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AN AGENT MARKETPLACE SUPPORTING NEGOTIATION FOR BUSINESS TO BUSINESS

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Abstract: Agents are able to support negotiation for business activities in a distributed and heterogeneous environment and application areas e.g. e-commerce. In this paper, we present a model for electronic marketplace supporting business to business negotiation for different types of goods and services. The agents of our marketplace could be implemented efficiently using an agent development environment e.g. JADE in compliance with FIPA specification for interoperable intelligent multi-agent systems.

Keywords: Business to Business, Electronic Marketplace, Producer, Negotiation, Consumer, Agent Role.

Introduction

Electronic Market (EM) is a market over Internet where a potential number of sellers and buyers are involving to sell and buy goods and services. There are some ongoing researches on electronic market model (Chavez and Maes, 1996 and Trilegiant Corporation, 2001), which are developed based on multi-agent technology (Kraus and Zlotkin, 1992). A user wish to buy or sell a good creates an agent, gives it some strategic direction, and sends it off into the agent marketplace (Chavez and Maes, 1996). A user can bid in an existing auction or start a new auction, where auctions come in many varieties depending on the type of goods involved, the mechanism for determining prices and communication protocols (Tampa, 2000).

There are some commercially available e-commerce website of some organizations provide marketing involved in the role of Business to Business where user can place order and observe the list of available items and buy goods (Fair Market Inc., 1997 and Tampa, 2000). Such organizations involved in Business-to-Business e-commerce buying goods from some producers and selling the goods to consumers.

In the market, goods are transferred from producer to consumer. The transfer of goods may be carried out directly from the producers to the consumers or through some third parties. These third parties involved in the market buy goods from producers or buy goods from some other third parties and sell directly to the consumers or sell to other third parties. In our work, the party involved in Business to Business are used as service provider. In order to build the model for such a market structure using multi-agent technology, the agents have to communicate each others and negotiate the terms and conditions before the actual transfer is carried on using various negotiation protocols. We will design an electronic marketplace using multi-agent technology where a large number of producers, consumers and service providers will engage their agents and the agents will involve in actual marketing for negotiation to make some profitable deals on behalf of their owner.

In order to build such a market model, a lot of issues arise. In this work, concentration is given on agent architecture, agent roles and negotiation protocols.

In the following section, we have discussed on the scenario of our marketplace, the basic assumptions on which we designed our agent based electronic market and the role of different parties involved in the market, the market model for our scenario and a typical example of conversion for negotiation among agents.

Scenario

In our scenario, we consider four sets of different product types (G), producers (P), service providers (S) and consumers (C) and producers, service providers and consumers will engage their agents in the electronic market. Producer has to maintain a list of product type that the producer can produce and the list of items stored by the producer where each item is a product type with the date of production. Several costs are related to the production of goods for any item of a product to the producer, but in our scenario only the initial cost to start the production, cost to start production in each day, marginal cost to produce an item and

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daily maintenance cost to store an item are considered. Producers know a private value associate with the gain to sell products. Service providers maintain a list of items stored and concentrate on the current cost to buy a product and the gain to sell products. Daily maintenance cost to store an item is also considered by service provider. Consumers also maintain a list of item stored and give attention to the current cost for buying an item. Consumers have an amount of power that is needed for a particular day and also a budget constraint to buy items from electronic market. Each item gives a certain amount of power to the consumer and there is a maximum limit to amount of each items that the consumer can consume in a particular day. The parameter need, power and amount may vary over the time. Based on the above parameters all the agents of producers, service providers and consumers negotiate with each other's in order to make deals in the electronic marketplace.

In real situation, the need, power and amount may be fixed over time or randomly change their values on the basis of some distributions, which may or may not be history based. Again all the various types of costs related to the producers have different effects for different product types in negotiation. Only a single protocol is not sufficient for all product types in electronic market. In some cases contract net is useful for negotiation and again in some cases auction is beneficial to reduce the storing cost for the producers or service providers. Again the consumers can buy some items for the next day. The delivery of a finite amount of items to different locations is depended upon the capacity of some actors involved e.g. actors may have a fixed number of trucks or a fixed Internet bandwidths etc. All the agents need the sufficient knowledge to work in such electronic market. The aim of this research is to develop an electronic marketplace supporting all the above factors where agents will work on behalf of producers, service provider and consumers for negotiating and making acceptable deals for their owner.

