Applying Mobile Agents to *E*-business

Ying-Hong Wang, Ching-Ling Wang, Hui-Hua Huang and Wen-Hung Lo

Department of Computer Science & Information Engineering
Tamkang University
Tamsui, Taiwan 251, R.O.C.
E-mail: inhon@mail.tku.edu.tw

Abstract

E-commerce and M-commerce can extend the marketing of a company or enterprise to unlimited region. Through Internet and WWW, the limitation of distance and region are broken for business behaviors. Agent technique is one of the important technologies developed to support the Internet applications. Especially, the Internet and WWW technologies broken the limitation of space, and the agent techniques solve the problems of temporality. Even if the users are off-line, the agents are still active in the world of computer network and play the roles that their users assigned. In this paper, a mechanism is proposed for *E*-marketplace based on agents and mobile agents. Some issues of research are discussed. They include the platform of mobile agents, the types and classifications of agents and mobile agents, behaviors of commerce transactions and processing models, negotiation mechanisms, etc. Moreover, they include the techniques of information retrieval, data mining, and knowledge base, etc. Based on the proposed mechanism of *E*-marketplace, the applications of E-commerce will be more effective, easier to develop, and more creating the marketing of business.

***Key Words*:** E-commerce, Agent, Mobile Agent, Aglet, Transaction Model, Negotiation Mechanism

1. Introduction

Due to the popularization of Internet and World Wide Web (WWW), the limitation of distance and region are broken for business behaviors. E-commerce can extend the marketing of a company or enterprise to unlimited region. To transact through Internet, more new techniques are developed for Internet and WWW applications. Agent technique is one of the important technologies developed to support the Internet applications. Especially, the Internet and WWW technologies broken the limitation of space for enterprise marketing, and the agent techniques solve the problems of temporality. Even though the users are off-line, the agents are still working in the world of computer network and play the pre-defined scenarios. Agent is software that assistants or represent the behaviors of users in the world of computer network. The basic properties of agents are following [1]:

- Reactive
- Autonomous
- Object-oriented
- Communicative
- Mobile
- Learning
- Believable

A mobile agent is an agent, which has the capability of mobility on the world of computer network. There are some advantages of mobile agent technologies are applied on network [1]:

- They reduce the network load.

- They overcome network latency.
- They encapsulate protocols.
- They execute asynchronously and autonomously.
- They adapt dynamically.
- They are robust and fault-tolerant.

The major objective of this rese arch is to propose agent technologies that support the related applications of E-commerce. This paper proposes a mechanism for *E*-marketplace based on agents and mobile agents. Some issues of research are reached. They include the platform of mobile agents, the types and classifications of agents and mobile agents, behaviors of commerce transactions and processing models, negotiation mechanisms, and so on. Moreover, they include the techniques of information retrieval, data mining, and knowledge base, etc. Based on this architecture of *E*-marketplace, the applications of E-commerce will be more effective, easier to develop, and more creating the marketing of business.

This article is organized as follows: section 2 describes the related works that include the developed platform, Aglet, and some researches of E-commerce based on agents and mobile agents. Section 3 introduces the *E*-marketplace platform based on Aglet. And the model of *E*-marketplace and classification of agents are shown in section 4. The last part of this article is our conclusions and future researches.

2. Related Works

2.1 Aglet

Aglets had been proposed by the Aglets team at IBM's Tokyo Research Laboratory [2]. Aglets are Java objects that can move from one host on the network to another. When the aglet moves, it takes along its program code as well as the states of all the objects it is carrying. A build-in security mechanism makes it safe to host untrustful aglets [3]. The system goals of aglets are following:

- Provide an easy and comprehensive model for programming mobile agents without requiring modifications to Java VM or native code.
- Support dynamic and powerful communication that enables agents to communicate with unknown agents as well as well-know agents.
- Design a reusable and extensible architecture.
- Design a harmonious architecture with existing Web/Java technology.
- Provide security mechanisms that are comprehensive and simple enough to allow end users to trust mobile agents.

2.1.1 Architecture of Aglet

We can use the Figure 1 to characterize the architecture of Aglet. The Aglet Context is a platform where Aglets execute. Each Aglet surrounded by Aglet Proxy. One Aglet sends the message to another via Aglet Proxy.

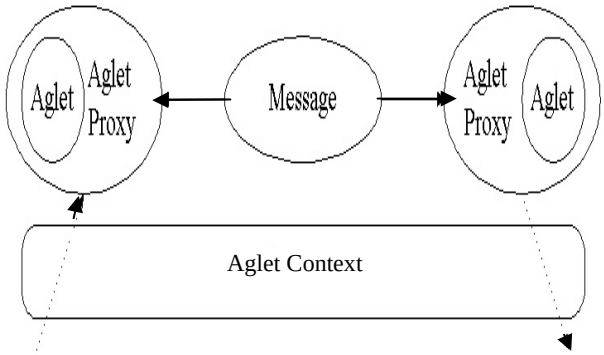

Figure 1. The basic model of Aglet

2.1.2 The Lifecycle (Behavior) of An Aglet (or Agent)

Behavior supported by the aglet object model is based on a careful analysis of the life and death of mobile agents. There are basically only two ways to bring an aglet to life: either it is instantiated from scratch (creation) or it is copied from an existing aglet (cloning). To control the population of aglets you can of course destroy them (disposal). Aglets are mobile in two different ways: actively and passively. The active approach is characterized by an aglet pushing itself from its current host to a remote host (dispatching). A remote host pulling an aglet away from its current host (retracting) characterizes the passive type of aglet mobility. When aglets are running, they take up resources. To reduce their resource consumption, aglets can go to sleep temporarily, releasing their resources (deactivation), and later can be brought back into running mode (activation). Finally, multiple aglets can exchange information to accomplish a given task (messaging).

