An architecture of knowledge management system based on agent and ontology

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Abstract

To solve the problems in knowledge management system (KMS), such as information sharing, the ability to extend and re-engineer, and the reusable ability of legacy systems in distributed and heterogeneous environments. This article presents a method based on agent and ontology of designing KMS. This method consists of two agencies. One is knowledge agency with three agents supporting knowledge management process. The other is application agency with three agents supporting knowledge application. In this method, ontology is used to represent the knowledge in knowledge base and the content in the message exchanged among agents. To demonstrate the advantages of this method, experiments have been carried out and the results imply that this method is efficient and effective for small and medium-size enterprises to design KMS.

Keywords KMS, multi-agent system (MAS), ontology

1 Introduction

As the problem of information overload has become more serious, KMS is recognized as a key element in knowledge management. KMS is an application system used in an organization to manage explicit or tacit knowledge as an information communicating platform. KMS is advantageous in enhancing the efficiency of an organization [1].


In software system, the agent means that software component can interact autonomously as a surrogate for its user with its environment and other agents to achieve the predefined goal, and also can react to changes in the environment. As described by Brennan, autonomous agent, cooperative agent and scalable agent are the typical characteristic ones of MAS [6]. A well structured set of concepts is actually able to improve the interoperability and sharing of information among different systems. Such an organization of concepts with respective links, fit to describe a domain of knowledge, is called ontology [7]. Ontology is used in this article to represent the knowledge in knowledge base and the content in the message exchanged among agents [8].

Previous researches pave a fundamental basis for the applications of agent and ontology in KMS. Different to the published studies mentioned earlier, this article mainly concerns the method based on the combination of agent and ontology to design KMS for small- and medium-sized enterprises with the purposes of giving support to each stage of a knowledge life cycle, enhancing the ability to extend and re-engineer and the reusable ability of legacy systems in distributed and heterogeneous environments. The proposed KMS includes two agencies: the knowledge agency for giving support to the knowledge management processes and the application agency for knowledge application.

The remaining sections of this article are organized as follows. In Sect. 2, the architecture of KMS with two agencies is introduced. In Sect. 3, knowledge agency with three agents is presented. In Sect. 4, application agency with three agents is depicted. In Sect. 5, the communication method between agents is given. In Sect. 6, applications of the proposed method are described. Finally, conclusions are presented in Sect. 7.
2 The architecture of KM

The main functions of KMS developed by the authors include two parts: knowledge management and knowledge application. To realize the functions of KMS, it is assumed that each function system consists of one MAS, which includes a mediator and other agents, as Fig. 1 shows.

![Fig. 1 The federated structure](image)

The mediator is responsible for the inner communication of the MAS and the communication with other MASs. The mediator is the coordination agent, the heart of this system, and the controller of the other agents within an application. It can communicate and cooperate with other agents, assign tasks to and receive data from proper agents, and communicate with and provide request data for other mediators. Two agencies are developed: knowledge agency for knowledge management, and application agency for knowledge application, as shown in Fig. 2.

![Fig. 2 The architecture of KMS based on agent and Ontology](image)

As indicated in Fig. 2, the framework of KMS consists of four layers with different functions and two agents (directory facilitator agent (DFA) and management system agent (MSA)). The DFA registers all the data that agents implement in this system, which provides a yellow-page service to the other agents. The MSA provides platform-typical management functions (such as life cycle monitoring, checking of all the entities’ correct behavior, and white pages) [5]. Another component is ontology, which provides a conceptualization of the knowledge domain. Ontology is used herein to represent the content in the messages exchanged among agents.

The first layer comprises users and resources. This layer presents a browser/editor to the knowledge manager, an ontology browser/editor to the ontology manager, and a problem-solving browser to common users for knowledge application [9]. This layer generates a personalized view of its information and presents it to the user on the basis of interface agent of the next layer. Resources contain intellectual assets of the organization, such as groupware, databases, model base and document systems [10].

Interface agent is used to realize communication between users and KMS, provide interface between users and the system, and interpret results for users. It gradually learns how to better assist users by observing and imitating users, understanding user’s interests and needs, and building up user’s profiles and disposition to use KMS. Through this layer, a virtual work environment is created, which enables knowledge management and application [4].

The third layer includes two agencies: knowledge agency for knowledge management, and the application agency for knowledge application. Next, various functions or responsibilities undertaken by each agency are discussed.

