Integrating Mobile and Intelligent Agents in Advanced e-Commerce: A Survey

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Abstract. The paper attempts to survey the existing research and development efforts involving the use of mobile agents and intelligent agents for advanced e-commerce solutions. In particular it aims at providing a representative view of the current research trends in developing intelligent and mobile agent-mediated e-commerce including location-aware, mobile and networked comparison-shopping, auction bidding and contract negotiation. A number of selected agent systems are presented with short overviews and then discussed in the context of agent-mediated e-commerce including the scope and specific solutions they address, provided support for agents' migration and users' mobility, and deployment approaches. Finally, a summary of the considered systems is presented together with some concluding remarks including the current state and trends in developing mobile and intelligent agents in advanced agent-mediated e-commerce.

1 Introduction

Future global information networks are often described as rich collaborative environments in which intelligent automated services (such as advertising, negotiation, financial transactions, order placement and delivery) enable enterprises to dynamically discover, interact and do business with each other. To be competitive in the new "e - economy" it is vital that researchers and industry alike are able to exploit emerging technologies that will form the basis of tomorrow's global information networks and act as the worldwide infrastructure for automated commerce. There are clearly many challenges in realizing such environments and today's technology already provides many of the tools for creating such dynamic service environments:

- **Agent technology** as a paradigm for structuring, designing and building systems that require complex interactions between autonomous distributed components. The Foundation for Intelligent Physical Agents, FIPA (www.fipa.org), is the leading international organization in research and development of standards for inter-

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active software systems based on the agent-oriented software engineering paradigm.

- Novel **business-to-business (B2B) technologies** such as market places, smart directories (Universal Description, Discovery and Integration - UDDI), trading standards (electronic business eXtensible Markup Language - ebXML), novel interaction paradigms (such as peer-to-peer) and web based integration (e.g., Simple Open Access Protocol - SOAP).
- New **web** and **semantic web standards** such as eXtensible Markup Language (XML), that enrich the semantic content of information published and form the basis of new interoperability mechanisms.

Following the web-centric paradigm shift [Ulieru, et.al. 2002] enabling the sharing of information, services and applications among suppliers, employees, partners and customers, an international effort referred to as the Global Dynamic Service Environment (Global DSE), is being conducted to provide an integrated information framework for inter-enterprise collaboration. This framework creates an environment by which enterprises can deploy and exchange services as well as create new, compound services. The value of this web-enabling environment extends across many domains, encompassing e-Business and e-Commerce; Internet-enabled services to society (such as e-Health [Ulieru and Geras 2002], e-Education, e-Collaboration); global communications; distributed manufacturing automation and robotics.

The Global DSE approach is to build upon the FIPA Agent standard as the underlying model for services – identifying the concept of a dynamic service with that of an agent as an autonomous system, capable of interacting with other agents in order to satisfy its design objectives. Other technologies then build on top of or into the agent framework to provide a rich/flexible environment. Although the technologies involved are mature enough to create and use an initial functional test bed and begin exploiting some of its benefits, extensive research is required to address the issues related to dynamic service composition. Such issues include: architectural requirements for interactive software systems, ontologies for multi-agent systems, security norms for multi-agent collaborative environments, market and other economic models in agent-systems engineering, gateways technologies for telecommunications networks, and coalition formation in multi-agent enabled organizations.

Electronic commerce offers new channels and business models for buyers and sellers to effectively and efficiently trade goods and services over the Internet. Agent-mediated e-commerce is concerned with providing agent-based solutions for different stages of trading processes in e-commerce including need identification, product brokering, merchant brokering, contract negotiation and agreement, payment and delivery, and service and evaluation (e.g. [Bailey and Bakos, 1997], [Chavez et al, 1997], [Guttman and Maes, 1998], [Gutman et al, 1998]). As the market quickly evolves, new advanced dynamic e-commerce (called also negotiated e-commerce or e-negotiation) solutions emerge to enable mapping more sophisticated and efficient negotiation models in business transactions to e-commerce, in particular in the contract negotiation and agreement stage of the trading process. It involves the development of e-commerce agents with more intelligent decision-making and learning capabilities in the context of automated contracting that can include comparison shopping, bidding in auctions and contract negotiations. At the same time the e-commerce environment

also becomes more complex and dynamic due to the business trends to trade in several inter-connected marketplaces and use new wireless communication channels and portable computing devices (e.g. PDAs, mobile phones) in emerging location-aware mobile e-commerce (m-commerce). Here the mobility aspects of agent technology are predicted to play a significant enabling role.

The creation of the DSE involves a whole range of technologies ranging from emerging business-to-business facilitators to web standards and Agent and Artificial Intelligence technologies. In particular however the Global DSE uses the Foundation for Intelligent Physical Agents (FIPA) standard as the basis for intelligent interoperability in the network. Other technologies are then considered to augment this.

