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A Fuzzy-Evolutionary Seller Agent for an Automatic Negotiation Framework on e-Commerce

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Abstract

The business achievement via e-commerce is getting more important at the present time. E-commerce implies several activities. One of the most significant activity is the consummation of negotiations between sellers and buyers with the aim of reaching agreements. In order to automate these activities the intelligent agent software model is applied. In this work, it is proposed the design of a seller agent for negotiating in competitive frameworks, where many seller agents and a buyer agent negotiate products or services based on several properties. In that context, the aim of the seller agent will be to make offers that improve the other ones sent by other sellers and to maximize its profit. The design is based on the application of fuzzy logic and evolutional algorithms.

1 Introduction

The appearance of technologies, such as Internet, has softened the achievement of business all around the world. This fact has caused the appearance of a new infrastructure to this new business paradigm known as *electronic commerce* (e-commerce). The e-commerce processes and technologies have introduced new ways of doing business. "E-commerce is based on sharing information between organizations by making use of a great variety of different electronic technologies, e.g. to do business... This also includes procedures, policies and strategies to support the incorporation of this whole information within the business framework" [14].

According to the entities which are involved in a negotiation it can be distinguished the following types of electronic commerce [10]:

- B2B(Business to Business): between manufactures and wholesalers. Wholesalers use electronic commerce to acquire directly produts from manufacturers who sell the desired products.

- B2C(Business to Consumer): between the wholesalers and consumers. Consumers buy directly products from the wholesalers via online by retailing transactions, without the necessity of going to any shop.
- C2C(Consumer to Consumer): among consumers in the way of exchanging products.
- C2B(Consumer to Business): between consumers and wholesalers, where they buy products from consumers.

Actually, B2B and B2C are the most important types of electronic commerce. As regards these types, some models have been proposed with the aim of specifying the different tasks and stages that sellers and buyers carry out in the negotiation processes. In particular, the BBT model (Business-to-Business Transaction) [10] for B2B e-commerce and the CBB model (Consumer Buying Behavior) [13] for B2C e-commerce. In the last years, there have been developed several systems which aim has been the automation of a large group of these tasks and stages. In general, the negotiation stage in such models is configured as the central axis of the whole process.

Negotiation is a process by which two or more parties try to reach an agreement or compromise by arguing [15]; it is not an aim itself, but a procedure to reach some objectives and to satisfy some desires [4]. A negotiation situation shows three main features: *interdependence*, the decisions which are taken in a negotiation process, are influenced by participants involved in it; *interest conflict*, there are pure competitive situations in which the participants have opposite interests, pure cooperative situations in which the participants have similar interests are similar and mixed situations where they, simultaneously, win or lose; and finally, *possibility of agreement*, many times, it is unknown if it is possible to reach a kindly agreement for participants. This possibility of agreement is defined by the occurrence of a zone for each negotiated aspect that is delimited by the top values of buyers and sellers (e.g. in a negotiation around the price of a car in one side the buyer knows his top value, that is to say, the maximun quantity that he could pay and in the other side, the seller knows which is the minimun selling price that he could offer). The top values are the quantity that it couldn't be exceeded if participants try to reach an agreement. From the point of view of the sellers, it is essential the previous knowledge of the following values for a negotiation process: reserved values that identify the desertion points; initial values that point out the entry points; and, optimum values that indicates the optimum sale points [4].

One of the most relevant aspects of the electronic commerce is that such a negotiation process will be turned into an automatic process to liberate the user. This fact has opened new lines of research, in which, there are being developed autonomous systems based on the application of *intelligent software agents*. In this way, the conception of electronic commerce carried out by intelligent agents has come up [1][10][13]. An intelligent agent is a software program that can perform a group of tasks by oneself with the aim of achieving some particular goals [12]. Due to, an intelligent agent has to possess the following features: autonomy, reactivity and proactivity. Within the electronic commerce framework, intelligent agents form the applied mechanism to model and simulate the seller's and buyer's behaviour that takes part in a negotiation process.

