



A Cooperative Task Oriented Knowledge Management Paradigm Based on Multiple Intelligent Agents¹

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ABSTRACT

This article presents a new knowledge management paradigm and its support framework realized by multiple intelligent agents, which is suitable to the dynamic feature of knowledge flow in the cooperative problem solving process of the Communities of Practice about the collaborative task. The new paradigm provides a sharing knowledge space called Knowledge Workshop to realize the knowledge management mechanism. Knowledge Workshop can be used to support the cooperative work, accumulate the new experiences, acquire the relevant knowledge, and organize these knowledge and experiences to facilitate the knowledge sharing and flowing for the Communities of Practice about a collaborative task, in order to benefit from knowledge assets mostly. The article also analyzes the dynamic feature of knowledge flow of the Communities of Practice about a collaborative task, and presents the knowledge flowing process model in a cycle of the collaborative task.

1 INTRODUCTION

Knowledge Management (KM) improves organizational performance by enabling individuals to capture, share, and apply their collective knowledge to make optimal decisions. Knowledge management plays an important role in promoting innovation and productivity of organizations^[1]. Though the importance of Knowledge Management in organizations has already been recognized, many tools and strategies of KM, which have been put into work in organizations, are not succeed presently. The main reasons for this are: most Knowledge Management software focus on the solution of knowledge's storage and retrieval, but not the dynamic features of Knowledge Flow^[2], especially the influence of KM's psychological and organizational aspects caused by these dynamic features; information management software components that used in Knowledge Management, cannot integrated with existing software, leading to new barriers for the information flow and making little use of all kinds of knowledge which accumulated in long organization's practice.

In the research and practice of Knowledge Management, the Communities of Practice (CoP) has always been treated as the basic organizational unit of KM (namely, the collection of people, knowledge entity as some experts regarded)^[1]. Nonaka described an abstract knowledge creation process and Win gives a more concrete knowledge creation process that integrates into business processes^[7]. This article presents a new knowledge management paradigm and its support framework realized by multiple intelligent agents, which is suitable to the dynamic feature of knowledge flow in the cooperative problem solving process of the Communities of Practice about the collaborative task.

The new paradigm and its multi-agent support framework can solve the above two problems effectively.

2 KNOWLEDGE FLOW'S DYNAMIC FEATURE OF COP ABOUT THE COLLABORATIVE TASK

Which problems knowledge management addresses is how to improve the identification, acquisition, storage, access, diffusion, reuse and maintenance of both internal and external knowledge^[6], so that the organization can maximize its benefit. Here we should distinguish those concepts: "data", "information" and "knowledge". Data is symbol, which is used to describe the things, such as the number, letter, graphic, image, sound, and language etc, and these symbols can transfer information just as long as they have been endowed with the semantic. Information has been packed with data in a useful and understandable way. Knowledge means learning capability, insight and experience. Knowledge provides the background that allows one to make the best decision. Knowledge can be in people's heads (tacit knowledge) or it can be written down or recorded through the information objects (explicit knowledge). Some of knowledge is implied in the information objects, which can exert the effect via the users having different tacit knowledge.

In this paper, the Community of Practice is defined as the organization members' collection which having and using knowledge, cooperatively accomplish a collaborative task as a team. The Community members' knowledge is supposed to have the same domain ontology for research reason. The purpose of knowledge management around Communities of Practice is to facilitate knowledge flow in order to make Knowledge Asset increment much more.

For every task, Communities of Practice's collaborative team has its own life cycle—creation, growing, maturation and ending. In every cycle, knowledge is keeping accumulate, update, evolve, and effect at end. Every cycle is a spire knowledge evolving procedure.

Knowledge resources, which should be managed in an organization, are divided as tacit knowledge and explicit knowledge^[3]. Tacit knowledge can be put into knowledge management system and be managed through a user profile. Explicit knowledge can be coded as special information objects to be managed. Here knowledge resources are named as knowledge objects, they can be a set of rules stored in a knowledge-base, or a model which used to solve a kind of decision problem in a model-base; or a program to achieve a function, just like a agent; or a user profile, and so on.