The growing number of research efforts in the areas of mobile e-commerce agents (e.g. [Kotz and Gray, 1999], [Papaioannou, 2000]) and agent-mediated e-commerce (e.g. [Bailey and Bakos, 1997], [Chavez et al, 1997], [Faratin et al, 1999], [Guttman and Maes, 1998], [Gutman et al, 1998], [Kowalczyk and Bui, 2000], [Lomuscio et al, 2000], [Maes et al, 1999], [Sandholm and Lesser, 1995] testify the potential benefits of integrating mobile agents in more advanced e-commerce applications. Some research has also been directed towards the use of mobile agents in intelligent agent-mediated e-commerce (e.g. [Dasgupta et al, 1999], [Griffel at al, 1997], [Sandholm, 2000], [Tu at al, 1999]).

The paper attempts to survey the existing research and development efforts involving the use of mobile agents and intelligent agents for advanced e-commerce solutions. It should be stressed that due to the practical and technical reasons the paper is not intended to be an exhaustive survey of all related research in this area. However it aims at providing a representative view of the current research trends in developing intelligent and mobile agent-mediated e-commerce. Some stationary agent-agent-mediated e-commerce systems are presented in Section 2. A number of selected intelligent and mobile agent systems in agent-mediated e-commerce including location-aware, mobile and networked comparison-shopping, auction bidding and contract negotiation are presented in section 3. They are discussed and summarized in Section 4 in the context of agent-mediated e-commerce including the scope and specific solution they address, provided support for agents' migration and users' mobility, and used deployment approaches. Section 5 presents concluding remarks including summary of the current state and trends in research and development of integrated intelligent mobile agents for advanced e-commerce.

2 Intelligent Agents in Dynamic E-commerce

There are many challenges in realizing the Global DSE. Highly interdisciplinary research (e.g., industrial engineering and control systems, distributed artificial intelligence and logic programming, information systems and communication technologies) is required to develop and implement dynamic services for a Networked Economy. The *Agent paradigm* for structuring, designing, and building software systems that have complex interactions among autonomous distributed components has proven to be an excellent tool for modeling large-scale distributed information environments (e.g., factory control and global supply chain coordination).

To enable the deployment of dynamic e-Commerce environments the European and the US Agentcities initiatives (www.agentcities.org), combined with international initiatives in FIPA (www.fipa.org), aim to create a global open information-exchange environment where dynamic services from geographically distributed organizations can be deployed, tested, interconnected and composed. Examples of such dynamic services are: B2B (Business to Business) dynamic value chain creation; dynamic pricing through trading exchange; automatic discovery of business partners; advertising and marketing. At this time there are large-scale initiatives in Japan, Europe, USA, Australia and New Zealand. In particular, Europe has two major Projects involving more than 50 organizations that already have been funded through the European Union's Fifth Framework Program.

Research on intelligent agents for dynamic e-commerce has already resulted in a number of interesting developments within the scope of agent-mediated e-commerce in particular for contract negotiation and agreement (e.g. [Bailey and Bakos, 1997], [Beam and Segev, 1997], [Gutman et al, 1998], [Maes et al, 1999], [Jennings et al, 2001]). A survey on agent-mediated e-commerce including well known early agent systems for e-commerce developed prior to 1998 such as Kasbah [Chavez et al, 1997] and Tête-à-Tête [Guttman and Maes, 1998] was presented in [Beam and Segev, 1997] and [Gutman et al, 1998]. For completeness, in this section we overview some selected new systems that have been proposed or further advanced since the above survey was conducted. Latest results regarding the implementation of e-Commerce strategies founded on the Global DSI infrastructure can be found in: [Sadeh et. Al, 2002] and [Dale and Ceccaroni, 2002]

AuctionBot [AuctionBot] is a well-known experimental Internet auction server developed at the University of Michigan. Its users can create new auctions by choosing from a selection of auction types and then specifying its parameters (such as clearing times, method for resolving tie bids, and number of sellers permitted). Buyers and sellers can then bid according to the auction's multilateral distributive negotiation protocols. In a typical scenario, a seller bids a reservation price after creating the auc-

