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Abstract

Business alliances are becoming ubiquitous globally. We are studying agent and multiagent tasks in electronic commerce, representative of normal business functioning. Our work is a study of the need for management functions in agent and multiagent tasks in electronic commerce. We observed and documented management tasks among multiagent networks and recommended specific roles for management that may be applied to business alliances.

Keywords: electronic commerce, network structure, multiagent

Introduction

Software agents and electronic commerce are two buzzwords of recent interest to software developers and business people. Software developers want to design, build and launch agent technologies. Businesses want to vastly increase sales through the magic of electronic commerce. The combination of agent technology and electronic commerce is becoming well established. A new complexity now, however, and our problem of interest is the use and management of multiagents (or groups of firms) buying and selling electronically.

Software agents are small computer programs that can perform tasks of a repetitive nature. In electronic commerce, they can be trained to search for particular products, prices, vendors and so on. They can also purchase goods, sell goods, negotiate contracts, track delivery of goods and handle customer service functions. Multiagents are groups of agents working together to perform a task. In electronic commerce, there may be a group of agents offering particular products that can be purchased as a single package. For example, individual agents may offer theatre tickets, restaurant reservations and hotel bookings and a multiagent, representing all three vendors, may offer a weekend getaway package.

Multiagents have all of the known problems of other integrated software. They often work better individually rather than in the group. As well, in electronic commerce, they are competing against other multiagent networks in very large, unknown worldwide markets. Our work is a study of multiagent structures (groupings) and management in electronic commerce. Our current contribution is the recommendation of specific management features for best results with particular agents and multiagents.

Business Alliances

Business alliances are becoming normal and necessary in today's marketplace. Enterprises must share knowledge, cooperate and trust their partners in order to minimize transaction costs and establish working relationships. (Larson 1992; Provan and Sebastian 1998; Uzzi 1997) Competition among alliances is common as firms form cooperative ventures to secure specialized market segments. Businesses need to know how best to manage and control their alliances for maximum profit, productivity, sales, and so on.

Local Kitchener-Waterloo examples of business alliances are the Descartes Systems Group Inc., Research In Motion Limited, and Brick Brewing Company Limited. Descartes will offer RIM's Inter@ctive wireless pager and Blackberry products with Descartes e-business software as part of its DeliveryNet offering to provide real-time scheduling and optimization of delivery and service activities. Descartes is also licensing its DeliveryNet.LOG supply chain software product to TNT Logistics outsourcing. In October 1999, Brick Beer and Grocery Gateway (www.grocerygateway.com) allied to make Brick Beer available online in the Toronto area.

Our research focuses on agent and multiagent systems in electronic commerce, representative of business alliances. Pattie Maes of MIT's Media Lab predicts that soon "agents will strategically form and reform coalitions to bid on contracts and leverage economies of scale". (Maes et al 1999) Our research objectives in this study are to relate traditional management techniques to agent and multiagent tasks in electronic commerce; to analyze the relationships; to identify management deficiencies in the agent systems; and to recommend potential solutions and strategies.

Research Problem and Importance

This research is centred on the use and management of multiagents buying and selling electronically.

Multiagents may be developed and dispatched easily, even by very small companies. Off-the-shelf ready-to-use 'Aglets' software is available free from IBM in Japan (www.trl.ibm.co.jp). (IBM 1997) Alternatively, software agents can be purchased at a minimal cost from companies such as BusinessBots in San Francisco. (Krantz 1999) These multiagents are buying and selling on behalf of an organization and therefore need to be controlled as much as any other part of the business. Proper planning, organization and control structures for these resources before use will enhance their positive impact on the firm's bottom line.

The multiagents in this research study represent groups of firms working together to achieve positive results for all firms in the alliance. The groups of firms are competing with other groups of firms for the same business. One group may be stronger than another under certain conditions. We identify and document the management conditions and deficiencies that may affect alliances. Finally, we recommend particular strategies for groups of firms to produce better results overall.

Software Agents in E-Commerce

An agent is a software program that performs tasks for either human or machine users. In electronic commerce, some tasks might be monitoring the market, identifying products and merchants of interest, negotiating prices, and so on. Agents in electronic commerce can do one or more of these tasks. Multiagents are groups of two or more agents working as one entity. The purpose of these agents or multiagents in electronic commerce is to buy and sell on behalf of their user. These agents, by definition, must be competitive self-interested agents, like their human counterparts, in order to obtain the best price or best product for their owner.