In this article, a *knowledge flow* is defined as a process of knowledge objects changing between people or knowledge processing mechanism

in organizational memory. A knowledge object has five crucial attributes: *content*, *owner*, *meta-level*, *locations*, and *context*, which, respectively, determine the sharable knowledge content, legal right to the possession of the knowledge object, the level in a spire knowledge evolving procedure, a place where the knowledge object is located, and the circumstances in which the knowledge object occurs. This knowledge flow reflects the knowledge level cooperation in a team, which has an important influence on the psychological and organizational aspects about KM.

In one cycle of Communities of Practice, knowledge objects are changing continually in the cooperative working process. So they can be divide into several levels and forms as follows:

- **Acquired Knowledge Objects:** Knowledge objects are acquired from the different kinds of information resources, which may affect in future collaborative task.
- **Filtered Knowledge Objects:** The user with tacit knowledge filters knowledge objects from the relative Acquired Knowledge Objects for the collaborative task.
- **Newly Created Knowledge Objects:** That is to say innovation knowledge, that objects are lastly confirmed through the domain knowledge analysis and negotiation about the collaborative task by the team members. This kind of knowledge object may be the result of members' tacit knowledge acted, or modification and update of existing knowledge objects, or newly created knowledge objects during the solving process of the collaborative task.
- **Reusable Knowledge Objects:** The Filtered Knowledge Objects, which are lastly confirmed through the domain knowledge analysis and negotiation about the collaborative task by the team members, can be reused.
- **Confirmed Knowledge Objects:** Knowledge objects, which have been used in collaborative task, validated in practice and confirmed by the experts, have some evidence effects on the collaborative task and should be spread in the CoP.
- **Accumulated Knowledge Objects:** Knowledge objects, which have been used in the collaborative task and whose effect can be checked in practice and confirmed by the experts, but cannot be recorded with clarity because its causal relation is not clear, are accumulated as the cases about the collaborative task.
- **Refined Knowledge Objects:** Some of these knowledge objects have been used in one cycle of the collaborative task, and need to be confirmed by the experts. The other of these knowledge objects is inferred by inductive reasoning from a great deal of cases. This kind of knowledge objects need to be transformed into the Newly Created Knowledge Objects, and be put into the collaborative task and validated in practice.

3 A KNOWLEDGE MANAGEMENT PARADIGM FOR THE COLLABORATIVE TASK

In this paper, a knowledge management paradigm for the collaborative task is presented to support group learning in the CoP about the collaborative task through building an effective knowledge management mechanism. The new paradigm provides a sharing knowledge space called Knowledge Workshop (KW) to realize the knowledge management mechanism. Knowledge Workshop can be used to support the cooperative work of the CoP, accumulate the new experiences, acquire the relevant knowledge, and organize these knowledge and experiences to facilitate the knowledge sharing and flowing for the Communities of Practice about a collaborative task, in order to benefit from knowledge assets mostly. Its core idea can be abstract as the 3K+2C mechanism (supposed the collaborative task's accomplish can be expressed as a serial of executing transactions, namely workflow):

Knowledge Sharing. It is to say that all of the organization members want to share their own knowledge with others, and in the cooperative working process, the knowledge objects accumulated by all the members, or new information and alteration about the task which apperceived by all the members, should submitted to the KW in time, so that the others can share the relevant knowledge objects or information from the Knowledge Workshop anytime. Here the knowledge's

representation is based on a sharing ontology for eliminating the semantic interpretations between agents.

Knowledge Exchanging. It means that the organization members need the cooperative work support tools to exchange knowledge in a cycle of the collaborative task, just like e-mail0chat0forums0Knowledge Workshop and so on. The knowledge exchanging can be "stated exchanging" or "unstated exchanging". For example, the community's members need evaluate and analysis the relevant knowledge objects after the accomplishment of the collaborative task, in order to accumulate and refine the knowledge, that will be "stated exchanging"; at the same, when the transactions' executing meet the block or difficulty, for example someone meets a problem he can't solve, there will be a emergency discussion, that will be "unstated exchanging". That is group knowledge, for they are based system considering, and can be used to eliminate conflicts effectively, produce fine cooperative relation.

