Using Intelligent Agents in Conjunction with B2B Interoperability

M. Brian Blake
Dept. of Computer Science
Georgetown University
Washington, DC 20057
(202) 687-3084
mb7@georgetown.edu

Todd Cornett
Dept. of Computer Science
Georgetown University
Washington, DC 20057
cornettt@georgetown.edu

Tepring Piquado
Dept. of Computer Science
Georgetown University
Washington, DC 20057
piquadot@cs.georgetown.edu

Abstract. *In recent years, there has been increasing work where intelligent software agents have been used to support electronic commerce and other Internet-based transactions. This use of agents also called Agent-Mediated Electronic Commerce, has mostly been seen in areas such as service discovery and knowledge management, automated negotiation and pricing, auctioning and transactional reasoning, and the control of workflow and supply chain management. The vast majority of electronic commerce systems (agent-based or otherwise) have been used to support buying and selling between businesses and consumers (B2C). This trend has carried over into agent research projects that also tend to favor the B2C paradigm. However, an emerging paradigm has arrived where businesses also collaborate on and coordinate transactions over the Internet (B2B). In this paper we discuss the differing focuses between B2C and B2B. Moreover, this paper presents the state of the art commercial and research agent-based systems for B2C and B2B. We also forecast the future research focuses that must be adopted in order for agent-based B2B to become a reality.*

1.0 Introduction

With the inception of the Internet (also, ARPANET) in the late 1960's, research organizations, corporations, and academic institutions have developed various means of utilizing this vast resource. The initial goals of the ARPANET and that of the first implementations utilized the Internet to provide a medium to disseminate information. Later, there was huge number of corporate implementations that allowed businesses to display and sell products. At this point, customers still made purchases by non-automated means (i.e. sending check by postal mail or credit card numbers by phone). Subsequently, businesses still had the need for a human-in-the-loop to complete the transactions. The next cycle in the evolution of the Internet led to the development of fully automated systems with real-time processing of credit card payments. Currently with these fully transactional systems, a large area of development has arisen. Traditionally, on-line businesses serviced individual consumers. However, with these fully automated transactional systems, other businesses have seen the value of using these automated services, specifically in integrating them with their already existing services. This trend for businesses to consolidate their automated services has led to a huge effort toward the research in business-to-business (B2B) modeling and implementations.

Several B2C business plans have led to B2B approaches. One example is in the healthcare service domain. Hospitals and health care organizations must maintain an inventory of medicines and equipment. Currently, several pharmaceutical companies have offered on-line services where consumers can order medicine and equipment on-line. The information systems departments at the hospitals and other healthcare organizations may want to integrate their local software-based inventory systems with the product ordering services of the pharmaceutical companies. In this way, automated functionality can be created to automatically make product orders when a certain part of the inventory needs to be replenished. By establishing generic B2B services, these healthcare providers can be assured that they get the timely purchases among all available product providers.

We believe that in creating B2B systems, the focus is more on the mediation and support architecture rather than on the transaction. Service providers (in this case, pharmaceutical service providers) must have systems to inform the business-based consumer of what services are available and how to access these services in software terms. Moreover, there needs to be some evolvable architecture that can be configured to correspond to any number of on-line services. This evolvable architecture would allow a consumer to support the changing semantics of other on-line service providers to be integrated into their own local processes. This paper continues in the following section with a survey of the state of the art B2C systems. Subsequently, state of the art systems in B2B are introduced in context of three pertinent focuses. Finally, we forecast the future of B2B systems.

2.0 Agents and Electronic Commerce

Intelligent software agents have received a great deal of exposure over the last decade in both industry and in research labs. There are many definitions for software agents, but the common characteristic of all agents is autonomy. Agents can perform independent activities that alleviate the need for regular, routine or even peripheral tasks. Also, agents can autonomously act as proxies for their human counterparts. Agents are becoming extremely popular in this age, where there is an emphasis on automation.

