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Agent-oriented approaches to B2B interoperability

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Abstract

The use of agents in electronic commerce has been explored greatly over the past several years. A large majority of this effort is toward commerce where businesses have direct transactions with consumers (B2C). However, the transactions that occur between businesses (B2B) are far more prevalent than B2C. Research where agents are used for B2B can be classified in five basic areas, service discovery, mediation, negotiation, process management (be it workflow or supply-chain management), and evaluation. At the 2001 International Bi-Conference Sessions on Agent-Based Approaches to B2B Interoperability (AgentB2B), practitioners were invited to present their research and industry efforts in each of these areas. This paper summaries the work and conclusions presented at these two events.

1 Introduction

Currently, research and applications where agents are used for B2B electronic commerce is in a relatively initial stage. There is a great deal of work where agents support electronic commerce, in general, but little work specifically attacks the problem of business-to-business interoperability. This is a tremendously complex domain that spans multiple concerns in the B2B transactional life-cycle. The purpose of the bi-conference sessions on agent-based approaches to B2B interoperability (AgentB2B) was to gather the top agent researchers in electronic commerce and discover the state of the art of agent systems that deal with B2B concerns. We received numerous agent papers, but the vast majority of these papers still dealt with B2C concerns as opposed to B2B. After the review, we accepted 14 papers that reflected work in the following areas. Those areas are

- state of the art survey of agents in B2B,
- knowledge management and mediation for service discovery,
- negotiation, auctioning and collaboration,
- process management and realisation,
- evaluation and evolution and
- state of the art software systems with B2B implications

Based on the preference of the authors and the focus of each of the sessions, these papers were split over 2 events. The first event was the workshop on agent-based approaches to B2B held at the 5th International Conference on Autonomous Agents (Agents2001) in Montreal, Canada. The focus of this first session was to present technologies that play a supporting role in B2B electronic commerce. This session addresses the mechanisms needed to help businesses discover and understand their capabilities. There were presentations that supported the negotiation and auctioning needed in these B2B domains. In addition, there was a presentation explaining the use of workflow in these domains. In other presentations, we looked at recent fielded systems in B2B as well as systems in B2C that had potential for B2B expansions. However, based on the presentations, we concluded that the majority of the work in this session focused on collaboration prior to the actual transactions.

The second session was the special session on agent-oriented software architectures for B2B interoperability at the 2001 International Conference on Artificial Intelligence (IC'AI2001) in Las

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Vegas, Nevada. The focus of this section was specifically on agent-oriented software architectures and implementations for B2B process and collaboration management. Unfortunately, two of the authors in this section did not present their work and consequently are not discussed in this paper.
The organisation of both sections including the subjects addressed is presented in Table 1.

The remainder of this paper will present the discussions of each of the presenters. The presentations will be discussed in context of the type of agent-based B2B contribution that is made. In the final section, the paper will discuss comments and conclusions that were made as a result of both sessions.

Table 1 Technical organization of the AgentB2B bi-conference sessions.

Agent-based approaches to B2B at Agent2001	
Presenter(s)	**Title of paper**
Agent B2B surveys	
Brian Blake	Innovations in software agent-based B2B technologies
B2B and relevant B2C Systems	
Monique Calisti	Agent-based framework for financial transactions
Catholijn M. Jonker	Intelligent agents in telecommunications
Process management	
Henrik Stormer	A flexible agent-based workflow system
Auctioning (negotiation)	
Tuomas Sandholm	Winner determination in combinatorial auction generalizations
Tuomas Sandholm for Kate Larson	Computationally limited agents in auctions
Mediation	
Alun Preece	A mediator-based infrastructure for virtual organizations
John Collins	A test-bed for multi-agent contracting and supply chain formation
Agent-oriented software architecture for B2B at IC'AI2001	
Agent B2B surveys	
Todd Cornett and Tepring Piquado	Using intelligent agents in conjunction with B2B interoperability
Agent-B2B software architectures	
Mark Matthews	Supporting dynamic change in B2B coordination
Lisa Schaefer and Gary Graf	Three-segment agent architecture using Jini for workflow
Ashis K. Pani	Implementing e-CRM using intelligent software agents on the Internet

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2 Contributions of presenters at the AgentB2B session at Agents2001[1]

As stated earlier, the first AgentB2B session at Agents2001 consisted of efforts for supporting technologies more than the actual transaction management modules. This section will discuss the contributions of authors based on the subjects relevant to their work.

