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Agent based approach for organization and personal knowledge modelling: knowledge management perspective

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Abstract The paper tries to bridge gap between knowledge management and artificial intelligence approaches proposing agent-based framework for modelling organization and personal knowledge. The perspective of knowledge management is chosen to develop two conceptual models—one describes the intelligent enterprise memory, another models an intelligent organization's knowledge management system. The concept of an agent-based environment of the knowledge worker for personal and organizational knowledge management support is introduced.

Keywords Knowledge worker · Organization's knowledge management system · Personal knowledge management · Intelligent agents · Multi-agent system

Introduction

Recently we can observe an epochal evolution from the industrial age to the information age in which the organizational networks have become highly variable while their environments increasingly dynamic. To be competitive organizations should react adequately, interpret non-standardized information for problem solving and decision making, as well as change their infrastructure and management strategies. Usually there are a lot of information and knowledge within organizations, but at the same time many of them (service organizations, in particular) are "information rich and knowledge poor." The information and knowledge assets, often called an "intellectual capital," i.e., knowledge that can be converted into value, make a great potential for organizations if utilized well (Apshvalka & Grundspenkis, 2003).

Knowledge management (KM) has become an effective way of managing organization's intellectual capital or, in other words, organization's full experience, skills and knowledge that is relevant for more effective performance in future. Two approaches have appeared in KM—people track and information technology track knowledge management (Sveiby, 2000). For representatives of the first track KM is the art of creating value from an organization's intangible assets. They strongly believe that only humans possess knowledge and are convinced that knowledge is not something that can be managed (Galliers & Newell, 2001). The information technology track KM corresponds to management of information field where researchers and practitioners are involved in construction of information management and knowledge-based systems, artificial intelligence, reengineering, groupware, etc. To them knowledge means objects that can be identified and handled in information and knowledge based systems. They argue that tacit knowledge of individuals may be elicited, transformed into explicit knowledge and thereby used to generate new knowledge, and to make all knowledge reusable and available for everybody in the organization.

The gap between both tracks is rather wide due to the different point of view on the actual nature of knowledge. Studies in KM mainly focus on organizational knowledge captured in corporate and/or organizational memories (Brooking, 1999; Grundspenkis, 2001; Walsh & Ungson, 1991) and on the development of knowledge management systems (KMS). However these initiatives in organizations have often run into difficulties mainly because the expansion of individual's personal tacit knowledge to knowledge of organization as a whole causes implementation problems. Research into the causes of emerged problems has shifted the

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closer attention to the human dimension of KM and, in result, some researchers have focused on personal knowledge management (PKM) skills and practices to emphasize this dimension (Apshvalka, 2004; Tsui, 2002). It is worth to add, that different aspects and dimensions of knowledge have been investigated in artificial intelligence (AI) for decades giving great potential for usage in KM. Unfortunately, this potential, especially the use of advanced techniques such as intelligent agents and multiagent systems, are underestimated and even ignored by the KM community. Analysis of a great number of publications shows that there is a difference of opinions even on fundamental terms, such as, "knowledge," "knowledge representation," "knowledge processing," etc. (Grundspenkis, 2001).

In this paper we try to bridge gap between KM and AI, describing two conceptual models which are under the development at the present moment. First, we discuss the essence of knowledge work and knowledge modelling, and its role for the development of intelligent enterprise memory. Second, we describe organizations as communities of agents and objects, and suggest a conceptual model of an agent-based environment of the knowledge worker.

Knowledge work and knowledge modelling

Paradigm shift from information to knowledge management causes emerging of a new type of intellectual work called "knowledge work." Knowledge work is about making sense. It may be also considered as content creation, i.e., the generation of new knowledge to stimulate the innovation process of organizations. Organizations today must take a more systematic approach to managing the main drivers of innovation, i.e., productivity improvements of the knowledge workers, and the rapid building and utilization of the organization's knowledge accumulated as an intellectual capital. In the field of KM all knowledge used to support organization's activities is considered to be an organization's intellectual capital that is formed from human knowledge, knowledge embedded in organization's business processes, products and services, as well as from internal relationships between agents operating in an organization, and relationships between an organization and its environment.

