B2B Electronic Commerce: Where Do Agents Fit In?

M. Brian Blake

Department of Computer Science
Georgetown University
234 Reiss Science Building
Washington, DC 20057
blakeb@cs.georgetown.edu

Abstract

With the inception of the Internet, huge opportunities have arisen for intelligent automation of business-based transactions. Intelligent agent architectures have gained acceptance in implementing this domain and supporting electronic commerce and other Internet-based transactions. This use of agents in electronic commerce has mostly been directed toward applications that support transactions between businesses and consumers (B2C). Another important domain is the automation of transactions that occur between businesses (B2B). Historically, legacy B2B systems have operated over private networks that are both inflexible and expensive. The success and acceptance of B2C applications over the Internet coupled with the expense and inflexibility of legacy B2B systems has led to the call for more research in B2B technologies that occur over the Internet. Moreover, agent researchers must rise to the challenge to offer agent-based solutions for the intelligent automation of B2B interoperability. In this paper, the problem space of the B2B domain is characterized and areas are suggested where agent researchers can initiate the development of agent-based B2B technologies and systems.

Introduction

Even before the acceptance of the Internet, corporations understood the benefit that electronically transmitted data could bring to transactions between businesses. This notion of electronically transmitted messages for such things as collaborating purchase orders and assisting order enactment and delivery led to the development of the first B2B (B2B Business Net 2002) systems over 25 years ago. These message transfer systems included B2B protocol standards (ASC 2002), such as Electronic Document Interchange (EDI), over mediums called value-added networks (VANS). An illustration of this legacy infrastructure is shown in Figure 1.0. Over the past 2 decades, these systems have gained and acceptance and maturity where corporations or trading partners are able to collaborate electronically. However, these systems are known for their inflexibility. In addition, there are huge expenses associated with both the B2B protocol and mapping software and the usage fees of the proprietary VANs. The benefits and acceptance of the Internet and its capabilities has tend to only exacerbate these original problems. The Internet has offered an inexpensive medium for corporations to reach consumers. Internet paradigms have led to the rise of influential small-to-medium enterprises (SMEs) (Hoque 2000). However, these SMEs have not widely accepted the legacy B2B technology, thus reducing the ability for collaboration with older, larger, more traditional corporations. Given the inflexibility and expense of legacy B2B systems, the acceptance and inexpensive nature of the Internet, and the need for collaboration for all enterprise (regardless of the size), researchers and industry alike are searching for B2B solutions that supercede the traditional ways of thought. The major focus of this paper is to identify areas where agent research can be of benefit in B2B solutions, specifically those solutions that use the Internet as a medium.

This paper will proceed in the following section with a non-exhaustive survey of work where agents are used in electronic commerce, specifically for business-to-consumer transactions. It is the belief of this author that some traditional agent-based B2C research can be extended for agent-based B2B electronic commerce implementations. The subsequent section attempts to characterize how Internet-based solutions can be used for B2B interoperability. The final section shows how state-of-the-art agent research can fit into these Internet-based solutions.

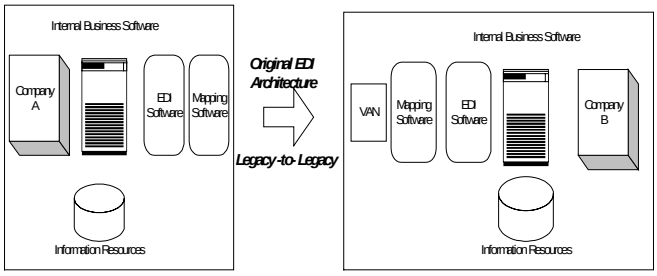

Figure 1.0 Legacy B2B Systems

Agents in E-Commerce using a B2C Model

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 (Jennings, Sycara, and Wooldridge 1998) 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 information-oriented era, where there is an emphasis on automation. This use of agents in electronic commerce has led to the well-established research area called Agent-Mediated Electronic Commerce (Dignum and Cortes 2001) (Moukas, Sierra, and Ygge 2000). Research projects include areas such as service discovery and knowledge management (Preece et al. 2001) (Singh et al. 2001), automated negotiation and pricing (Collins et. Al 2000) (Sandholm 2000), auctioning and transactional reasoning (Andersson et al. 2000) (Sandholm 2000), and the control of workflow and supply chain management (Blake 2000c) (Helal et al. 2001) (Walsh and Wellman 2000). This section gives a non-exhaustive view of the use of agents in Electronic Commerce.

