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Multiagent Brokerage with CBR

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Abstract

This paper classifies multiagent-based e-commerce into multiagent-based auction, multiagent-based mediation and multiagent-based brokerage and gives a brief survey of related works in each. The paper proposes a framework of CMB, a CBR system for multiagent brokerage, which integrates CBR, intelligent agents and brokerage, in which we also propose a knowledge-based model for CBR. The key insight is that an efficient way for applying CBR in e-commerce is through intelligent agents or multiagent systems, and the work of a human broker should be done by a few intelligent agents in a cooperative way. This approach will facilitate research and development of CBR in multiagent e-commerce.

Keywords

e-commerce, auction, brokerage, multiagent system (MAS), case-based reasoning (CBR)

INTRODUCTION

The revolution of the Internet and the WWW has changed traditional commercial activities such as shopping, brokerage, negotiation and retailing. Customers can purchase a large selection of merchandise items from an ever- increasing number of Internet stores (Liang and Donng 2000). Basically speaking, there are two forms of e- commerce applications (Cunningham 1999): ones that simply put existing products and means of selling online, and others that create new ways of selling online using intelligent techniques. The first category is a natural mapping from traditional commerce, while the latter can be considered as an intelligent transformation from traditional commerce to intelligent e-commerce, which involves the birth of new business processes made possible by the Internet and new technology to make it successful. Applying intelligent agents and CBR (case-based reasoning) in e-commerce belongs to the latter category.

Applying intelligent agents or multiagent systems in e-commerce can be considered as multiagent-based e-commerce, which has been among the most rapidly growing areas of research and development in information technology in the last few years. For example, there are a number of studies on multiagent-based auctions (Zhang and Wong 2000), brokering (Sun and Finnie 1999), negotiation, mediation (Moukas et al 2000) and the bargaining process (Finnie et al 1999).

CBR potentially has a large role to play in facilitating e-commerce, because it is experience-based reasoning, which has played an important role in business. For example, CBR systems have achieved practical success in customer support, sales support (Wilke et al 1998), and help desk operations. CBR has also been used in multiagent auction and negotiation (Matos and Sierra 1999, Zhang and Wong 2000). However, applying CBR in multiagent e-commerce is still in its infancy, although there are some studies on CBR in multiagent negotiation and auction (Zhang and Wong 2000). To our knowledge, there are no studies on applying CBR in multiagent brokerage. This paper first classifies multiagent-based e-commerce into multiagent-based auction, multiagent-based mediation and multiagent-based brokerage[1] and gives a brief survey of related works in each. Then the paper proposes a framework of CMB, a CBR system for multiagent brokerage, which integrates CBR, intelligent agents and brokerages. The main idea behind it is that an efficient way for applying CBR in e-commerce is through intelligent agents or multiagent systems. Further the work of human brokers such as searching for information for customers, matchmaking and bargaining should be done by a few intelligent agents within a MAS (multiagent system) in a cooperative way. This approach will facilitate research and development of CBR in multiagent e-commerce.

1. For brevity, we use “multiagent” instead of “multiagent-based.”

MULTIAGENT E-COMMERCE

Just as human agents have played a critical role in traditional commerce, as the software counterpart of human agents, intelligent agents or multiagent systems will also be playing an important role in e-commerce. Multiagent e-commerce is any attempt to apply agents or multiagent systems technology to e-commerce. Recently, multiagent e-commerce has drawn increasing attention, promising a revolution in the way we conduct some of the most important activities in traditional commerce: negotiation, auction, mediation, and brokerage. Auction-based e-commerce, mediation-based e-commerce, and brokerage-based e-commerce can be considered as the important aspects of intelligent e-commerce systems. All three involve AI technologies. How to use intelligent agents and multiagent systems in auction-based e-commerce, brokerage-based e-commerce and mediation-based e- commerce has become a central issue in multiagent-based e-commerce, which are respectively realized by multiagent auction systems, multiagent mediation systems and multiagent brokerage systems. All these systems can be considered a specialisation of multiagent negotiation systems, as shown in Figure 1.

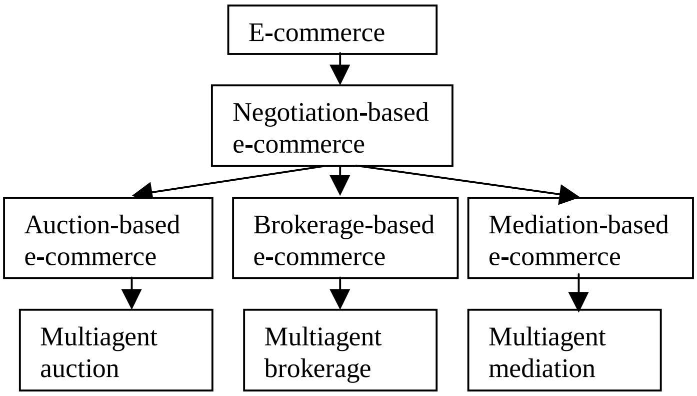

Figure 1: Multiagent e-commerce

MULTIAGENT NEGOTIATION

Negotiation in e-commerce is a process by which two or more parties multilaterally bargain resources for mutual intended gain, using the tools and techniques of e- commerce (Bichler and Segev 1999). Negotiation basically consists of a negotiation protocol, negotiation strategies and negotiation processing[2]. While negotiation protocol comprises the rules (i.e. legitimate actions) of the negotiation, negotiation strategies define how to win the negotiation.