2.1 Agents in B2C

The best way to categorize how agents are being used in B2C is to look at the underlying electronic commerce model. This electronic commerce model can be mapped directly to the buying behavior of the consumers. In the Consumer Buying Behavior (CBB) Model [13], Guttman et al. formalize 6 stages of behavior. Those stages are Need Identification, Product Brokering, Merchant Brokering, Negotiation, Purchase and Delivery, and Product Service and Evaluation. Even with the volatility of the market over the past 4 years, this model still accurately defines electronic market place, but only from a B2C perspective. However, the scope of technologies over the past four years has changed.

The six CBB stages incorporate several traditional Marketing Consumer Buying Behavior models [13]. These stages present an excellent point of departure in categorizing the underlying supporting technologies

- *Needs Identification* is the stage where customers conceptualize a need for a product or service, perhaps when exposed to available service/product information.
- *Product Brokering* is the stage where the customer evaluates determines what it is he/she needs to buy.
- *Merchant Brokering* is the stage where a customer determines from whom, a specific product/service should be bought.
- In the *Negotiation* stage, a consumer may interact with a service/product provider to determine the terms of the transaction (i.e. price, quantity, quality of service, etc.) It is in this stage, that some sort of auctioning may occur among a number of interested consumers.
- *Purchase and Delivery* is the stage where the consumer can specify the terms of how to receive the product or service.
- *Product Service and Evaluation* is the stage where the consumer can advocate his/her satisfaction of the process, products, or services rendered.

Recent state of the art systems in B2C have transformed over the past four years. Initially, there was an emphasis on agents to perform only the mediation-based stages (i.e. product brokering, merchant brokering, and negotiation). Currently, all stages are being implemented with intelligent agents. The *Need Identification* stage has been incorporated into the large of area research into *recommender systems*. Schafer et al. believe that recommender systems are changing from novelties used by a few E-commerce sites, to serious business tools that are re-shaping the world of E-commerce. Recommender systems have the ability to analyze historical purchase data and recommend solutions to customers. For B2C, product suppliers can keep preference information on their customers and notify them when relevant product/services are available. For example, Amazon.com might note that one of its customers prefers African history literature.

When a new article or book is published in African history, Amazon.com has systems that send e-mail alerting the customer of the upcoming product. There are many other recommender systems for current on-line product/service providers [21]. Agents have been incorporated into recommender services for both the seller and buyer. As described above, intelligent information agents have been traditionally used on the seller side to analyze vast amounts of data and alert users of relevant products. Currently, agents have been programmed with the user interests in mind. These agents can analyze market trends and determine if the users are getting reliable information or the best deal for their on-line transactions [22]. Specifically, Sens et al. discuss ways in which transactions can be optimized.

As aforementioned, *Product Brokering, Merchant Brokering*, and *Negotiation* stages can be categorized as mediation-based stages. All of these stages deal with the customer interacting with the product/service provider to coordinate which product, which vendor, and what price or conditions. The main body of work in this area surround current mediation systems and auctioning systems. Current product brokering and merchant brokering systems take large amounts of product data and to assist the user in narrowing down the selection. Traditionally, agents have been incorporated in these environments to do the mundane tasks of browsing and comparing [5]. The responsibilities of these agents have not been extended in current research. In addition, there is also a huge amount of work in negotiation, auctioning, and reasoning. This is a multi-discipline area across business, marketing, computer science, and economics. The resulting transactional reasoning for negotiation and auctioning from all the aforementioned disciplines have been incorporated into agents and agent environments to coordinate and compute specific market interaction [19] [20].