Agents for E-Commerce using the CBB Model

An earlier effective method to categorize how agents are being used in Electronic Commerce is by using the underlying electronic commerce model. This electronic commerce model can be mapped directly to the buying behavior of the consumers. The Consumer Buying Behavior (CBB) Model (Guttman, Moukas, and Maes 1998) formalizes 6 stages of behavior as in Table 2.1. These 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 the electronic market place, but only from a B2C perspective.

The Need Identification stage is consistent with the large of area research into Recommender systems. 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 (Schaefer, Konstan, and Riedl 1999). 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 (Sen, Dutta, and Mukherjee 2000).

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 helps the user narrow down the selection. Traditionally, agents have been incorporated in these environments to do the mundane tasks of browsing and comparing (Chavez and Maes 1996). This research has not changed. 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 interactions (Sandholm 2000).

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 (WfMC 2002) (Blake 2000b) (Shrivastava and Wheater 1998) and also to monitor the progress in supply chain. In addition, mobile agents can migrate across multiple on-line services to directly control each task (Meng, Helal, and Su 2000).

In the Evaluation stage, the most significant advancements using agents are in implementations supporting Customer Relationship Management (CRM) (Pani 2001). CRM solutions provides value-added services to consumers in attempt to win their loyalty to Internet businesses. One such service is suggesting applicable products to the consumer. Intelligent information agents are the ideal solution for mapping customer-purchasing history to available inventory.

An Agent Perspective to the B2B Process Model

The CBB model represents an excellent approach to showing how agents are or can be used in electronic commerce. Similarly, understanding the B2B process model is the key for understanding how agents can be used in the B2B domain. In this section, we introduce an extended process model that is consistent with B2B commerce.

Understanding the B2B Process

In initial studies, the goal was to try to model how the knowledge and technologies where agents are currently being used in B2C and general electronic commerce can be used in the B2B domain (Blake 2001b). There was definitely some suggestion for reuse in that approach, however in order to connect agent technologies to the B2B domain, first the B2B domain pertinent to the agent

qualities needs to be conceived. The major flaw in the earlier work is that B2B commerce is inherently different from the B2C protocol and processes. (Hoque 2000) detailed several general B2B Buying Process steps as Requisitioning, Request for Quote, Vendor Selection, Purchase Order, and Payment Processing. It is our belief that the domain of interest for agent researchers needs further extension. Here, we extend the B2B Buying Process with the addition of the Delivery and Evaluation/Evolution phases to support the entire B2B process. This extended B2B process model is summarized in Table 3.1.

Agent-Mediated B2B Process Model
• *Requisitioning* is the phase where corporate purchasing agents decide what products and services are desired.
• *Request for Quote* is the phase where businesses solicit and search for products or services from external companies/vendors.
• *Vendor Selection* is performed by the initiating company to determine which products/services are most compatible.
• A *Purchase Order* is created and transmitted to the pertinent external company for the selected products/services.
• *Delivery* of products/services typically equates to the integration of companies business automation mechanisms
• The initiating company must compensate other collaborating companies in the *Payment Processing* phase
• *Evaluation and Evolution* is the phase where a business must evaluate the services provided by other companies and vendors.