2.1.3 The Operation of Aglet

The following list summarizes the fundamental operations of an aglet: creation, cloning,

dispatching, retraction, deactivation, activation, and disposal (see Figure 2).

- *Creation* The creation of an aglet takes place in a context. The new aglet is assigned an identifier, inserted into the context, and initialized. The aglet starts executing as soon as it has been successfully initialized.
- *Cloning* The cloning of an aglet produces an almost identical copy of the original aglet in the same context. The only differences are the assigned identifier and the fact that execution restarts in the new aglet. Note that execution threads are not cloned.
- *Dispatching* Dispatching an aglet from one context to another will remove it from its current context and insert it into the destination context, where it will restart execution (execution threads do not migrate). We say that the aglet has been "pushed" to its new context.
- *Retraction* The retraction of an aglet will pull (remove) it from its current context and insert it into the context, which the retraction was requested.
- *Activation and deactivation* The deactivation of an aglet is the ability to temporarily halt its execution and store its state in secondary storage. The activation of an aglet will restore it in the same context.
- *Disposal* The disposal of an aglet will halt its current execution and remove it from its current context.

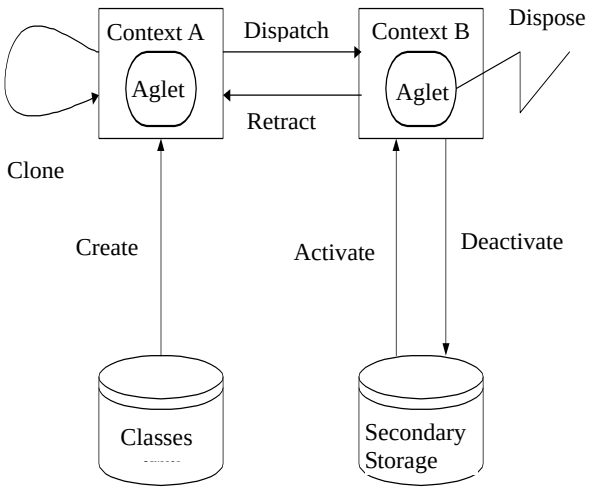

Figure 2. The lifecycle of an Aglet

2.1.4 The Aglet Context

An aglet uses the Aglet Context interface (shown in Figure 3) to get information from its environment and send message to the environment and other active aglets in that environment. It provides means for maintaining and managing running aglets in an environment where the host system is secured against malicious aglets.

The aglet context is typically created by a system that has a network daemon whose job is listening to the network for aglets. Incoming aglets are received and inserted into the context by the daemon. Often, a user interface component will provide a graphical or command line interface to the context.

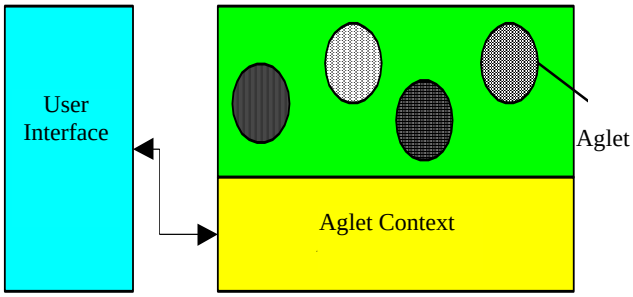

Figure 3. The Aglet Context

2.2 E-commerce

What is E-commerce? The simplest definition is the business based on Internet. E-commerce is beginning from the 1970's Electronic Funds Transfer, EFT in the financial marketing, and 1980's Electronic Data Interchange, EDI in the general companies. In the other way, the techniques of electronic message exchange are widely applied in the workflows, and supply chains among the intra-enterprise and inter-enterprises. Beginning from 1990's, the on-line services based on Internet change the relationship of the producers, suppliers, and consumers. Due to the advantages of Internet, it can create more marketing chances, more benefit, and more choices. That's why many companies and enterprises care about the E-commerce. The characteristics of E-commerce are following:

- Product
- New sales channel
- Direct saving
- Time to market
- Customer service
- Brand or corporate image

- Technology learning and Laboratory organizing
- Customer relationship
- New Product capabilities

There are four categories of E-commerce shown as follows [4].

2.2.1 Business to Business (B2B)

B2B is an acronym for business-to-business, a type of E-commerce involving a transaction from one business to another via the Net. B2B incorporates everything from manufacturing to solution providers. With improved efficiency and lightning speed, businesses can access procurement sites and services to get multiple bids, issue purchase orders, make payments, etc. The volume of money involved in B2B transactions has already surpassed individual consumer transactions by 10:1 as reported by the Aberdeen Group. And the potential growth is impressive. The Yankee Group predicts American business-to-business commerce will grow 41% annually over the next five years.

The true value of B2B is the consolidation of suppliers and the buying power of the conglomerate. A good example of B2B is Covisint; the Internet auto parts supply exchange formed by GM, Ford, and Daimler Chrysler. This exchange, an Internet portal that links an online supply-chain, is now the world's largest Internet Company. It is also a key step in the application of Internet technology to traditional industry.