There are four dimensions that affect the design and operation of a multiagent negotiation system: ability of negotiation agents, autonomy of agents, number of parties (agents) involved, and the number of issues negotiated (Adam et al 1999). The dimensions of the ability of negotiation agents range from no bargaining to bargaining for everything. Autonomy of agents could range from full autonomy where the agent conducts the negotiation without any human intervention to an advisor system that operates in a helper mode to a human negotiator. The negotiation process can involve only two parties (e.g. buyer and seller) or multiple parties (e.g. buyer, seller, and broker). In terms of the number of issues, negotiations can vary from single issue (e.g. price) to multiple issues (e.g. integration bargaining).

In the buying and selling environment, negotiation agents need to manage their own negotiation strategies during the whole negotiation process. Current e-commerce trading systems which look at e-negotiation usually use a lot of predefined negotiation strategies (Guttman et al 1998, Maes et al 1999). For example, Kasbah assists the negotiations between buyer and seller by providing agents that can autonomously negotiate and make the best possible deal on the user's behalf and allows the agents to use predefined negotiation (anxious, cool-headed and frugal) strategies in the generation of offers/counter-offers. The user needs to decide which negotiation strategy his agent should follow during negotiation.

There are two different types of negotiation: distributive negotiation and integrative negotiation (Guttman and Maes 1998). The latter is the decision-making process of resolving a conflict involving two or more parties over

2. Sun, Z. (2000) Towards Understanding CBR and Intelligent Agents in E-commerce, seminar presentation at School of Information Technology, Bond university, Australia.

multiple interdependent, but non-mutually exclusive goals. In essence, integrative negotiation is a "win-win" type of negotiation, while distributive negotiation is a "win-lose" type of negotiation. From a merchant's perspective, integrative negotiation is about tailoring its offerings to each customer's individual needs resulting in greater customer satisfaction. From a customer's perspective, integrative negotiation is about conversing with retailers to help compare merchant offerings across their full range of value resulting in mutually rewarding and troublefree shopping experiences. Therefore, an integrative negotiation through the space of merchant offerings can help maximize goals of consumer-owned shopping agents and merchant-owned sales agents across each product's full range of value.

Multiagent negotiation is one of the main research activities in multiagent e-commerce (Matos and Sierra 1999, Zhang and Wong 2000), because negotiation is the common basis for auction, mediation and brokerage in commerce. In what follows we examine auction, mediation and brokerage with MAS.

MULTIAGENT-BASED AUCTION

Auction is a trade type that involves a seller (agent), many potential buyers (or buyer agents), and an auctioneer governing the auction (Jung and Jo 1999). The seller basically doesn't participate in auctioning but tells the auctioneer what the reserved price of the product is. The buyers bid sequentially to compete for the product to be sold. The main auction rule is that a bid is required to be higher than the last bid. During the final stage of the auction, the auctioneer indicates that he is willing to accept the highest bid. The highest bidder expresses his wish to accept the auctioneer's offer (Rakotonirainy 2000).

The dramatic development of the Internet has led to a plethora of e-auctions on the Internet, which offer integration of the bidding process with contracting, payments and delivery (Timmers 1999). The sources of income for the auction provider are in selling the technology platform, in transaction fees and in advertising. Benefits for suppliers and buyers are increased efficiency and time savings, no need for physical transport until the deal has been established.

E-Auction can be improved using MAS (multiagent system) techniques, that is, a set of user agents subscribed to an e-auction web-site forms a community. A set of trade-objects are published for sale by e-auction (Rakotonirainy 2000). A subcommunity is formed when (1) a vendor offers a trade-object with a reserved price, and (2) an auctioneer takes charge of the offer and sets the auction rules.

Once the two roles (i.e. vendor, auctioneer) are fulfilled, the auctioneer opens the auction and bidders can start bidding, as shown in Fig. 2. Examples for multiagent auction are ONSALE® and AuctionBot.

ONSALE® is an e-auction site where people submit bids on products according to the rules of the auction (Whitaker 1999). There is an opportunity for intelligent agents to participate in these e-auctions. Prototype marketplaces have been developed where potential buyer agents compete against each other using game theoretic strategies to outwit the other bidders.

