Fuzzy Knowledge for Agent Oriented Knowledge Management in E-Commerce

Wei long Liu [1,2],
[1] School of Economic Management, Shandong Normal University, Jinan, P.R.China, 250014
weilongliu@gmail.com

Xin Zhang [2],
[2] School of Information Management, Shandong Economic University, Jinan, P.R.China, 250014
zh-xin@sdie.edu.cn

Fang Jin [3]
[3] Institute of Mathematic and Economic, Shandong Economic University, Jinan, P.R.China, 250014
Jinfang621@tom.com

Abstract

Knowledge management plays important role for personalized service in e-commerce. However, the incompleteness of knowledge has degraded knowledge collaboration in the context of e-commerce. This paper has addressed issues of knowledge acquisition for servicing user with needed information and product through agent technology and fuzzy ontology. Seller agent and buyer agent was constructed in this paper, which solve knowledge acquisition and utilization. In the end, the framework of knowledge management has been implemented to cut out knowledge application, and validation of the framework was verified by related empirical data.

Keywords: agent, Knowledge management, e-commerce, fuzzy ontology

1. Introduction

Owing to its immense and growing influence on all parts of the market and the commercial organizations within it, knowledge management (KM) has become of the primary focuses of management science [1]. As contrasted to other managed resources such as assets, capital and people, knowledge is characterized by perpetual regeneration: the more often knowledge is used, the more knowledge is produced. Increasingly, companies have come to view knowledge as a resource ever more critical to their success. Knowledge management is generally comprised of three main functions [2]: (1) Knowledge creation, which encompasses the further sub-processes of acquisition, storage, validation, processing of new knowledge and integration with existing knowledge. (2) Knowledge transfer, which addresses the questions of how, what, when, to whom, in what form and to what purpose knowledge is delivered; and (3) Knowledge application, which defines the mechanisms by which knowledge is employed.

The most important step of these knowledge management functions is the complete corporate knowledge acquisition, which is the prerequisite of knowledge transfer and application. How this knowledge is acquired, it must turn to many ways: technological, human-oriented or behavioral.

In e-commerce the primary medium of knowledge acquisition is the computer; this fundamental difference raises many issues in the knowledge management in the domain of e-commerce.

Agent and fuzzy ontology, synergy of artificial intelligence (AI) technology and social behavior, provide a chance for addressing challenges in KM in e-commerce.

In this paper, we organize as follows. The next section introduces relationship between KM and e-commerce, with emphasis on challenges of KM in e-commerce and sources of uncertainties. Third section clarifies the agent technology, fuzzy ontology and their roles of KM in e-commerce. Section four constructs the framework of agent-based KM application in e-commerce, and is detailed with components of this application.

2.E-commerce and knowledge management

Electronic commerce is the process of electronically conducting arbitrary forms of business between entities in order to achieve the organization's objectives [3].

2.1 Knowledge management

The definition of knowledge management has different brands. Of these, some focus on knowledge sharing among individuals or organizations. Some

978-0-7695-3305-6/08 $25.00 © 2008 IEEE
DOI 10.1109/FSKD.2008.533

emphasize use of technology to capture, manipulate, and locate knowledge, which is synonymous with information management. Others focus on knowledge utilization to improve enterprise's efficiency and effectiveness. Still others center on intellectual capital to enhance the enterprise's economic value.

One reason of different definitions for knowledge management is rooted in different academic disciplines and areas of professional expertise. Wiig [4] sorted knowledge management practices into four categories: people-centric, information management & IT focus, intellectual capital focus and enterprise's efficiency and effectiveness. Other reason is that alternative perspectives on knowledge devoted to different perceptions of KM [5]. Knowledge may be viewed from several perspectives (1) a state of mind, (2) an object, (3) a process, (4) a condition of having access to information, or (5) a capability. If knowledge is viewed as an object, or is equated with information access, then knowledge management should be similar to information management. If knowledge is a process, then the implied knowledge management focus is on knowledge flow and the processes of creation, sharing, and distribution of knowledge. The view of knowledge as a capability suggests a knowledge management perspective centered on building core competencies.

2.2 Knowledge management in e-commerce

Knowledge management is a prerequisite for e-commerce and its increasing customer centric focus. To operate in e-commerce environment, an organization has to have good command of knowledge on its markets, customers, products and services, methods and processes, competitors, employee skills and its regulatory environment.

When observing the traditional deals from a knowledge perspective, we must draw on knowledge about products, customers and sale process to complete trading transactions. To effectively manage the organizational knowledge, we argue that knowledge related to products and customer behavior must be retained in the corporation's knowledge base. Then during the communication between the customer and seller, the seller makes recommendation based on stored knowledge.

