B2C AND C2C E-MARKETPLACES
A Multi-layer/Multi-agent Architecture to Support them

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Abstract: Due to the growing of the Internet and the users' trend to acquire products via Internet, the e-commerce has become in a new very important business opportunity. In this paper we present a multi-agent and multi-layer architecture to support general purpose e-marketplaces. The presented system is compound of software agents that can be able to act in the users' benefit reducing their search time and facilitating the product acquisition. These agents are grouped in different layers giving support to B2C and C2C e-marketplaces. The interaction between the different agents is explained through the paper although we remarks the agents used to search, acquire and recommend products. We have also used the fuzzy logic in these agents because we believe that is very useful in order to facilitate its use and reduce the search and acquisition time.

1 INTRODUCTION

Nowadays the importance of B2C and C2C e-commerce is undeniable. Thousands of acquisitions take place over the Internet every day (Turban et al., 2008). This fact leads firms to a new market that is growing at this moment. An e-marketplace can be defined as a site of electronic exchange where firms register as sellers or buyers to communicate and conduct business over the Internet. E-marketplaces are reaching a bit summit as medium that allows to small companies to commercialize their goods (Wise and Morrison, 2000). Some examples of this trend are E-Bay (eBay Inc., 2010), Todocoleccion (Zoconet, 2010), etc., which generate lots of transactions every day. This work is focused on B2C and C2C e-Marketplaces that include on-line transactions of consumer goods or services based on flexible price systems, such as auctions or fixed price systems, such as direct sales (Buy it Now).

It is needed to exploit the technology establishing architectures which address the requirements of this kind of systems in order to achieve the full development of these e-marketplaces and their success. In previous works, a centralized architecture called e-ZOCO (Miguel and Castro-Schez, 2009) was developed to give support to an e-marketplace (Lopez-Lopez et al., 2009a). This architecture presents performance problems when the data layer contains lots of data and when lots of users are concurrently connected. This kind of centralized architectures are not therefore scalable when such parameters grow up, demanding for solutions that rely on distributed control and data distribution. Furthermore, e-commerce applications are integrating more and more techniques based on Artificial Intelligence to provide the users with new capabilities and opportunities for business. Within this context, Multi-Agent Systems (MAS) (Weiss, 1999) can contribute to overcome these limitations and improve the quality of e-marketplaces.

In order to design the architecture of the e-Marketplace MAS, the relevant services that determine the characteristics of this kind of portals and their functionality have been analyzed, as well as the different actors that interact within the market.

Furthermore, in the devised design, there exists an agent based on fuzzy logic whose goal is to assist users in the buying process (Lopez-Lopez et al., 2009a).

In order to develop this proposal, the set of specifications of the Foundation for Intelligent Physical Agents (FIPA) committee has been adopted, which represents the *de facto* standard in the field of MAS (*http://www.fipa.org/*).

An e-marketplace implementation is not trivial. The e-marketplaces evolution has shown that there

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are a set of features common to the most successful e-marketplaces today (Bruckner and Kiss, 2004; Li et al., 2001; Bar, 2001; Hu, 2009; Brunn et al., 2002).

The rest of the paper is organized as follows: The features which are offered in the most successful e-marketplaces are presented in Section 2. Section 3 presents a general description of the multi-layer and multi-agent architecture. In Section 4, an example of interactions between agents, users and environment is described. Finally, Section 5 is devoted to the conclusions and future work.

2 GENERAL DESCRIPTION

The main aim of the proposed architecture is to support a virtual market where both the sellers and buyers depicted as persons or virtual agents can interact and come together to carry out electronic transactions. These agents provide a range of common services to this kind of portals but with the added value of managing from an approach based on intelligent agents.

These basic services encompass aspects like the management of shops and users within the portal, product catalog, product buying/selling, product search and recommendation within the portal, messages between the users, users' trust, dispute between users, or reporting useful information. Furthermore, they are used as a design guide to determine the necessary intelligent agents for the proposed system.

The proposed architecture facilitates the use of these e-commerce services in a free and open way, allowing the portability and ensuring the interoperability. These features that draw a framework based on Service-Oriented Computing (Huhns and Singh, 2005) fits with the MAS notion. The agents communicate and cooperate to improve the quality of services that compose the e-marketplace.

It is necessary to highlight that a service can be represented by an agent and that an agent can represent several services (see Figure 1).

The adoption of FIPA pursues two main objectives: i) to assure the interoperability with other MAS that follow the guides defined by FIPA, and ii) to provide a set of basic management services common to any application developed from this general purpose system.

The FIPA standard defines three common basic services (conceived like agents in the architecture) to any MAS (FIPA, 2000): i) Agent Management System, ii) Message Transport Service and iii) Directory Facilitator. This allows to adopt an homogeneous approach in which all the platform components are agents providing relevant services for the proposed system.