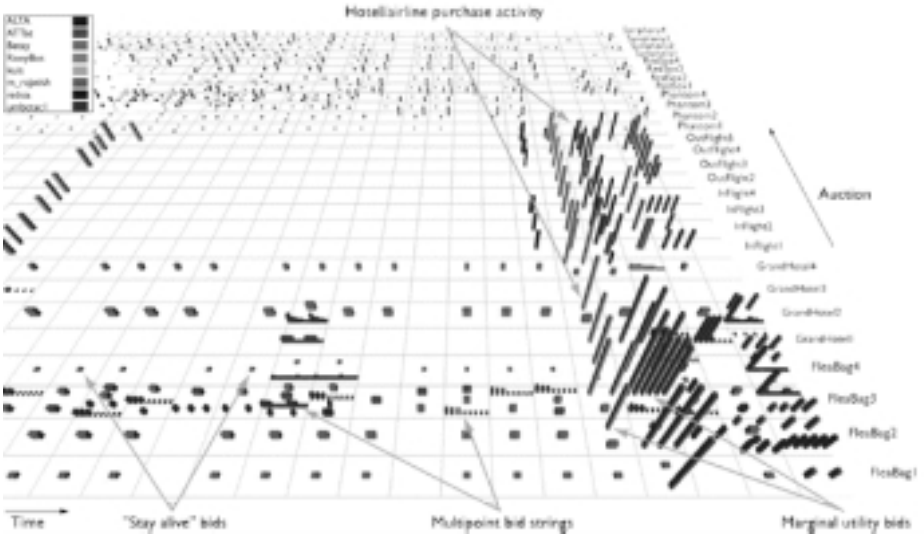

Fig. 1. Visualization of TAC games [TAC]

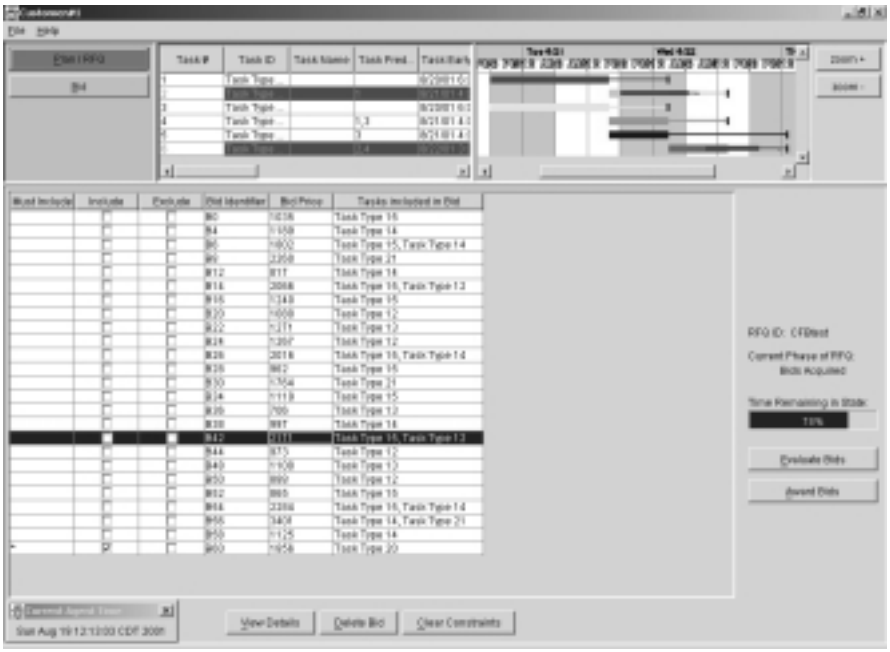

Fig. 2. Bid evaluation in MAGNET

tion and lets AuctionBot manage and enforce buyer bidding according to the auction's protocols and parameters. AuctionBot also provides an application-programming interface for users to create their own bidding agents to autonomously participate in the AuctionBot auctions. In particular AuctionBot has successfully been used to host Trading Agent Competitions [TAC] designed to promote, evaluate and showcase trading agents competing in a challenging market game consisting of several simultaneous auctions. The TAC competitions have resulted in a number of interesting systems of bidding agents developed by different research groups (e.g. [Greenwald and Boyan, 2001; Stone et al, 2001])

MAGNET (Multi AGent Negotiation Testbed) [MAGNET] is an experimental architecture developed at University of Minnesota to provide support for complex agent interactions, such as in automated multi-agent contracting, as well as other types of negotiation protocols. Agents in MAGNET negotiate and monitor the execution of contracts among multiple suppliers. A customer agent issues a Request for Quotes for resources or services it requires. In response some supplier agents may offer to provide the requested resources or services, for specified prices, over specified time periods. Once the customer agent receives bids, it evaluates them based on cost, risk, and time constraints, and selects the optimal set of bids that can satisfy its goals. An example of the bid evaluation screen shot is shown in Figure 2. Suppliers are then notified of their commitments, and the Execution Manager is called to oversee completion of the plan. Plan maintenance includes re-negotiating existing commitments, re-bidding portions of the plan and re-planning [Collins and Gini, 2000].

eNAs (e-Negotiation Agents) [Kowalczyk and Bui, 2000a] and *FeNAs* (Fuzzy eNAs) [Kowalczyk, 2001] are prototypical intelligent trading agents developed at CSIRO [ITA] to autonomously negotiate multiple terms of transactions in e-