Assumptions

The following assumptions are considered for designing a model for an Electronic Marketplace.

- The time grain is the day.
- Number of registered members of different Producers (P), Service Providers (S) and Consumers (C) are m , n and q . The registered numbers have login to join in the electronic market.
- G is a set containing I different product type.
- Item describes a particular product type with the date of production.
- Several costs related to each product type.
 - The cost to start production of items of such a product.
 - The cost to be able to produce an item of such a product each day.
 - The cost to produce an item of such a product.
 - The daily cost to maintain an item of such a product in the store.
- Attributes related to Producer
 - The current cost to produce products
 - The current gain to sell products
 - Information related to the producer can produce item of a product type or not.
 - The number of items of each product type the producer can produce each day.
 - List of items stored by the Producer
- The relationship between different types of costs is a factor for changing the behaviour of Producer, for example
 - products with a high global initial cost, but with a minimal production cost for item and without any storing cost.
 - products with a high global initial cost plus a medium initial cost to produce an item each day, but with a small production cost and a storing cost for item depending on the size.
 - products with a high global initial cost plus a medium initial cost to produce an item each day, but with a production cost for item depending on the kind of product and with a storing cost for item depending on the size.
 - products with a high global initial cost plus a medium initial cost to produce an item each day, but with a production cost for item depending on the kind of product and with a storing cost for item depending on the size and on the kind of product.
- Attributes related to Service Provider
 - The current cost to buy the item
 - The current gain to sell the item
 - List of items stored by the Service Provider
- Attributes related to Consumer
 - The current cost to buy items
 - The need of power for a particular day

- The power given by an item for a particular day
 - The amount of power from a product type that a consumer can daily consume
 - List of items stored by the Consumer
- The need, power, amount of consumer may vary over time, e.g., they are fixed, randomly assume a value basis of different distribution (no history based) or randomly modify their value basis of different distribution (history based).
- Product Type may effect negotiation, e.g. multimedia or software electronically delivered and frozen food have different storing cost.
- Some constraints for product delivery, e.g., each actor has limited capacity or fixed Internet bandwidths etc.

Roles of Different Parties

Three types of parties are mainly involved in the above-described scenario. They are producers, service providers and consumers. The roles of each party have significant impacts in the design of agent architecture and their protocols for electronic marketplace. A brief description on the roles of each party is included in this section.

Roles of Producers: Producers fix a target to the sell volume and estimate the cost of production of an item based on the initial cost to start the production, cost to start production each day, marginal cost to produce an item and daily maintenance cost to store an item. The producers calculate the desired price of the item in order to maintain the target gain and negotiate with some service providers or some consumers.

Role of Service providers: Service providers calculate the average cost of each product type that was needed for buying the stored items. Service providers know the daily cost for storage and a target gain to maintain by selling the products. The service providers calculate the desired price for selling an item and negotiate with some consumers or some service providers. Again, the service providers have to buy goods from some producers or some other service providers in order to keep minimum limit in the store and fulfil the market demand. So, the service providers have to negotiate with producers or some other service providers to buy items. While negotiating to buy an item, the service providers use past experience and the present desired price to sell such items. Service provider can buy items on demand of some consumers or some other service providers. In such case, negotiation of buying items depends upon the price at which service provider can sell the items. Service providers always have to consider the current market demand, cost and price for items because the gain is depended upon the success of both buying and selling items.

Role of Consumers: Consumers determine the list of daily-required items based on the consumers need and buy items from marketplace. The consumers also have the estimated desired price that they can spend for buying each item. Consumers have the budget constrain to buy items from markets. The consumers negotiate with service providers or some producers to buy required items. Consumers can also buy items for using in the next day.

A Model for Electronic Marketplace

The different roles of producer, service provider and consumer described above can be modeled in the electronic market where each individual producer, service provider and consumer will engage their agents and agents will work on behalf of their owner. In this section, such an electronic market model using agents is proposed.

Selling and buying are mainly two types of role in the electronic market and are involved to negotiate using message passing protocols. The agents can use any one of the protocols from set of supported protocols in the electronic market. In time to time these two roles of agent may have to change their protocols and strategies. For providing all the other roles of a business process, the producers, service providers or consumers have to assign additional roles to their agents.

The producer can engage an agent named as Producer Agent (PA) having the roles of producing and selling and the agent will play all the roles that a particular producer assign to the agent. The PA having the role of producing would be responsible to keep records of the updated list of stored items as well as various costs related to producing the items. The PA would play the role of selling in order to sell items for the desired price to service providers or consumers.