From the seller point of view, in which this work is based, the different advances are focused on designing intelligent agents that make tasks of the seller in his commercial activities. The different stages of a negotiation process are been examined for both buyers and sellers. The stages for a seller are [11]: the offer planning, the identification of possible clients, the negotiation, the order setting and client support.

In this work, it is suggested an intelligent agent that tackles the automation of the seller negotiation stage within of an automatic negotiation competitive framework for B2B or B2C contexts. In such frameworks, there will be carried out several negotiations over products or services based on distinct aspects between a lot of sellers and only a buyer.

The rest of the paper is structured in the following way. Section 2 provides a description of the frame in which the designed agent is applied. Section 3 concentrates on a short explanation of the theorical foundations in which it is based the seller agent. Section 4 discusses the used mechanism to automate the generation of offers during the negotiation process. The detailed description of the structure of the seller agent is given by Section 5. Finally, it is showed the concluding remarks and future extensions of this work.

2 Application Framework

In general, one significant property of negotiations in E-commerce is the number of participants. It can be distinguished the following negotiation scenarios in E-commerce [1]: *one-to-one* (this scenario is composed of a seller and a buyer). Initially the buyer or the seller makes the other one offers of items that are offered. While the negotiation is held, each side can choose one of the following actions: to accept the terms of sale, to make a counter offer, or go on; *many-to-one* (in this scenario many sellers and one buyer have a negotiation or, on the contrary, only one seller with many buyers). In the first case, the auction models are used by the buyer to ask for a good or service, and, the sellers compete with each other for the business. In the other case, the sellers use the auction models that put the buyers against each other to obtain the highest profit, and finally, *many-to-many* (many sellers negotiate with many buyers), where the sellers offer their goods or services together with their conditions and the buyers show the services or products they desire and the price they are willing to pay.

In this paper, we concentrate on B2B or B2C competitive frameworks of E-commerce, where negotiations are held between a buyer and many sellers, that is to say, many-to-one negotiation scenarios. In such a context, a buyer agent establishes a negotiation with several seller agents that offer the desired good or service. The aim of the buyer agent is to take advantage of the competition among sellers. As result of that, the buyer agent will specifically carry out the following actions:

- To receive offers from seller agents.
- To analyze the received offers identifying the significant characteristics associated to each good or service offered, and finding the offers equally beneficial.
- To select sellers with offered products equally beneficial and to ask for improving their offers by bearing in mind the rest of similar offers.
- To support the decision by helping him to identify the most suitable deal according to its owner requirements and preferences, the state of the negotiation process, the market state and the state of the company or consumer owner of the agent.

There are several approaches in this way. A possible solution to the design of buyer agents that automate the negotation phase is suggested in [7].

In this negotiation process, both the seller and the buyer agents handle offers where several characteristics of goods or services will be negotiated. For this reason, a wide range of data types are used. The most common types are: ordinal (e.g. supplier's type), nominal (e.g. supplier's country), boolean (e.g. cash on delivery?), ranking (e.g. quality of product), and continuous (e.g. price, quantity). This fact is borne in mind in this work.

The suggested seller agent is guided to be applied in negotiation frameworks such as the above-described framework. This agent, once the negotiation process is started with a buyer agent, will try to improve its offer based on the opponent offers and its optimum value whenever its reserved values will never be exceeded. Therefore, it is assumed: on the one hand, that the terminology used by agents is shared and, on the other hand, that all the previous required knowledge of the aspects of negotiated products or services, the connection and dependence among aspects, ... it is known. The acquisition of all this information is out the scope of this work.