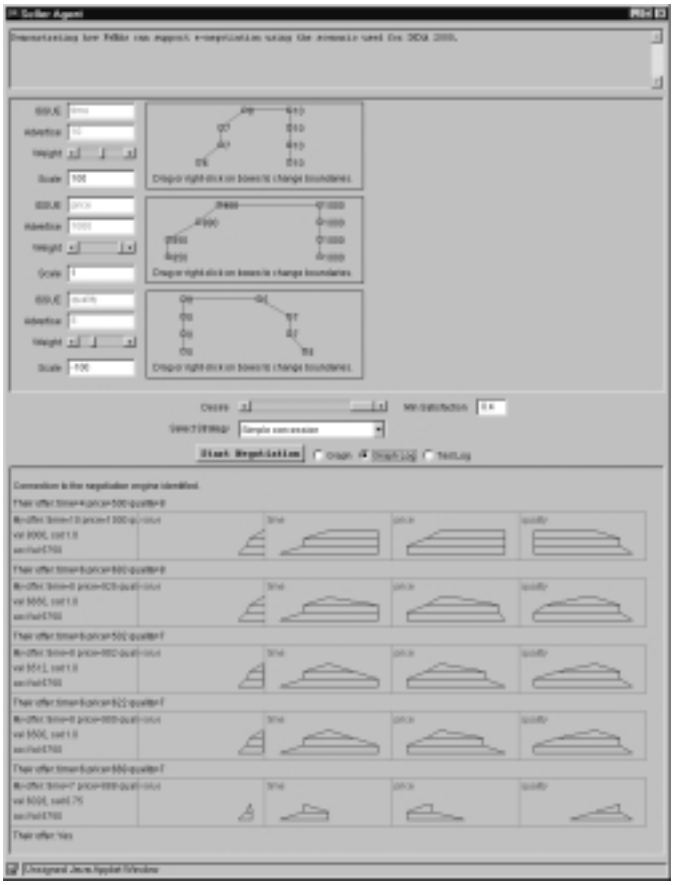

Fig. 4. FeNA agent displaying propagation of fuzzy constraints during negotiation

commerce trading. The agents can engage in integrative negotiations in the presence of limited common knowledge about other agents' preferences, constraints and objectives through an iterative exchange of multi-attribute offers and counter-offers.

Fuzzy eNAs can also flexibly negotiate with fuzzy constraints and preferences (see Figure 3). The F/eNAs environment can consist of many autonomous trading agents representing buyers and sellers that can engage in concurrent bi-lateral negotiations according to a number of user-selected negotiation strategies. The eNAs and FeNAs agents have been demonstrated with a number of test-beds of e-commerce trading [Kowalczyk and Bui, 2000a; Kowalczyk and Bui, 2000b].

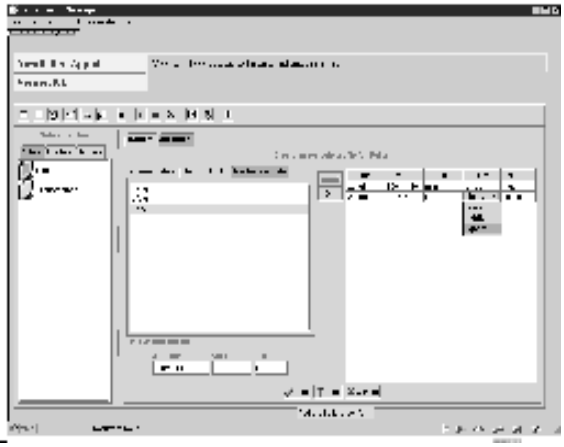

Fig. 3. Casba Agent Interface

Casba (Competitive Agents for Secure Business Applications) [Casba] is an Esprit funded project to develop a framework for an electronic marketplace using multi-agent technology. Casba aims at provid-

ing a set of tools for setting up, administering and managing an electronic agent market on the Internet.

Several auction types are supported and automated using agent technology. The libraries include flexible negotiation strategies that can be adapted to various product categories. Casba's toolset incorporates objects and interfaces for interacting with existing Web servers, database management systems and e-commerce platforms.