Knowledge base stores data either as marked-up flat files or in databases with schemes that are consistent with the domain document type definition (DTD). The knowledge is stored in knowledge base after it is processed by annotation agent. Knowledge should be organized by an appropriate taxonomy for the ease of its retrieval. Thus, ontologically annotated extensible markup language (XML) documents are chosen as data scheme of the knowledge base.

3 Knowledge agency

Knowledge agency is in charge of giving support to the KM processes. It consists of acquisition agent, evaluation agent, and annotation agent, as shown in Fig. 3.

![Fig. 3 Knowledge management based on agent and Ontology](image)

Acquisition agent retrieves, filters, and merges information (data, models etc.) from heterogeneously distributed information sources and acquires knowledge by using different techniques and tools, such as data mining (DM) and online analytical processing (OLAP) [3–4].

Evaluation agent evaluates knowledge, checks whether the knowledge is old, and then decides to delete the old knowledge or not by comparing it with new knowledge, and whether to add new knowledge or to combine both of them [11].

Annotation agent decides a format of the knowledge
obtained and stores the knowledge in knowledge base. There are many different techniques to store knowledge, most of which are related to the retrieval method used. In the architecture proposed in this article, new ontologically annotated XML documents are created and the knowledge in the knowledge base is stored.

Figure 3 shows how knowledge agency realizes the function. This process involves two main phases: the acquisition of knowledge and the storage of knowledge. This process consists of four steps as follows [12]:

**Step 1** Build and implement an ontology, which can be an enterprise-developed ontology or one imported from the external world on which the enterprise members agree.

**Step 2** Generate an annotation DTD from the ontology. The enterprise members must first agree on the format of the XML documents. This leads to the definition of the DTD. The annotation DTD indicates the elements that can be used as ontological annotations in the documents. This annotation lets a document have a semantic value to enable its retrieval.

**Step 3** Acquire and evaluate the knowledge. Acquisition agent can retrieve, filter and acquire knowledge. Evaluation agent evaluates the knowledge.

**Step 4** Create annotated XML documents and store the knowledge. Annotation agent creates new ontologically annotated XML documents and stores the knowledge in the knowledge base. The knowledge worker can also specify appropriate concepts for documents manually.

4 Application agency

The application agency is in charge of giving support to the knowledge application. It consists of translation agent, search agent, and disseminator agent, as shown in Fig. 4.

![Fig. 4 The knowledge application based on agent and ontology](image)

Translation agent recovers information in a user’s query form, translates the user’s request into ontologically annotated XML documents, and sends the documents to search agent [11].

Search agent searches the needed knowledge in the knowledge base by searching the ontological annotations. If the system does not find exact answers, it can seek approximate ones. It can exploit ontology’s concept hierarchy to find an answer corresponding to sub-concepts of the initial request’s concept [3].

Disseminator agent presents the needed knowledge to users through interface agent, presenting different views of the same data, such as a graphical view, a table of contents, or the actual data according to the profile and disposition to use KM system. The presentation of different views can greatly assist user-friendly diffusion of the knowledge among different classes of users.

Figure 4 shows how application agency realizes the function. This process involves two main phases: the searching of knowledge and the presentation of knowledge. This process consists of four steps as follows [12]:

**Step 1** Making a request. The user expresses the request in a browser such as Internet explorer by using the query interface. When a user expresses a request, the query interface lists the concepts of ontology.

**Step 2** Sending the request to search agent. When the user clicks on the search button to confirm the information that the user entered in the query form, translation agent translates this request into ontologically annotated XML documents and sends the requests to the search agent.

**Step 3** Searching for knowledge. The search agent searches the needed knowledge in the knowledge base by searching the ontological annotations.

**Step 4** Presenting the answers to the user. Disseminator agent presents the views of the searched knowledge to the user according to the user’s disposition.