3 Theorical Foundations

This section concentrates on a short account of the theorical foundations on which is based the seller agent's strategy of negotiation, the scope of this research. Initially, it is supposed that the buyer agent has a detailed description of the good or service is going to be negotiated with the buyer agent. This description consists of a set of features the product must have ($\mathcal{V} = \{v_1, v_2, \ldots, v_n\}$) and the set of values $\mathcal{C}v_i$ each feature v_i could take ($\mathcal{C}v_i = \{Cv_1, Cv_2, \ldots, Cv_n\}$). Moreover, the agent has also information about the priority attached to each feature ($\mathcal{P} = \{p_{v_1}, p_{v_2}, \ldots, p_{v_n}\}$). This information will be useful at the moment to generate offers along a negotiation process and it can be acquired in several ways, as example, see [8] [16].

Due to the fact that the negotiation is a dynamic process in which the number of negotiated variables could be changed, that is to say, any variable could be gone away or added, the definition of the negotiation space is dynamic too. In any case, the knowledge of the variables that could be used in the negotiation process makes it possible to establish the dimensions of the negotiation space. Thus, the negotiation is itself a searching process of a point in the mentioned space that satisfies the need of buyers and sellers (Fig.1).

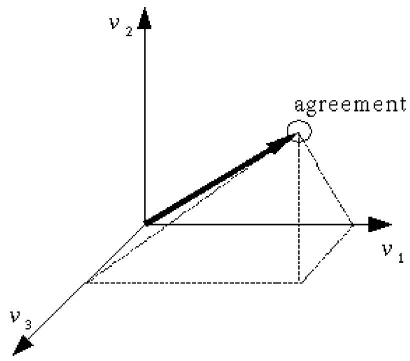

Figure 1: Negotiation space for three variables

The definition of the negotiation space, before a negotiation process will be started, enables to locate, initially, offers that point out the starting, the desertion and the optimum situations to the seller agent. In the same way, along the negotiation process, the different offers that have been made by other seller agents as well as the offers that the agent will generate could be placed (Fig.2). This fact facilitates that the seller agent carries out its main goal, that is to say, the generation of the counter-offers that do not move away from the actual negotiating area of the searching space. These counter-offers must make good the following two aspects: to be closed to the opponent offers which are supposed more profitable for the buyer and to improve its offer without moving away its optimum values so far or reaching any desertion value. To achieve this goal, it is needed the application of a mechanism that permits to measure the similarity between offers. In the next subsection it is explained in depth.

3.1 Similarity Evaluation between Offers

The fact that the values of variables of each offer can be of different nature implies the use of a formalism that makes it possible to represent both accurate and vague information. Therefore, it is proposed the use of the trapezoidal function of the Fuzzy Logic, so, each Cv_i will be a set of trapezoidadal functions. In this way, it could be analyzed the similarity between two offers $\mathcal{O}_x$ and $\mathcal{O}_y$ based on a variable v_i, as the measure result of the calculation of the area of the fuzzy set "between" based, in its turn, on the two fuzzy values that these offers hold for the selected variable. This measure is formally defined by [6].

The above-mentioned measure presents one problem. This considers that two offers $\mathcal{O}_x$ and $\mathcal{O}_y$ are equal even if the intersection between their areas is not

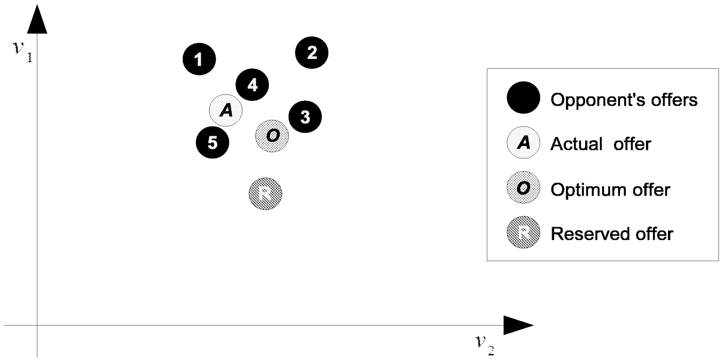

Figure 2: Location of offers in step n of negotiation process

null. In this way, if the offers $\mathcal{O}_x$ and $\mathcal{O}_y$ take the values A and B respectively to the variable v_i (see Fig.3), it could be said that these offers are equally beneficial according to the measure suggested in [6]. Nevertheless, the position of the ideal value and the fact that the value A is more closed to it, makes the offer $\mathcal{O}_x$ to be considered more beneficial and not equal to the offer $\mathcal{O}_y$.