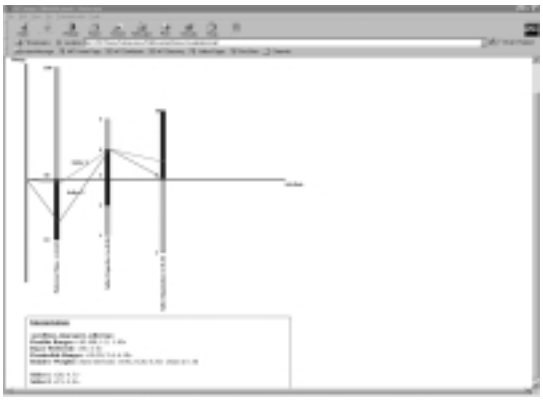

Fig. 5. MARI Visualization

MARI (Multi-Attribute Resource Intermediaries) [MARI] is a project initiated at MIT Media Lab to develop an intermediary architecture intended as a generalized platform for the specification and brokering of heterogeneous goods and services in e-commerce. It aims at allowing both buyers and sellers to specify relative preferences for the transaction partners and different product attributes. MARI facilitates automation in the brokering process with the agents acting as proxies for buyer/ seller interests. Figure 5 presents an example of MARI visualization of changing preferences during that process.

It should be noted that there also are a growing number of other important ongoing research efforts that have already provided several significant contributions to intelligent agents in e-commerce. For example AgentLinks' SIG on Agent-Mediated e-Commerce [AMEC] and ACM SIG on e-commerce [SIGecom], which bringing together active researchers and research groups from academia and industry working on different aspects of intelligent negotiation agents, are good reference sites for the latest developments in that dynamic R&D area.

3 The Mobility Aspect in Dynamic and Mobile E-commerce

Mobile agents have been recognized as a very prospective technology for both dynamic and mobile e-commerce applications (e.g. [Sandholm, 2000], [Griffel at al, 1997]) but the research in that area is still in very early stages. Although most of the related research considers mobile communication and location-aware computing, there is also growing research on deploying mobile and intelligent agents in advanced e-commerce including location-aware, mobile and networked comparison shopping, mobile auction bidding and mobile contract negotiation.

3.1 Location-aware shopping

Agora [Fonseca et al, 2001] is a project conducted at HP Labs to develop a testbed for applications of agent technology to a mobile shopping mall. A scenario involves mobile shoppers with personal digital assistants (PDA) interacting with store services while in the mall, on the way to the store, or in the store itself. Mall-wide services, such as directories and locators are available through the PDA connected to

the wireless network that provides an URL-based access to the virtual presence of the mall and its services on the Web. Intelligent agents represent both shoppers and the store, and participate in on-line auctions to bid for desired products based on shopper's preferences. A lightweight version of a scenario involving mall infrastructure agent, store agents, a shopper personal assistant and bidding agent, and an English auction agent has been implemented with a multi-agent system Zeus from BT Labs [Zeus] and additional Java-based support software.

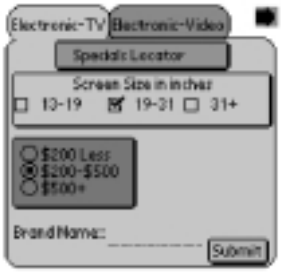

Fig. 6. Display of a mobile courier agent presenting product options

Impulse [Impulse] is an on-going research project at MIT Media Lab that explores a scenario in which the buying and selling agents can run on wireless mobile devices and engage in multi-parameter negotiation for comparison-shopping at the point of purchase. The buyer agent resides on a PDA equipped with a GPS receiver and a wireless Internet connection that enables the URL access and communication with the seller (provider) agents (see Figure 6). The agents have been implemented with a Java-based mobile agent system called Hive [Taylor, 2000] also developed at MIT Media Lab.

3.2 Mobile Comparison Shopping

An agent-based framework for mobile commerce has been proposed by [Mihailescu and Binder, 2001] (referred as MB later in this paper). It provides three types of agents, i.e. device agents, service agents and courier agents. The device agent is a stationary agent that resides on a mobile device and provides access to wireless services such as a location-based comparison-shopping. The service agents are owned by service providers and handle service requests from the users. They are heavy-weighted mobile agents operating within the wired network. The courier agents are single-hop light-weighted mobile agents that can migrate from a service agent to a mobile device in order to establish communication with the user. Figure 7 shows a display of a mobile courier agents presenting product options available for the user. A test-bed has been developed for a shopping center scenario where consumers can access a web portal wirelessly via their PDA devices for services such as product location, product comparison and store location with the envisaged possibility of negotiation. The test-bed has been implemented with the use of Java-based tools including Aglets SDK for service agents and KVM SDK for the device agent and courier agents.

Fig. 7. Impulse displaying user's preferences

3.3 Networked comparison shopping

MAgNET (Mobile Agents for Networked Electronic Trading) [MAgNET] is a mobile agent-based system prototype developed at University of California with Java and IBM Aglets SDK to enable buyers to comparison shop for

items from different online sellers. In MAgNET, a human buyer creates a mobile shopping aglet that compares quotes for an item from different online sellers by visiting those seller sites and returns to the buyer with the best offer that it obtains (see Figure 8). It can also allow the buyer to send a mobile agent to various suppliers to purchase component parts needed to produce a complex product [Dasgupta et al, 1999]. It can also be possible for a supplier to create and dispatch a mobile agent to potential buyers to survey customer responses, determine market values of products, and sell products.

