COM_ELECTRON: An Agent-Based Electronic Commerce System

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Intelligent agents technology has proved to be efficient in many applications from industry, and in the last years it became the key technology for the Internet and Web-based applications development. The paper presents an electronic commerce system COM_ELECTRON that is dedicated to second hand products trading.
***Keywords**: Intelligent agents, Negotiation,Agent-Based Electronic Commerce.*

Introduction

Multi-agent systems provide an efficient model for the development of electronic commerce systems [1]. As defined in [2], electronic commerce (EC) is "an emerging concept that describes the process of buying and selling or exchanging products, services, and information via computer networks including the Internet". A multi-agent system (MAS) is a set of interacting agents which share a common environment, in the case of electronic commerce, the Internet environment. An agent-based electronic commerce system is an electronic commerce system mediated by intelligent agents. Several agent-based e-commerce systems were reported in the literature (for some recent surveys see [3], [4], [5]), most of them being still experimental systems in which different types of coordination, negotiation, learning, reasoning techniques are tested. One of the next generation types of electronic commerce server eMediator is presented in [6], and demonstrates some ways in which algorithmic support and game theoretic incentive engineering can jointly improve the efficiency of electronic commerce. The eMediator server has several components: an auction house, a safe exchange planner, a coalition formation support, and so on.

In this paper we present an agent-based electronic commerce system COM_ELECTRON, under development at University of Ploiesti, dedicated to second hand products trading. The system was simulated in JADE [7], a Java-based multi-agent system development platform which is FIPA compliant [8]. So far, we have experimented various negotiation scenarios. The objective of COM_ELECTRON is to maximize the profit viewed as an increased number of transactions and deals agreed after some rounds of bilateral negotiation.

The architecture of COM_ELECTRON system

Figure 1 shows the mesh architecture of the agent-based electronic commerce system COM_ELECTRON. Several types of agents appear in the electronic market, similar with those from a real-world market, buyers, sellers, facilitators, mediators, brokers, etc. The virtual environment involves the existence of the following types of agents: buyer agents (B_i), seller agents (S_j), and middle agents such as mediator agents (MD), brokers (BR), facilitators (FT). All agents are linked to the JADE platform. A buyer agent is the client's agent and represents the client's interests in the electronic marketplace.

A seller agent is an agent associated to a merchant that sell different products. Middle agents represent various agent intermediaries that act as brokers and discovery services for other agents in the Internet. Agent BR allows the sharing of non-agent services. He may interface requester agents to provider agents by intermediating requested service transactions. In this case, all the communication has to go through the broker. Agent FT provides a type of yellow pages services for other agents, i.e. the description of the registered agents and the services they offer. The communication between a buyer agent and a seller agent could be realized directly as soon as an agent FT helped in finding each other, or through a mediator agent. The matchmaker agent is another type of MD agent which has the role of pairing requester agents with provider agents by means of matching and which do not interfere between the agents. The shopping agents (i.e. buyer agents) are using the agent architecture described in [9].

In electronic commerce agents have their own goals to pursue. For example, the goal of a buyer is to maximize its utility function, i.e. to obtain the minimum price for a product, while the goal of a seller is to maximize its utility function, i.e. to obtain the maximum profit, the maximum price for the same product. In such a context, negotiation between the buyer and the seller is a way to improve the number of deals made in the electronic transactions. In COM_ELECTRON the agents coordination is realized by a negotiation mechanism.

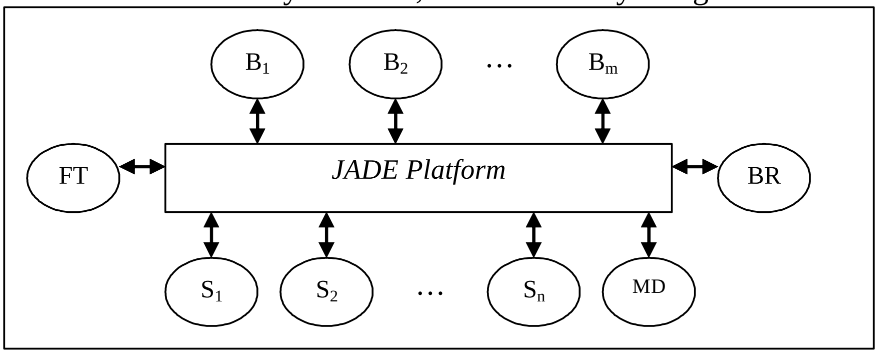

Figure 1. The architecture of COM_ELECTRON.