Table 3.1 Extended B2B Process Model for Agents

The Four Hemispheres of Agent Concern Underlying the B2B Process

We discovered in this research that agent capabilities are not one-to-one with the process phases. The agent capabilities are most effective when applied to a grouping of the phases. Consequently, in addition to the extended process model (Table 3.1), there are also underlying sub-processes that are important to B2B practices with respect to agent concerns. The four sub-processes are sourcing, procurement, workflow/supply chain management, and supplier relationship management. There is a great deal of overlap in these processes, because some phases are common across multiple processes. The four hemispheres of sub-processes can be mapped onto the extended B2B Commerce Model as illustrated in Figure 3.1.

Sourcing is a process that must occur as a first step in B2B commerce. Typically during sourcing, a company has a team of analysts who collect and analyze data about resources they may need. These analyst develop and initiate a strategy to obtain the needed resources that entails the negotiation and collaboration with outside suppliers to create purchasing agreements. The sourcing sub-process incorporates the phases of requisitioning, request for quote, and vendor selection. The procurement sub-process overlaps with the sourcing sub-process. Typically, a strategy for obtaining resources has been determined prior to the procurement process. Once the requisition has been approved, businesses must make on-going decisions on who to buy their resources from. Orders are placed and confirmed and a payment is provided. Typically, the transaction is recorded and reported in some fashion.

Once a business has a firm agreement with a supplier, then the workflow and supply chain management process begins. A business may want to establish a long-standing supply chain with their external suppliers. In some cases, multiple external suppliers may be needed to fulfill a business requirement. This may entail creating and managing a workflow composed of external suppliers to fulfill many related resource requirements. Supplier Relationship Management is the ability for businesses to evaluate their own services and evolve them to better meet the need of the businesses for which they supply services/products.

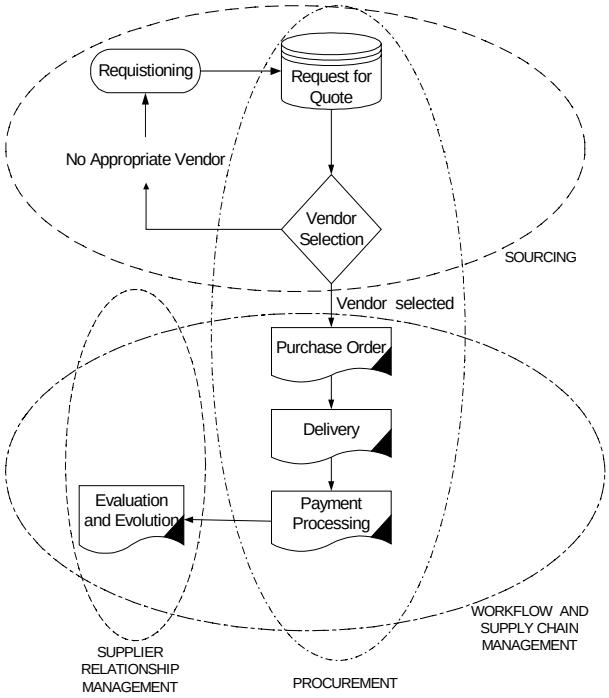

Figure 3.1 Four Hemispheres of Concern in B2B Domain

B2B Research Approaches and How Agents Fit In

The diagram in Figure 3.1 represents a breadth of areas using the Internet as a solution space for B2B electronic commerce. This section further explains each of the 4 sub-processes presented in Figure 3.1 and shows how agent technology can be inserted into the individual areas. Furthermore, current state-of-the-art agent research is evaluated in each proposed area, in some cases, where agent research for B2C can be extended.

Agent-Support for Strategic Sourcing

Requisition, request for quotes, and vendor selection are major aspects of sourcing. What sets sourcing apart from procurement is that typically sourcing becomes an issue when a business is making an initial purchase or must make a set of new, unique purchases. In this case, businesses must have technologies that not only determine what resource is needed, but they also must understand what suppliers are available to provide the resource. At times, establishing this understanding of need is as easy as monitoring a database. Other times, identifying needs requires intelligent services to derive this information. In short, sourcing can be defined as the iterative process of creating appropriate requisitions and request for quotes while researching and negotiating with vendors to determine if there is a match between what is needed and what is currently offered externally. In all cases, businesses must understand their own service offerings and have systems that encapsulate this knowledge.