The research areas supporting the *Purchase and Delivery* phase have emerged greatly over the past few years. There are a plethora of systems that have been built to support workflow and supply chain management in electronic commerce. These systems incorporate agents to manage the tasks in the workflow and also to monitor the progress in supply chains [4] [23]. Continuing research by Shrivastava and Blake use agents to implement transactional workflow systems that enables sets of inter-related tasks to be carried out and supervised in a dependable manner. In addition, mobile agents can migrate across multiple on-line services to directly control each task [15]. Meng et al, are developing a suite of protocols for *self-organizing agent communities.* The protocols are based on a three-tier architecture of agents, brokers, and superbrokers. However, the *Evaluation* stage still has not seen significant reported implementations with agents.

2.2 Incorporating Agents into B2B Scenarios

Business-to-business (B2B) systems in general are not as mature as B2C systems. We believe that in order to progress and make B2B more accepted in production, we must examine traditional B2C systems. Experience gained from the agent architectures used in B2C infrastructures can be the foundation for new agent-based B2B systems.

2.3 Inconsistencies using CBB for B2B

B2B transactions are not as compatible with consumer buyer model as with B2C. There are several principles that are shared, but the B2B scenario places emphasis more into mediating how services can be integrated than in product purchasing. Typically, the product purchasing is a byproduct of some adopted service. For example, a university's bookstore may incorporate Amazon.com's on-line services to offer additional books to students. In doing this, the university integrates the book buying service into a larger range of their local services, such as offering school paraphernalia and alumni products. When students actually purchase books through this integrated service that is more of a byproduct of the B2B coordination. Of course, there are cases where the B2B interoperability entails one business buying products directly from another business, but typically this still is a part of some service-based integration.

Consequently, B2B interoperability focuses more on the business systems than on the consumer purchasing/transactional needs.

3.0 Agents Specifically for B2B

There are several focuses that must be adapted for B2B technologies to be universally accepted. These main focuses in the Foundational phase, *Universal Representations*, *Adaptive Architectures*, and *Mediation*. These three focuses represent the bulk of work being performed currently for agents in B2B.

3.1 Universal Representations

The idea of a platform-independent knowledge or data representation is not specific to agent-based B2B systems. Considering the heterogeneous nature of applications just within the on-line service domain, for system interoperability, universal data format and representations are a must. Over the last decade, there have been several efforts to create a data format that is acceptable to all software environments. The most notable effort is the work developing the Extensible Markup Language (XML) [9]. Currently, XML is the best choice for a language for representing data across multiple platforms. RosettaNet [18] is a consortium of over 400 companies with the main thrust of creating a standard business interchange protocol. This organization has embraced XML in this large-scale effort.

However, in agent-oriented B2B systems, agents typically communicate as proxies for businesses. Traditionally, the Knowledge Query and Manipulation Language (KQML) and supporting protocols have been the methodology of choice for the implementation of agent communications [3][10]. KQML uses a Lisp-based text representation that is not widely accepted for business transactions. If agents are to be used in B2B, there is a need for a consolidation of the accepted industry based representations like XML and the languages that the agents can understand. The latest research trends have taken it one step further. Currently there has been the creation of an *Agent Communication Markup Language (ACML)*, which combines the traditional agent communication concepts of KQML with the industry acceptable universal format of XML [11]. Underlying the ACML is the Business Rule Markup Language (BRML). BRML is the B2B-specific content language [12]. Grosof's research includes business rules for e-commerce, including interoperability and conflict handling, using a technical approach based largely on declarative logic programs in XML. On-going research in this area will assure the consolidation of agents into B2B.

3.2 Adaptive Architectures

As ambitious as it may sound to create universal data representations, the creation of universal software processes borders on the impossible. With the large variety of available technologies and application environments, on-line businesses use a myriad of diverse implementations. In addition, these technologies are evolving at an insurmountable rate. For B2C systems, on-line services are independent thus having the freedom to use any platform with minimal constraints. In the B2B environment, business must integrate with the services of other businesses.