BusinessBots, a San Francisco firm, (www.bizbots.com) has developed a product called JAM (Java Agent-enabled Marketplace). (Ma 1999) JAM matches your buy order (price, purity, etc.) with someone else's compatible sell order, and then sends software agents out to link many sites, doing haggling, quality estimation, and reputation management to deliver an optimal deal for all concerned. The JAM agents can also procure lists of product lines and current inventories for your software agents to review. JAM pilot systems are being developed for the chemical, financial services, transportation and bandwidth industries.

Research Method

We surveyed about 40 agent-based web sites and 15 articles in books, magazines and journals. From these sources, we identified, observed, documented and associated specific management issues, agent and multiagent tasks and collaborative work within multiagent networks. The general management literature provided a number of specific issues that should be of concern in all management situations. These traditional management tasks were documented and then reduced to a small number of issues relevant to electronic commerce. A number of electronic commerce agent and multiagent systems were reviewed on-line and in current literature. Their common buying and selling work was listed and synthesized. Additional collaborative work required of multiagent systems was noted separately. The agent and multiagent tasks in electronic commerce were documented and related in tables to the relevant management concerns. The tables were then analyzed to identify areas of management weakness and recommend strategies for future multiagent development.

Research Results

Management Issues

The general management literature provided a list of typical management concerns. (Eccles et al 1992) These issues include items such as plan, organize, staff, evaluate, decide, delegate, monitor, co-ordinate, lead, control, and document. The information systems management literature also noted the need for project management, security, and management of data, personnel, hardware and software. (Barki, Rivard, Talbot codes, IS management, level two)

The complete list of seventeen documented management concerns was later reduced to four items for the purposes of this study. Plan, organize, evaluate and control were identified as the most relevant issues for agent and multiagent management in electronic commerce.

Agent Tasks

Agent systems are already frequently used in electronic commerce. Their work may include one or more of need identification, product or merchant brokering, negotiation, payment and delivery, service and evaluation. These tasks were identified and documented by Maes et al from consumer buying behavior (CBB) research. Sandholm's research offered supplementary information on negotiation tasks. (Maes et al 1999; Sandholm 1999)

A. Need Identification

Need identification from an agent viewpoint can be subdivided into market monitoring followed by user notification. Stock market sites may contain monitor agents that will watch particular stocks and then notify, buy or sell as directed when the stock price reaches a

predetermined level. The Amazon.com site contains a notification agent called 'EYES' to monitor the amazon catalog and tell customers when a new book by a particular author is available or when a new video has been released. (www.amazon.com)

B. Product Brokering

Product broker agents will recommend particular products to a user through constraint-based reasoning, rule-based reasoning, or collaborative filtering. PersonaLogic (www.personalogic.com) helps users by defining product features and constraints to narrow the search. Firefly (www.firefly.com) will recommend products to users based on purchases made by other similar users. Broadvision, Inc. personalizes their product offerings for individual customers. Other sites use data-mining techniques to discover customer purchasing behavior patterns.

C. Merchant Brokering

Andersen Consulting's CSTaR group (www.ac.com/services/cstar) is researching prototype finder agents which can cover a large range of information management tasks. BargainFinder, now discontinued, was an Andersen agent which did real-time price comparison shopping on the net, including finding appropriate sellers. An interesting effect with this agent was that some online sellers clamored to be included because they compete on price and not much more. Others refused Andersen access to their prices because they felt that they offered more to customers, and wanted the customers to see the added value for themselves.

Jango (jango.excite.com), a commercially available product, issues product requests from the user's web site rather than a central server as with the Andersen product. This avoids the 'blocking' problem by some merchants noted above.

D. Negotiation

Contract negotiation tasks may include price bidding, agreement and establishment of detailed terms of sale during a defined time period. AuctionBot (auction.eecs.umich.edu) is a general-purpose research system allowing users to select auction types and parameters for bidding. Kasbah (kasbah.media.mit.edu), from the MIT Media Lab, is an online, multiagent consumer-to-consumer transaction system working with a number of agents negotiating in a central agent marketplace. Agents buy and sell directly with each other and later rate each other on negotiation honesty, product accuracy, and so on. This rating system, the 'better business bureau', allows future agents to better decide whether to deal with this agent or not.

Also from the MIT Media Lab, Tete-a-Tete (ecommerce.media.mit.edu/tete-a-tete) allows consumer-owned shopping agents and merchant-owned sales agents which can cooperatively negotiate price, warranties, delivery time, return policies and so on. This system offers a large number of features, preferences and offerings for very complex bargaining.

Negotiation agents can find deals and prepare contracts for their users in very large and complex undertakings. For example, one type of agent-to-agent negotiation might be task reallocation among agents. Some agents are too busy, others not busy enough, or one may be more efficient in a particular setting. Tuomas Sandholm, a university researcher in the Multiagent Systems Research Group at Washington University in St. Louis, built a system in 1990 called Transportation Cooperation Net (TRACONET). This system allowed agents representing individual firms to take on delivery tasks from other agents or to give out tasks to others. As an extension to this system, Sandholm added abilities to cluster (multiple tasks for one payment), swap (trade tasks), deal with multiagents (more than two firms) and to combine all of the above into one contract.