5 The communication

As shown in Fig. 5, to express communication and organize communications between agents, the knowledge query and manipulation language (KQML) is used. The KQML that facilitates the connection between agents is a kind of language and protocol that exchanges information and shares knowledge. The communication between agents must be constituted by a certain network protocol, which in this article is the transmission control protocol/internet protocol (TCP/IP). Common object request broker architecture (CORBA) can help us carry out software bus in application system and enhance reuse ability of sub-systems. Ontology is used to represent the content in the messages exchanged among agents to reduce the conceptual and terminological confusion that often appear among different people and organizations [7]. To realize communication between agents, a communication switch agent (CSA) is developed. An agent sends message to CSA, the CSA wraps the message of KQML to the access format of CORBA message and converts the access format of CORBA to the semantics of KQML.
6 Application study

The proposed architecture is applied to design an e-commerce KMS in a Chinese computer company. Java is used to develop the system and Protégé 2000 developed by Stanford University is used to build the domain ontology. The functional architecture of the e-commerce KMS, as shown in Fig. 6, has five main components: interface agent, ontology, application agency, knowledge agency, and knowledge base. In this application, the authors tried their best to achieve the goal of letting the customer obtain precise information of the products that match information about wanted products for which the customer enters into the system [5,13–15].

![Fig. 6 The e-commerce KMS architecture](image)

The user includes customer, seller, and knowledge manager. Customer can send a request and obtain the results, validate a concrete product based on interface agent for customer and mediator of the application agency. Seller can send a request and retrieve wanted products matching up to customer’s wishes, respond to the request processed by customer, and produce the particular type of product and orders requested by a customer based on interface agent for seller and mediator of the application agency. The knowledge worker can acquire, evaluate and store the knowledge based on interface agent for knowledge worker and mediator of the knowledge agency.

Knowledge base includes product knowledge and customer knowledge, which can be shared by all sellers and customers, and its contents are ontology-dependent. Product knowledge deals with product characteristics, such as product ID, category, technical specifications, functions, application area, manufacturer, quantity, product structure, pricing, etc. Customer knowledge deals with customer’s need, wishes, preference, shopping type, product experience, educational background, etc.

Ontology is used to define a common vocabulary for agents to communicate with one another and explicitly formalize the domain knowledge in e-commerce, such as knowledge about the product, by which the product category is classified. Product ontology, which is in charge of two tasks: communication protocol and enhancing precision of retrieving information, is established as a kind of communication language, which contains the main concepts used by customers to indicate their preferences to the seller, and the ones used by the seller to search the product that customers exactly need. A computer is composed of several elements: monitor, keyboard, mouse, motherboard, CPU etc. And a computer has several attributes: price, trademark, guarantee, etc. The computer ontology segment is shown as follows:

```xml
<owl:Class rdf:ID="CPU">
  <rdfs:subClassOf rdf:resource="#Computer"/>
</owl:Class>
<owl:Class rdf:ID="Motherboard">
  <rdfs:subClassOf rdf:resource="#Computer"/>
</owl:Class>
<owl:DatatypeProperty rdf:ID= "Price">
  <rdfs:domain rdf:resource="#Computer"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID= "Trademark">
  <rdfs:domain rdf:resource="#Computer"/>
</owl:DatatypeProperty>
```

To demonstrate the advantages of this architecture, a series of experiments is carried out to compare the simulation results of a method without agent with those of the proposed method with agent and ontology. These two simulations have the same conditions, algorithm and data. And the architecture is evaluated in terms of the following two indicators. The Recall and the Precision are defined as follows, respectively:

\[
\text{Recall} = \frac{|A \cap B|}{|B|} \times 100\%
\]

\[
\text{Precision} = \frac{|A \cap B|}{|A|} \times 100\%
\]

![Fig. 7 and 8](image)

The Recall and the Precision are based on a reference collection, which consists of a set of testing documents, a set of example queries, and a set of relevant documents chosen by specialists for corresponding queries. Let \( B \) be the set of relevant documents for a given information retrieval request, and \( A \) be the answer set of documents searched by the system. Figures 7 and 8 show that the Recall and the precision of the method with agent and ontology are higher than the one with changes of the key words.
7 Conclusions

As the problem of information overload has become more serious, KMS is increasingly being recognized as a key element in knowledge management. Different to the published studies mentioned earlier, this article is mainly concerned with solving the problems, such as sharing of information, the ability to extend and re-engineer, and the reusable ability of legacy systems in distributed and heterogeneous environments. A method based on agent and ontology is proposed to design KMS, which includes two agencies. To show the advantages of this method, a series of experiments is carried out to compare a method without agent with the proposed method with agent and ontology. The results imply that this article provides a very efficient method based on agent and ontology to design KMS for small- and medium-sized enterprises and solve the problems in KMS.

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References