Knowledge Spreading. It is that the refined and approved knowledge in the Knowledge Workshop should be spread. These knowledge objects will be stored in the organizational memory to support the organization members to solve problems in the future, regardless he is the member of this CoP or not. It can accelerate the flow of knowledge, and benefit the organization rapidly.

Case Accumulating. It is important that the Cop members should record the relevant cases as Accumulated Knowledge Objects during a transaction of the collaborative task is executing, until the transaction finished, then analysis and evaluate the accumulated cases, extract knowledge to form the Newly Created Knowledge Objects, or filter the low score cases to maintain a reasonable case storage, and implement knowledge accumulation. The individual (or group) all can use the case based reasoning technique to implement individual learning (or group learning).

Credit Inspiring. It is to say that in order to unify the individual goals to the organization goal, it must remove the individual's enthusiasm, encourage the individual who has contribution (that is to say, enhance his credit degree), the higher credit degree who has, the higher priority in knowledge workshop who has, the priority will affect the next learning procedure.

In one cycle of the collaborative task in CoP, the knowledge flow model of the knowledge paradigm described above can be denoted as fig. 1.

4 KNOWLEDGE MANAGEMENT SUPPORT FRAMEWORK BASED ON MULTIPLE INTELLIGENT AGENTS

Applying the Multi-Agent Systems (MAS) techniques to KM has the following reasons: 1. Multi-Agent Systems are convenience to manage the distributed, dynamic, loose coupled and huge information resources in an organization; 2. Multi-Agent Systems can provide the unified framework for distributed heterogeneous components which can realize the cooperative problem solving; 3. Multi-Agent Systems techniques can be used to coordinate the interoperability in the different knowledge levels.

Based on our knowledge management research work about the collaborative planning of multi-department, we propose a knowledge

Fig. 1 The knowledge flowing procedure model about 3K+2C mechanism in one cycle of the collaborative task

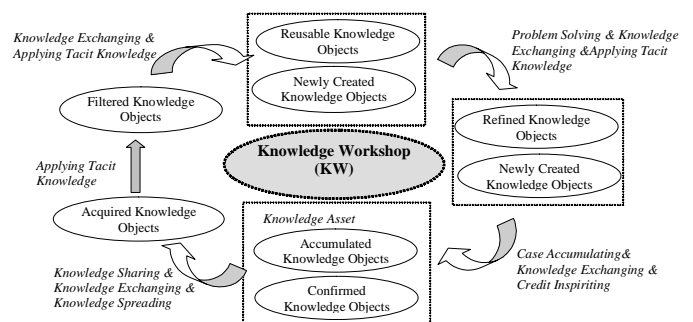
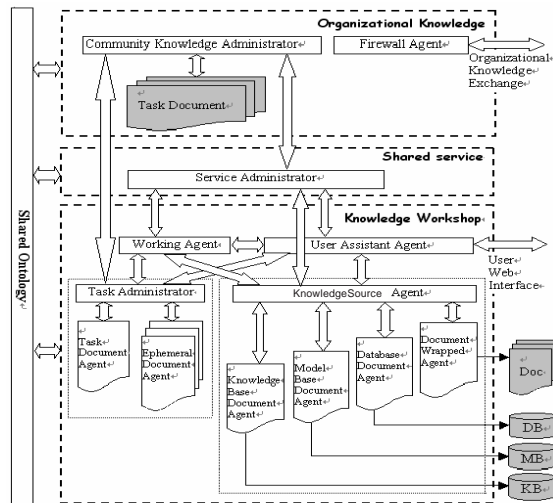