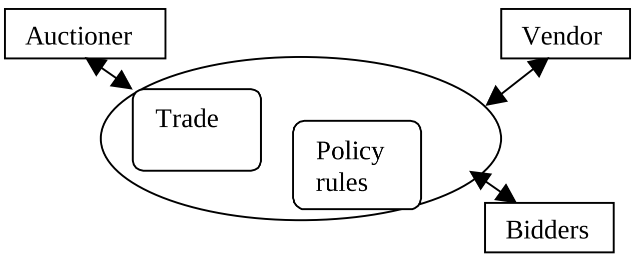

Figure 2: E-auction environment after Rakotoniriny (2000)

AuctionBot is a general-purpose e-auction server (Maes et al 1999). Its users create new auctions by choosing from a selection of auction types and then specifying its parameters such as clearing times and method for resolving tie bids. Buyers and sellers can then bid according to the auction's multilateral distributive negotiation protocols.

MULTIAGENT-BASED MEDIATION

Having an independent intermediary mediating the interests of two opponents (e.g. buyers and sellers) is a common setting in real life business interactions. For e-business to business cooperation, mediation is even more important (Fankhauser and Tesch 1999). Mediators, as special intelligent agents, have been proposed to optimise the whole buying experience and revolutionize commerce (Moukas et al 2000). The personalized, continuously running, autonomous nature of agents make them well-suited for mediating consumer behaviours involving information filtering and retrieval, personalized evaluations, complex coordination when certain prespecified conditions apply (Maes et al 1999). Over the past few years, the Media laboratory at MIT has developed a few multiagent systems that help mediation-based e-commerce activities such as T@T and Market Maker (formerly known as Kasbah) (Moukas et al 2000).

T@T is a multiagent electronic marketplace and engages consumer-owned shopping agents and merchant-owned sales agents. T@T sales agents automate the negotiation process for merchants (Moukas et al 2000). Shopping agents, on the other hand, actively assist shoppers during negotiations by providing a level of decision support to help them decide which merchant offering best meets their needs.

Market Maker is also a multiagent electronic marketplace where agents buy and sell to one another on behalf of consumers (Maes et al 1999). The consumer must decide whether it is a buying agent or selling agent. In the Market Maker environment, a selling agent is analogous to a classified ad. A user creating a new selling agent describes the item the agent is to sell. For a buying agent, the user specifies the values for a list of parameters: Sell by, desired price, and lowest acceptable price. Selling agents are proactive. Basically, they go into the marketplace, contact buying agents, and negotiate with them to find the best deal. A selling agent is autonomous in that, once released into the marketplace, it negotiates and makes decisions on its own, without requiring consumer intervention. Nonetheless, the consumer has high-level control of the agent's behaviour because in creating a new selling agent, the user sets several parameters to guide it, that is, desired date to sell the item by, desired price and lowest acceptable price (Moukas et al 2000). The user always has final control. When a selling agent reaches an agreement with a buying agent, the respective users may want to give an OK before the agents "shake hands" on the deal. The agent has a negotiating strategy, which can be chosen from the negotiation strategies predefined in Market Maker.

The MIT Media Lab's multiagent-based mediation systems are already creating new markets (e.g. low-cost consumer-to-consumer) and reducing transaction costs in a variety of business models (Moukas et al 2000).

MULTIAGENT BROKERAGE

Brokerage is another trade type that involves multiple buyers, multiple sellers, and a broker, which can be considered as a concrete form of mediation. A typical example is the real estate broker. Both buyers and sellers submit their requests to the broker. The broker tries to match the requests. From the viewpoint of business history, brokerage is one of the main trading transactions in traditional business activities (Finnie et al 2000). It still plays an important role in consumer purchasing and decisions and commercial transactions (Liang and Donng 2000). In this process, the seller (agents), buyer (agents) and the broker constitute the main parties which affect the exchange of goods. Their own primary goals essentially determine their characteristics, behaviours and roles in the brokering (Finnie et al 1999).

On behalf of a seller, the seller agent's primary goal is long term profitability through selling as many products as possible to as many buyers or buyer agents as possible for as much money as possible with transaction costs as low as possible (Finnie et al 1999). As a representative of a buyer, the buyer agent's primary goal is to have the buyer's special needs satisfied through the purchase of well-suited products from appropriate sellers or seller agents for as little money and transaction cost as possible. It is obvious that there is a conflict between a seller agent's primary goal and that of a potential buyer agent. The main goal of a broker, as the agent of both buyer agent and seller agent, is to resolve this conflict to satisfy both of them through a bargaining process. In other words, the primary goal of a broker is to make best use of his available information to help satisfy both of these goals and at the same time to earn as much money as possible through the bargaining process. Brokers thus play a central role in bargaining processes.

