Where does this knowledge come from? The financial balance sheet, based on such tangible assets as capital and equity, does not tell us. Yet this is what stock market investors look for when they decide to raise the market value of a company—they invest in the specific know-how of the company to produce future cash flows. At its simplest, the knowledge movement in organizational thinking is about refining rules of thumb used by investors into techniques and methodologies for the knowledge auditing of organizations. This new view of organizations should help investors to make their choices in a more informed way by basing them on a sound, systematic ground.

More than that, it should aid managers to identify the real weaknesses and strengths of the organizations they run, and to set up the priorities in order to make them grow.

Thus, the knowledge movement has proposed to put knowledge on the balance sheet in the form of intangible assets that account for organizations' intellectual capital. Such intangibles include: employees' competence; the internal structure of organizations, given by their patents, their own models, concepts and processes, their administrative system and IT infrastructure; their external structure, given by the relationships they have developed with customers and suppliers, their brand names, trademarks, image and reputation (Sveiby 1997). Some companies, most famous Skandia, a Swedish financial services firm, have started to develop knowledge auditing methodologies and to publish an intellectual balance sheet.

But there is more than this. With respect to earlier, more scientific approaches to knowledge, from western epistemology to artificial intelligence, the knowledge movement has brought the new awareness that organizational knowledge is something inherently fluid and elusive, so inextricably linked with humans that people very often take it away once they leave the place; something that defeats being captured by rules and formulas and that comes in many different shapes and forms, one form dynamically transmuting into another. In particular, we have learned to distinguish between *explicit knowledge* and *tacit knowledge* (Nonaka and Takeuchi 1995).

Explicit knowledge is formal knowledge that can be packaged as information and can be found in the documents of an organization: reports, articles, manuals, patents, pictures, images, video, sound, software etc. Tacit knowledge is personal knowledge embedded in individual experience and is shared and exchanged through direct, eye-to-eye contact. Clearly, tacit knowledge can be communicated in a most direct and effective way. By contrast, acquisition of explicit knowledge is indirect: it must be de-coded and re-coded into one's mental models, where it is then internalized as tacit knowledge.

In reality, these two types of knowledge are like two sides of the same coin, and are equally relevant for the overall knowledge of an organization. Tacit knowledge is practical knowledge that is key to getting things done, but has been sadly neglected in the past, falling very often victim to the latest management fad. For instance, the recent spate of business process re-engineering initiatives, where cost reduction was generally identified with the laying off of people—the real and only repositories of tacit knowledge—has damaged the tacit knowledge of many organizations. Explicit knowledge defines the identity, the competencies and the intellectual assets of an organization independently of its employees; thus, it is organizational knowledge *par excellence*, but it can grow and sustain itself only through a rich background of tacit knowledge.

Indeed, the other great discovery of the knowledge movement lies in the following simple observation: knowledge that doesn't flow doesn't grow and eventually ages

and becomes obsolete and useless—just as money which is saved without being invested eventually loses value until it becomes worthless. By contrast, knowledge that flows, by being shared, acquired and exchanged, generates new knowledge. Existing tacit knowledge can be expanded through its socialization in communities of interest and of practice, and new tacit knowledge can be generated through the internalization of explicit knowledge by learning and training. New explicit knowledge can be generated through the externalization of tacit knowledge, as happens, for instance, when new best practices are selected among the informal work practices of an organization. Existing explicit knowledge can be combined to support problem-solving and decision-making, for instance through the application of data mining techniques to identify meaningful data relationships inside corporate databases. These four different phases of the knowledge life-cycle—socialization, internalization, externalization and combination—have been formalized by Nonaka and Takeuchi (1995) in the diagram in Fig. 1. Under this view, "knowledge management" can be explained as the management of the environment that makes knowledge flow through all the different phases of its life-cycle.

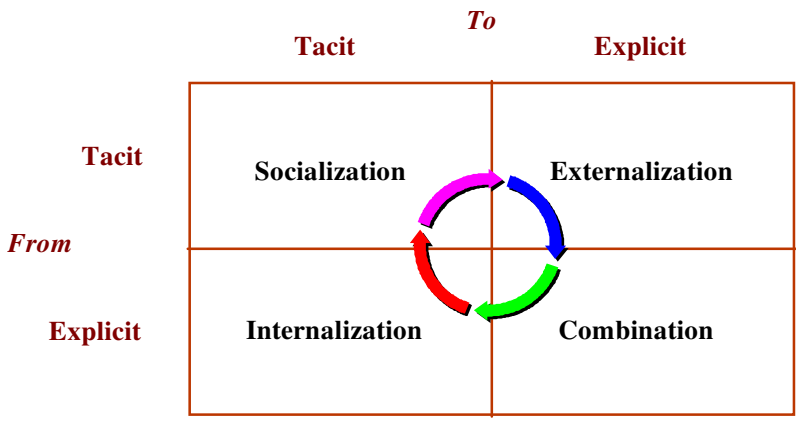

Figure 1. Knowledge Conversion as proposed by Nonaka and Takeuchi (1995)