2.2.2 Business to Consumer (B2C)

Another example of E-commerce is more familiar and easier to relate to. B2C is similar to traditional retailing by a business to a consumer. The novelty is that the retailing is now done on the Internet rather than at a brick and mortar store location. Note that the novelty is the medium used, in this case, the Internet. The idea of using a different approach for retailing rather than a fixed store location has been around awhile. Back in 1886, a jeweler unhappy with a shipment of watches refused to accept them. Much to the delight of the manufacturer, a local telegraph operator bought the whole shipment. Being an opportunist, he used the telegraph to sell all the watches to fellow operators and railroad employees.

In only a few months this young man was so successful he quit his job and started his own store. The name of the young man was Richard Sears, and you have seen his name on many a catalogue and any Sears Roebuck store that you may have visited. Just think what Mr. Sears could do with B2C and the Internet!

2.2.3 Customer to Business (C2B)

The Internet has given birth to another entirely new concept-C2B-that is consumer-to-business like Priceline.com. This is buying and selling where the consumer takes the initiative to contact the business establishment. The business has become reactive rather than the traditional proactive approach.

Consumer to Business is a growing arena where the consumer requests a specific service from the business. Example: Harry is planning a holiday in Darwin. He requires a flight in the first week of December and is only willing to pay $250. Harry places a submission with in a web based C2B facility. Dodgy Brothers Airways accesses the facility and sees Harry's submission. Due to it being a slow period, the airline offers Harry a return fare for $250 [5].

2.2.4 Customer to Customer (C2C)

Internet auctions have given rise to another category-C2C or consumer-to-consumer like the eBay and Yahoo auctions. The consumer initiates the selling to another consumer using business as an intermediary.

These sites are usually some form of an auction site. The consumer lists items for sale with a commercial auction site. Other consumers access the site and place bids on the items. The site then provides a connection between the seller and buyer to complete the transaction. The site provider usually charges a transaction cost. In reality this site should be call C2C.

2.3 Agent Techniques on E-commerce

We have served some researches and commercial products that they apply the agent-based techniques to Internet shopping or *E*-marketplace. The essential descriptions are following:

Sakaguchi et al. [6] proposed a shopping assistant agent for Web-shops. The shopping assistant agent works on a web server, a PCs-sale site. The agent has been applied to help potential buyers of built-to-order (BTO) PCs. There are three features of the interaction with this agent. (1) Two interaction channels: selection and con-

versation. (2) Flexible topic change: the user can trigger a new conversation flow even in the middle of a conversion. (3) Personalized Interaction: the interaction is personalized according to user behavior. There are three methods for the user to get advice from this agent. (1) Answer questions from the agent. (2) Ask the agent questions. (3) Refer to an additional message from the agent.

Lesser et al. [7] developed an information-gathering agent that processes Web documents to create product models and recommend purchases based on user selection criteria. The architecture of this information-gathering agent includes the following components:

- Resun (Resolving Sources of Uncertainty) planner: a blackboard-based interpretation planner
- Information extractors: test-extraction tools
- Document classifiers: text-processing filters
- Server information database: a local database of information sources stored
- Object database: a local database stores product information
- Design-to-Criteria (DTC) scheduler: an agent-control problem solver
- TAEMS modeling language: a Task, Analysis, Environment Modeling, and Simulation language
- Task assessor: a software module manages the interface between the Resun opportunistic planner and DTC scheduler.

Dasgupta et al. [8] applied the Java mobile agent technology, called Aglet, to the networked electronic trading. The buyers dispatch their Aglets to various suppliers, where they negotiate orders and deliveries, returning to the buyer with their best deals for approval. The proposed system, called MAgNET, handles the deep supply chain, where a supplier may need to contact further suppliers of subcomponents in order to respond to an enquiry.

Esmahi and Dini [9] proposed an intelligent agent market place that involves multiple mobile agents interact with other. The market place providers an infrastructure for exchanging offers and requests. Potential business partners can exhibit their services and available resources, search for offers from service provider, or send their own offers. There are three types of agent acts in the market place: the market place manager, the buyer agents and the seller agents.

Vermeulen and Bauwens [10] are to establish standards of describing information and services that are offering to telecom network users on-line. They provided a generic service model and proposed a set of solutions using standard languages, such as KQML and SGML, within a distributed architecture hosting intelligent agents. The roles of agents in this proposed model are described as follows:

- The Personal Assistant agent: it will represent the consumers or end-users of the service.
- The On-line Provider agent: it will represent the sellers or content providers.
- The Service Broker agent: it will represent the brokers or business intermediates.
- The Resource Manager: it will represent the infrastructure providers.

KQML (Knowledge Query and Manipulation Language) is chosen as the communication language between the different types of agents. KIF (Knowledge Interchange Format) and SQML (Standard Generalized Markup Language)/XML (extensible Markup Language) are chosen as content languages for exchanging information.

Lee et al. [11] introduce an open infra-structure for agent-based E-commerce on the Internet. It is a multi-agent system in which six semiautonomous agents interact or work together to perform a user's goal. It is mainly composed of following agents:

- User Agent (UA) is a personalized learning interface agent that provides active assistance to the user and becomes smarter and more adaptive to its user,
- Customer Agent (CA) acquires user's request that which product he/she wants,
- Supplier Agent (SA) acquires user's request that which products he wants to sell and then advertises/unadvertised himself to the matchmaker agent (KBMA),
- Navigation Agent (NA) plays a role of commerce E-specific search engine. NA finds corresponding counterpart who can satisfy user's demand, and retrieves product of user's interest,
- Knowledge Base Management Agent manages the knowledge base – including Product Ontology, Agent Yellow Oage, Label/Supplier Description, and so on, and
- Payment Agent (PA) provides a payment

service for market transaction between customer and supplier.