A recent system from the same Washington University research group uses an auction server, part of an electronic commerce server named eMediator, in lieu of agent-to-agent negotiation. The new system accepts tasks and bids centrally and can aggregate or separate tasks as needed. The eMediator server supports auctions, combinatorial bidding, bidding via price-quantity graphs, and mobile agents. Further refinement even includes levels of commitment, providing agents with the ability to get out of a contract by paying a decommitment penalty.

E. Payment and Delivery

F. Service and Evaluation

These items are additional tasks identified by Maes et al. Their research as of March 1999 did not document agent products that could handle payment, delivery, service or evaluation.

G. Summary of Agent Tasks

The common buying and selling tasks for agents are listed below. Activities include:

1. Monitor markets
   Software agents can be programmed to watch particular sectors of the electronic commerce marketplace to provide ongoing buy and sell activity updates. For example, an agent can monitor a competitor's online prices.
2. Notify users
   If particular limits are reached or certain conditions met, then the agent will notify the user to act. For example, stock prices could hit a particular low or high that would trigger either the agent or the user to buy (low) or sell (high).

3. Search
   Given user instruction, agents can search electronically for particular products, vendors or prices. The agents can easily be given product features, a set of preferred vendor characteristics and a price range to use in the online exploration.
4. Recommend
   Based on the electronic search, agents recommend particular products or services to their users. A list of options can be delivered, sorted by a variety of the given criteria, or one specific best buy may be suggested.
5. Negotiate
   Once a buy or sell decision is made, agents can negotiate on price, optional product features, warranties, terms of delivery, penalties and return policies. This bargaining and negotiation is often very time-consuming and complex for both humans and agents.
6. Track delivery
   FedEx, UPS and other courier companies offer personal computer software which tracks purchased goods through the maze of cities, airports, and carriers to their destination. This existing software is not currently being used with agent technologies in electronic commerce, but should not be too difficult to replicate. The new software then could track either online activity, such as the completion of a stock purchase, or physical delivery of purchased goods to a specific location.
7. Serve customers
   Agents can provide a number of value-added services to customers, such as reminders of imminent warranty or policy expiration, notification of new products that may be of interest, and suggestions for cost savings through higher quantity purchases.

Multiagent Tasks

Multiagent software must handle the individual buying and selling tasks noted above as well as the collaborative work necessary to have more than two agents working together. First, responsibility for project completion and success must be given to or assumed by one agent or one multiagent group. Additional tasks involve coordination of work, allocation of labour, scheduling, information transfer among agents, consolidation, and synthesis of results. (Ferber 1999) These additional tasks are documented below.

1. Assume responsibility
   One agent or group of agents in the multiagent system must take responsibility for the individual work and collective success of the project as a whole. This responsibility may be chosen by the agent or may be built in to one of the agents who can then act as a management or collaboration agent.

2. Coordinate
   Individual agents must be assigned specific tasks to be completed within a particular time frame, depending on agent skills and availability. In a vacation planning system, agents must be sent out to obtain quotes on hotel rooms, theatre tickets and restaurant meals. This work must be done concurrently for fastest results to beat a competing vacation system.

3. Allocate
   Based on agent skills and availability obtained in the coordination phase, specific tasks can be allocated to particular agents. Task distribution would normally be based on skills and experience first with availability and other commitments second. Thus, an agent with experience in obtaining hotel prices and available in an hour would be chosen over a general-purpose search agent who is available now.

4. Schedule
   Once tasks have been assigned to particular agents, a schedule for work completion can be developed. This schedule can be based on previous similar tasks or can be estimated and revised as the work proceeds. This schedule will give the managing agent information on which agents will be working on particular tasks at specific points in time. It will also provide a forecast for overall project completion.

5. Transfer information
   Previous multiagent tasks were involved with sending agents out to do their work. As agents return with search results, information needs to be transferred to a central data repository. This repository can be used to gather all information as it arrives.

6. Consolidate
   Information needs to be combined and organized so that it will be meaningful for its multiagent system purpose. Hotel information, for example, could be separated from other data in the vacation planning system. It could then be characterized and sorted by various criteria such as location, accommodation star rating, price range and so on.