There is a need for adaptive architectures that can be configured to change at run-time (*Run-time Evolution*). Currently, several technologies support this run-time evolution. Systems are being built with functionality that allows outside programs to discover their internal functions/functionality at run-time (*Introspection*). In addition, *Reflection* is the feature in architectures and programming languages that allows outside programs to invoke their functions/functionality at run-time. The latest development environments are embracing this paradigm of introspection and reflection, such as Java/Java Beans, Enterprise Java Bean architectures, CORBA frameworks, Jini Architecture, and Hewlett Packard's E-Speak [26] [28].

In addition to the post-design time configuration that can occur using reflection and introspection, there also need to be mechanism for control. Most B2B systems run as either a workflow or supply chain. A workflow is a series of steps (each one implemented by a task) to

accomplish a specific job. The Workflow Management Coalition (WfMC) does extensive research in the specification and standardization of Workflow Management Systems [29]. A workflow can have different paths based on the results of the independent steps while a supply chain works as a long running workflow. In the B2B paradigm, independent steps/tasks in the workflow or supply chain are realized by the services of multiple businesses.

Presently, agents built on top of these adaptive architectures can be used to control the underlying workflow and supply chain management concerns [4][8][14][23][25]. In some cases, mobile agents can navigate to each of the businesses and invoke the services explicitly. These technologies toward adaptive workflow are aforementioned in context of the CBB model's Purchase and Delivery Stage. However for B2B, agents will be coupled with adaptive architectures to create the full development and production environment incorporating both control and adaptation. Most recently, there are the beginnings of large-scale agent environments built on technologies like Jini, CORBA, Microsoft MSMQ, and HP E-Speak [1][6].

3.3 Mediation

Mediation in B2B can be defined as the communication and coordination needed to integrate services. Before one business can use another businesses' services, the business must undergo the following mediation steps.

1. Identify the specific needs and represent the requirements that fulfill the need.
2. Become aware that a pertinent service is available that might fulfill the requirements.
3. Match requirements to the provisions of the service-provider

Presently, agents are brokers for the businesses in this mediation environment. Agents can encapsulate the requirements and provisions for an on-line business. Current agent-based B2B research is toward agent-based mediation environments where multiple businesses collaborate their services [7][17]. In the following phase, negotiation and auction-based reasoning will need to be incorporated into these type environments. The future goal is to incorporate this mediation environment into the real-time systems.

3.4 Nonfunctional Concerns in Agent B2B

Universal representations, adaptive architectures and mediation environments have to be designed to accommodate certain nonfunctional concerns in the B2B environments. B2B transactions require security as in B2C, but there also needs to be additional rigor as far as privacy. Even among businesses that collaborate, there is an additional requirement for the confidentiality of their intellectual property. In addition to confidentiality, B2B systems must have production strength processes to handle large amounts of requests.

Currently, the demands of agent-based B2B systems merely mention a need for the expansion of security agents and fail to make any progress in the direction. Although the development of security in the area of agent-based B2B is lacking, progress has been made in the realm of B2C under the protocol of KQML. Thirunavukkarasu, et. al. describe the security provided by the Knowledge and Query Manipulation Language, which allows agents to communicate between themselves, share their knowledge, and work together to solve a problem [30]. As the need for B2B transactions grows, the progression of a secure communication between agents, like that of the challenging market of B2C, will expand to fill those needs.

3.5 Reusing B2C Technologies

As the three main aforementioned focuses are solidified there needs to be the incorporation of negotiation reasoning throughout the agent-based mechanisms. This negotiation can be incorporated in the mediation mechanisms as well as the operational transactions. Historically, there has been a great deal of research in the area of negotiation and auctioning. However, currently, Jennings et. al. [16] describe the three different approaches to an agent negotiation scheme, the game theoretical, heuristic and argumentation model. The game theoretical model emphasizes the approach around the anticipation of other agents' decisions in negotiation. Mainly agents

ask for themselves and other agents, "What is the most rational decision to make?'. In the heuristic model, the emphasis is taken off of the reliability of the other agents and placed on computation and decision-making costs. To contrast the dependency on the trading proposals, Jennings, et al. [16] explain the argumentation approach as a model built on the opinions of the agent making the argument. These opinions can be based on information introduced above and beyond the limitation of the existing trading proposals. Sierra, et. al. [24] extend this description of the argumentation model to include the different types of opinions and proposals in a more technical manner. The three types, threats, rewards, and appeals, help to explain to the decision making process that agents use to symbolically resolve a conflict in the best way possible. The concepts of all three of the aforementioned models are useful in situations where businesses will negotiate on each others' services and products.