An electronic brokerage is an attempt to automate the traditional bargaining process whereby human seller agents, buyer agents, and a broker bargain resources for mutual intended gain to finalise a deal, using the tools and techniques of e-commerce (Finnie et al 2000). With the rapid development of the Internet and WWW, the electronic brokerage market is growing exponentially[3] based upon the promise of speed, convenience, and cost-effective access to markets. Further, most brokers on the Internet concentrate on the aggregation of information from underlying electronic catalogs (Bichler and Segev 1999). Anderson Consulting's Bargainfinder and Netbo's Jango are some of the most well known examples for brokers supporting dynamic data gathering. Guttman et al. (1998, 1999) analyse seven brokerage services and show which phases they support based on

3. http://www.zonaresearch.com/info/press/99-sep21.htm

MAS technology. Electronic brokerage is regarded as a core functionality in overcoming many current limitations of e-commerce (Bichler and Segev 1999). In our previous work (Finnie et al 1999, Finnie et al 2000), we proposed a framework for a broker-centred multiagent bargaining processes. The original ideas of it is that the work of a human broker, for example, searching for requirement information of buyers and supply information of sellers, matchmaking and bargaining, etc. should be done by a few intelligent agents in a MAS in a cooperative way. Further, as opposed to other multiagent brokerage systems, our broker's main task is bargaining in the e-marketplace on behalf of both agents of the seller and the buyer. However, multiagent brokerage systems is still in a very early stage, although there are more and more brokerage services available on the Internet. In what follows, we extend our previous work using CBR and propose a framework for CMB, a CBR system for multiagent brokerage, which integrates CBR, intelligent agents and brokerage.

CASE-BASED REASONING

There are many AI technologies such as neural networks, fuzzy logic and knowledge-based technology available to facilitate multiagent e-commerce systems (Nilsson 1998). CBR is one of them. CBR is reasoning based on previous experiences or cases, that is, a case-based reasoner solves new problems by adapting solutions that were used to solve old problems (Kolodner 1993). Therefore, we call CBR the form of reasoning combining deduction and experience-based reasoning, briefly,

$$\text{CBR} = \text{Deduction} + \text{Experience-based reasoning} \tag{1}$$

Further, similarity-based reasoning is a special form of experience-based reasoning, because there is an experience principle in business activities, for example, "Two goods with similar quality features have similar prices". Therefore, we specialize (1) as reasoning combining deduction and similarity-based reasoning, that is,

$$\text{CBR} = \text{Deduction} + \text{Similarity-based reasoning} \tag{2}$$

Based on (2), we can extend (1) to the following reasoning model:

$$\frac{P', P' \approx P, P \to Q}{\therefore Q'} \tag{3}$$

where $P, P', Q,$ and Q' represent compound propositions, $P' \approx P$ means that P' and P are similar. Q and Q' are also similar. This is the theoretical foundation for CBR, in particular for case retrieval. For example, we can consider a case (p, s) as a rule, that is, $p \to s$, where p is a problem description, while s is the corresponding solution description of p. In this case, we express our above discussion in the following model, which is a concrete form of (3):

$$\frac{p_0, p_0 \approx p_1, p_1 \to s_1}{\therefore s_0} \tag{4}$$

where p_0 is the problem description of a customer, $p_0 \approx p_1$ means that p_0 and p_1 are similar with the similarity degree r, $p_1 \to s_1$ is the case retrieved from the case base, and thus s_0 is the satisfactory solution to the requirement of the customer with the similarity degree $r \times k$, where k is the certainty factor of rule (case) $p_1 \to s_1$. Usually, $k = 1$, because the case in the case base is the result of experience, i.e. a successful solution to a problem. (4) is the implementation-oriented realization of the CBR world.

There has been an important influence of knowledge-based systems on CBR systems in most CBR literature (Aamodt and Plaza 1994, Kolodner 1993, Watson 1995). For example, the case base in the CBR system can be considered as a variant of the knowledge base in knowledge-based systems. Experience plays an important role in CBR just as knowledge does in knowledge-based systems. Based on this idea, we propose an knowledge-based model for CBR, as shown in Fig. 3.

In this model, similar to the inference engine in expert systems (Hayes-Roth 1992, Hayes-Roth 1994), we use a deductive engine in CBR for the reasoning mechanism, because we refer to CBR to an extension of deductive reasoning. However, we ignore working memories including the user interface in the figure. In fact, it is important that in the user interface, the user should know what the problems are, etc. The major part of the CBR systems is the case base and the deductive engine. The case base consists of reasoning-oriented predicate-like facts and rules about the subject or problem solving available. The deductive engine consists of all the processes that build and manipulate the case base to derive information requested by the user based CBR. At least the deductive engine consists of the following processes (Watson 1995)(also see Fig. 3.):

- Retrieve the most similar cases in the case base,
- Reuse the retrieved cases to attempt to give the solution to the problem(s),
- Revise the retrieved cases, and
- Retain the new case as a part of a new case base.