7. Synthesize
   The amount of information that can be gathered by agents in multiagent systems is huge. To avoid information overload and narrow the list of possible solutions, a unifying selection criterion needs to be implemented. For the vacation planning system, particular constraints were put on each individual search. Hotels had to be in a certain geographical area, theatres had to be showing particular productions, and restaurant entrees had to be below a

certain price limit. Now that the system is combining hotel, theatre and restaurant data, there must be additional criteria to choose the best *combination* of the three items. This synthesis can be easily achieved with a weighting system on each of the three search items. A more complex system might evaluate weightings for the specific features of each search item. Either way, the many combinations of options available to the multiagent system user can now be ranked and recommended as a complete vacation package.

Agent and Multiagent Management

The relevant management issues and agent tasks in electronic commerce were cross-referenced in Table 1. This table shows very little correlation between our four management concerns and the electronic commerce agent tasks.

Table 1. Management and Agent Tasks

	Plan	Org	Eval	Control
Monitor			Y	N
Notify	N		N	N
Search	Y	Y	N	N
Recommend	N	Y	Y	N
Negotiate	Y	Y	Y	Y
Track			N	Y
Serve	Y	Y	Y	Y

The front-end electronic commerce tasks (monitor, notify, search, and recommend) show minimal need for management work before a sale. The monitor agent needs to be able to evaluate sites, the search agent needs to be able to plan and organize, and the recommend agent needs to organize and evaluate. The notify agent needs no management skills at all. None of these front-end agents need to control anything in their work.

The back-end agent tasks (negotiate, track, and serve) require much more ability in management to make the sale and then to follow up. The negotiate and serve agents require all of our management abilities to plan, organize, evaluate, and control their work. The tracking and delivery agent provides lower-level monitoring services and therefore requires only the need to control a delivery route as needed.

Table 2. Management and Multiagent Tasks

	Plan	Org	Eval	Control
Assume	N	N	N	Y
Coordinate	Y	Y	Y	Y
Allocate	Y	Y	Y	Y
Schedule	Y	Y	Y	Y
Transfer	Y	N	N	Y
Consolidate	Y	Y	N	Y
Synthesize	Y	Y	Y	Y

Table 2 was similarly constructed for management issues and multiagent tasks. This table shows a very high correlation among management issues and multiagent tasks. Multiagent systems already display a number of management characteristics. Since the multiagents must work together and co-ordinate tasks, this result is not unexpected. The multiagent task of assuming responsibility for a project is built in before work begins and requires only control functions. Information transfer is a lower-end task and thus requires only planning and control. The ability to consolidate information needs no evaluation capacity. Otherwise, all multiagent tasks require all chosen management abilities.

Recommendations

Agents and multiagents in electronic commerce should be developed with built-in management capabilities as documented in Tables 1 and 2, and expanded upon below.

1. Monitor, search and recommend agents should include only a subset of management tasks as required.

2. Agents performing low-level processing, such as notifying and tracking, should be developed with no or minimal management functions.

3. Back-end agents performing purchasing negotiations and providing after-service to customers should be outfitted with a complete collection of management skills.

4. All multiagents should be created with all management capabilities.

Conclusions

Agents and multiagents in electronic commerce have varied needs for intrinsic management functioning. Front-end agents and agents performing lower-level processing functions have less need of management functions, as their work is fairly simple. Back-end agent tasks in electronic commerce and multiagent work require a large, complete set of management skills. No particular management ability appears to be more important than another overall in this domain.

The multiagents in this study were representative of groups of firms working together in business alliances. We should therefore be able to extrapolate, and verify through further empirical research, that such firms require a full set of management skills. This extrapolation is only valid, however, if the alliance businesses perform the same tasks as the multiagents. Therefore, firms in alliances require strong management abilities if they assume group responsibility, coordinate work, allocate tasks, schedule projects, or transfer, consolidate or synthesize collective information.

Future Work: Mobile Agents and Multiagent Networks

This research was done as the foundation for a more complex study of mobile agent and multiagent network management. Mobile agents and multiagents are launched from their owner's location and sent to diverse computers to do their work. This software is available free on the Internet, allowing even inexperienced users the ability to flood other computers with unlimited agents. (IBM 1997) We plan to study agent and multiagent mobility management from two viewpoints: the agent's owner (sender) and the target market (receiver). Owners do not want to lose control of their agents (i.e. have another person or computer change the characteristics of their agent) nor do non-owners want to have their computers overrun by large numbers of unsolicited agents.

Another research project is already underway on multiagent network structures. This undertaking began with existing work on organizational and computer network structures. (Quinn 1992; Stallings and VanSlyke 1998; Tanenbaum 1996) The study will identify, characterize and classify network topologies into hierarchical, bus, star, ring, and peer-to-peer structures to see how multiagents can best work together. These networks will be compared on a wide variety of factors. Expected results will produce recommendations for particular network structures under certain circumstances, or conversely will recommend the best variables for a given network topology.

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