The main difference between human knowledge and organizational knowledge is that individual knowledge is combination of individual's own knowledge, experience and skills, but organizational knowledge is a sum of individuals' knowledge and knowledge already existing in organizational systems, processes, products, rules, and culture. There are three types of knowledge within every organization: individual, group and enterprise knowledge (Hummingbird, 2001). It is worth to point out that this classification of knowledge types is not the only one that is used in KM and AI. As examples let's mention only three different classifications of knowledge types. The most popular in KM is the distinction between tacit (resided in humans) and explicit (formalized) knowledge (Nonaka & Takeuchi, 1995). Tacit knowledge is personal knowledge gained through experience. It may be shared and exchanged through direct communication with others. Explicit knowledge is represented in documents, e-mails, knowledge repositories (data and knowledge bases), etc. Explicit knowledge can be formalized in words and numbers and it is easy distributed and shared. Acquisition of explicit knowledge is indirect because it must be encoded and decoded in one's mental models where it is kept as tacit knowledge. In (Kirikova & Grundspenkis, 2000) distinction is made between natural and artificial knowledge. Natural knowledge may be considered as a non-tangible knowledge system, and it is located in human beings. Generally speaking, any piece of knowledge can be recorded (documented) by means of a particular knowledge object, for instance, it can be fixed in the author's brain, or written on the paper, remembered by other human beings, etc. So, human beings can possess natural as well as artificial knowledge. Depending on the possessor's type, artificial knowledge can be tangible or non-tangible in case, if it is just remembered by a human being. Tangibility means that artificial knowledge is recorded in at least one object that is not a human being's brain, i.e., that knowledge is possessed by some tangible human artifact. Artificial knowledge possessors are passive and active ones. Passive possessors, for instance, documents, articles, reports, manuals, patents, audio and video records, and so on, can represent information but cannot change it or generate new knowledge, that is, they lack knowledge processing capabilities. Active possessors, such as expert systems, intelligent decision support systems, artificial neural networks, active and intelligent databases, intelligent agents and multiagent systems have capabilities to process knowledge amalgamated in them and produce new units of artificial knowledge by using artificial intelligence methods and techniques. Artificial intelligence community has worked out its own explicit or artificial knowledge typology, namely, declarative, procedural, heuristic, structural and meta-knowledge. Notice that each attempt to classify knowledge types reveals additional facets and clarifies the real nature of knowledge. Traditional knowledge engineering boundaries should be expanded to make it an interdisciplinary field. This will allow to reach common understanding of essence of knowledge and, as a consequence, more effective identification of knowledge sources, possessors and types in different organizations.

Information is converted into knowledge through human process of shared understanding and sense making at both a personal level and an organizational level. Knowledge workers are trying to turn available information into knowledge

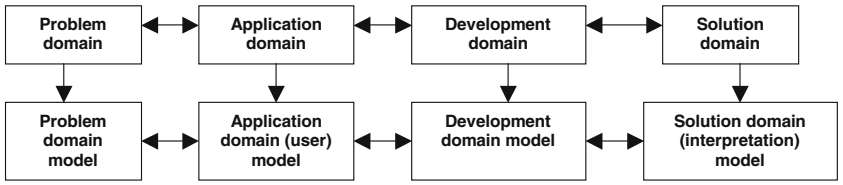

Fig. 1 Four classes of domains and corresponding models

and to generate new knowledge to stimulate the problem solving and decision making by using four classes of models that correspond to four different domains as it is shown in Fig. 1.