Knowledge management in the context of e-commerce will face up to many challenges for complex and dynamic business environment. Dynamic uncertainties mainly come from virtual trading place and customer. Tab.1 specially illustrates sources of uncertainty.

Tab.1 illustration for sources of uncertainties

Source of dynamic change	Types of Uncertainties
Virtual trading place	Uncertainties in stock
	Uncertainties in goods and service sold
	Prices Uncertainties
	Uncertainties in the amount of information to be present in a transaction or a dialog
	Uncertainties in store ownerships, e.g. merging or acquisition between stores
	Uncertainties in business model, business practices and policies
Customer	Uncertainties from customer different interest and preference of different brands
	Uncertainties from global customer with different background, e.g. cultural, educational
	Uncertainties in role played in making purchase decisions, e.g. decision maker or influencer

Other particular emphasis is given to the challenge in an e-commerce context is that the knowledge gap between the buyer side and the seller side. Typically, buyer possesses the full knowledge about products, in which knowledge is about product properties, technical specification, application area, product structure, pricing, etc. On the other hand, the customer is the one who possesses the customer knowledge, in which knowledge is about customer's need, wishes, preference, shopping type, product experience, educational background, etc. This leads to so-called knowledge gap that must be bridged during the sale process [3].

These above- mentioned challenges are at individual level in KM in e-commerce. At an organizational level, KM must supports different organizational processes with different business models and cultural environments to be integrated, transparent and traceable. Moreover, several business processes will transcend the boundaries of the organization, as electronic links to distributors, suppliers and other partners make the organization an extended, networked enterprise. These firstly result in the problem of difficultly converting information into knowledge: different organizational setting and therefore different sets of tacit knowledge. On the other hand, the problem is that different cultures have different mental models of collaboration or trust. Collaboration and trust in KM are critical success factors for knowledge sharing and use.

3. Agent technologies and fuzzy ontology

3.1 Agent technology

To deal with changing environment and social interaction in KM in the context of electronic commerce, we believe that agent technology [6] is an appropriate technology to design a kind of KM tool.

Applying agent technology to the development of KM tool is quite natural given the level of sophistication of software agents today. Ludger van Elst et al. [7] clarified how agent technology meets the KM requirement for definition of agents (with the defined features autonomy, social ability, reactive behavior, and proactive behavior). E-commerce has been among the domains where agent plays the most important role ranging from "search agents" to "auction-agents". Kasbah created at MIT for C2C and recommender system Firefly based on collaborative filtering [8-9] provided good quality searching service of requested goods. Multiple references can be found in [10], [11] and [12]. These applications modeled negotiation between buyers and sellers in e-commerce using a group of agents, in which a group of agents will come to a mutually acceptable agreement on some matter (e.g. price).

Most of applications of the agent technology to e-commerce have been center on the buyers in the process of searching, auctioning and price negotiations. In this paper, we are concerned with knowledge capture for personalization of interaction between on-line shop and a customer, and use shared ontology for sales process, where agents agree on the meaning of concepts defined in the ontology.

3.2 Fuzzy ontology of customer need

Ontology is a formal explicit description of concepts in a domain of discourse [13], and defines classes (sometimes called concepts), properties of each concept describing various features and attributes of the concept (sometimes called roles or properties), and rules (sometimes called role restrictions). Ontology together with a set of individual instances of classes constitutes a knowledge base.

Fuzzy ontology augments standard ontology with fuzzy information about the domain. A Fuzzy ontology (PO) [12] is an explicit, formal knowledge representation that expresses knowledge about a domain of application. This includes:

- ▪Types of entities that exist in the domain;
- ▪Properties of those entities;
- ▪Relationships among entities;
- ▪Processes and events that happen with those entities;
- ▪Statistical regularities that characterize the domain;

Where POs are used for the purpose of comprehensively describing knowledge about a domain and the uncertainty associated with that knowledge in a principled, structured and sharable way, ideally in a format that can be read and processed by a computer. They also expand the possibilities of standard ontology by providing a means of representing the statistical regularities and the uncertain evidence about entities, which uses fuzzy relations between components of the ontology in order to preserve a common structure. The concept is presented in the e-commerce domain.

In this paper, we use ontology to define a common vocabulary for agents to communicate with one another, and to explicitly formalize the domain knowledge in e-commerce, especially knowledge about the product and sale process, by which the product category is classified with fuzzy relationship.

4. Framework of fuzzy knowledge for agent–based knowledge management in e-commerce

4.1 The framework of the system

The system architecture, which is shown in Fig.1, has five principal interconnected components. The most important component is JADE, which is FIPA (Foundation for Intelligent Physical Agents) compliant agents platform. These agents implement in this application get registered in the Directory Facilitator (DF), which provides a yellow pages service to the other agents, and the Agent Management System (AMS), which provides platform-typical management functions (such as life cycle monitoring, checking of all the entities' correct behavior and white pages).