The service provider can engage an agent named as Service Provider Agent (SPA) having the roles of service providing, buying and selling. The SPA having the role of service providing would responsible to keep records of the updated list of stored items as well as various costs related to service providing. The SPA would play the role of buying in order to buy items from producers or some other service providers. The SPA would play the role of selling in order to sell items to consumers or some other service providers.

The consumer can engage an agent named as Consumer Agent (CA) having the roles of consuming and buying. The CA having the role of consuming would be responsible to keep records of the updated list of

stored items as well as prepare the daily list of required items. The CA would play the role of buying in order to buy items from service providers or producers.

Interaction between PA and SPA: The PA and SPA generally play the role of selling and buying respectively while they are interacting each other in the electronic market in order to make profitable deal for their owners. Agents use some predefined protocols and they may switch their interaction protocols over time from the available protocols. An agent may interact with multiple agents at the same time using different interaction protocols. When SPA wish to buy some items from PA, the SPA initiates by sending a message to one or more PAs. The message may contain some information related to the requested items e.g., description of the items, price, time of delivery, terms of payment or request for some information etc. Each PA should response the message by executing some actions or sends a reply message indicating the reaction of PA after receiving such message from SPA. Such message passing may occur several rounds in order to come into the agreement for some issues related to the current negotiation. Similarly, the PA can initiate negotiation by sending message to some SPA e.g., declaring some auction to sell items or doing advertisement about new opportunities offered by producers. If the SPA may provide service on demand to CA then SPA also need to negotiate with PA where the items and conditions of such a negotiation between SPA and PA is depended on the other negotiation between SPA and CA.

Interaction between SPA and CA: The SPA and CA generally play the role of selling and buying respectively while they are interacting each other in the electronic market in order to make profitable deal for their owners. Agents may switch their interaction protocols over time from some available protocols. An agent may interact with multiple agents at the same time using different interaction protocols. When CA wants to buy some items from SPA, the CA initiates by sending a message to one or more SPAs. The message may contain some of the information related to the description of requested items, price, time of delivery, terms of payment or request for some information etc. Each SPA may response the message by performing some actions or reply the message received from CA. Such message passing may occur several rounds in order to come into an agreement for some issues related to the current negotiation. Again, the SPA can initiate by sending message to some CA e.g., declaring some auction to sell items or doing advertisement about new opportunities offered by service providers. Therefore, anyone of the SPA or CA may need to initiate the interaction.

The general agent architecture for our electronic market model is shown in the following figure.