In the KM context, models are used to provide a number of knowledge-oriented services starting with knowledge acquisition, capturing and encapsulation, and ending with automatic knowledge distribution and reuse. Generalized knowledge acquisition and representation process is depicted in Fig. 2. The central module of this schema is an intelligent enterprise memory (IEM). The concept and model of IEM based on seven phases of knowledge life cycle for the first time was proposed in (Grundspenkis, 2001). The IEM is considered as a structure that can support the sharing and reuse of individual knowledge worker's and enterprise-wide knowledge, experience and lessons learnt. It can be created through process of acquisition, capturing and representation of tacit (informal) and explicit (formal) knowledge coming from different sources.

The purpose of the IEM is to provide the functionality to identify, acquire, store, distribute, and reuse all captured knowledge for future use. The model has seven layers:

1. *Knowledge Source Layer* consists of various knowledge sources where tacit and explicit knowledge is captured. Knowledge at this level is tangible and non-tangible as well. It is possessed both by natural and artificial knowledge possessors.
2. *Knowledge Acquisition Layer* is needed to facilitate systematic acquisition of relevant knowledge in a given application domain.
3. *Knowledge Formalization Layer* is a prerequisite for efficient representation and processing of explicit knowledge. The AI community has developed four different classes of formalization languages, namely, logic, networks, structured representations and rules. To make knowledge formalization more effective and to avoid case-specific formalizations, appropriate taxonomies and ontologies may be very helpful. The KM community pays little attention to knowledge formalization aspects except issues of case descriptions
4. *Knowledge Representation Layer* is the crucial layer in KM information technology track providing bases for explicit knowledge processing when knowledge is stored into a knowledge base, cases are stored is a case base or the structure of neural network is determined.
5. *Knowledge Processing Layer* may be considered as "explicit knowledge flow engine" in KM process which provides knowledge combination. A plethora of reasoning and machine learning methods have been offered and may be used in KM. Knowledge flow is supported also by many KM technologies.
6. *Knowledge Application Layer* is the second relevant layer for knowledge flow in organizations. Such activities as knowledge reuse and transfer depend on the quality of systems used. Many technologies are proposed in KM. Knowledge-based systems, namely, decision support systems, management information systems and expert systems should be added as instruments for easy access, analysis, use, reuse and distribution of captured organizational knowledge.
7. *Knowledge Users Layer* provides consulting and advisory services to organization's knowledge workers or the public. To intensify the knowledge distribution nowadays modern information technology facilities are used in rapidly increasing numbers. Among these tools the most popular ones are Web and video conferencing, collaborative work tools and intranets of organizations. Explanation modules of knowledge-based systems also can fulfill mission of knowledge dissemination.

If one looks at the model of IEM from the viewpoint of four phases of knowledge life cycle (Nonaka & Takeuchi, 1995) several similarities could be found. Tacit and explicit knowledge sources are identified at the first layer. All knowledge acquisition methods and tools that support knowledge externalization process are placed in the second layer. Explicit knowledge is captured at the third and fourth layers. Knowledge processing tools that support the process of generation of new explicit knowledge implemented in applied systems (decision support, management information, expert systems, hybrid intelligent assistants, intelligent agents and multiagent systems) are included in the fifth and sixth layers. Internalization of knowledge, i.e., the conversion of explicit knowledge into new individual knowledge is the essence of the seventh layer.

Relationships between KM process and the layers of the IEM are reflected in Table 1.