Fig. 8. MAgNET's Cart view: The quotes brought back by the shopping aglets [MAgNET]

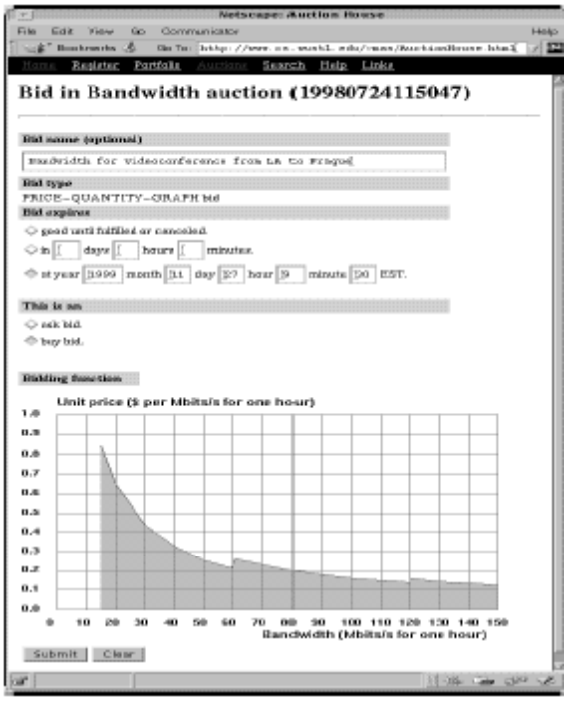

Fig. 9. eAuctionHouse bidding agent

3.4 Mobile Auction Bidding

eAuctionHouse [eAuctionSite] is a prototype of the Internet auction server developed as a component of a dynamic e-commerce platform eMediator [eMediator] at the University of Washington. It supports combinatorial auctions with bidding via quantity-price graphs through the Web browsers (see Figure 9), and use the integrated mobile agent system called Nomad for automated bidding and auction monitoring in selected auctions [Sandholm, 2000]. Nomad is based on the Concordia mobile agents system [Concordia] and allows the users to generate mobile agents within the eAuctionHouse through the Web browser and launch them onto the agent dock within the eAuctionHouse site. The agents can then be executed locally to actively participate in two auction types on the user's behalf

even when the user is disconnected from the network. In bidding the agents follow game-theoretical dominant strategies based on the user's reservation price (English auctions) and number of bidders (single-item, single-unit, sealed-bid first-price auctions).

BiddingBot [Fukuta el al, 2001] is a multi-agent system developed at Nagoya Institute of Technology, which can support attending, monitoring, and bidding in multiple auction sites. It consists of several cooperative bidding agents that have been implemented with a mobile Java-based agent framework called MiLog [Fukuta el al, 2001]. In BiddingBot, multiple bidding agents can attend different auctions and bid on behalf of users simultaneously in order to obtain the items at the best price. BiddingBot's bidding agents can bid according to autonomous and coordinated bidding mechanisms designed for the agents. Figure 10 shows an example of the user interface of BiddingBot

Fig. 10. An example of BiddingBot

3.5 Mobile contract negotiation

Electronic contract negotiation has been investigated as an application niche for mobile agents by [Griffel at al, 1997] in the scope of the OSM project [OSM] at University of Hamburg. In particular, a mechanism for contract document circulation has been developed to support the contracting parties engaged in the electronic contract negotiation with contract documents represented as mobile objects. More specifically, mobile agents are used to circulate the contract data objects between the negotiating participants who can review and alter the contract terms. A contract-carrying agent can also have a responsibility and a role for dealing with the contract while avoiding explicit locking mechanisms. An experimental prototype of a mobile agent system has been built to allow the users to get involved in the contract negotiation process through their Web browsers.

DynamiCS [DynamiCS] is an actor-based framework for mobile negotiation agents proposed by the same group at University of Hamburg [Tu et al, 2000]. It involves integration of intelligent decision-making capabilities into mobile agents based on plug-in mechanisms enabling dynamic composition of mobile negotiation agents [Tu et al, 1999]. In particular the DynamiCS framework aims at providing flexibility in integrating negotiation strategies into mobile agents dynamically. It also uses rule management mechanisms to manage actors and coordinate plug-ins' mobility. DynamiCS has been implemented with Java using Voyager system [Voyager] as the basic mechanism for distribution and mobility.