Sohn and Yoo [12] also proposed architecture of *E*-marketplace based on mobile agent technologies. The major components of this architecture are described as follows:

- Management Agent for Conductor (MACD) is an agent that manages conductor. MACD supervises people joining or disjoining as members of this marketplace.
- Setup Agent for Member (SAMM) is an agent created by MACD when a user be to join as a member in the market. And the SAMM will migrate to user's context.
- Guide Agent for Member (GAMM) assists member to divide products.
- Management Agent for Provider (MAPR) handles product data for a provider member.
- Consignment Agent for Provider (CAPR) helps providers to consigning his products to be sold to shop.
- Management Agent for Consumer (MACR) handles information for a consumer member.
- Brokering Agent for Consumer (BACR) collects product data by visiting shop.

Chrysanthis et al. [13] applied the idea of mobile agents to establish virtual enterprises that involves advertising, negotiating and exchanging control information and data. They proposed a workflow model for virtual enterprises and described how the mobile agents work on.

3. The Mobile Agents Platform for *E*-marketplace

3.1 The Architecture for *E*-marketplace

Figure 4 presents the proposed architecture for E-commerce marketplace; it is divided into three layers.

3.1.1 Mobile Agent Platform

This bottom layer of the architecture for *E*-marketplace is the mobile agent platform. The Mobile Agent Platform has developed by several institutes and organizations in recent years, such as Zeus, Jade and IBM Aglet. In this paper, IBM Aglet is chosen as our Mobile Agent Platform. IBM Aglet is adopted as our Mobile Agent Platform. IBM Aglet supports the creation, clone, deletion and migration of mobile agent.

3.1.2 Interface

Interface layer is developed to build connection between Mobile Agent Platform layer and E-commerce Platform layer. This layer will provide some necessary components for E-commerce especially. These components provide necessary services such as GUI connection, database connection, and security mechanisms for E-commerce over IBM Aglet.

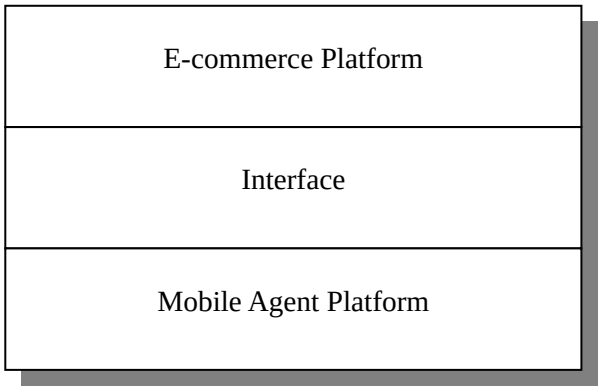

Figure 4. The architecture of system platform

3.1.3 E-commerce Platform

E-commerce Platform is the top layer of this architecture. With the support of Interface layer and Mobile Agent Platform layer, programmer can design various applications for E-commerce. For example: mobile agents for buyer and seller, recommendation system for consumer, and negotiation mechanism of market.

3.2 The Roles of Agents and Mobile Agents in E-commerce Environment

There are four types of server in the proposed architecture for *E*-marketplace, they are: (1) Coordinator Server, (2) Marketplace, (3) Buyer Agent Server, and (4) Seller Server. Each server includes several agents and/or mobile agents (see Figure 5). They are described as follows.

3.2.1 Coordinator Server

Coordinator Server is an environment where there is a Coordinator Agent (CA). The CA is a static agent has responsibility to manage its E-commerce domain. CA has several abilities: (1)

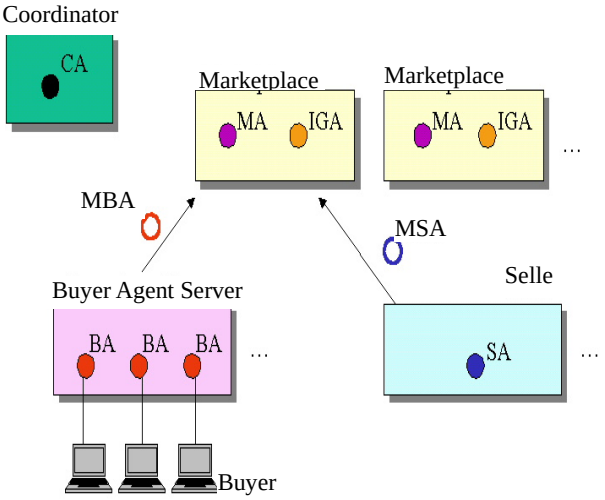

Figure 5. The architecture of electronic commerce environment

initials an E-commerce domain, (2) monitors Marketplaces, Buyer Agent Servers and Seller Agents, (3) manages Marketplaces, Buyer Agent Servers and Seller Agents, (4) provides the functions of register and authentic query, and (5) cooperates with other CA.

3.2.2 Marketplace

Marketplace is a platform that supports the various facilities of business transaction for mobile agent. There are two kinds of Static Agent and two kinds of Mobile Agent in the Marketplace:

(a) Management Agent (MA) MA is a static Agent has responsibility that (1) manages the registration of Mobile Agents when they enter into this Marketplace, (2) manages the activities of agents in this Marketplace.