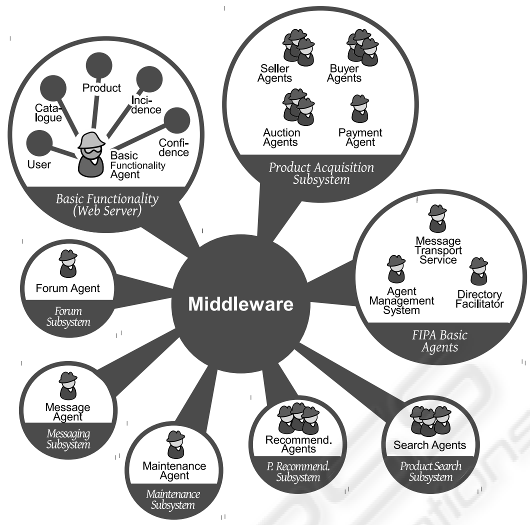

Figure 1: Overview of the Multi-Agent Architecture.

Figure 1 shows the different layers that compose the e-commerce architecture and how the communications between them is carried out. Next, each one of these layers is described.

2.1 User Layer

The user layer represents the interface between the e-marketplace users and the set of provided services. Such interface is accessible from a web browser.

There are three different user roles: i) the Administrator, responsible for managing the e-marketplace; ii) the Buyer, representing the users interested in buying products (via direct shopping or auctions); and iii) the Seller, representing the users interested in selling products to the buyers of the e-marketplace (via direct marketing or negotiation). A user can assume multiple roles simultaneously.

When the user registers to the system as a buyer or a seller, he/she can delegate on software agents certain operations, allowing them to act in their benefit. The inclusion of this kind of intelligent agents in e-marketplace is within the semantic web (Hendler, 2004). The intelligent agents which are described below have the ability to interpret the market information, satisfy the user requests and generate a benefit for the user who represents. This allows to reduce the human interaction and automate several tasks related to the portal management.

2.2 Multi-agent Layer

In this section the multi-agent layer that supports the e-marketplace services is described. We will focus on the functionality provided by each agent and the interactions between them. To facilitate the understanding of the proposal, the subsystems that compose the multi-agent layer are discussed (see Figure 2).

2.2.1 Basic Functionality

The *Basic Functionality Agent* carries out several simple services and does not require intelligence because it implies reactive behavior.

This agent comes into operation simultaneously with the e-marketplace by performing two management operations within the multi-agent architecture (shared with the others agents of the system): i) register to the FIPA agent platform through the *Agent Management System* to obtain a valid and unique identifier, and ii) Register to the *Directory Facilitator* in order to facilitate its location from a functional description. To do that, a description according to the ontology defined by FIPA must be used (FIPA, 2000).

This agent provides the following services:

a) User Management

The user management implies two tasks mainly: i) to assure the correct subscription, modification and deletion of users within the portal; and ii) to manage the delegation of the users' tasks to the intelligent agents that act in their benefit.

b) Catalog Management

The catalog management involves the proper administration of such catalog by the portal administrator. This component is considered like a set of classes or categories $C = \{object, c_1, c_2, \ldots, c_n\}$ hierarchically organized through an *is a* relationship. Such relationship is transitive, fact which ensures that $\forall\, c_i,\ c_i$ *is an* $object$. The class $object$ is the root class.

When a seller puts up a product for sale, it must belong to some class c_i. Hence, each class comprises a set of objects $c_i = \{e^1_{c_i}, \ldots, e^n_{c_i}\}$. Each $e^j_{c_i}$ belonging to a class c_i is described by means of a set of attributes or variables $V_{c_i} = \{v^1_{c_i}, \ldots, v^m_{c_i}\}$, which values serve to distinguish between different products belonging to the same class. Furthermore, each variable $v^j_{c_i}$ has a *range of definition*, denoted as $RDV^j_{c_i} = \{x_1, x_2, \ldots, x_n\}$, which specifies the possible values x_k that the variable $v^j_{c_i}$ may take. The range of definition of class c_i, denoted as RDV_{c_i}, is defined as $RDV_{c_i} = \{RDV^1_{c_i}, \ldots, RDV^m_{c_i}\}$. The variables that describe a product class may represent different data types (Castro-Schez et al., 2004).

c) Product Management

A mechanism to manage the portal products is needed. Its main function is to allow the users to register/delete products and check the constraints imposed by the catalog definition according to the data types of the category variables. Thus, the consistency and uniformity of e-commerce portal catalog is guaranteed. This functionality maintains a reactive scheme that allows to check the user data when there are interactions with the portal.

d) Dispute Management

The dispute management is reduced to an action performed by the user. This action is to describe the dispute and register it via the communications kernel into the data layer. Another relevant task is to monitor each dispute during its life cycle when necessary and as established in each case.

e) Trust Management

One of the main problems for users in e-marketplaces is reliability since the user does not often know the other party when carrying out transactions. To overcome this limitation, most of the portals have a trust system that allows to associate a "prestige" to each user within the community or the portal. This "prestige" depends on aspects such as efficiency in the buying process or the product description fidelity given by the user interested in selling.