The negotiation model

Negotiation is a process whereby agents communicate to reach a common decision. It involves identification of interactions (through communication) and modification of requirements (through offers and counter-offers). COM_ELECTRON uses an integrative negotiation, more specifically, a service-oriented negotiation model, similar with that described in [10]. It is based on a variation of two parties, many issues value scoring system and was used by generic negotiating agents for business process management applications. Negotiation range over a set of issues that describes the characteristics of the product (e.g. price, quality, features, manufacturer, service facilities - if any, and so on). The issues are quantitiative or qualitative. The quantitative issues are defined over a real domain (i.e. $x[j] \in D_j = [min_j, max_j]$). Qualitative issues are defined over a totally ordered domain (i.e. $x[j] \in D_j = \{q_1, ..., q_n\}$).

When an agent receives an offer $X = \begin{pmatrix} x[1] \\ x[2] \\ \cdots \\ x[n] \end{pmatrix}$, where n is the total number of issues, it rates it according to a function $V^a(x^t)$ that uses a linear combination of the scores for the different issues.

$$V^a(x^t) = \sum_{j=1}^{n} w_j^a(t) * V_j^a(x^t[j]) \qquad (1)$$

where $w_j^a(t)$ is the importance of issue j for agent a at time t.

Each agent has a scoring function $V_j^a : D_j^a \to [0,1]$ that gives the score that agent a assigns to a value of issue j in the set of its acceptable value. If the score of the received offer is greater than the score of the counter-offer the agent would send at this moment, then the offer is accepted. Usually, the negotiation has a deadline. If the deadline was not reached yet, then the other agent will send a counter-offer and this process will continue till a deal is made or till the deadline, or till one of the agents want to interrupt the negotiation process due to different reasons. It has been demonstrated that negotiation convergence is achieved when the scoring value of the received offer is greater than the scoring value of the counter-offer the agent intended to respond with (see relation (2)).

$$V^a(x^{t_n}_{b\to a}) \geq V^a(x^{t_{n+1}}_{a\to b}) \qquad (2)$$

where a and b are the two agents involved in the negotiation process.

The negotiation thread between two agents *a* and *b* (i.e. a buyer and a seller) at time t_n is a finite sequence of offers and counter-offers with length *n*, as given by relation (3).

$$(x^{t_1}_{a\to b}, x^{t_2}_{b\to a}, \ldots, x^{t_n}_{a\to b}) \qquad (3)$$

Each agent has apart from the scoring function, a negotiation strategy, and a reservation price. For the buyer agent the reservation price (R^b) represents the maximum price the buyer could afford to pay for a certain product, while for the seller agent, the reservation price (R^s) represents the minimum price the seller would accept for that product. A deal may arise only if a zone of agreement exists, i.e. if $R^b > R^s$.

The negotiation strategy used by the agents involved in COM_ELECTRON is a function of different types of negotiation tactics, such as time dependent, resource dependent, and behavior dependent. For example, a time dependent negotiation tactic models the fact that the agent is likely to concede quicker as the deadline for the negotiation approaches. Let's f_a be the function associated to the offer agent *a* send to agent *b* for issue *j* at time *t*, $f_a:[0, t_{max(a)}]\to[0,1]$, where $t_{max(a)}$ represents the maximum time agent *a* afford to negotiate. In this case, the offer that agent *a* send to agent *b* is given by relation (4).

$$x^t_{a\to b}[j] = \begin{cases} \min^a_j + f_a(t)(\max^a_j - \min^a_j), & \text{if } V^a_j \text{ is decreasing} \\ \min^a_j + (1 - f_a(t))(\max^a_j - \min^a_j), & \text{if } V^a_j \text{ is increasing} \end{cases} \qquad (4)$$

Relation (5) gives a family of polynomial functions parameterised by a value β, a positive real number, for time dependent negotiation tactics.

$$f_a(t) = \left(\frac{t}{t_{\max(a)}}\right)^{\frac{1}{\beta}} \qquad (5)$$

The global objective of the agent-based e-commerce system COM_ELECTRON is the maximization of the profit viewed as an increased number of transactions and deals agreed after some rounds of bilateral negotiation.

The experimental system

The experimental system was simulated in JADE. We have considered the case of second hand products selling such as cars and electronic devices (computers, printers etc). In such cases it is a usual way to allow the negotiation mostly of the price, taking into account different characteristics of the product. During the negotiation process the two agents, the buyer and the seller are exchanging ACL messages with offers and counter-offers. In figure 2 it is given an example of such a message exchanged during the price negotiation for a second hand car.

(*inform*

: sender S_{Ioan}
: receiver B_{Silvan}
: content (price Opel_No178 7500)
: in-reply-to round-2
: language sl
: ontology Onto-MR

)

Figure 2. Example of an ACL message.