The second component is the database: Product DB and User DB. Product DB can be shared by all seller agents, which store products characteristics, such as ProductID, category, functions, manufacturer, quantity etc. This database contents are ontology-dependent. User DB's information are extracted from user explicitly entering data by filling forms or answering questionnaires and tracking user browsing behavior and legacy data (e.g. transactions and browsing logs, purchase history).

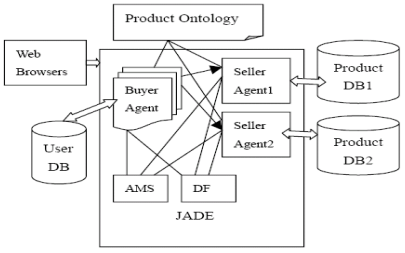

Fig.1 Conceptual framework of agent-based knowledge management in e-commerce

The third component is two types of agent: buyer agent and seller agent. The buyer agent functions include getting user request, processing them and returning the obtained results. Regarding the seller agent, it responds to request processed by buyer agent and produces result of a particular type product and orders requested by users.

Another important component is the product ontology. The ontology, which is developed by Protégé 2000, is saved in OWL file and represent the specific relevant domain knowledge we are dealing with, constructing a common set of terms (concept) that allows different types of agent to communicate one another.

The last component is the user interface, in which user interacts with the system, such as registering to the system and filling the form about user information, browsing pages and commenting products, which is implemented by JSP.

In the following paragraphs, three of these components are detailed more precisely.

4.2 The buyer agents and the seller agents

The buyer agent processes user request and validates a concrete product, as well as assists in gathering and using of the user information. For example, a first-time user who is registering into system can provide it with some personal information. At this stage, agent makes decision to choose product mainly according to user first input.

The seller agent is in charge of receiving processed request from different buyer agents. Through communication protocol defined in the product ontology, the seller agent knows user needs, and retrieves wanted products matching up with customer wishes.

In this application, the seller agent is responsible for communication with buyer agent and retrieves product from database. In these operations, the product ontology carries two tasks: communication protocol and enhancing retrieving precision.

4.3 Product ontology

In order to maintain a conversation, agents must have a common language. The product ontology is established as a kind of communication language, which contains the main concepts owning to the domain we are dealing with.

These concepts are the ones the buyer agent utilizes to indicate the customer's preferences to the seller agent, and the ones the seller agent utilize to search exact product.

A product ontology related to the computer product is shown in Fig.2. This ontology shows how a computer is composed of by several elements: monitor, keyboard, mouse, motherboard, CPU, etc. (Fig.2)

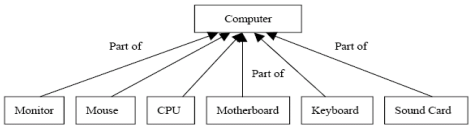

Fig.2 Segment of computer ontology

It also generates an OWL file with designed ontology's description. Fig.3 shows the segment of computer ontology in OWL Lite format with a membership implemented by Protégé 2000, which is compatible with JADE platform.

```
<owl:Class rdf:ID="Motherboard">
  <rdfs:subClassOf rdf:resource="#Computer"/>
</owl:Class>
<owl:Class rdf:ID="SoundCard">
  <rdfs:subClassOf rdf:resource="#Computer"/>
</owl:Class>
<owl:Class rdf:ID="Keyboard">
  <rdfs:subClassOf rdf:resource="#Computer"/>
</owl:Class>
<owl:DatatypeProperty rdf:ID="guaranty">
  <rdfs:domain rdf:resource="#Computer"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="price">
  <rdfs:domain rdf:resource="#Computer"/>
</owl:DatatypeProperty>
<mem:hasmembershipValue>0.7</mem:hasmembership
Value>
```

Fig.3. Segment of computer ontology in OWL with membership for customer

Fuzzy information (e.g., relationship between product demand and supply, delivery time, etc.) is an important part of the information that needs to be communicated between partners in e-commerce. Unfortunately, traditional ontology formalisms have no consistent support for uncertainty, thus providing no means of ensuring semantic consistency with respect to issues of uncertainty or data quality.