3.6 The Future of Agent-Based B2B Systems

The future of agent-based B2B systems is in the construction of industry-strength agent-based B2B development environment. Toward this end, there is work being completed between the Defense Advanced Research Projects Agency (DARPA) and a large group of research labs. Their work with the Control of Agent Based Systems (CoABS) Grid is toward a totally integrated agent environment for system interoperability and service discovery (mediation). This work contains the same concepts that will be necessary to have a fully integrated agent-oriented B2B environment [27].

4.0 Conclusions

Using agents in B2B implementations is a relatively new technology, although agent-mediated electronic commerce and B2C have been explored greatly. In order for agent-oriented B2B technologies to be widely accepted, these technologies must support the performance, security, and flexibility required in the corporate environments. In addition, the agent-oriented B2B technologies need to adopt the standard practices and technologies that are popular within the electronic marketplace.

In doing this work weaknesses were discovered among agent-based B2B approaches. One weakness is the lack of collaboration among agent communication research and B2B representation efforts. In order for agents to be accepted in B2B interoperability, agent communication efforts like ACML and BRML will need to collaborate with industry efforts in B2B representations such as RosettaNet. Also, we feel that component-based architectures in industry and research labs will naturally need to be designed with more flexibility to make them more adaptable. Although agents represent the next logical step in automated B2B interactions, we must conclude that there is a great deal of addition research and development that must occur before this becomes a reality.

REFERENCES

[1] B2B Business.Net http://www.b2business.net/

[2] Blake, M.B., "A Development Approach for Workflow-Based E-Commerce using Reusable Distributed Components" Americas Conference on Information Systems (AMCIS2000), August 2000 (Track on Workflow Technology and E-Commerce Applications), Long Beach, CA, August 2000

[3] Blake, M.B., KOJAC: Implementing KQML with Jini to Support Agent-Based Communications in Emarkets, AAAI-2000 Workshop on Knowledge-based Electronic Markets (KBEM2000) (AAAI Press, Technical Report WS-00-04) Austin,TX, August 2000

[4] Blake, M.B., WARP: An Agent-Based Process and Architecture for Workflow-Oriented Distributed Component Configuration, Proceedings at the 2000 International Conference on Artificial Intelligence (IC'AI2000) Las Vegas, NV, June 2000

[5] Chavez, A and Maes, P. Kasbah: An agent marketplace for buying and selling goods. In Proceedings of the First International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology, 75-90, April 1996.

[6] Chen, H., Therani, M., and Sheng, O. "E-Commerce Agent Research and Curriculum Development through HP E-Speak: A Framework

for Creating Wireless B2B Solutions" http://ai.bpa.arizona.edu/go/ecommerce/index_introduction.html/

[7] Collins,J. and Gini,M. " A Testbed for Multi-Agent Contracting for Supply Chain Formation" Workshop on Agent-Based Approaches to B2B at the 5th International Conference on Autonomous Agents (Agents2001), May 2001

[8] Decker, K., Sycara, K., and Williamson,M. "Middle-Agents for the internet, " In the Proceedings of the 15th International Joint Conference on Artificial Intelligence, Nagoya, Japan, August 1997

[9] Extensible Markup Language (XML), W3C Recommendation, February 1998, on-line at http://www.w3.org/TR/1998/REC-xml-19980210