InterMarket [InterMarket] is a research project proposed to develop an Intelligent Mobile e-Marketplace System at Intershop Research and Fredrich Schiller University

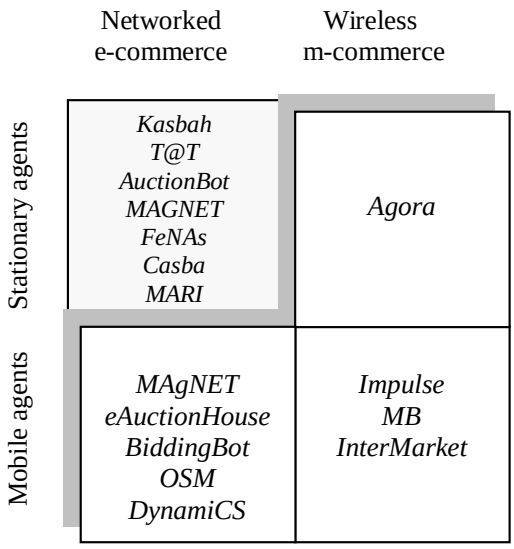

Fig. 11. The extended scope of AMEC with mobile agents and m-commerce

based on a mobile agent system Tracy [Tracy]. It aims at enabling mobile access and automated trading in e-marketplaces based on integration of mobile agents and intelligent decision-making agents offered as an add-on component to a commercial e-marketplace platform. InterMarket proposes stationary (or networked mobile) intelligent trading agents to automate the users' decision-making and negotiation tasks in e-marketplaces, and mobile agents to support deployment of the trading agents and provide mobile access and communication to e-marketplaces from mobile devices such as Personal Digital Assistants (PDA) or mobile phones.

4 Discussion

The systems presented in the previous section aim at providing new capabilities for advanced e-commerce solutions with the use of the approach based on agent technology. The mobility factor adds several aspects to the scope of agent-mediated e-commerce and specific solution they address, provided support for agents' migration and users' mobility, and their implementation and deployment approaches that are briefly discussed in the remainder of this section.

E-commerce solutions

The e-commerce application areas mobile agents considered in this paper include comparison shopping, auction monitoring and bidding, and contract negotiation that are common application areas in agent-mediated e-commerce. They extend however the scope of the previous agent-mediated e-commerce applications to wireless m-commerce (Agora, Impulse, MB, InterMarket) and mobile agent-mediated networked e-commerce (MAgNET, eAuctionHouse, BiddingBot, OSM/DynamiCS). Figure 11 summarizes the extended scope of agent-mediated e-commerce with the agent systems considered in the paper including also stationary agents e-commerce systems from section 2.

Agent support

The intelligent agents aim at providing automation support for decision-making tasks in e-commerce. The mobile agents extend that support by allowing for participation in several marketplaces in networked e-commerce and enabling users' mobility

and wireless participation. The agents' mobility add ubiquity power to the participants to the e-Commerce game. In particular it allows the agents to quicker respond to local changes in marketplaces and make trading decisions faster than remote agents or human participants could. The agents can move across the network to reduce network traffic and communication latency and can also perform their trading tasks when the users are disconnected from the network. In addition some of them enable portable devices that support users' mobility, i.e. they allow the users to access, move and disconnect from the wireless network while the agents perform trading tasks on their behalf. Figure 12 summarizes the scope of decision support and mobility in the considered agent systems.

Deployment approach

Most presented systems have been deployed with general-purpose mobile agent systems that have been extended with decision-making (intelligent agent) capabilities. Typically they have used commercial agent development tools such as Concordia in eAuctioHouse, IBM Aglets in MB and MAgNET, and Voyager in OSM/Dyna-miCS. Some systems have also used prototypical mobile agent systems such as Hive in Impulse, Tracy in InterMarket and MiLog in BiddingBot. The use of third-party systems provides specific mobility and communication capabilities, and permits implementation of some high-level application specific functions. The use of proprietary systems typically allows for more flexible implementation at the expense of the development costs. However in almost all cases an additional Java-based software component has been required even when commercial tools have been used. Figure 13 summarizes the used deployment tools.

Most efforts focus on developing intelligent trading agents to automate the users' decision-making and negotiation tasks, and mobile agents to support deployment of the trading agents and enable agents' mobility and users' access from mobile devices. However there is a trade-off between decision-making capabilities that make the agents "heavy" and mobility of agents that requires the agents to be "light weighted" due to the limited network bandwidth and device computational resources. For example eAuctionHouse deploys mobile agents that are created within the e-marketplace by the users through the Web browser for participation in the bidding processes on the