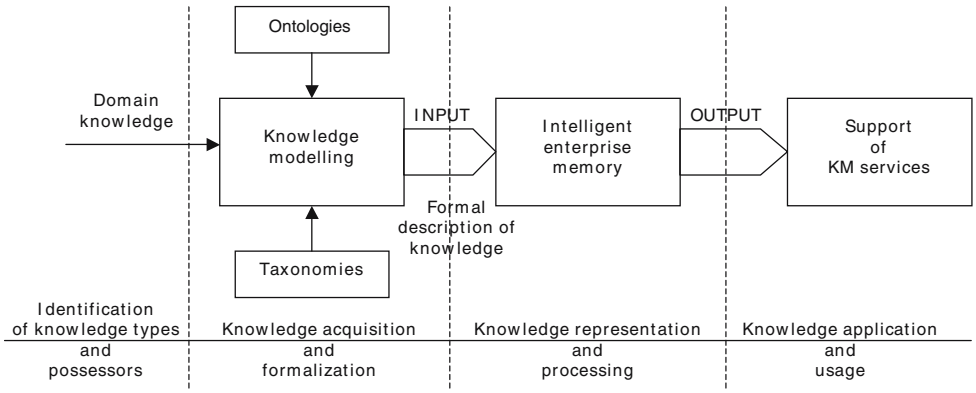

Fig. 2 Generalized knowledge acquisition and representation schema

Table 1 Mapping of KM process to IEM model

Components of knowledge management process	Layers of enterprise memory model
Knowledge identification and creation	1, 2, 5
Knowledge acquisition, inference and generation	2, 5
Knowledge storage	3, 4, 5
Knowledge aggregation	5
Access, analysis, use-reuse of knowledge	5, 6, 7
Knowledge distribution and sharing	6
Consultations	7

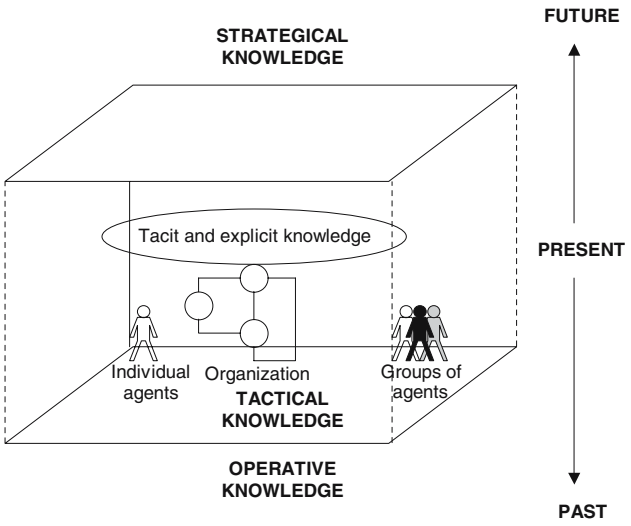

Fig. 3 Organization's "knowledge space"

Organizational and personal knowledge management supported by multi-agent system

From the systems theory point of view, any type of organization may be considered as a set of various objects together with relationships between them. In other words, organizations are systems which components are active or passive objects (Grundspenkis & Kirikova, 2005). Agents, in turn, may be natural, e.g., humans, or artificial ones, such as, software agents and robots. Artificial agents are acting within a real environment (robots) or within a virtual environment, that is, cyberspace (robots and software agents). All agents are called knowledge workers whose decisions effect their environment, which could consist of other agents and/or passive objects, for instance, other types of software and/or hardware that include also control devices. Environment entities can be local to the agent (the same platform or machine on which agent resides) or remote, if agent is connected via some type of network with other objects (Knapik & Johnson, 1998).

A wide variety of organizations considered as collections of active objects, i.e., agents or knowledge workers, and passive objects, allow to predict that it will be impossible to develop an effective general purpose KMS usable for all classes of organizations. At the same time, the role of KM is steadily growing, particularly for organizations operating in rapidly changing environments. Thus, new solutions appear, new technologies are introduced, and new methodologies are developed. In (Grundspenkis & Kirikova, 2005) organization's knowledge life cycle is represented as an organization's knowledge space that is organized form of data, information and knowledge captured in past, and used at present and in the future to get additional value out of them. This is shown in Fig. 3.