Frictionless Commerce has an agent-based application that promises to handle the full sourcing process. Technical details of their architecture are not readily available in publication, but it is clear that the underlying iterative data correlation is an excellent capability needing the use of agents. Searching virtual markets and encapsulating resource and capability offerings is a repetitive task that agents can perform. Agents can also encapsulate current business services. Data analysis agents can be used to determine shortcomings. A multi-agent framework of external resource agents and internal service agents can coordinate and determine if correlations can be made that reduce the business shortcomings. Agents in this framework will need inference abilities to perform these data mining activities.

There are several current agent projects that have capabilities that may meet the needs in these areas. (Maes 1997) did initial work using agents that perform various information gathering and associated tasks. One such area was the use of personal assistant agents for machine learning. In fact, later implementations of this work probably led to the establishment of Frictionless Commerce. InfoSleuth (Nodine et al. 2000) is a multi-agent architecture that gathers information from distributed sources and intelligently presents the composite information. (Payne 1997) details areas where interface agents can be used for learning and rule induction. IDM (Bose and Sugumaran 1998) is another multiple agent architecture that attempts to do direct data mining that helps businesses gather intelligence about their internal commerce. (Helmer et al. 1998) uses intelligent agents to mine security data. ASCEND (Blake 2002a) is a new project in the preliminary stages that uses multiple intelligent agents to determine correlation in aviation domains between weather, policies, and airport performance. The extension of projects like InfoSleuth can lead to the use of agents that gather business-specific information, both locally and from distributed sources. Other aforementioned data-mining-specific projects have the potential to create intelligent correlations for sourcing, in some cases with just the change to the business-based data.

Agents and Electronic Procurement

Procurement overlaps with sourcing as far as requesting quotes and making vendor selections. In this research, we assert that the major effort in procurement is towards determining the correct vendor with the assumptions that the correct resource or service is known. During procurement a request for quotes may uncover several vendors/suppliers. Businesses must choose the correct vendor/supplier from among these offerings. Collaboratively the two businesses negotiate on a contract, the consumer business can then transmit a purchase order. The final step is setting up the delivery of the actual resource of service.

There are several underlying emerging technologies that assist procurement over the Internet, such as electronic marketplaces, matchmaking services, the Semantic Web, and document integration. Electronic and virtual marketplaces can be defined as distributed repositories that store product and service information. As of late, these repositories contain Extensible Markup Language (XML)-based representations (W3C 2002). Businesses can browse these repositories and try to find services/products that match their needs. Matchmaking functionality allow businesses to specify their needs and actively attempts to find matching services/products from within the electronic marketplaces. Agent capabilities can be used for matchmaking services as in sourcing. The main problem in these electronic marketplaces is the mismatch in the representations and the data that specify the business offerings. The Semantic Web (Hendler 2001) is an emerging technology where an emphasis is on the convergence of ontologies and further the emergence of the Web as a universal service repository. The Semantic Web uses the Resource Description Framework (RDF) specifications (RDF 2002) to describe web-accessible resources and services. There are also other XML-based languages, such as xCBL (CommerceOne, Inc.) (XCBL 2002) and cXML (Ariba and Microsoft Corporations) (CXML 2002) that further describe B2B specific services and product offerings. These two, however, are just a couple examples of business specification "standards". (Bussler 2001) illustrates the sheer magnitude of new and existing standards (RosettaNet 2002). Currently these more specialized languages (xCBL and cXML) are being evolved so that they are compatible with RDF (Omelayenko and Fensel 2002). Agents can impact electronic marketplaces by encapsulating the matchmaking services and browsing this type of information in order to make the buyer and seller connections (document integration). This is a tedious task that is well suited for the use of agents. In addition, setting up the delivery of products/service is basically an information exchange agreement between a consumer and a supplier business.