The Basic Functionality Agent performs the following tasks: to process the score of each transaction carried out in the portal to determine the user's prestige, to provide the user's prestige to other users or agents when they request this information, and to control the concurrent access of different users to such information.

2.2.2 Product Acquisition Subsystem

This subsystem provides all the services related to the product purchase/sale within the portal. A user (or an agent) executes it in order to acquire the product. The acquisition may be through direct purchase, auction, negotiation, etc. It is composed of the following agents: sellers, buyers, auctioneers, and payment agent.

Since the auction processes are common in e-marketplaces, it is interesting to equip the system with an auction agent. Within this context, such an agent registers request for auction, usually on demand by seller agents, registers the bids carried out by buyer agents and controls that the process is normally developed. Moreover, there is another agent, the Buy-It-Now Agent, which controls the process of direct sales.

The seller agent automates some tasks related to the product sale process: i) to contact with other users

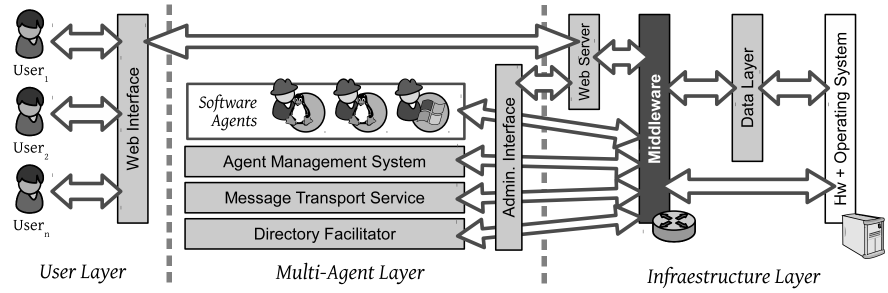

Figure 2: Overview of the multi-agent layer that supports the e-marketplace.

or agents interested in acquiring products according to the sale constraints imposed by the represented user, ii) to ask the buyer users or agents for direct shopping processes in the appropriate time and in the best conditions for its owner, and iii) to initiate auction processes to obtain benefits from the competition between several buyer users or agents interested in some product managed by the seller agent.

The buyer agent is responsible for representing the buyer user in the portal with the aim to obtain benefit. Its responsibilities are as follows: i) to represent the buyer user in the product direct shopping processes within the portal, ii) to send bids to the seller agent in an auction process, which satisfy the seller's constraints when the best circumstances occur in order to acquire the product, and iii) to order periodic searches in the portal, having into account the buyer's preferences.

Nowadays, little attention has been paid to the payment system due the fact of being an e-marketplace prototype. A payment agent will be included in the future. This agent will allow to make transfers related to the cost of the purchased product.

2.2.3 Product Search Subsystem

The product search subsystem is formed by a set of search agents. Two main functionalities have been delegated to them: i) to provide an arranged product list which may be of interest for a buyer because they are similar to the provided ideal product description, and ii) to advise to the portal users in the product search process by giving information about the set of more frequently used variables by the portal users in previous searches.

The search agent owns one or more descriptions of products or ideal objects (o_i) for the buyer (or its buyer agent). An ideal object specification consists in the set of variables $V'_{c_i} \subseteq V_{c_i}$ selected from the whole set of variables describing the class c_i together with their required values, which are selected from the described domains of definition DDV'_{c_i}. Plus, each variable is provided with a weight $P(v'^{j}_{c_i}) \in [0,1]$, which establishes its importance (Castro-Schez et al., 2005).

From such an ideal description o_i, which may be precise, imprecise or both, the agent provides a similar list of products. The imprecision is mainly due to the ignorance related to the knowledge of the market. To deal with vagueness and precise information, an homogeneous information representation model is maintained. The common representation formalism used in this work is based on the use of Fuzzy Sets (Zadeh, 1965).

The next step is to calculate the similarity between each product $e^{j}_{c_i} \in c_i$ of the list of similar products and the ideal object. Basically, this search process consists in calculating the partial distance between each one of the variables that compound the ideal object and the other products c_i. Afterwards, when this process ends up the global distance is calculated as the weighted sum of the partial distances depending on the importance of each attribute that describes the product. In this way, the search agent can build a list of ordered products based on the global distance with the more relevant products for the user/agent.

Finally, this agent can be replicated on different machines to distribute the workload associated with its two main functions (search and counseling). The design solution adopted for carrying out such replication is to use a master-slave scheme and a synchronization mechanism between replicas. To do this, the *pattern observer* (Gamma et al., 1995) has been used.