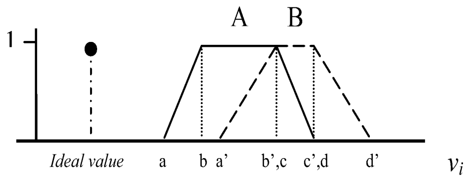

Figure 3: Measurement's problem, *area(between(A,B))=0*

For this reason, it will be applied a measure based on the measure proposed in [9] that overcomes this problem (1).

$$d(\mathcal{O}_x, \mathcal{O}_y, v_i) = d_1(\mathcal{O}_x, \mathcal{O}_y, v_i) + d_2(\mathcal{O}_x, \mathcal{O}_y, v_i) \tag{1}$$

$$d_1(\mathcal{O}_x, \mathcal{O}_y, v_i) = \begin{cases} \frac{(a'-b)+(b'-a)}{2}, & \text{if } b \leq a', \\ \frac{b'-a}{2}, & \text{if } a' < b < b' \\ 0, & \text{in any other case} \end{cases} \tag{2}$$

$$d_2(\mathcal{O}_x, \mathcal{O}_y, v_i) = \begin{cases} \frac{(a-b')+(b-a')}{2}, & \text{if } b' \leq a, \\ \frac{b-a'}{2}, & \text{if } a < b' < b \\ 0, & \text{in any other case} \end{cases} \tag{3}$$

This measurement calculates the defined area by that set of values which are covered by the offer closeness to the ideal value $\mathcal{O}_x$, and not by the other one, the farthest offer $\mathcal{O}_y$. The above-mentioned problem is solved by using the application of this measurement. The offer $\mathcal{O}_x$ is more profitable that the offer $\mathcal{O}_y$ (see Fig.4).

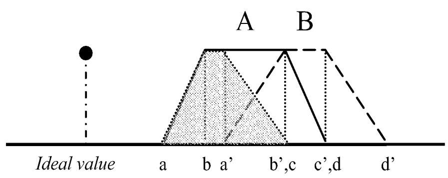

Figure 4: Applied Measure

This measure could be normalized as it is defined in (4), where, $d(\mathcal{O}_x, \mathcal{O}_y, v_i)$ is the above-mentioned measure and $d(min(v_i), max(v_i), v_i)$ is the space between the biggest and the minor value to the variable v_i.

$$d_n(\mathcal{O}_x, \mathcal{O}_y, v_i) = \frac{d(\mathcal{O}_x, \mathcal{O}_y, v_i)}{d(min(v_i), max(v_i), v_i)} \tag{4}$$

Finally, the similarity between two offers $\mathcal{O}_x$ and $\mathcal{O}_y$ is defined as the sum of the existing normalized distances for each variable ($v_i \in \mathcal{V}$) that are in gear in a negotiation process ($|\mathcal{V}| = n$), which is calculated by (5). Therefore, the smaller value between two offers $\mathcal{D}(\mathcal{O}_x, \mathcal{O}_y)$, the bigger similarity.

$$\mathcal{D}(\mathcal{O}_x, \mathcal{O}_y) = \frac{\sum_{i=1}^{n} d_n(\mathcal{O}_x, \mathcal{O}_y, v_i)}{n} \tag{5}$$

To provide a concrete example of similitary evaluation between two offers, let's suppose an accommodation renting scenario where somebody wants to rent accommodation and there are several real state agencies interested in renting him one of their accommodations. This negotation is carried out by intelligent agents in a virtual negotiation framework. Futhermore, the negotiated aspects of each accommodation and its definition domains are shown in Table 1.