A new problem (the target case) is matched against cases in the case base after the case base has been built. One or more similar cases are retrieved from the case base (Finnie and Wittig 1998). A solution suggested by these cases is reused and tested for success. If necessary, the retrieved case(s) will probably be revised to produce a new case which can then be retained in the case base.

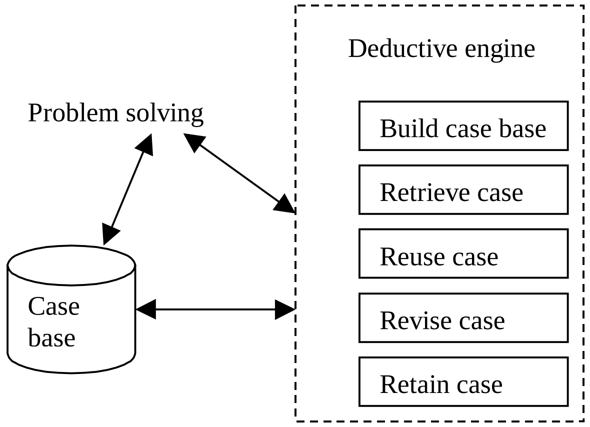

Figure3: Knowledge-based model of CBR

Let us look at an example. Suppose we have a case base about second-hand cars *C*. Suppose also that every car has exactly seven attributes in our case base and suppose that the problem description attributes are the first six, i.e. *P* = {*year, power, mileage, make, model, body shape*} and the solution description attribute is the last one, i.e. *Q* = {*price*}and the range of the year, power, mileage, and price are numerical and the range of other attributes can be considered as qualitative, such as "bad", "good", and "excellent". The global similarity can be defined by aggregation of local similarities $S_i, i = \{1, 2, \ldots, 6\}$ for each problem description attributes. Now Peter wishes to buy a second hand car with problem description $P_0 = \{p_1, \ldots, p_6\}$ using the mentioned CBR system provided by the dealer. He will retrieve the case base of second-hand cars and determine which car(s) have the similar features to his requirements. For example, there may be three cars retrieved which are similar to what he requires. Then he considers the price of them and chooses the retrieved car with the lowest price. He may ask the seller to revise the service of the car if he buys, for example, the seller should provide 1 year's guarantee instead of six months's guarantee. After the deal is done, the dealer will retain this new selling case in the case base of second-hand cars *C*.

Matos and Sierra (1999) presents two types of agent architecture: one based on case-based and another based on fuzzy logic, to model a negotiation strategy. At each step of the negotiation process these architectures fix the weighted combination of tactics to employ and the parameter values related to these tactics. When an agent is provided with the case-based architecture, it uses previous knowledge and information of the environment state to change its negotiation behaviour.

Similar to Mates and Sierra, Zhang and Wong (2000) use CBR techniques to acquire negotiation strategies from previous negotiation experiences and then propose a Case-based Negotiation (CBN) agent for used car trading. The CBN agent can perform either as a car buyer agent or car seller agent. Then agents revise and adapt negotiation strategies in each decision-making episode of the negotiation process. The strategies are defined based on the knowledge, past experience and information available to the negotiating agents.

CMB: INTEGRATION OF CBR AND MULTIAGENT BROKERAGE

In this section we introduce the framework of CMB, a CBR system for multiagent brokerage, which is an ongoing project started in 1999 (Finnie et al 1999, Finnie et al 2000). The goal of CMB is to automate brokerage in e- commerce through integrating CBR and MAS technology to assist the broker to work in the electronic brokerage or bargaining process. The key idea behind it differs from research in other frameworks, for example Zhang and Wong (2000) and Plaza (1997), in that we stress that the task of a human broker should be done by a few intelligent agents in CMB in a cooperative way, and only some of the agents (negotiation agent, seller agent, etc.) in a multiagent brokerage system possess CBR ability. Moreover, if an agent has CBR ability, then its basic architecture consists of its own case base and deductive engine (see Section 3). The system performance of CMB depends on not only the intelligence of its individual agent but also the cooperation, coordination, communication and negotiation with other agents (Finnie et al 1999, Finnie et al 2000).

CMB is a broker-centred MAS. The system architecture (Fig. 4.) consists of three multiagent subsystems (Finnie et al 1999, Finnie et al 2000): intelligent buyer agent subsystem, intelligent seller agent subsystem, and intelligent broker. While the intelligent seller agent subsystem consists of all available intelligent seller agents on-line, the intelligent buyer agent subsystem comprises all available buyer agents[4] on-line. The intelligent broker is also a MAS.