(b) Information Gathering Agent (IGA) IGA is also a static Agent in the Marketplace. IGA will gather the related information in the Marketplace. They include the records of transaction, the information of the productions, the requirements of customers and so on.

(c) Mobile Buyer Agent (MBA) MBA stands for the buyer, moves from one Marketplace to another Marketplace and trades with Mobile Seller Agent.

(d) Mobile Seller Agent (MSA) MSA stands for the seller, moves among different Marketplaces and trades with MBA.

3.2.3 Buyer Agent Server

The Buyer Agent Sever provides the web interface that lets users can control their agents to carry the E-commerce activation out via standard Web-browser. There is a Buyer Server Management Agent (BSMA) manages the Buyer Agent Server. The BSMA will produce Buyer Agent (BA) for each user to serve its homologous user. BA will generate Mobile Buyer Agent (MBA) according to the requirements of the user. The MBA stands for its user to go to every marketplace to make bargains.

There are several elements in Buyer Agent Server. They are:

(a) Http Agent (HttpA) HttpA provides the Web interface, let users can use all services of the Buyer Agent Server with web browser.

(b) The Buyer Server Management Agent (BSMA) The BSMA is the manager of this Buyer Agent Server. BSMA has several abilities: (1) according the requirement of the user to create a Buyer Agent, (2) manages and monitors all Agents in the Buyer Agent Server and (3) provides the functions of registration and authentic query.

(c) Buyer Agent (BA) One BA serves a specific user. BA can create MBAs according the necessities of the user. BA also manages MBAs that execute missions in Marketplaces.

(d) Mobile Buyer Agent (MBA) MBA is created by BA and migrate to marketplaces. It stands for user to collect the information of interesting productions and execute the bargains.

(e) User DB User DB stores the profiles and information of users.

(f) Agent DB Agent DB is managed by BSMA and stores the information of agents in the Buyer Agent Server.

3.2.4 Seller Server

Each company, which wants to join this *E*-marketplace, should build a Seller Server. There are two Agents in a Seller Server, include:

(a) Seller Agent (SA) SA has two main functionalities: (1) manages Seller Server, (2) creates Mobile Seller Agents and dispatches them to Marketplaces for selling productions.

(b) Mobile Seller Agent (MSA) MSA moves among various Marketplaces and executes missions that are assigned by SA.

4. The *E*-marketplace Model

Based on the proposed E-commerce architecture and the roles of static Agents and mobile Agents, the activities and behaviors among servers and agents are designed to perform a transaction in the *E*-marketplace.

4.1 Transaction Center

The architecture of transaction center for proposed *E*-marketplace is composed of three parts: system platform, functional agents and knowledge bases.

4.1.1 System Platform

System platform is a mobile agent platform that was described in section 3. It uses IBM Aglet as the platform base and additional needful functions are provided for developing electronic commerce. Therefore, the transaction center uses IBM Aglet to be system platform and allows mobile agents to migrate and execute on this platform.

4.1.2 Functional Agents

Six functional agents are designed to provide services in *E*-marketplace. They are Management Agent, Information Gathering Agent, Broker Agent, Transaction Agent, Auction Agent and Contract Agent. The tasks that functional agents are responsible for are described below respectively:

(a) Management Agent (MA)

- Verify identification of MBA or MSA that entered marketplace.
- Monitor the change of behavior states of MBA or MSA in marketplace.
- Announce marketplace information that includes auction place information and member credit information.

(b) Information Gathering Agent (IGA)

- Act as a contact window between marketplace and marketplace and provide equal query from other marketplaces.
- Provide query services to users and gather specified shopping information such as hot product information and discount information.

(c) Broker Agent (BroA) According to product specifications that user requested, provide a suggestion list that records suitable sellers or buyers.

(d) Transaction Agent (TA) If MBA or MSA requested one-to-one negotiation service, TA must construct a communication connection between buyer and seller and record the processes of negotiation and transaction.

(e) Auction Agent (AucA)

- Open or close auction place for MSA.
- If MBA requested auction service, AucA must let it join opened auction place.
- Collect bids and send the highest price to MSA and MBAs that joined auction place.

(f) Contract Agent (ConA)

- Confirm transaction agreements for MSA and MBA.
- If user broken agreements, ConA must adjust user's credit in marketplace.

4.1.3 Knowledge Bases

Knowledge bases in marketplace include member data, mobile agent information, transaction records, product information, and market information. Besides, knowledge bases also include mobile agent design pattern and ontology that uses to define communication keywords.

Some operation rules in transaction center are described below:

- Users can design their own MBA or MSA. As long as MBA or MSA designed by user adopted communication keywords and message format that defined by transaction center, MBA or MSA can enter marketplace and request services.
- When MBA or MSA arrived at marketplace, MBA or MSA must register to Management Agent first. After MBA or MSA passed the identification, Management Agent will open limits of authority up.
- When MBA or MSA passed the identification, MBA or MSA can request services from functional agents directly.
- Two ways to provide transaction between buyers and sellers: one-to-one negotiation and

auction. Buyers and sellers transact through functional agents in marketplace. For example, buyers sent message to sellers to buy a product through Transaction Agent and Transaction Agent records this process.

- Functional agents cooperate by message pass in transaction center and access database directly.

4.2 The Design of Agent Behavior States

Beginning with mobile agents arrived at marketplace, until mobile agents left the marketplace, behavior states of mobile agents will be changed according to the actions of mobile agents in marketplace. The transfer of agent behavior states will help us to know what agents do in marketplace and help us to manage mobile agents.