2 Information Technology for Knowledge Management

There is an ongoing lively debate about the role that information technology can play for knowledge management. On the one hand, information technology is used pervasively in organizations, and thus qualifies as a natural medium for the flow of knowledge. A recent study from the American Productivity and Quality Center shows that organizations embarking in knowledge management efforts generally rely, for accomplishing their goals, on the setting up of a suitable IT infrastructure (AP&QC 1997). At the other end of the spectrum, leading knowledge management theorists have warned about the attitude that drives management towards strong

investments in IT, possibly at the expense of investments in human capital; see for instance Sveiby (1997a).

The danger that this viewpoint sees is that IT-driven knowledge management strategies may end up objectifying and calcifying knowledge into static, inert information, thus disregarding altogether the role of tacit knowledge. Knowledge management strategies of this type would bring back the ghost of the infamous, and none too far in time, re-engineering days, when the corporate motto was "More IT, less people!"; they conjure grim scenarios of organizations with enough memory to remember everything and not enough intelligence to do anything with it.

Part of the problem here derives from a linguistic ambiguity: nowadays information technologies are as much about creating direct connections among people through such applications as electronic mail, chat-rooms, video-conferencing and other types of groupware as they are about storing information in databases and other types of repositories. As for information databases, they can also be fruitfully re-thought, in a knowledge management perspective, as resources for the sharing of best practices and for preserving the intellectual capital of organizations. Generally speaking, investments in IT seem to be unavoidable in order to scale up knowledge management projects. The best way of applying information technology to knowledge management is probably a combination of two factors: on the one hand, the awareness of the limits of information technology, and of the fact that any IT deployment will not achieve much, if it is not accompanied by a global cultural change toward knowledge values; on the other hand, the availability of information technologies that have been expressly designed with knowledge management in view. This last topic, the design and application of knowledge-oriented information technology, provided the focus for the conference on Practical Applications of Knowledge Management held in October 1996 in Basel, Switzerland (Wolf and Reimer 1996). For this special issue of J.UCS on *Information Technology for Knowledge Management* we selected several contributions to the PAKM conference and asked the authors for extended versions of their papers. The selected contributions relate to technologies supporting various types of organizational knowledge during different phases of its life-cycle.

2.1 Process Management

The two papers *Two complementary tools for the cooperation in a ministerial environment* by Prinz and Syri and *Ariadne: supporting coordination through a flexible use of knowledge in work processes* by Simone and Divitini deal with workgroup and workflow support of knowledge work. They specifically address process knowledge, which is explicit, formalized knowledge about executing sequences of work activities.

Prinz and Syri show how existing process knowledge can be enriched by letting workers externalize their understanding of new types of tasks through dynamic extensions of the workflow. Furthermore, they show the benefit of coupling formalized ways of doing things with non-formal work practices obtained through

direct interactions among people. These non-formal practices create the conditions for sharing tacit knowledge about processes. They describe a workgroup system where both approaches co-exist and communicate, and show its use in the context of a ministerial environment. They point out how the system was easily accepted by the ministerial workers because it fits, and extends, the way they already do work.

Simone and Divitini start from the complementary aspect of internalizing process knowledge. They argue that workflow management systems can be "knowledge-enabled" by moving them to a higher level in the value chain: from systems for executing processes to systems for learning about processes while they are executed. This means essentially that the workflow management system must come with different levels of sophistication in the definition of a given process, just as a search engine may provide basic search features for casual users and more sophisticated features for advanced users. As workers get more acquainted and confidential with the process, they will choose and experiment with more sophisticated ways of doing things. This in turn may lead to the creation of new process knowledge, as workers may decide to design themselves new definitions for certain parts of the process, or to add new sub-processes. Simone and Divitini describe an experimental workflow management system that supports this free interplay between learning and creation of process knowledge, and present a case study of its application in a typical organization of knowledge workers, namely a funding agency for R&D projects.