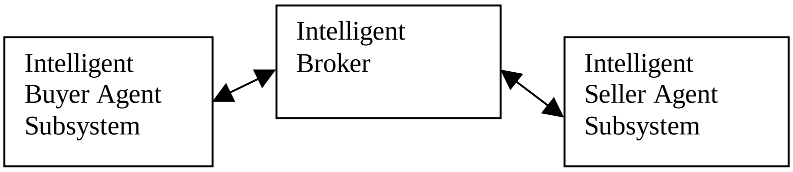

Figure 4: Architecture of CMB

In CMB, the customer can create his own agents: either buyer agent or seller agent. Furthermore, the buyer agents, seller agents and intelligent broker are all proactive. The seller agent tries to cooperate and negotiate with the intelligent broker to find a most satisfactory deal to sell the goods of his seller. The buyer agent also tries to cooperate and negotiate with the intelligent broker to get what his buyer needs at lowest price. The intelligent broker proactively searches all available information about the request and supply of goods on the e-market (Finnie et al 2000).

Every intelligent buyer and seller agent in CMB is semi-autonomous, in that, once entering into the electronic bargaining process, the intelligent buyer (seller) agent negotiates and makes decisions on his own, without requiring his buyer's (seller's) intervention.

Business experience plays an important role in commercial activity. Therefore, buyer agents and seller agents should have CBR ability to make decisions during bargaining with the intelligent broker. Usually, they retrieve or revise the related business information and adapt the bargaining strategies in order to get most profits. For example, Peter asks his buyer agent to buy a second-hand car using CMB. The buyer agent will use the CBR subsystem provided by CMB for each buyer agent to collect the information of second-hand cars according to the requirements of Peter and build a case base of second-hand cars. Then he will use CBR to recommend a possible solution, i.e. a second-hand car to Peter. If Peter is not completely satisfied with the recommended car, the agent has to bargain with the intelligent broker to revise the attributes of the car such as revising the after-sales services. If Peter accepts the recommended car, the agent will retain the new case in the case base and the intelligent broker also save the new case into his own case base of second-hand cars.

As shown in Fig. 5, the intelligent broker comprises a buyer (seller) collaborative agent, an information-gathering agent, an interface agent, a managing agent, a matchmaker agent, a transaction agent, a negotiation agent, a buyer request database (BDB), and a seller supply database (SDB). The key insight behind it is that the work of the human broker should be modelled by the activities of a few agents within a MAS in a cooperative way. In what follows, we look at only a few of the mentioned agents in some detail (see Finnie et al 2000 for detail).