4.4 Algorithm for formation of fuzzy customer demands' ontology

Fuzzy classification decision tree learning algorithm [14] (Fig.4) is a top-down multilevel ontology (concept hierarchy) guided search in a hypothesis space of decision trees. Recall that the decision tree algorithm recursively selects at each step, an attribute from a set of candidate attributes based on an information gain ratio criterion and membership between concepts. A set of candidate attributes to choose from for growing the tree rooted at that node. In our case, each attribute has associated with a hierarchically structured taxonomy in which there are many possible values of the attribute. Thus, the learning algorithm has to choose not just a particular attribute, but also an

appropriate level of abstraction in the taxonomy. To facilitate description of FCDT learning algorithm, we assume the following notations: A={A1, μ 1 ， A2, μ 2…, An, μ n} is an ordered sequence of attribute names. C={C1, μ 1, C2, μ 2, Cm, μ m} is a set of mutually disjoint class labels (target attributes), P={p1,p2..pi.., pn} is a pointer vector where pi is concept (in fact, is attribute) in taxonomy, let S be a training data.

```
CDT algorithm:
Function ODT (S, A, C,P)
Create a root node for the tree;
Initialize root;
If S =empty, return a single node with value failure;
If S=C,return a single node with C;
If P is empty return a single node with most freqent of C;
Else
Begin
Let D be the attribute with largest Gain_Ratio(D,S) among attributes in P;
Let {djj=1,2,3…n} be the values of attribute D;
Let {Sjj=1,2,3…n} be the subsets of of S consisting respectively of instances of value dj for attribute D;
Return a tree with root labeled D, arcs labeled d1, d2,..dn respectively to the tree;
If S=empty , add a new branch with most frequent C for each branch in the tree
Else
For each value dj in D
update the Pointer Vector P to Pj by substituting pj for dj;
construct the subtree by calling CDT(Si,A,C, P);
End Function
Return Root;
```

Fig.4 Fuzzy classification decision tree learning algorithm (FCDT)

FCDT learning algorithm is based on high-level abstraction using domain ontology and is able to induce multi-level classification rules. For instance, it may uncover fuzzy relationships between very general concepts (high abstract attributes) and those at lower levels of generality.

5. Conclusions

This paper focuses on the ways in which the new context of electronic commerce creates business opportunities for the provider of intelligent technology (agent technology) to support knowledge management.

We address core issue of customer knowledge acquisition by agent technology. The buyer agent, as a product experience tool, interacts with customer and refines customer real needs, and also constructs a product experience model (user model) for every customer. The seller agent can precisely retrieves product matching up with customer fuzzy needs for the product.

The result from this paper is that agent technology is the best choice to address KM with fuzzy knowledge in the context of e-commerce.

References

[1] Nonaka and H. Takeuchi. The Knowledge Creating Company. Oxford University Press, New York, 1995.

[2] Minor Gordon‡, Janina Jakubczyc, Violetta Galant, Marcin Paprzycki. Knowledge Management in an E-commerce System. http://mpaprzycki.swps.edu.pl/mp/cvr/ research/ICECR5_2002.pdf.

[3] Noy, N.F., Musen, M.A.: The PROMPT Suite: Interactive Tools For Ontology Merging And Mapping. Int. J. Hum-Comput. Stud. 59(6) (2003) pp.983-1024

[4] Karl M.Wiig. Knowledge Management: An Emerging Discipline Rooted in a Long History. http:// emarkets.grm. hia.no/gem/Topic7/KM-Emerg_Discipl.pdf.

[5] Maryam Alavi, Dorothy E. Leidner. Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. http://www.cs.kent.ac.uk/teaching/03/modules/CO/6/06/material/rec/AlaviLeidnerKM.pdf.

[6] AV Smirnov, M Pashkin, N Chilov. Agent-based support of mass customization for corporate knowledge management. Engineering Applications of Artificial Intelligence, 16(2003),349-364.

[7] Ludger van Elst1, Virginia Dignum2, Andreas Abecker. Towards Agent-Mediated Knowledge Management. http://www.dfki.uni-kl.de/~elst/papers/LNAI29260001.pdf.

[8] A. Chavez and P. Maes. Kasbah: An agent marketplace for buying and selling goods. First International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology,(1996).

[9] Martin Svensson , et.al. A Recipe Based On-line Food Store. http://lieber.www.media.mit.edu/people/lieber/IUI/Svensson/ Svensson.pdf.

[10] Bock, J. Ontology Merging using Answer Set Programming and WordNet. Honours Thesis, Griffith University (October 2006)

[11] G. de Paula, F. Ramos, G. Ramalho. Bilateral Negotiation Model for Agent-Mediated Electronic Commerce. Third Workshop on Agent-Mediated Electronic Commerce; (2001),1—14.

[12] Valentina Tammaa, Steve Phelpsa, Ian Dickinsonb, Michael Wooldridge. Ontologies for supporting negotiation in e-commerce. Engineering Applications of Artificial Intelligence 18 (2005) 223–236.

[13] Natalya F. Noy , Deborah L. McGuinness. Ontology Development 101. http://www.ksl.stanford.edu/people/dlm/.

[14] Zhang xin, Liu weilong.Improving Recommender System by Using Ontology.The Fifth Wuhan International Conference on E-Business(2006). P.R.C. p1266-1271.