Case-Based Reasoning and Multi-Agent Systems in Support of Tacit Knowledge

Ali R. Montazemi
Michle G. DeGroote School of Business
McMaster University
Hamilton, ON L8S 4M4, Canada
montazem@mcmaster.ca

Abstract

Organizations increasingly need to maintain and share the knowledge of their employees. There are two types of organizational knowledge: product-specific knowledge and skill-specific knowledge. Product-specific knowledge is well known and can be documented in many forms (e.g., user manuals, maintenance manuals, expert systems, and standalone case-based reasoning systems). However, skill-specific knowledge is acquired by the knowledge-workers through experience. The objective of this research is to present a framework in support of sharing knowledge among knowledge-workers. This framework makes use of multi-agent systems to retrieve information from a set of heterogeneous case libraries.

Introduction

Organizations support creative individuals and/or provide context for them to create knowledge (Nonaka and Takeuchi 1995). Organizational knowledge creation, therefore, should be understood as a process that "organizationally" amplifies the knowledge created by individuals and crystallizes it as part of the knowledge network of the organization. This process takes place within an expanding "community of interaction" which crosses intra- and inter-organizational levels and boundaries. Knowledge may be enjoyed as a speculative diversion, but it is needed for decision making. The genesis of ideas and the authentication of knowledge are part of a continuos process which ultimately brings knowledge to bear on decision – when the organizational environment is working ideally. In real life, the process may fail to bring knowledge to bear, when required knowledge is somewhere in the organization. What matters, then, is the knowledge actually used at the decision-making point, not the knowledge in the process of development or authentication, nor even the knowledge clearly apparent to particular individuals in the organization (Montazemi et. al. 1996). In addition, knowledge is usually the property of individual decision makers in the organizations and when they leave their experience is lost by the organization at a great cost. This cost becomes particularly significant for the organizations that produce knowledge intensive products. To ameliorate this dilemma, knowledge management has become a central theme in today's business literature and a common cited source of competitive advantage. The consensus is that effective knowledge management requires reengineering organizational processes for optimal flow of information and knowledge within organization with the support of information technology. To this end, a variety of information technologies such as enterprise resource planning (ERP) and knowledge-based systems have been adopted by the organizations to better utilize organizational knowledge resources.

Enterprise resource planning systems, adopted in recent years by large and medium size firms, is defined as a strategic business solution that integrates all the business functions, including manufacturing, finance and distribution (Davenport 1993). ERP systems encompass traditional transaction processing systems as well as non-transaction-based systems such as data warehouse and

supply chain optimization. Such integrated systems improve management of information resources and enable decision-makers to better access required information across the organization. ERP systems are in support of explicit knowledge (i.e., knowledge that is transmittable in formal and systematic language). However, a considerable portion of organizational knowledge can be categorized as tacit (Kitano and Shimazu 1996). Tacit knowledge is personal, context-specific, and therefore hard to formalize and communicate (Davenport and Prusak 1997). Knowledge-based systems (KBS) can be used in support of tacit knowledge. The objective of this paper is to present a framework for sharing tacit knowledge among knowledge-workers. The framework makes use of multi-agent system for the retrieval of information from heterogeneous case libraries.

KBS in Support of Tacit Knowledge

KBS deployed by the organizations have delivered a great array of benefits, including (Hayes-Roth and Jacobstein 1994):

- Order-of-magnitude increases in speed of complex-task accomplishment
- Decreased personnel required
- Reduced training time
- Improved decisions
- Retention of volatile or portable knowledge
- Improved customer service

There are a variety of techniques that can be employed towards development of KBS. However, our focus in this paper is on case-based reasoning (CBR) systems that are particularly suitable in support of tacit knowledge (Dieng et. al. 1998; Montazemi and Gupta 1997). A CBR system supports decision-makers when solving new decision problems on the basis of past experience (i.e., previous cases). To assist a decision-maker, the process followed by a CBR system is as follows: a previous case (or cases) similar to the new decision problem (new case) is (are) retrieved; the solution of the previous case is mapped as a solution for the new case; the mapped solution is adapted to account for the differences between the new case and the previous case; and the adapted solution is then evaluated against hypothetical situations (Aamodt and Plaza 1994; Gupta and Montazemi 1997; Montazemi and Gupta, 1996). To aid in future decision making, feedback of the success or failure of the evaluated solution is obtained from the decision maker (Montazemi and Gupta 1997). Thus CBR make it possible to capture and reuse tacit knowledge in form of case management.

CBR systems have been adopted successfully in support of complex decision problems within a variety of decision environments (Leak 1996). These CBR systems are generally developed in support of specific task domain with little ability to share their reasoning processes among other related decision domains. In fact, this deficiency has been cited to exist for KBS (Hayes-Roth 1997). For example, a diagnostic CBR system for repair of AC-Motors is unable to assist a designer with the design of a new AC-Motor. Obviously, inability to share embedded knowledge among different types of knowledge workers reduces the value of CBR systems in the context of organizational knowledge management. To ameliorate this problem, we are working on an adaptive CBR architecture that makes use of multiagent systems in support of accessing required information by different types of decision-makers.