4. For convenience, we use x agent to stand for intelligent x agent, where x is i.e. buyer or seller, etc.

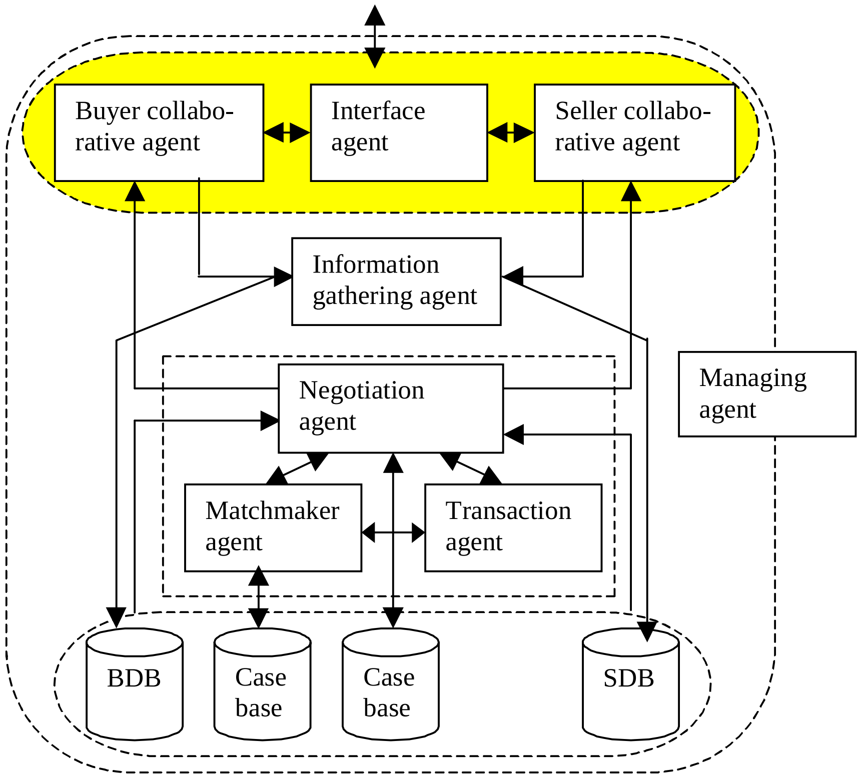

Fig. 5. Intelligent broker (subsystem) after Finnie et al 1999

- The buyer (seller) collaborative agent is a software agent that proactively cooperates with the buyer (seller) agents to get the request/supply information and special information about the buyers and sellers, and then save it into BDB or SDB respectively, if necessary. In certain cases, the buyer (seller) collaborative agent decides if a buyer agent and a seller agent can directly contact each other in order to reach a deal.
- The information-gathering agent is a mobile agent that proactively roams around the main search engines in the Internet such as Excite and Yahoo (Finnie et al 1999). It interacts and collaborates with them in order to search and analyse the required market information indirectly from individual Web sites and then puts it in the corresponding data or knowledge bases. For example, the information-gathering agent uses search engines to search all available information of second-hand cars and then save it in SDB.
- The matchmaker agent searches the database and matches a request of goods from a buyer agent and a supply of those goods from a seller agent using appropriate matching algorithms. Because similarity-based matching is a basic technique for information matching and similarity-based matching is a kind of experience-based reasoning, the matchmaker should have CBR ability during matching. He also matches the goods-requesting buyer agent and the goods-supplying seller agent and then sends the matched information to the interface agent or buyer (seller) collaborative agent after transaction analysis by the transaction agent. For example, the matchmaker retrieves the case base of second-hand cars and tries to determine which seller agent's car matches the requirements of Peter's buyer agent.
- The negotiation agent is an autonomous, mobile and proactive agent that performs not only integrative but also distributive negotiation strategies during negotiation with the buyer agent and seller agent. Because business negotiation is complex and difficult in some cases, the intelligence of the negotiation agent lies in that he can change his negotiation strategies according to the changing available (information) resources. Thus, the negotiation agent should be adaptive and may use a range of available AI technologies. Adaptation is usually based on experience. Further negotiation experience plays an pivotal role for the negotiation agent during the bargaining. Therefore the negotiation agent should have CBR ability during the negotiation. For example, the negotiation agent uses not only the mentioned case base of second-hand cars, but also the case base for the preference of buyer (agent) and seller (agent) when bargaining with buyer agent and seller agent, because similar preferences of the customers usually lead to similar solutions.

It should be noted that autonomy and mobility of agents are the most important features different from stationary intelligent systems (Huhns and Singh 1998). Autonomous and mobile agents are well suited for e-commerce (Lange and Oshima 1999). A commercial transaction may require real-time access to remote resources, such as stock quotes and perhaps even agent-to-agent negotiation. Different agents have different goals and implement and exercise different strategies to accomplish them. We envision agents embodying the intentions of their creators, acting and negotiating on their behalf. Autonomous and mobile agent technology is a very appealing solution for this kind of problem. Furthermore, we like to suggest a comparison that the evolution of autonomous and mobile MAS from stationary intelligent systems is similar to the evolution of missiles from bullets. This may be the real reason why autonomous and mobile MAS have drawn increasing attention in the world.

The feature of CBR in CMB lies in that some of the agents in CMB have CBR ability. This is different from CHROMA (Plaza et al 1997) and CBN (Zhang and Wong 2000), in which every agent has CBR ability. The reason is that we should follow a principle of intelligence parsimony in a MAS, that is, the requirement of certain intelligent ability for an agent depends on what it "really requires" when it does work on behalf of a human agent.

CONCLUDING REMARKS

In this paper we first classified multiagent-based e-commerce into multiagent-based auction, multiagent-based mediation and multiagent-based brokerage and gave a brief survey of related works in each. Then we proposed a framework of CMB, a CBR system for multiagent brokerage, which integrates CBR, intelligent agents and brokerage. We also briefly discussed CBR from both a logical viewpoint and a knowledge-based viewpoint and proposed a knowledge-based model for CBR. The key insight is that an efficient way for applying CBR in e-commerce is through intelligent agents or multiagent systems. Further the work of a human broker such as searching for information for customers, matchmaking and bargaining should be done by a few intelligent agents within CMB in a cooperative way. This approach will facilitate research and development of CBR in multiagent e-commerce. In future work we investigate implementation-oriented issues to experiment with proposed model.

REFERENCES

Aamodt, A. and Plaza, E. (1994) Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches. *AI Communications*, IOS Press, 7, 39-59.

Adam, N.R., Dogramaci, O., Gangopadhyay, A. and Yesha, Y. (1999) *Electronic Commerce: Technical, Business, and Legal Issues*, Prentice Hall PTR, Prentice-Hall Inc.

Bichler, M. and Segev, A. (1999) A Brokerage Framework for Internet Commerce, *Distributed and Parallel Databases* 7, 133-148.

Cunningham, P. (1999) Intelligent Systems in Electronic Commerce. Invited talk on ICCBR-99, Germany, URL http://www.iccbr.org/iccbr99.

Fankhauser, P. and Tesch, T. (1999) "Agents, A Broker, and Lies". In *Proc. of 9th Intl Workshop on Research Issues on Data Engineering: Information Technology for Virtual Enterprises* (RIDE-VE'99), Sydney, Australia, March 23-24, 56-63.