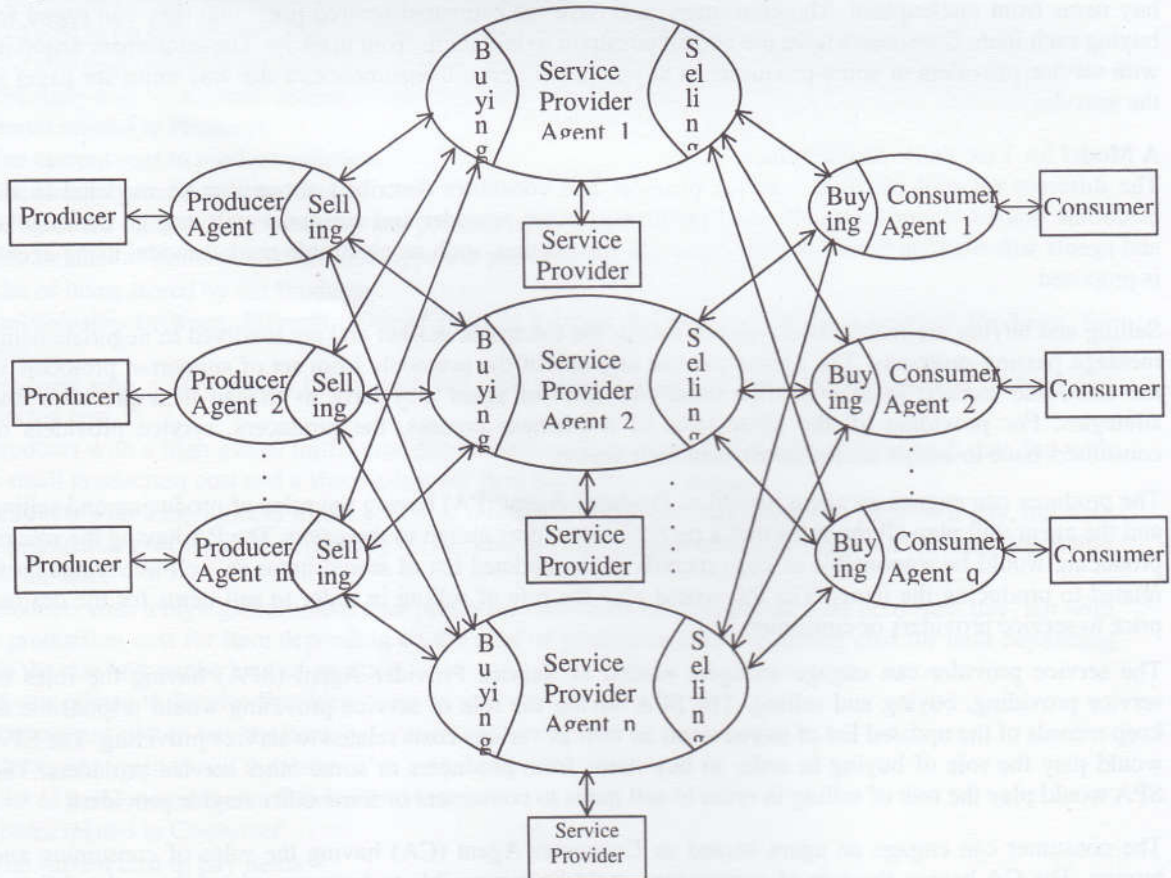


Figure 1: Agent architecture for our electronic market model

Each of the roles of agents can be implemented using JADE behaviour object[9]. The behaviours may be activated on some internal or external events. When message are received from some other agents, the messages should be parsed and some events should be added in the queue. Then the behaviour scheduler takes each event from the queue and activates one or more existing behaviours waiting for such events or creates a new behaviour. The running behaviours may also generate some events and add then into the queue. Again the running behaviour may block itself to wait for some events to be occurred. Few common roles for each type of PA, SPA and CA are listed below.

The roles of PA

1. Producing

- Maintaining the list of stored items.
- Calculate the cost of production and fix the target gain.
- Offer discount to increase total sells volume and reduce storing cost.
- Negotiate with SPA or CA to produce items on demands.

2. Selling

- Negotiate with SPA to sell items.
- Advertising or providing information about products.

The roles of SPA

1. Service Providing

- Maintain the list of stored items.
- Calculate the cost of items and fix the target gain.
- Offer discount to increase total sells volume and reduce storing cost.
- Offer service on demand.

2. Buying

- Find the PAs, which are able to produce required items.
- Negotiate with PA or other SPA to buy items.

3. Selling

- Negotiate with CA or other SPA to sell items.
- Advertising or providing information about services.

The roles of CA

1. Consuming

- Prepare a list of required items for each day and also for future days.
- Maintain the list of stored items.
- Prepare budget constraints for each day

2. Buying

- Find the SPAs those are able to provide the required service.
- Negotiate with SPA or PA to buy items.

An Example of Conversation for Negotiation among Agents

In the market, an agent may initiate negotiation with one or more agents for buying or selling items. Outcome of two negotiations may depend on each other. The behaviours for two different negotiations should be scheduled based on their priority and dependency. In order to design the details of individual agent behaviours, the sequence of messages for interactions among agents have a significant effect. One typical case of negotiations among agents and their conversations are presented in this section.

A consumer agent, CA_{q1} wish to buy 10 items of I_1 type product. The CA_{q1} initiates negotiation by sending messages to a service provider agent SPA_{n1} describing the desire of CA_{q1} . After receiving the message from CA_{q1} containing request to sell, the SPA_{n1} may find that six items of I_1 type product are available in the store. Therefore the stored items are not sufficient to fulfil the demand of CA_{q1} . So SPA_{n1} can either inform the CA_{q1} about the limitation of stored items or initiate a negotiation with some PAs to buy more four items of I_1 type product. If SPA_{n1} informs CA_{q1} the limitation of the store, the CA_{q1} has three options (i) CA_{q1} can initiate a negotiation with other SPA_{n2} to buy ten items, (ii) CA_{q1} can buy six items from SPA_{n1} and buy rest four items from some other SPA or (iii) CA_{q1} can request SPA_{n1} to buy four more items of I_1 type product from some PA and also include an additional condition to SPA_{n1} for offering discount. If CA_{q1} choose the option (iii), the SPA_{n1} may negotiate with CA_{q1} for reducing the discount and initiate a negotiation with PA_{m1} by sending message to buy four items I_1 type product. PA_{m1} may submit bid to sell four items to SPA_{n1} . SPA_{n1} may request to PA_{m1} for offering some discount. PA_{m1}