We design thirteen agent behavior states and classify these states into two categories. One is common state, and the other is service-request state. They are shown as Figure 6.

- Common state: It means that agents register into, ready on, and leave out one marketplace. Common states include [*Checking*], [*Ready*], and [*Leaving*] states.
- Service-request state: It means that agents request services from functional agents. When functional agents serve MBA or MSA, the mobile agents will be on service-request states. Service-request states include [*Information Waiting*], [*Information Request Fail*], [*Broker Waiting*], [*One to One Negotiation Initial*], [*Negotiation Responding*], [*Negotiation Fail*], [*Auction Initial*], [*Auction Processing*], [*Auction Fail*], and [*Contract*] states.

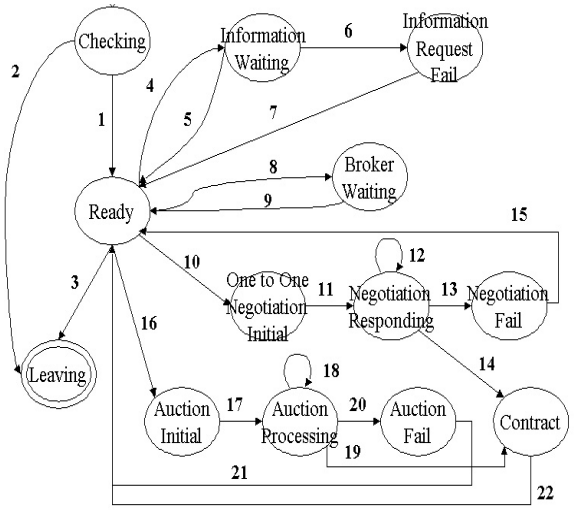

Figure 6. Agent behavior state graph

4.2.1 The Rule of State Transition

(a) Rule 1 The initial state is [*Checking*], and it means that mobile agents login marketplace and Management Agent check their identification.

(b) Rule 2 When mobile agents pass identification, their state will be [*Ready*], and it means that mobile agents have authority to request functional agents to provide their services.

(c) Rule 3 In a marketplace, mobile agents request their necessary services, their state will come into corresponding service request state. It means that mobile agents are served by a specific functional agent.

(d) Rule 4 The final state is [*Leaving*], and it means that mobile agents are possible to leave marketplace, identify failed, or idle over a specified time in the marketplace. On this state, mobile agents will leave marketplace or be disposed by Management Agent.

4.3 The Management of *E*-marketplace

The management of this *E*-marketplace is to monitor the change of agent behavior states and provide distinct services, which are responsibility of particular functional agents in this *E*-marketplace. There are three steps of marketplace management:

- The first step is identification of MBA or MSA. When MBA or MSA entered marketplace, MBA or MSA must register to Management Agent (MA) immediately. MA will request MBA or MSA to provide the information that is useful to identify MBA or MSA of itself. This information includes member ID and some data such as AgletID. MA will set the state of MBA or MSA to be [*Checking*]. If MBA or MSA pass the identification, MA will set the state of MBA or MSA to be [*Ready*], otherwise set it to be [*Leaving*]. MA records the state of agent into “mobile agent information” in database. “Mobile agent information” is similar to a billboard; it lets all functional agents know what MBA or MSA do and who serve MBA or MSA. The purpose of the first step of management is let legal agents acquire authority to request services and enforce illegal agents leaving or dispose illegal agents directly. The advantage is to preserve

system resources.

- The second step is the period that MBA or MSA act in marketplace. MBA or MSA can request functional agents to provide services and all messages between MBA and MSA will passed through functional agents. Therefore, functional agents can understand what MBA or MSA do and can manage MBA or MSA that they serve. For example, if Auction Agent agrees some MBAs to join the auction place, Auction Agent will set the state of MBA or MSA to be [*Auction Initial*]. When MBA or MSA joined the auction place and auction products or bid in the auction place, Auction Agent will set the state of MBA or MSA to be [*Auction Processing*] and update "mobile agent information" in database. This state means two facts: one is that the Auction Agent serves these MBAs or MSAs presently, and the other is that these MBAs or MSAs are active, not idle. The purpose of the second step of management is that market can understand activities of MBA or MSA and know which functional agents they are served. Market can divide agents into two classes: active and idle. Over specified time, idle agents are not allowed existing in marketplace.
- The third step is to handle MBA and MSA leaving marketplace and release marketplace resources. Two major operations need to be completed in this step:

1. Find all agents that state is [*Ready*] in "mobile agent information". If their existing time is over system default time, MA will set the state to be [*Leaving*] and send alert message to these agents to ask them to leave.
2. Find all agents that state is [*Leaving*] in "mobile agent information". If MA has already sent alert message to these agents and the time is expired, MA will force these agents to dispose.

4.4 Transaction Processes

This subsection introduces the processes of transaction in the *E*-marketplace. The steps of shopping and selling goods for buyers and seller will be described respectively.