All organization's business processes are supported by intelligent agent activities, such as decision making and acting. More detailed examination of business process support from the inside reveals that managers, researchers and assistants, advisers, secretaries, etc. are employed as searchers, schedulers, and planners to do the diverse mundane tasks. Let consider perspectives of intelligent support of these activities by communities of intelligent agents, or so-called multi-agent systems (Knapik & Johnson, 1998; Woodridge, 2002). This "inside look" on intelligent organization is shown in Fig. 4. The conceptual model of an intelligent organization's knowledge management system (OKMS), which is based on

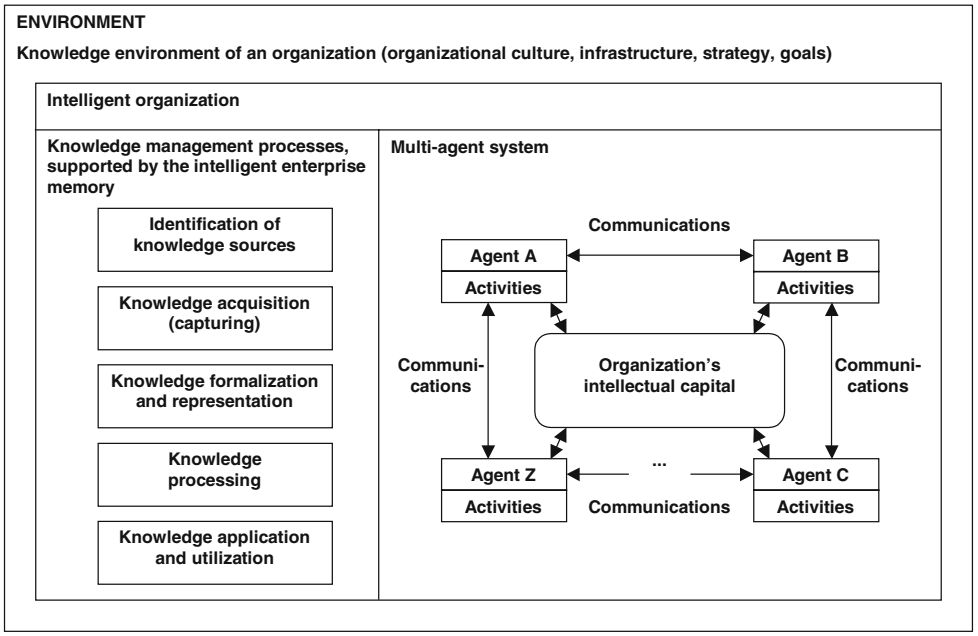

Fig. 4 Organization's knowledge management supported by multi-agent system

an intelligent agent paradigm, is described in (Grundspenkis, 2003). The basic idea behind the conceptual model is that the OKMS should operate like the human brain and fulfill the following basic functions: knowledge acquisition through sensors, knowledge formalization, representation and storage in the knowledge space (IEM), knowledge inference, sharing, and utilizing. As it is shown in Fig. 4, the conceptual model consists from two main parts: an intelligent organization as a multi-agent system for business process support and a KMS. The conceptual model has three layers called an "engine room", a structural layer, and a "cooperation platform" as it is shows in Fig. 5. The "engine room" is an integrated set of technologies, hardware, and software to provide knowledge acquisition, storage, processing, retrieval, and representation. The purpose of the structural layer is to identify intellectual resources of the organization, and to organize knowledge to make it easily accessible and applicable. A "cooperation platform" is the physical and/or virtual environment where organization's intelligent agents may communicate with each other for effective knowledge sharing and distribution to achieve the business process goals. A "cooperation platform" maintains such components as video conferencing, chat rooms, electronic white boards, and other tools for cooperative work (groupware).

In (Grundspenkis, 2003) the potential already manifested by intelligent agents and multi-agent systems for KM is discussed and three groups of agents are marked. First, agents that may promote the KM and may be used as organization's common vehicle of the "engine room". Nowadays there already exist a number of agents that may be used as KM promoters, for example, network agents, database agents, connection and access agents, network software distribution agents, and intelligent Web agents (Knapik & Johnson, 1998; Web Intelligence, 2003). Second, among agents that provide communications, such agents as messaging agents, collaborative agents, cooperative agents, communication facilitators, team agents, and others may be listed (Ellis & Wainer, 2002; Knapik & Johnson, 1998).