[10] Finin, T., Labrou, Y., Mayfield, J., "KQML as an Agent Communication Language." J.Bradshaw (ed.), Software Agents, MIT Press, 1997

[11] Grosof, B. and Labrou, Y., An Approach to using XML and a Rule-based Content Language with an Agent Communication Language, IJCAI-99 Workshop on Agent Communication Languages, Stockholm, Germany 1999

[12] Grosof, B., Labrou,Y., and Hoi Y. Chan "A Declarative Approach to Business Rules in Contracts: Courteous Logic Programs in XML. Proceedings of the 1st ACM Conference on Electronic Commerce (EC-99) Denver, Colorado: ACM Press, 1999.

[13] Guttman, R., Moukas, A., and Maes, P. "Agent-mediated Electronic Commerce: A Survey". Knowledge Engineering Review Journal, June 1998.

[14] Helal, A., Jagatheesan, A., Wang, M., and Krithivasan,R., "Brokering Based Self Organizing E-Service Communities". Proceedings of the 5th International Symposium on Autonomous Decentralized Systems (ISADS-2001)/ IEEE Computer Society Press , March 2001

[15] J. Meng, A. Helal, and Stanley Su, "An Ad-Hoc WorkflowArchitecture Based on Mobile Agent and Rule-Based Processing," Proceedings of the 2000 International Conference on Parallel and Distributed Computing Techniques and Applications, Las Vegas, NV, June 2000

[16] Jennings, N.R.,Faratin,P., Lomuscio, A.R., Parsons, S., Sierra, C., and Wooldridge, M., Automated Negotiation: Prospects, Methods and Challenges Pacific Rim International Conference on Artificial Intelligence 2000

[17] Preece, A., Flett, A., Sleeman, D., Curry,D., Meany,N., and Perry, P., "Better Knowledge Management through Knowledge Engineering" IEEE Intelligent Systems,Vol. 16, No. 1, January 2001

[18] RosettaNet http://www.rosettanet.org/

[19] Sandholm, T. " eMediator: A Next Generation Electronic Commerce Server", International Conference on Autonomous Agents (AGENTS), Barcelona, Spain, June 2000

[20] Sandholm, T., Agents in Electronic Commerce: Component Technologies for Automated Negotiation and Coalition Formation. Autonomous Agents and Multi-Agent Systems, 3(1), 73-96 2000

[21] Schaefer,J.B.,Konstan,J., and Riedl, J." Recommender Systems in E-Commerce" , Proceedings of the ACM Conference on Electronic Commerce, November 1999

[22] Sen, S. Dutta, P.S., and Mukherjee,R, "Agents that represent buyer's interests in E-commerce", AAAI-2000 Workshop on Knowledge-based Electronic Markets (KBEM) Austin, TX, August 2000

[23] Shrivastava, S. and Wheater, S., "Architectural Support for Dynamic Reconfiguration of Large Scale Distributed Applications" *The 4th International Conference on Configurable Distributed Systems (CDS'98)*, Annapolis, Maryland, USA, May 4-6 1998

[24] Sierra, C., Jennings,N.R., Noriega,P., and Parsons,S., A framework for argumentation-based negotiation. In Intelligent Agents IV: Agent Theories, Architectures, and Languages, 1998.

[25] Singh, M., Yu, S., and Venkatraman, M., "Community-Based Service Location", Communications of the ACM, 44(4) April 2001

[26] Sun Microsystems Inc., Java Language Specification and the Distributed Event Model Specification, http://java.sun.com.

[27] The CoABS Grid, http://coabs.globalinfotek.com/

[28] The Hewlett Packard Company, E-Speak, http://www.e-speak.hp.com/

[29] The Workflow Management Coalition (WfMC) http://www.wfmc.org/

[30] Thirunavukkarasu,C., Finin,T., Mayfield, J. Secret Agents - A Security Architecture, Proceedings of the Workshop on Intelligent Information Agents, (CIKM'95)Baltimore, MD USA, Dec. 1995