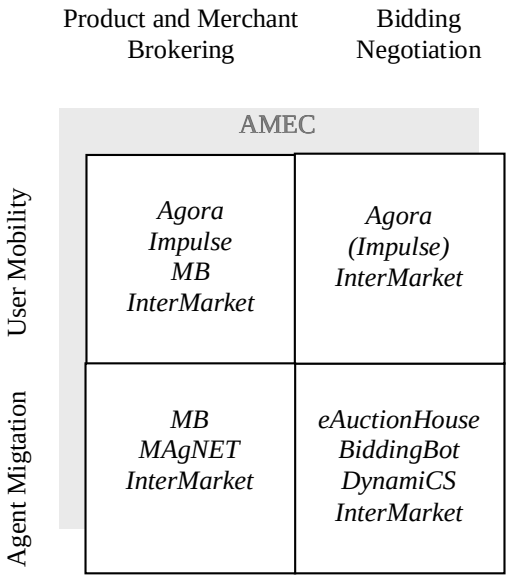

Fig. 12. . Mobility/migration and decision support

Fig. 13. Deployment tools used in agent-mediated e-commerce

users' behalf. InterMarket also deploys intelligent trading agents within the e-marketplace with a mobile agent system, but it enables mobile access with the use of mobile communication agents that can reside on the users' personal computers and mobile devices, and move to the e-marketplace to deliver the users' instructions to the trading agents. [MAgNET] integrates some decision-making capabilities into mobile agents that allow the shopping agents to compare quotes from different seller sites they can visit. DynamiCS proposes plug-in decision-making capabilities for mobile agents that permit flexible change of the decision-making capabilities within the agents keeping them reasonable small. To cope with the limited computational resources of the mobile devices and wireless network bandwidth, some systems like MB and InterMarket adopt "light weighted" mobile communication agents to deliver instructions to "heavier" decision-making agents operating within the networked environment.

Table 1 summarizes the intelligent mobile agent systems presented in this paper in the context of the all aspects considered in the paper.

5 Conclusion

This paper presents a survey of the existing research and development efforts involving the use of mobile agents and intelligent agents for advanced e-commerce solutions. A number of the selected agent systems have been overviewed with an aim to provide a representative view of the current research trends in developing intelligent and mobile agent-mediated e-commerce including location-aware, mobile and networked comparison shopping, auction bidding and contract negotiation.

In general the considered systems aim at providing new capabilities for advanced e-commerce solutions with the use of an approach based on agent technology, in particular focusing on integration of the complementary capabilities of the intelligent and mobile agents. The intelligent agents aim at providing automation support for decision-making tasks in e-commerce. The mobile agents extend that support by allowing for participation in several marketplaces in networked e-commerce and enabling users' mobility and wireless participation. It extends the scope of the agent-mediated e-commerce to wireless m-commerce and mobile agent-mediated networked e-commerce.

	Application areas		Agent support		Implementation	
	Networked e-commerce	*Wireless m-commerce*	*Decision Tasks*	*Mobility and Migration*	*Stationary Agent System*	*Mobile Agent System*
Agora		Comparison shopping	Product and Merchant Brokering Bidding	User	Zeus Java	
Impulse		Comparison shopping	Product and Merchant Brokering (Negotiation)	User		
MB	Comparison shopping		Product and Merchant Brokering (Negotiation)	User Agents		Aglets SDK KVM SDK Java
MAgNET	Comparison shopping		Product and Merchant Brokering	Agents		Aglets SDK Java
eAuctionHouse	Auction Bidding		Bidding	Agents		Concordia Java
BiddingBot	Auction Bidding		Bidding	Agents		MiLog
OSM Dynam-iCS	Contract Negotiation		Negotiation	Agents		Voyager
InterMarket	Comparison shopping and negotiation		Product and Merchant Brokering Negotiation	User Agents		Tracy KVM SDK Java

Table 1. Summary of Intelligent Mobile Agent E-commerce Systems

In most cases a considerable software development effort was required to implement decision-making capabilities and support software enhancing the agent systems used during the development. It is consistent with several views on the early stage of maturity of agent development tools available today. Therefore there is still a need for agent development tools that can support efficient deployment of both agents' mobility and decision-making in e-commerce applications.

Recently a number of standards and technologies have emerged in relation to electronic business-to-business trading processes. Dominant examples are ebXML, RosettaNet, eCo and WFMC standards. They cover the interoperability spectrum from the data exchange to business process collaboration, and are becoming widely used as business process infrastructures. Agent technology can augment these existing standards and frameworks to enable truly open and flexible trading processes with reduced negotiation and transaction costs. The end result of this fusion will be an intelligent infrastructure for cross-organisational business processes that enables e-Commerce service to interact dynamically to discover each-other to form new, compound, more complex services.

The focus of our future research and collaboration with the Global Agentcities Task Force will be to demonstrate the value added by agents in dynamic e-Commerce

by focusing on service level agreements and trading contracts. We thus hope to stimulate work on agent-based prototypes which can demonstrate dynamic and open trading processes.

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