Third, so-called personal agents are search, filtering, workflow, and assistant agents (Knapik & Johnson, 1998). Their primary purpose is to support the knowledge work of staff members of intelligent organization. The concept of the agent-based environment of the knowledge worker was proposed in (Grundspenkis, 2003). According to this concept the knowledge worker is embedded into a multi-agent system that consists of three circles of agents, namely personal agents, communication agents, and agents for access to external systems (network, databases, etc.) as it is shown in Fig. 6.

Knowledge management works best when knowledge workers take the initiative and responsibility for what they know, don't know, and need to know. Doing so not only makes the individual knowledge worker more valuable to the organization, but it also enhances the value of intellectual capital of an organization. The concept of personal knowledge management (PKM) emerges in this context (Apshvalka & Grundspenkis, 2005). PKM is defined as a collection of processes that an individual needs to carry out in order to gather, classify, store, search, and retrieve knowledge in his/her daily activities (Tsui, 2002). PKM is considered from different perspectives; for instance, some authors focus on attempts how to utilize a computer to help the knowledge worker to manage his/her knowledge, while others focus on problem-solving skills or arranging ideas (Apshvalka & Grundspenkis, 2005). To get a complete understanding of PKM, it is necessary to put all perspectives together and look at this kind of KM as a process of managing personal information and knowledge,