may reply that PA_{m1} will offer 5% discount for five to ten items and 10% discount for more than ten items. SPA_{n1} evaluates such discount offer and may come to believe that if SPA_{n1} can buy five items with 10% discount then SPA_{n1} can sell four items to CA_{q1} and one item will be stored for selling in future and SPA_{n1} can maintain the target gain and for this SPA_{n1} may request to PA_{m1} for offering 10% discount for five items. In reply to this request, the PA_{m1} may reply that 10% discount may be given for ten or more items. Let consider a case in real situation, within this conversion SPA_{n1} receives another request to sell eight items of I_1 type product to CA_{q2} . In such situation, the SPA_{n1} can buy twelve (four + eight) items of I_1 type product from PA_{m1} with 10% discount. After that total stored volume become eighteen (six + twelve) and SPA_{n1} can sell ten items to CA_{q1} and eight items to CA_{q2} and terminates the negotiation with a successful outcome. Here, SPA_{n1} has to carry on two negotiations with CA_{q1} and CA_{q2} for selling items and one negotiation with PA_{m1} for buying items. In real situation in the electronic market there may be many such cases where the agents may have to handle multiple negotiations. The messages for this conversion for negotiation are listed below.

CA_{q1} asks SPA_{n1} to submit its proposal to sell 10 items of I_1 type product.

SPA_{n1} informs CA_{q1} that it cannot sell 10 items of I_1 type product because it has 6 items of I_1 type product in the store.

CA_{q1} asks SPA_{n1} to submit its proposal to sell 6 items of I_1 type product.

SPA_{n1} informs CA_{q1} that it can sell 6 items of I_1 type product for \$300.

CA_{q1} asks SPA_{n1} to buy 4 additional items of I_1 type product from some PA and submit its proposal to sell 10 items of I_1 type product and to offer discount.

SPA_{n1} informs CA_{q1} that it can sell 10 items of I_1 type product for \$500 and 5% discount can be offered for 10 items of I_1 type product.

CA_{q1} asks SPA_{n1} to submit its proposal to sell 10 items of I_1 type product and to offer 8% discount for the 10 items of I_1 type product.

(After several rounds both agents may come into an agreement)

CA_{q1} accept proposal of SPA_{n1} .

SPA_{n1} asks PA_{m1} to submit its proposal to sell 4 items of I_1 type product.

PA_{m1} informs SPA_{n1} that it will sell 4 items of I_1 type product for \$180.

SPA_{n1} asks PA_{m1} to offer discount to sell 4 items of I_1 type product.

PA_{m1} informs SPA_{n1} that it will offer 5% discount for 5 to 10 items and 10% discount for more than 10 items of I_1 type product.

SPA_{n1} asks PA_{m1} to offer 10% discount for 5 items of I_1 type product.

PA_{m1} informs SPA_{n1} that it will offer 10% discount for 10 or more items.

(After several rounds both SPA_{n1} and PA_{m1} come into an agreement)

(Before coming the agreement between SPA_{n1} and PA_{m1} , the SPA_{n1} may receive a new call for proposal message from CA_{q2} , which accelerate the negotiation steps between SPA_{n1} and PA_{m1} .)

(After several round both SPA_{n1} and CA_{q2} come into agreement)

CA_{q2} accepts proposal of SPA_{n1} .

SPA_{n1} accepts proposal of PA_{m1} .

Negotiation ends.

Conclusions

In this work, a model for electronic marketplace is presented. Only the parties involving in the electronic markets are taken into consideration for designing the model. We discussed one typical case of negotiation in the electronic marketplace as an example. A wide range of typical cases should be considered for designing agent's behaviour. An experimental evaluation of the model should be undertaken. In order to implement such an electronic marketplace in a distributed and heterogeneous environment, a lot of issues

e.g., ontology sharing, agent mobility, security etc. should be considered. Our proposed market could be implemented using JADE agents, but the designer of individual agents may select different agent development kits and use different platforms and in such case the interoperability in another essential issue.

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