2.1 Agent B2B surveys

The session began with a presentation from Brian Blake of Georgetown University. This presentation set the context for all the subsequent presentations. Blake presented results from a survey that he had conducted over the prior 4 months. The point of departure of his presentation was the widely accepted and cited electronic commerce survey conducted by the MIT Media Laboratory in 1996 (Guttman *et al*. 1998). In this survey, Guttman and Maes describe the consumer buying behaviour model. This buying behaviour model consists of the stages of needs identification, product brokering, merchant brokering, negotiation, purchase and delivery and product service and evaluation. Blake argued that these stages are not as relevant to B2B commerce. Blake insisted that B2B commerce focuses more on services than on products, in addition there is a need for the emphasis on non-functional concerns, like security, performance and failure-handling. Consequently, Blake proposes another model called the Agent B2B Evolution (ABE) Model. In this model, he presents the stages of development in agent systems that are more geared to B2B. These developmental stages focused on universal representations, adaptive architectures, service and product mediation and re-engineering of current B2C negotiation for B2B, culminating with the creation of full life-cycle development tools. Finally, Blake presented relevant technologies in each of the development stages. He mentioned the use of XML for an agent communication language with the creation of the Agent Communication Markup Language (ACML) (Grosoff & Labrou, 1999). Blake asserted the need for more efforts that unite agent research to the industry efforts in B2B electronic commerce system development. Finally, Blake stated that there is a need for more Internet technologies in the construction of agent systems to further lessen the gap between B2B tools and current agent technologies.

2.2 Relevant agent-based B2C applications

The next two researchers presented their findings in the development and fielding of agent-based applications for B2C that have relevance to B2B commerce. The first presenter, Monique Calisti of the Swiss Federal Institute of Technology, spoke about her research that uses agents to potentially support banking, investments, insurance, mortgages and wealth management. Calisti presented the Financial Agent-based Transaction (FAT) system to explore how agents can automate financial interactions in both a B2C and B2B setting. This FAT system shows how agents can support or even replace humans in financial services as on-line transactions evolve. The FAT system is essentially agent middleware that can abstract the "technological idiosyncrasies" of the software financial services among businesses as well as allow more flexible interaction between consumer and provider (B2C) and provider and provider (B2B).

Catholijn Jonker of the Vrije Universiteit and American Management Systems (AMS) presented an intelligent agent system for use in an automated recharging system for prepaid mobile phones. Jonker presented the problem of the routine human task of recharging cellular phones for more minutes once the current prepaid amount has been used. Currently, this research has led to development of the MOBIE system, which was developed by the Intelligent Agent Initiative Team at the AMS Corporation. The pilot of this system has been deployed and is readily usable in industry. The MOBIE system consists of a server-side agent that can be programmed with the personality of a user. Jonker discussed how this personalisation is a major thrust in their research in addition to the Enterprise Java

[1] The full papers of the AgentB2B sessions can be found at `http://www.cs.georgetown.edu/~blakeb/AgentB2B/papers/`

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Bean-based architecture that the agent system is built upon. Jonker further discussed findings of the difficulty of combining industry standards with agent technologies. One major concern is the lack of robustness when integrating rule engines and other agent tools with current industry technologies such as Java. Another concern is that object-oriented methodologies, which are prevalent in industry, have no concept of agent pretenses like autonomy.

2.3 Workflow management

A critical aspect in B2B electronic commerce systems is the conceptualisation of the underlying technologies that will support the execution of transactions. Since collaborations among businesses tend to be more long-term than for B2C transactions, the B2B processes tend to follow the paradigm of either workflow or supply-chain management. Henrik Stormer of the University of Zurich presented work where agents are used for workflow management. This work is relevant as B2B transactions tend to be modeled as a workflow consisting of the services of multiple businesses. Stormer presented multiple Java-based agents that could be used to support workflow. The main benefits of his findings were that agents release the need for decentralised servers, they can support multiple-process definition languages, they can support the separation of duty (distributed control) and support inter-organisational work and mobile devices.

2.4 Auctioning

Auctioning is an area where, in the past, groups of consumers could bid on products. In the B2B arena, these auctioning techniques can be extended for enterprises to collaborate with multiple sub-contractors. As a co-author of both papers in the area of auctioning, Tuomas Sandholm of Carnegie Mellon University made both presentations in this area where agent systems can be used to control auctioning processes. The first area presented by Sandholm (speaking for Kate Larson, also of Carnegie Mellon University) is the area of computationally limited agents in auctions. Sandholm discusses the composition of B2B auctions where local plans and schedules can be used to compute the price of a product. Sandholm suggested that agents can not only bid on items, but also be used to determine the valuation of items. This computation of item valuation is typically in the context of limited resources. Sandholm presented several agent-based strategies and algorithms that can be used to make these valuations with the knowledge of limited computational resources.

Sandholm made a second presentation in the area of winner determination in combinational auction generalisation. In this presentation, Sandholm presented his results in situations where multiple items can be auctioned, based on consumers' preferences. Both presentations showed that the area of auctions could strongly support the collaboration that must occur among businesses in the B2B domain.