Thus, this need for service delivery mechanisms further emphasizes the importance of document integration. A further call for agent-based document integration stems from other nonfunctional concerns of connectivity. Specifically, information exchange must also support the connection of Internet-based businesses to those legacy systems that operate over VANs.

As in sourcing, there are also specific agent projects that potentially can assist in the procurement domain. At the time of publication, there is only one agent-based project that the author is aware of that explores electronic procurement directly. (Chari and Birkin 2001) describes an agent architecture specifically for electronic procurement, however this project is in the initial stages and works mostly in the academic domain. Other agent projects in the electronic procurement domain deal with underlying document integration and matchmaking functionality. DOGGIE (Williams and Ren 2001) is an agent architecture that attempts to converge heterogeneous ontologies. Sycara (Decker, Sycara, and Williamson 1997) (Sycara and Widoff 2002) has several projects that use agents for matchmaking. There are numerous multiple agent environments that establish virtual marketplaces (Dellorocas and Klein 2000) (Gijsen, Szirbik, and Wagner 2002), contract negotiation environments (Collins et al. 2002) (Collins et. Al 2001), and business knowledge management (Preece et al. 2001). The major concern is for these architectures to increase their robustness, security, and flexibility. In several forums specifically for Agents and B2B electronic commerce, industry participants were hesitant to fully endorse these technologies based on these shortcomings (Blake 2001). Additionally, agent researchers supporting these collaboration technologies and environments need to support the emerging Semantic Web and XML-based business specifications. Another shortcoming is the use of agents to connect legacy B2B systems with Internet-based technologies. The author is not aware of any such projects at the time of this paper.

Payment processing is a phase where businesses pay for services or products received. In the context of this paper, we consider negotiation of pricing in this phase as well. Typically, price negotiation is included with service negotiation in the vendor selection phase. There is currently a strength and multitude of projects that incorporate agent-oriented price negotiations for B2C interactions and general electronic commerce. Forums like Agent-Mediated Electronic Commerce present more work in agent-mediated pricing and negotiations than can be presented in the scope of this paper. Most exemplary work, as discussed earlier, has been performed in the area of auctioning and price negotiation. Agent-based B2B researchers need to leverage the agent-mediated price negotiation research and agent pricing algorithms that currently exist. The additional work in this area should be toward extending the existing work to support business-specific pricing models as opposed to B2C-driven models.

Agent-Mediated Supply Chain and Workflow Automation

After the purchase order phase, businesses must decide how service of products will be delivered. A possibility with the Internet as a medium is the sharing of service offerings. Businesses may enhance their own service offerings by collaboratively connecting with the electronic service offerings of another on-line business. The major emphasis here is toward the configuration of systems that allow for the delivery of the business resources. Cross-organizational workflow and virtual/dynamic supply chain technologies are technologies that make this delivery phase possible when using the Internet as a medium. The current effort toward Web Services is another area where agents can be effective. The use of Web Services for functional specification and interactions has attained a great deal of attention currently. The Simple Object Access Protocol (SOAP) (SOAP 2002) is a protocol that contains a framework where message composition and their responses can be specified. This protocol is specific mostly to Web Services over HTTP. Web Service Description Language (WSDL) (WSDL 2002) allows the specification of the services that use these messages. To date the Web Services technologies are mostly toward the specification of interfaces and communication. Other technologies such as the Universal Description, Discovery (UDDI) Repository (UDDI 2002) allows the publication of Web Services. From a B2B commerce perspective, it is forecasted that businesses will use these Web Services for service offering as well as creating Web Services that help realize product offerings. The final aspect is the specification and control of the workflow and supply chain paradigms of which these services will be contained. There is initial work toward the workflow specification languages for Web Services in the Web Services Flow Language (WSFL) (WSFL 2002) and Business Process Markup Language (BPML) (BPMI 2002). Agent can be important in interpreting these specifications and managing the control, security, and flexibility of the workflow or supply chains composed of Web Services. In addition, the delivery of services is another area where legacy systems and Internet-based systems must connect.