2.2.4 Product Recommendation Subsystem

The product recommendation subsystem can be understood as a natural extension to the search subsystem. The goal pursued is to make suggestions or recommendations to the portal users depending on the relationships between variables to perform realistic searches. Furthermore, this subsystem facilitates the analysis of the information gathered by the search agent by taking into account the user's preferences. In this way, the main responsibility of this subsystem is to offer a product classification service depending on these preferences or the *fitness* for the portal users.

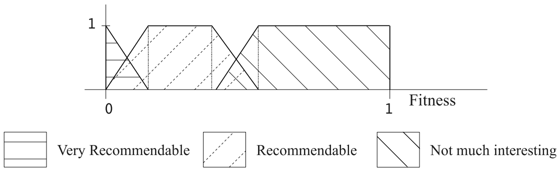

Figure 3: Definition domain of the variable *fitness*.

The agent that gives support to the product recommendation subsystem is the recommender agent, which has been designed as an utility-based agent, that is, it is based on an utility function that allows to establish the more interesting products for users (Lopez-Lopez et al., 2009b). In order to make recommendations close to the user, the recommender agent uses the linguistic variable *fitness*, which takes three values: *very recommendable*, *recommendable* and *not much interesting* (Figure 3). In this way, the agent is able to associate each element e_j to one or two of these values by means of a fuzzyfication process, making use of the global distance existing between the ideal product o_i and each $e^j_{c_i} \in c_i$.

2.2.5 Maintenance Subsystem

Most e-marketplaces provide mechanisms for generating reports and statistics about the portal use in order to improve and refine them. Within this context, the maintenance agent is responsible for generating reports about the following aspects: i) Activity of the portal and registered users/agents. This private information can be internally used to suggest items or offers in an intelligent way. Furthermore, it is possible to reward the more active users within the portal; ii) more desired items; iii) more purchased/sold items; iv) transactions made within the portal (direct sales or auctions); v) number of registered users; vi) number of unregistered users; vii) number of inactive users.

2.3 Infrastructure Layer

The infrastructure layer represents both the software and hardware resources used by the e-marketplace supported by the multi-agent architecture discussed in the previous section. When it comes to software, the infrastructure layer hosts the following components: i) a web server that supports the portal web interface to make easy the interactions between the portal users, ii) a communications middleware that allows the communication between the agents of the multi-agent layer and provides basic services such as location or implicit activation. Furthermore, it gives support to secure communication channels to guarantee the data integrity, and iii) a relational database management system to deploy the database of the e-marketplace.

3 THE COMMUNICATION FLOW

In order to understand the architecture presented here, we show the communication steps between the agents since a user registers a product in the e-marketplace until this is acquired by another user.

Suppose that a seller wants to register a product in the e-marketplace. Then, he interacts with the e-marketplace interface that communicates with the web server. In the web server a service communicates with the *Basic Functionality Agent* that informs the user about the required data to register the product, checks this data and, finally, makes it persistent into the *Data Layer*.

Now suppose that a buyer wants to acquire a product. The first event for him is to interact with the e-marketplace interface. Next, he has three possibilities: i) to buy the product (if possible), ii) to bid for it (if possible), or iii) to delegate the acquisition of the product to a software agent. In all the cases, the web server has to interact with the suitable software agents. When the acquisition process finalizes, the appropriate agent contacts with the *Payment Agent* that is responsible for the payment. A message is sent to both the seller and the buyer at this point. This message is shown to the suitable user via the interface of the involved agent, the *Buyer Agent* or the *Seller Agent*.

Then, the general communication mechanism is as follows: i) to interact with the user interface, ii) to execute the suitable service in the web server, iii) to locate the suitable software agent via the middleware, and iv) to execute the software agent.

4 CONCLUSIONS

The consolidation of the Internet as an everyday technology has opened a new environment of business oportunities. Many firms have expanded their business in the past decade to take advantage of the new information technologies, whereas others have emerged and are solely based on them. This fact has caused the appearance of new business paradigms, along with new technological infrastructures to support them. This is the case of electronic commerce (which can be defined as any business that is electronically transacted).

Third-party (independent) B2C and C2C e-marketplaces are reaching a bit summit as a medium that allows to small companies to do business by means of Internet. These portals are based on complex technological architectures. One of the main reasons why e-marketplaces fail are related to their technology that is not mature often.

To address this challenge, a multi-agent architecture has been presented to overcome the limitations of previously arhitectures developed. The new designed architecture has the following advantages: i) scalability to easily extend the system functionality, ii) it is efficient in computional terms, since the calculations are distributed over several machines depending on the workload, iii) it uses open standards to promote the interoperability and data exchange among companies processes and system internal processes, iv) it is general, being possible to sell or buy goods or services of any kind, and v) it has a safety communication framework to avoid "man in the middle" attacks.

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