4.4.1 The Steps of Shopping

- Buyer creates a MBA at buyer agent server or buyer local host. Buyer specifies tasks and marketplace address to MBA, and dispatches it to the marketplace (1 of Figure 7).
- MBA migrates to the specific marketplace and registers to Management Agent. After MBA passed the identification, Management Agent will give the authority to MBA (2 of Figure 7).
- MBA sends product information that buyer needs to Broker Agent. Broker Agent will record the information in database and give MBA a suggestion list (3 of Figure 7).
- MBA has done the tasks and go back to buyer agent server or buyer local host (4 of Figure 7).
- After buyer received the suggestion list that MBA brought back, buyer can choose sellers to transact and decide the manner of transaction, for examples one-to-one or auction. Then buyer sends a MBA to the marketplace and completes the shopping (5 of Figure 7).
- In the marketplace, MBA can ask Transaction Agent to make a negotiation with the chose seller (6 of Figure 7). Transaction Agent will ask the chose seller whether the seller agrees to negotiate or not (7 of Figure 7) and response to MBA (8 of Figure 7). Another way for bargain, MBA can also send message to Auction Agent for joining into auction procedures. If Auction Agent agrees, MBA can join auction place and bid products.
- If MBA has made a transaction with the seller, MBA ask then Contract Agent to confirm the transaction and Contract Agent will record this transaction in database (9 of Figure 7).
- MBA goes back to buyer agent server or buyer local host and reports results to buyer (10 of Figure 7).

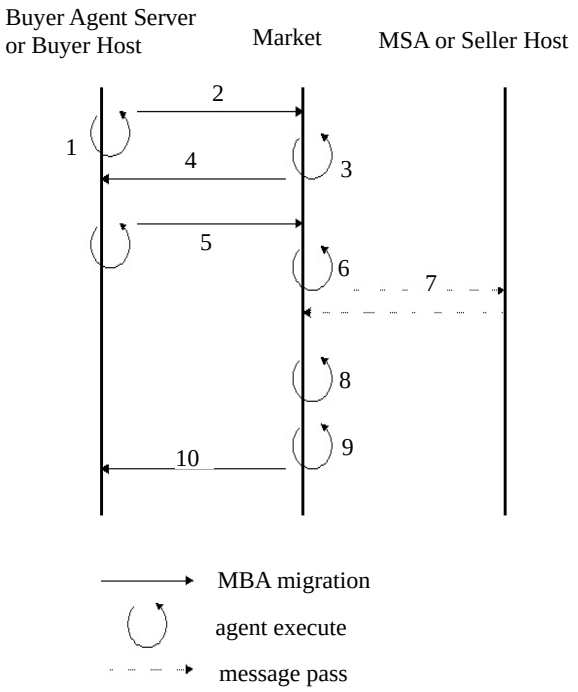

Figure 7. The process of transaction for buyer

4.4.2 The Steps of Selling Goods

- Seller creates a MSA at seller local host. Seller specifies tasks and marketplace address to MSA, and dispatches it to the marketplace (1 of Figure 8).
- MSA migrates to the marketplace and registers to Management Agent. After MSA passed the identification, Management Agent will give the authority to MSA (2 of Figure 8).
- MSA sends product information that seller hopes to sell to Broker Agent. Broker Agent will record the information in database and give MSA a suggestion list that records buyers who may need products that seller sells (3 of Figure 8).
- MSA goes back to seller local host and report results to seller (4-1 of Figure 8). Seller decides buyers to merchandise and send MSA back to marketplace (4-1-1 of Figure 8). MSA requests Transaction Agent to ask buyers whether buyers agree that MSA merchandises goods to buyers or not (4-2, 4-2-1 of Figure 8). When buyers agree, buyers can decide the place that buyers accept the promotion, marketplace or buyer local host.
- There are two places that buyers accept promotion, marketplace and buyer local host. If seller merchandises goods to buyers in marketplace, they should negotiate through Transaction Agent (5-1 of Figure 8). If the place which buyers requested is buyer local host, MSA should migrate to buyer local host (5-2 of Figure 8) and negotiate with Buyer Agent (5-2-1 of Figure 8).
- If MSA has made a transaction with the seller, MSA asks Contract Agent to confirm the transaction and Contract Agent will record this transaction in database (5-1 of Figure 8).
- MSA goes back to seller local host and report results to seller (6 of Figure 8).

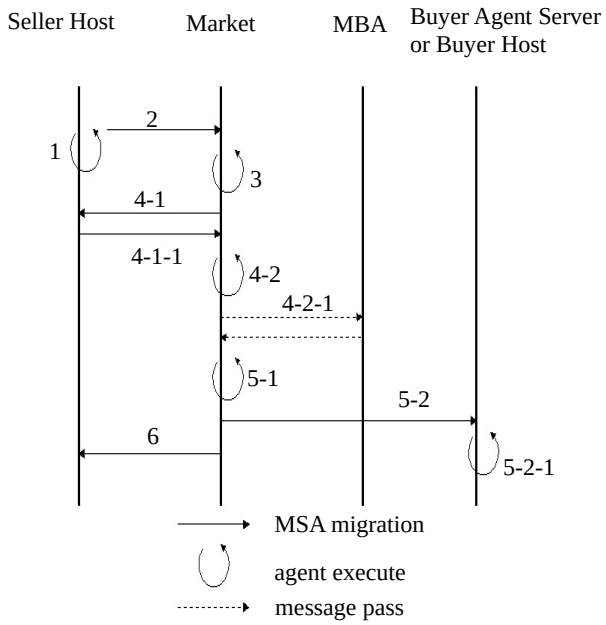

Figure 8. The process of transaction for seller

4.5 One to One Negotiation

The purpose of one-to-one negotiation mechanism allows that buyer have more chances to get better price by bargaining with sellers. The one-to-one negotiation mechanism also make that seller can have more chances to contact buyers and sell his products. One-to-one negotiation processes are represented as below.