2.2 Corporate Memories

The role of corporate (or organizational) memories in knowledge management is addressed in three papers: *Negotiating the construction and reconstruction of organisational memories* by Buckingham Shum; *Corporate memories for knowledge management in industrial practice: prospects and challenges* by Kühn and Abecker; and *From natural language documents to sharable product knowledge: a knowledge engineering approach* by Rösner *et al.* Corporate memories record the accumulated knowledge about the services and the products of an organization, with the purpose of supporting the continuous enhancement of knowledge-intensive work practices and of alleviating the risk of "corporate amnesia" due to experts taking away their knowledge when they leave.

It is possible to build a corporate memory in a totally unstructured way: by maintaining all documents and recording all practices of an organization. This approach seems inexpensive; it involves, however, amassing a lot of irrelevant information that will need to be filtered later on. The opposite approach involves an intensive initial knowledge engineering effort leading to the construction of corporate knowledge bases and expert systems. Buckingham Shum proposes a middle way, which can be particularly viable for organizations of knowledge workers: the recording of relevant team activities through the use of hypertextual representations linking the different steps of the activities, highlighting the different options considered at each step and associating actions and decisions with role and

competencies of the people involved. Such hypertextual representations are created and negotiated *ex vivo* by knowledge workers, rather than reconstructed *post mortem* by knowledge engineers; they record process knowledge related to knowledge-intensive problem-solving and decision-making activities. The negotiation aspect is very relevant, because explicit knowledge comes often dressed with a deceitful appearance of "objectivity" which in reality hides a specific point of view. Acknowledging the existence of this point of view and allowing for its negotiation is an important step towards getting organizations knowing themselves and making workers fully empowered. In this way, the negotiated point of view will effectively reflect the committments of all involved stakeholders, and not just of single groups and individuals holding "power" roles and positions in the organization.

Rösner *et al.* describe instead a full-fledged knowledge engineering approach suitable for building corporate memories from the product knowledge of large manufacturing organizations such as automotive industries. Starting from the collections of documents about the products of these organizations (product specifications, instruction manuals, trouble shooting guides etc.), they show how to extract the explicit knowledge that is in there and integrate it with further explicit knowledge obtained by externalizing the tacit knowledge related to the context of use of the documents. The knowledge thus acquired is represented in the form of conceptual graphs that relate the different parts of the products, associate parts with properties and connect single actions for operating the products into complex plans corresponding to full operating instructions. They show then how the initial investment needed for building this type of knowledge bases pays off in a number of ways: by providing capabilities for automatic multilingual document generation, by providing a knowledge space of existing product knowledge to support the fast design of new products, by providing a language-independent semantic representation of product knowledge that could be used to enforce enterprise coherence for companies operating in multilingual and multicultural environments.

Kühn and Abecker's paper complements Rösner *et al.*'s work by defining the software engineering requirements for supporting this type of corporate memories: on the basis of three case studies in different manufacturing organizations, they point out the need of strong integration of corporate memories with existing IT infrastructures, with particular regard to existing capabilities for database management, document management and business process support. They describe a corporate memory architecture that meets these requirements, and point out the paradigm shift of corporate memories from artificial intelligence to a more general framework for IT integration.

2.3 Information Filtering

The papers *Profiling with the INFOrmer text filtering agent*, by Sorensen *et al.*, and *A framework for filtering news and managing distributed data*, by Amati *et al.*, come from the information retrieval community and describe different systems for

information filtering. Information filtering has become a crucial type of IT support for knowledge workers, who are faced with ever increasing amounts of information, both from sources internal to the organization and from external sources such as the Internet and the World Wide Web.

Sorensen *et al.* present an intelligent filtering system where individuals may have profiles, representing long-term "interests," that are used to measure the relevance of information. These profiles can then be used to compile natural language queries into weighted graphs that capture the semantic content of the query with respect to the given profile. If the query is very specific, and contains a lot of related words, then the computational overhead of building a graph for the query and for the requested information pays back by returning answers that match accurately the interests of the user. Furthermore, profiles can be dynamically updated through user relevance assessments. Thus, this system provides information filtering capabilities that can be flexibly adapted to the context and the needs of specific categories of knowledge workers.

The paper by Amati *et al.* complements the one by Sorensen *et al.* by showing how user profiling can be advantageously combined with less expensive and more conventional information retrieval techniques. Their approach provides adaptive information filtering capabilities that can answer simpler queries with more accuracy than standard non-adaptive information filtering systems. They also show how to automate part of the "workflow" related to the search of information through an intelligent agent system that leverages memory-based reasoning techniques to select relevant information sources and make suggestions for such actions as storing returned documents into appropriate folders, deleting, printing etc. These agents learn and tune their own behaviors by direct observation of users' behaviors.

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