Finnie, G., Sun, Z. and Weber, K. (2000) A Intelligent Broker-centered Multiagent Architecture for Bargaining Process, *Proceedings of the International Conference on Artificial Intelligence* (IC-AI'2000), Las Vegas, Nevada USA, 175-181.

Finnie, G., Sun, Z. and Weber, K. (1999) A Multiagent-based Intelligent Broker Architecture for Bargaining Process, in Kowalczyk, R. & Lee, M. (eds.) *AIEC'99 Proceedings*, CSIRO, Sydney, Australia, 47-56.

Finnie, G. and Wittig, G. (1998) Intelligent Support for Internet Marketing with Case based Reasoning, *Proc. of 2nd Annual CollECTeR Conf. on Electronic Commerce*, Sept. Sydney, 6-14.

Guttman, R.H., Moukas, A.G. and Maes, P. (1998) Agent-mentioned Electronic Commerce: A Survey, *Knowledge Engineering Review*, 13,147-159.

Guttman, R.H. and Maes, P. (1998) Agent-mediated Integrative Negotiation for Retail Electronic Commerce, URL http://ecommerce.media.mit.edu.

Hayes-Roth, F. (1992) "Rule-based Systems", in: Shapiro, S.C. (ed.) *Encyclopedia of Artificial Intelligence*, Vol.1- 2, New York: Wiley and Sons, 963-973.

Hayes-Roth, F. and Jacobstein, N. (1994) The State of Knowledge-based Systems, *Communications of The ACM*, 37 (3), 27-39.

Huhns, M.N. and Singh, M.P. (1998) *Readings in Agents*, San Francisco: Morgen Kaufmann Publishers.

Jung, J. and Jo, G (2000) Brokerage between Buyer and Seller Agents Using Contraint Satisfaction Problem Models, *Decision Support Systems* 28, 293-304.

Kolodner, J. (1993) *Case-based Reasoning*, San Mateo: Morgan-Kaufmann.

Lange, D.B. and Oshima, M. (1999) Dispatch your Agents; Shut off your Machine, *Communication of The ACM*, 42(3), 88-89.

Liang, T.P. and Donng, H.S. (2000) Effect of Bargaining in Electronic Commerce, *Intl J of Electronic Commerce*, 4, 23-43.

Maes, P., Guttman, R.H. and Moukas, A.G. (1999) Agents that Buy and Sell, *Communications of The ACM*, 42(3), 81-91.

Matos, N. and Sierra, C. (1999) “Evolutionary Computing and Negotiating Agents” in Noriega, P.; Sierra, C. (eds) *Proc. of the First Intl Workshop on Agent Mediated Electronic Trading* (AMET-98), Berlin: Springer- Verlag, 126-50.

Moukas, A., Zacharia, G., Guttman, R. and Maes, P.: (2000): Agent-mediated Electronic Commerce: An MIT Media Laboratory Perspective. *Intl J. of Electronic Commerce*, 4, 5-21.

Nilsson, N.J. (1998) *Artificial Intelligence: A New Synthesis,* San Francisco, California: Morgan Kaufmann Publishers, Inc. .

Plaza, E., Arcos, J.L. and Martin, F. (1997) “Cooperative Case-based Reasoning” in *Distributed Artificial Intelligence meets Machine Learning,* LNAI 1221, Springer Verlag, 180-201.

Rakotonirainy, A., Seng, W.L. and Zaslavsky, A. (2000) “Towards Multiagent Support for Open Mobile Virtual Communities” in H.R. Arabnia (ed.) *Proceedings of the International Conference on Artificial Intelligence* (IC-AI'2000), Las Vegas, Nevada, USA, 127-33.

Sun, Z. and Finnie, G. (1999) “Applying Intelligent Technology to Investment Information Brokering” in Tonkes, E., et al (eds.) *Proceedings of the International Conference on Advanced Investment Technology,* Gold Coast, Australia, 341-351.

Timmers, P. (1999) Electronic Commerce: Strategies and Models for Business-to-business Trading, John Wiley & Sons Ltd.

Watson, I. (1995) “An Introduction to Case-Based Reasoning” In Watson, I.(ed.): *Progress in Case-Based reasoning,* Springer, Berlin.

Whitaker, B. (1999) Intelligent Agents for Electronic Commerce, URL http://www.ncr.com/journal/whit/.

Wilke, W., Lenz, M. and Wess, S. (1998) “Intelligent Sales Support with CBR” in Lenz, Mario et al. (eds.): *Case Based Reasoning Technology: from Foundations to Applications,* Berlin: Springer LNCS, 1400, 91-113.

Zhang, D. and Wong, W. (2000) “Using CBR for Adaptive Negotiation” in Shi, Z. Faltings, B. and Musen, M. (eds.) *Proceedings of Conference on Intelligent Information Processing,* Beijing, China, 428-37.

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