The agent ontology is specific to each product category. For example, in the case of cars trading the ontology is Onto_MR, and in the case of electronic products trading is Onto_ElectronicProducts. Figure 3 presents a sequence from the ElectronicProducts Ontology [11].

Figure 4 shows a screenshot of the system's user interface in the case when a learning capability was included in the agent negotiation model (as described in [12]) in order to increase the number of deals made by COM_ELECTRON. In this case the seller agent specifies the product is looking for (a laptop), the product manufacturer (HP), other characteristics of the product, and the parameters for a possible negotiation of the price: the initial price (used to start a negotiation), the reservation price, and the learning rate.

```
package ontologieProduseElectronice;
import jade.content.onto.*;
import jade.content.schema.*;
public class OntologieProduseElectronice extends Ontology {
public static final String NUME_ONTOLOGIE="OntologieProduseElectronice";
// vocabularul de termeni
public static final String PRODUS="Produs";
public static final String NR_PROD="numarserial";
public static final String CALCULATOR="Calculator";
public static final String NUME_CALCULATOR="nume";
public static final String TIP_PROCESOR="tip-procesor";
public static final String CAPACIT_MEM_RAM="capacitate-memorie-RAM";
public static final String CAPACIT_HD="capacitate-hard-disc";
public static final String DETINE="Detine";
public static final String DETINE_PROPRIETAR="proprietar";
public static final String DETINE_PRODUS="produs";
public static final String VINDE="Detine";
public static final String VINDE_CUMPARATOR="cumparator";
public static final String VINDE_PRODUS="produs";
// restul termenilor …
// instanta ontologiei
private static Ontology instanta=new OntologieProduseElectronice();
public static Ontology getInstance() {  return instanta;  }
// constructorul privat
private OntologieProduseElectronice() {
    super(NUME_ONTOLOGIE, BasicOntology.getInstance());
    try {
      add(new ConceptSchema(PRODUS), Produs.class);
      add(new ConceptSchema(CALCULATOR), Calculator.class);
      add(new ConceptSchema(LAPTOP), Laptop.class);
      add(new ConceptSchema(IMPRIMANTA), Imprimanta.class);
      add(new ConceptSchema(CD_WRITER), CD_Writer.class);
      add(new ConceptSchema(SCANNER), Scanner.class);
      add(new PredicateSchema(DETINE), Detine.class);
      add(new AgentActionSchema(VINDE), Vinde.class);
      add(new AgentActionSchema(CUMPARA), Cumpara.class);
      ConceptSchema cs = (ConceptSchema) getSchema(PRODUS);
      cs.add(NR_PROD, (PrimitiveSchema) getSchema(BasicOntology.INTEGER), ObjectSchema.OPTIONAL);
      cs = (ConceptSchema) getSchema(CALCULATOR);
      cs.addSuperSchema((ConceptSchema) getSchema(PRODUS));
      cs.add(NUME_CALCULATOR, (PrimitiveSchema) getSchema(BasicOntology.STRING));
      cs.add(TIP_PROCESOR, (PrimitiveSchema) getSchema(BasicOntology.STRING));
      cs.add(CAPACITATE_MEM_RAM, (PrimitiveSchema) getSchema(BasicOntology.INTEGER));
      cs.add(CAPACITATE_HD, (PrimitiveSchema) getSchema(BasicOntology.INTEGER));
      // restul descrierilor de structura ale conceptelor …
  }
  catch (OntologyException oe) {
      oe.printStackTrace();
    }
  }
}
```

Figure 3. ElectronicProducts Ontology

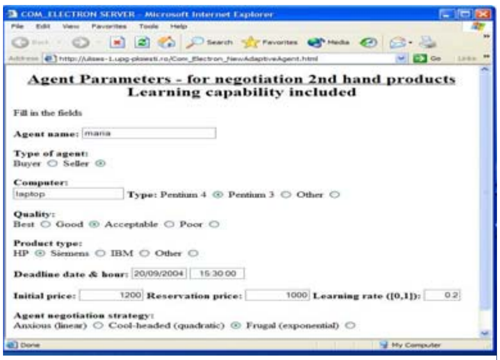

Figure 4. User interface.

Conclusion

One of the main directions of the Internet and Web applications development is given by the intelligent agents technology. In the case of electronic commerce the solution offered by this technology can improve the efficiency of electronic trading. In this paper we have focused on an agent-based electronic commerce system, COM_ELECTRON, developed as a simulation in JADE. Our system is dedicated to second-hand products selling (such as electronic products, cars), and allows the price negotiation. The global objective of COM_ELECTRON is the maximization of the profit viewed as an increased number of deals agreed after bilateral negotiation.

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