2.5 Mediation architectures

The final major topic in the first AgentB2B session is in the area of mediation. This area has two important aspects. The first is that businesses need to have a certain ontology and method for representing their business capabilities. Alun Preece of the University of Aberdeen presented the Knowledge Reuse and Fusion/Transformation (KRAFT) agent architecture. KRAFT consists of mediator agents that allow a coordinated means for multiple organisations to exchange business information. Preece discussed his work with respect to a subset of KQML that allows multiple business-oriented agents to interact and distribute knowledge.

The second aspect of mediation is the architecture and underlying systems that support the mediation process. John Collins and Maria Gini of the University of Minnesota presented an agent-based architecture and demonstrated a prototype where supply-chain scenarios could be assembled from multiple businesses. Collins presented customer and supplier agents that collaborate to create supply-chain transactions based on a common market ontology and independent market sessions.

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Collins asserted that this prototype is highly extensible and configurable; however, in order to quantify the architecture there needs to be a set of benchmark problems among implementations that have solutions in this area.

3 Contributions of the presenters at the AgentB2B session at IC'AI2001

The second AgentB2B session at IC'AI2001 more specifically targeted B2B architectures and implementations. This section will discuss the presentations that were made at this second session.

3.1 Agent-based B2B technology survey

Todd Cornett and Tepring Piquado gave the first presentation. These undergraduate research assistants of Brian Blake of Georgetown University presented an extension of the original survey presented at the first AgentB2B session. In addition to the current agent research projects that span the ABE model, Cornett and Piquado detailed specific applications that currently use agents internally. The Lost Wax Company (2001), with the help of Nick Jennings, uses an agent architecture to handle the entire B2B conceptualisation and realisation process. Frictionless Commerce (2001), originating out of the MIT Media Lab, has internal agents that manage procurement among businesses. They also discussed the Agent-B2B project at Georgetown University where agents are used as the workflow-based middleware among multiple businesses. The difference in this approach is that these agents connect the underlying heterogeneous services of the multiple businesses from the bottom up. Cornett and Piquado discussed the lack of full lifecycle development tools using agents.

3.2 Agent-based software architectures for B2B commerce

The remainder of the session contained reports on B2B architectures and applications. Mark Matthews of the MITRE Corporation presented the agent architecture called SWAP to support dynamic change in B2B coordination. Matthews illustrated the problem that occurs when multiple businesses coordinate by one policy of workflow or supply chain and later have to change to an entirely new policy. The SWAP approach uses an agent architecture that analyses the ability for collaborating businesses to change from one policy to another at design time.

Lisa Schaefer of the MITRE Corporation and Gary Graf of the Arizona State University presented a prototypical agent architecture built on Sun Microsystems's Jini architecture and the JavaSpace server to support workflow management. This prototype has a graphical user interface and agent-oriented mechanisms that facilitate software development among multiple groups of software developers.

Ashis Pani of the Information Technology and Systems Area at XLRI Jamshedpur presented an architecture for electronic Customer Relationship Management (e-CRM). Pani discussed an approach for satisfying the relationships between customers and business organisations; however, this approach can be extended to relationships among business organisations.

4 Conclusions

Based on the presentations made and the conversations at both sessions, one major conclusion is that B2B research, especially that research which specifically incorporates agents, is being evolved from agent research that initially supported B2C concerns. Specifically, this evolution occurs with an increase in scope and functional performance. The work in mediation and knowledge representation, however, does seem to originate from B2B origins. Such industry standardisation efforts, as RosettaNet and CommerceXML, seem to have driven the need for agents to represent the vast knowledge that is shared among on-line businesses.

There were industry participants from Lost Wax, the Frictionless Commerce, CombineNet (2001), and OpenWebs (2001) companies. From the industry B2B participants in both sessions, there were

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several overlying questions: "how secure is this architecture?", "how well does this implementation perform for thousands of transactions?" and "can this system evolve over time?". Essentially, these concerns and others were based on non-functional issues as to whether the systems can perform in industry and particularly the benefit of such systems over traditional EDI systems. Unfortunately, the answer from many of the agent researchers is that they have not determined the strength of their systems or that the system is still in the prototype stage. In addition, many researchers admitted that their proof of concepts were not scoped well to handle the multitude of business concerns. Based on these responses, we have to conclude that agent-based systems currently lack the maturity to undertake the rigours of the B2B domain, at least at a production level.

Following the success of the initial AgentB2B sessions, there will be an additional session in 2002 at the Eighteenth National Conference on Artificial Intelligence (AAAI-2002). Also, there will be a special section in the *International Journal of Electronic Commerce* (*IJEC*) in the summer of 2002 with articles dealing with the use of agents in B2B electronic commerce research and applications.

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