4.5.1 One-to-One Negotiation Processes of MBA

- MBA requests Transaction Agent (TA) to construct a one-to-one negotiation connection with seller that MBA wants to transact. MBA must send information that includes product specification, seller id, price and quantity to

Transaction Agent.

- After TA received messages that MBA sent, TA will find if there is any MSA corresponding to seller id that MBA sent in the marketplace. If TA found MSA, TA will send message to MSA and inquire whether MSA agrees to negotiate or not. If TA didn't find MSA, TA will send message to Seller Agent at seller host and inquire whether seller agrees to negotiate or not. If yes, seller must send a MSA to marketplace to negotiate with MBA.
- After MSA received the negotiation message, MSA must give a response to Transaction Agent. MSA can agree or reject the negotiation request.
- After TA received the response from MSA, TA will tell MBA that one-to-one negotiation is beginning and send the first price that MBA offers to MSA if MSA agree to negotiate. If MSA didn't agree, one-to-one negotiation fails.
- MSA can measure the negotiation content that MBA sent. If MSA agrees, MSA should send message to TA. If MSA doesn't agree, MSA can do one of the following two things.
- Request TA to terminate this negotiation. It will cause negotiation to fail.
- Counter-offer a new negotiation content to TA.
- After TA received the response from MSA, TA will record the detail of process and tell MBA the response of MSA.
- In the same way, MBA can measure the negotiation content that MSA sent. If MBA agrees, MBA should send message to TA. If MBA doesn't agree, MBA can do one of the following two things.
- Request TA to terminate this negotiation. It will cause negotiation to fail.
- Counter-offer a new negotiation content to TA.
- Repeat steps from 5 to 7. If the number of negotiation turn is over the default value, TA will enforce negotiation to break. A negotiation turn means that a communication from MBA to MSA or MSA to MBA through TA.

4.5.2 One-to-One Negotiation Process of MSA

- MSA requests Transaction Agent (TA) that MSA want to negotiation with buyers, and sends buyer id to TA.
- After TA received message that MSA sent, TA will find if there is any MBA corresponding to buyer id that MSA sent in the marketplace. If TA found MBA, TA will send message to MBA and inquire whether MBA agrees to negotiate or not. If TA didn't find MBA, TA will send message to Buyer Agent at buyer agent server or buyer host and inquire whether buyer agrees to negotiate or not. Buyer can respond in three ways:

1. Agree to negotiate and send a MBA to marketplace.
2. Agree to negotiate and request MSA to migrate to the site that Buyer Agent is located at.
3. Not agree to negotiation.

- TA sends the response of buyer to MSA.
- MSA can select one of the two ways to respond:

1. MSA got the address of buyer from TA and migrate to the site that buyer is located at. MSA starts to negotiate with Buyer Agent.
2. MSA waits for MBA's arrival in the marketplace. If MBA arrived, MSA will start to negotiate with it.

- If the place that MBA negotiates with MSA in is the marketplace, the message from MBA to MSA or from MSA to MBA will pass through Transaction Agent. In the other words, Transaction Agent is a mediator for one-to-one negotiation mechanism. Transaction Agent will monitor the process of one-to-one negotiation to avoid MBA and MSA wasting system resources.

5. Conclusion and Future Works

In this paper proposes the design of an *E*-marketplace model. It provides automaticity and convenience compared with current electronic marketplaces. The functional agents in this marketplace provide various services and devised transaction mechanism to mobile agents to transact in marketplace effectively. The presented transaction center has several advantages:

- Each functional agent is responsible for different tasks, and cooperates to provide services in the marketplace. It is flexible that we can increase or decrease the number and the kind of functional agents in the marketplace if necessary.
- Agent behavior states are designed according

to the action of mobile agents in the marketplace. It is useful that electronic market can maintain transaction order and system resources by monitoring the change of agent behavior states.

- One-to-one negotiation mechanism helps buyer to bargain with sellers over the price, and also helps sellers to get more opportunities of selling products. Sellers don't wait for matching by market any more, but merchandise their products in various ways actively.
- Different buyer may hope that his MBA has different negotiation strategy, and different seller may hope that his MSA has different selling strategy. Not all users have the same MBA (MSA) that has the same functionality. Therefore, the MBAs and MSAs who entered the *E*-marketplace are bargaining with user's predefined strategy.

The proposed transaction center will improve in some directions.

- *Cooperate with payment and delivery system* A complete marketplace not only provides transaction service, but also payment and delivery service. Therefore, we will use mobile agent technology to incorporate payment and delivery system in our *E*-marketplace.
- *Find a better way of matching buyer and seller and use it in Broker Agent* An important function of market is to help user to find suitable transaction objects. There are several ways to match buyer and seller such as using dependency graph. It is very important to find a better way to match buyer and seller, and we will focus on it in the future.
- *Increase data mining mechanism in Information Gathering Agent* Information Gathering Agent is an important role in collecting information. A great deal information maybe need to analysis and extract useful part. We will incorporate data mining technology in Information Gathering Agent.
- *Increase more transaction ways* Our electronic market provided three ways to let buyer and seller transact: shop directly, one-to-one negotiate, and auction. We will increase more transaction ways in the future to promote transaction activities.
- *Strengthen the function of the trusted third party* Contract Agent plays the role of the trusted third party in the marketplace. It is the beginning step to confirm transaction agreements for buyer and seller. We will cooperate with some certificate providers to strengthen the function.

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