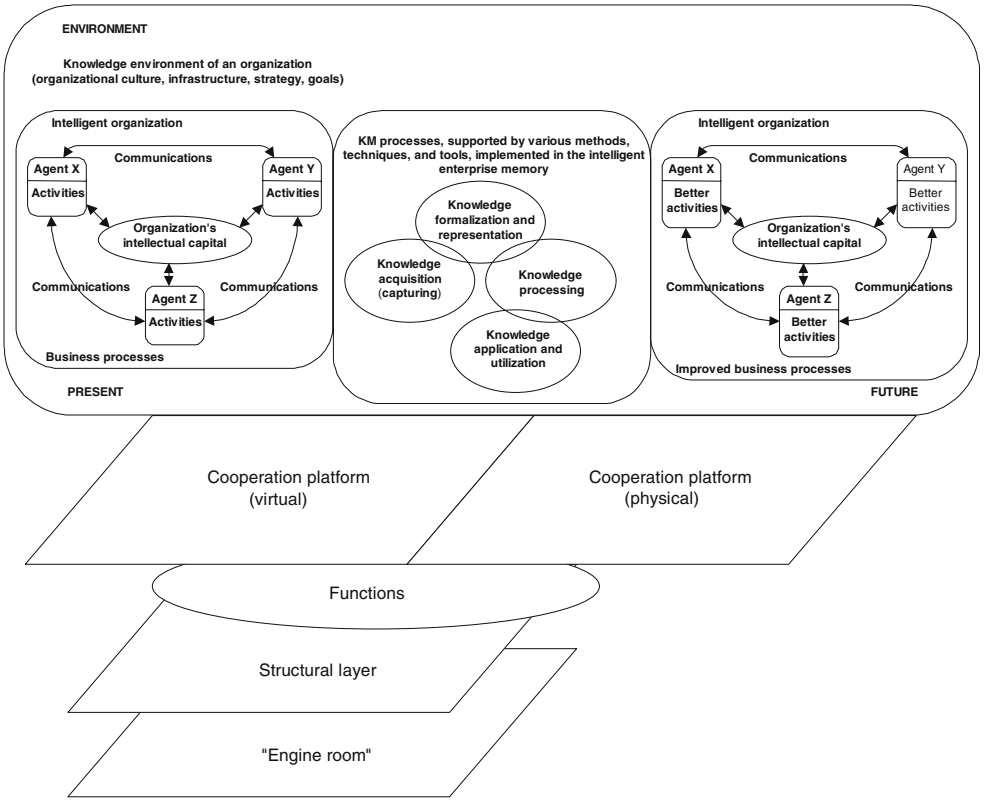

Fig. 5 Three layers of the OKMS

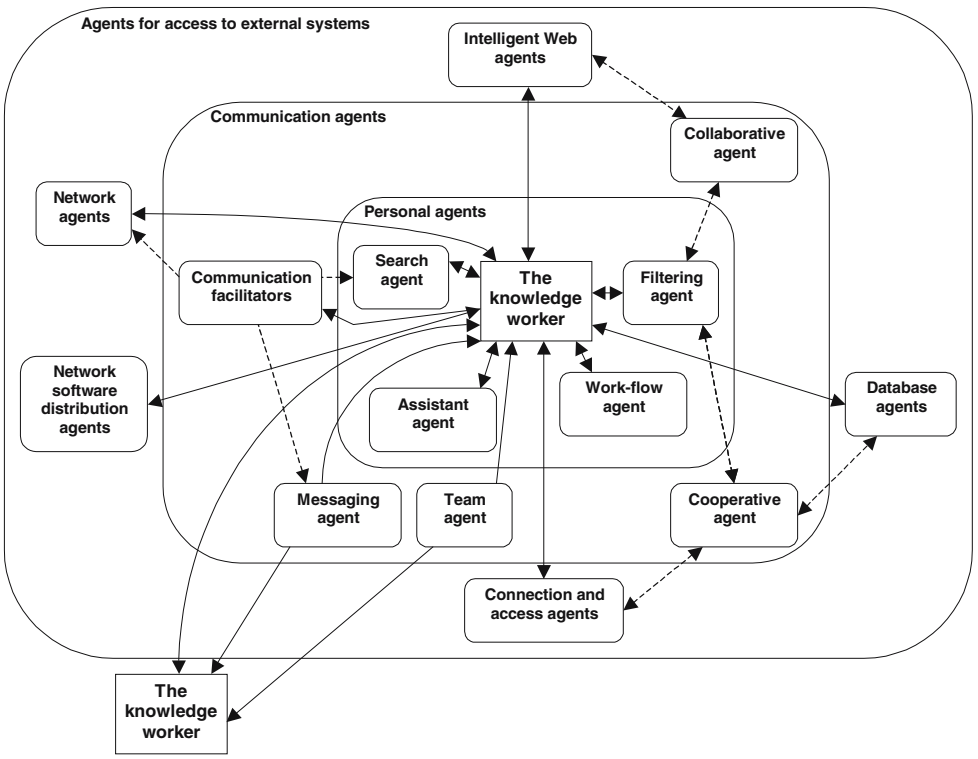

Fig. 6 An agent-based environment of the knowledge worker (→ denotes data, information and knowledge flows, - - → denotes possible connections between different agents)

and arranging ideas to be able to solve problems skillfully. The objectives of PKM extend further than giving employees access to intranets, systems, and standards. The final goal is to make knowledge workers better in capturing, sharing, and using knowledge, and maximizing their personal effectiveness in the social and relationship building of their jobs (KM Magazine).

Nowadays technologies can help individuals to make decisions and perform actions. In complex cases more sophisticated support is needed to make knowledge worker's activities really effective. This is where such technologies as intelligent agent and multi-agent systems should help to find and generate needed information and knowledge using the intelligent enterprise memory.

Conclusions

This paper has identified the possible role of two conceptual models which at present are under the development. First, intelligent enterprise memory is described for knowledge management process support. Second, the conceptual model of an intelligent organization's knowledge management system is discussed.

Regardless that a lot of work should be done to achieve considerable results in implementation of the proposed framework, the potential of using intelligent agents and multi-agent systems to develop more intelligent KMS even now is rather high. We hope that both conceptual models together with an agent based environment of the knowledge worker will serve as a platform for researchers to investigate directions towards development of more and more intelligent systems for organizational and personal knowledge management.

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