Multiagent Interface

Interaction with a computerized system is essentially a dialogue between the user and the system that allows completion of a user's task. The dialogue depends on the task domain, the mode of interaction, and user's goals. Agents perform tasks on behalf of the user to enhance the human computer dialogue.

An agent is considered to be adaptive when it uses knowledge and conditions in the environment to determine its actions. Two types of knowledge are needed to determine the actions: (1) domain knowledge, and (2) user knowledge. Domain knowledge is needed to perform actions in a particular domain, and user knowledge is needed to adapt the actions to differences among individual users. For example, the task of an adaptive agent to retrieve applicable cases would be to assist decision makers describe new cases by recommending relevant descriptors. And the task of an adaptive agent to present the retrieved cases to the decision-maker would be to select the pertinent part of the previous cases and use that as a base for recommending solution in support of solving the new problem (new case). Application of the adaptive interface agents to define a decision problem and recommending solutions has been proved to be useful for a standalone decision problems (e.g., decision-makers required to diagnose and repair AC Motors). The challenge is to extend access and use of CBR systems by decision-makers with diverse needs and backgrounds (Plaza, Arcos and Martin 1997). This challenge can be handled by means of multiagent systems (MASs).

Research in MASs is concerned with the study, behavior, and construction of a collection of autonomous agents that interact with each other and their environments. MAS can be defined as a loosely coupled network of problem solvers that interact to solve problems that are beyond the individual capabilities or knowledge of each problem solver. These problem solvers, often called agents, are autonomous and can be heterogeneous in nature (Sycara, 1998). The characteristics of MASs are that (1) each agent has incomplete information or capabilities for solving the problem and, thus, has a limited viewpoint; (2) data are decentralized; and (3) computation is asynchronous. Multiagent systems (MASs) offer modularity. If a problem domain is particularly complex, large, or unpredictable, then the only way it can reasonably be addressed is to develop a number of functionally specific and nearly modular components (agents) that are specialized at solving a particular problem aspect (Sycara, 1998). This decomposition allows each agent to use the most appropriate paradigm for solving its particular problem. When interdependent problems arise, the agents in the system must coordinate with one another to ensure that interdependencies are properly managed. This methodology can be adopted in accessing embedded knowledge from different domain-specific case-bases.

Multi-CBR Systems

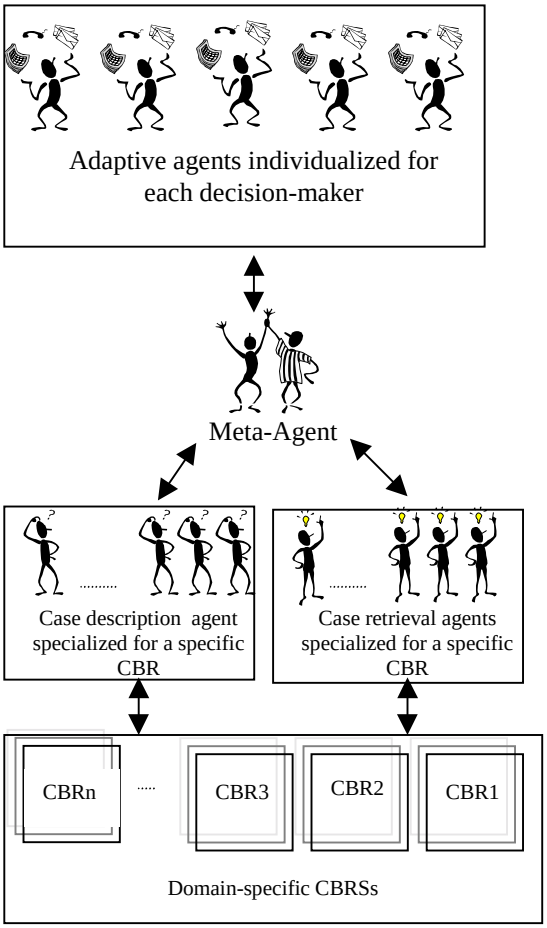
The overview of the multiagent multi-CBR system that we are developing is depicted in Figure 1. The components of this system are as follows.

- User-agent is responsible for learning the subjective preference of the decision-maker. Probabilistic cognitive map methodology will be used in the development of this agent.
- Case-description agent is specialized in the structural relationship among descriptors of each case-base and work with the user-agent to improve selection of pertinent information in previous cases. A probabilistic semantic net will be used in the development of this agent.
- Case-retrieval agent uses the retrieved information to prepare a report and explain findings (new case versus previous matched cases).
- Meta-agent is responsible to plan execution of action among different agents to fulfill the information requirements of the decision-maker as much as possible.

- Case library of CBR systems are domain specific. Object oriented methodology is used to enable access to parts of a case

pertinent to the needs of individual decision-maker.

Figure 1
MASs in Support of Multi-CBR



Concluding Remarks

Tacit knowledge is believed to be context specific and based on the decision-makers' experience and cognition. This paper proposes a framework to make use of multi-agent systems and case-based reasoning systems to manage tacit knowledge. The significance of this framework will be assessed through an empirical investigation.

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