Fig. 2 A knowledge management support framework based on Multiple Intelligent Agents



management support framework based on Multiple Intelligent Agents (shown in fig. 2). In this system, the MAS techniques are required at the following two aspects: on the one hand, the User Assistant Agent can work with Task Administrator Agent and Service Administrator Agent, to choose the correct data, assemble the needed components, provide information to the special user or object in the most suitable way; and on the other hand, the Working Agents and some background agents, which perform the task (i.e. problem solving), can use the distributed objects management, database, workflow, message, transaction, search, index and network capability, to discover, connect, and access the relevant data and service in security. In order to achieve these functions, this paper present a new kind of intelligent agent, named Smart Document Agent (SDA), which has the feature of both the document and agent. SDA cannot only cooperate with the traditional agents to solve the problem, but also manage the special document dynamically with user's interaction.

When the knowledge is stored, on the one hand, depending on the ontology that we can use DAML+OIL ontology modeling language to describe the knowledge, and store it as the documents or knowledge base; on the other hand, we can use Smart Document Agent and other intelligent agent technology to integrate the original knowledge resource in the organization, for example, the user (or agent), profile, program, rule, model, case, data, and so on. Thus the knowledge flow can be guaranteed to run among the different dimensions freely.

The system architecture is made up of following components:

Shared Ontology (SO). It is shared by all the members of the CoP, and provides concepts and relations in the collaborative task domain. SO is composed of three parts: 'a\$domain ontology, which is used to describe external technical knowledge, including the definition of the main concepts and relation between them in the task domain and the description of the property with which the agent can deal; b\$Document ontology, which is used to describe the classification and relationship of the document in which the organization knowledge is stored; c\$Procedure ontology, which is used to model the procedure and plan the task, here a collaborative task plan is described as a cooperative working procedure model. SO is not only used to unify the knowledge communication in the CoP, but also used as the base on which the CoP's members can build the user profile to illuminate the request and answer of the information.

User Assistant Agent (UAA): It takes charge of the interaction between the CoP's members and the system; that is to say, it can understand the user and provide information to user intelligently. Every member of the CoP will be built a User Assistant Agent named with his name. The UAA includes a user interface and a user model. The user interface realizes the simple communication with the user; the user model includes user's preference and a dialog model about the user. UAA

organizes the documents automatically for the user with the help of Task Administrator in the Knowledge Workshop.

Service Administrator(SA): It logs in all information resources that may be used, mainly including Facilitating Agent. When received a request for special information, it searches the information resource, which have logged in, and provides relevant information service.

Task Administrator(TA): It includes two main functionality modules: 'a\$Technology Agent\$ managing the information coded from the external technology knowledge which mainly includes in all Working Agents used to solve problem and relevant knowledge source, just like Document Wrapped Agent, Database Document Agent, Knowledge Base Document Agent, Model Base Document Agent, etc.; b\$Process Agent\$ Managing the information coded from the implicit procedure knowledge, including following agents: the Task Document Agent and the Ephemeral Document Agent.

Community Knowledge Administrator (CKA). It mainly used to manage experience knowledge and evaluation knowledge, such as Confirmed Knowledge Objects and Accumulated Knowledge Objects, accumulated after the collaborative task finished.

5 CONCLUSION

We are now using the multi-Agent supported framework proposed in this paper to develop a prototype of a knowledge management supporting system. This prototype can be used to aid the decision-making in cooperative planning among multiple units. In this prototype system, the CoP members taking part in the cooperative planning can share the Organizational Knowledge. They can realize the cooperative solving with the aid of Multi-Agents and can also learn from the experiences. Now we have already finished the development of dual-natured Smart Document Agent that has both the nature of document and Agent, and have also provided it with the facilities to support the information exchange and cooperative problem solving with Working Agent. This Smart Document Agent can also interact with users to manage specific document dynamically. The Working Agent in this prototype system is developed using multiple intelligent Agents cooperative working platform MBOS. Currently, the User Assistant Agent (UAA) is still under developing, and many functions of Task Agent (TA) are needed to modify.

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FOOTNOTES

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