Several agent technologies and projects support this domain. (McIlraith 2001) is in the preliminary stages of work that explores the composition of Semantic Web-Based Services using agents from a modeling perspective. Some matchmaking, as in the procurement process, must take place prior to the composition of service. There is work (Massimino et al. 2002) that specifically explores Web Service matchmaking. The Lost Wax company has a commercial application that uses agents in the B2B enactment. Other research (Blake 2002b) explores agents for the workflow and supply chain management of Web Services, specifically.

For general supply chain and workflow automation (Walsh and Wellman 2000), there are many excellent agent projects as discussed in Section 2.0. The main goal should be aligning these projects with the emerging Internet-based

technologies. Some initial progress to this end is the initial convergence of agent communication protocols and languages that use XML-based languages (ACML and DAML) (Grosof, Labrou, and Chan 1999) (CoABS Grid 2002), even those that combine agent communication, business rules and XML (BRML) (Grosof and Labrou 1999).

Agent-Based Supplier Relationship Management

A new area in electronic commerce is assuring the satisfaction of the consumer. As in CRM, there is business value in maintaining the relationship with consumer businesses. In traditional storefronts, a distributor may send a gift (e.g. a free turkey) to a store that it supplies to maintain a relationship with the owner. In the dynamic environment of the Internet, a suppliers need to proactively maintain the cost-effectiveness and utility of their offerings or products. Similar technology as presented in the sourcing and procurement process can be used to assure the cost-effectiveness of suppliers' products. At the time of this paper, there was no work where agents intersect with SRM. Consequently, agent-based processes specifically for SRM represent an open area for agent research.

Conclusion: Opportunities for the Future of Agents in B2B E-Commerce

Based on the research opportunities for agents, we believe B2B solutions over the Internet can be separated into three areas, adaptive technologies, replacement technologies, and peripheral technologies. Adaptive technologies are those which connect legacy B2B Systems to Internet-based E-Commerce Systems. Adaptive Technologies integrate with and leverage on existing legacy B2B systems and protocols. Replacement technologies attempt to connect two Internet-based E-Commerce Systems using the Internet as the VAN, thus replacing legacy systems. Finally, the peripheral technologies are those that assist in B2B Transactions without claims to explicitly affect the infrastructure, but can be used for either Adaptive or Replacement.

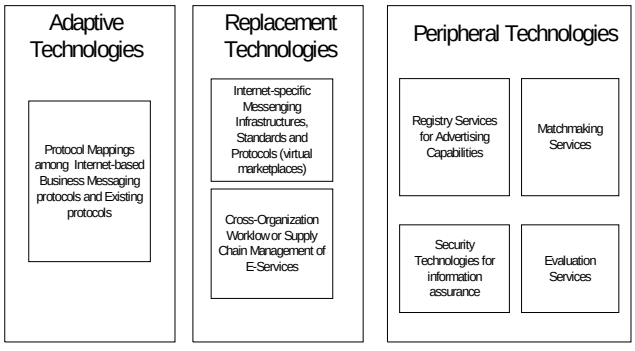

Figure 6.1. Taxonomy of Areas Where Agents Can Impact B2B Technologies

By separating into these three areas, we can classify each of the opportunities (as in Section 5.0) that agent researchers have in the domain of B2B electronic commerce. A taxonomy of these areas and specific opportunities is illustrated in Figure 6.1.

In this research, four hemispheres of agent concern were introduced to help categorize how agents can assist current B2B efforts. These areas represent opportunities for agent researchers to advance the state of the art in B2B systems. Probably the most critical area, at this time, is for agents to help the integration of business knowledge, both representation and data. Moreover, this integration would greatly assist the integration of legacy and emerging technologies. Once information can be properly disseminated and collaborated, then agents can be used to mediate the composition of services among businesses. Future work (Blake 2002b) of the author is in the area of business service composition and enactment.

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