In such situation, let's imagine that there are three seller agents (A, B, C) negotiating with the buyer agent and each seller agent knows the opponent's offers in each negotiation step. If in the step n the agent (A) would like to inquire how much differs its offer from the others (B, C) the agent only has to apply the above-mentioned similarity measure. If the offers are respectively: $\mathcal{O}_A$*(cheap, average_bad, shared house, average)*, $\mathcal{O}_B$*(average, bad, flat, far)* and $\mathcal{O}_C$*(expensive, average_bad, flat, near)*, the results of similarity are shown in Table 2.

Negotiation Aspect	Definition Domain (DDV)
Rental rate	{Cheap(100,100,250,300), Average(250,300,400,450), Expensive(400,450,600,600)}
Lodging condition	{Bad(1,1,1,1), Average_bad(2,2,2,2), Average_good(3,3,3,3), Good(4,4,4,4)}
Lodging type	{Room in guest house(1,1,1,1), Shared House(2,2,2,2), Hall(3,3,3,3) Flat(4,4,4,4) Apartment(5,5,5,5)}
Distance to center of town (minutes walk)	{Near(0,0,15,25), Average(15,25,30,35) Far(30,35,50,50)}

Table 1: Negotiated aspects in negotiation process

	$d_n(\mathcal{O}_A, \mathcal{O}_B, v_i)$	$d_n(\mathcal{O}_A, \mathcal{O}_C, v_i)$
v_1	0.54	1.00
v_2	0.33	0.00
v_3	0.50	0.50
v_4	0.38	0.10
	0.44	0.40
	$\mathcal{D}(\mathcal{O}_A, \mathcal{O}_B)$	$\mathcal{D}(\mathcal{O}_A, \mathcal{O}_C)$

Table 2: Results of similarity evaluation between offers

4 Automatic Generation of Offers

The negotiation process could be considered as a searching process as it was shown in Section 3. From this point of view, the negotiation strategy, which is used by the seller agent to generate new offers could be based on the application of searching and optimization techniques to find solutions in search spaces where each point represents one possible solution that could be more or less suitable depending on the negotiation state. Among the different choices to get to that aim, it will be applied "genetic algorithms" [2] in this work. The genetic algorithms are a part of the evolutionary computing that consists in generating a new solution from the evolution of a previous set of solutions. The seller agent's negotiation strategy suggested in this paper, presents a similar behaviour, that is to say, the generation of new counter-offers is based on the evolution of an inital set of acceptable selling offers bearing in mind the offers made by the other seller agents along the negotiating process too.

Genectic algorithms are techniques based on the concept of evolution and, in particular, they are based on the concepts of variation and natural selection. The basic skeleton of this kind of algorithms is described in Algorithm 1.

Algorithm 1 Genetic Algorithm's Skeletom

1. Generate an initial random population of n-elements ("chromosome" - suitable solutions)
2. Evaluate the fitness of each chromosome in the population

repeat ▷ Originate the next generation

    4. Selects two chromosomes based on fitness

    5. With a crossover probability cross over the selected chromosomes to form new offspring

    6. With a mutation probability mutate new offsrping

    7. Compute fitness of each offspring chromosome according to a certain criterion

    8. Update the current population

until stopping criterion is satisfied

10. Return the best solution in current population

The algorithm suggested does not match accurately in the above-described way due to the special features of the application domain. Next, the most prominent aspects of this algorithm are explained.

The representation of information is the first aspect to emphasize, that is to say, the structure of chromosomes. Each chromosome must represent an existing offer in the negotiation process. An offer will be defined by a set of variables ($\mathcal{V}$) and each variable will present a fixed number of fuzzy sets in which the variable domain is split ($\mathcal{C}_v$). According to this definition, the structure of each chromosome is based on a chain of elements where these symbolize each one of the existing fuzzy sets (Fig.5). The length of this chain $\mathcal{L}_{chromosome}$ depends on the number of the fuzzy sets ($|\mathcal{C}_v|$) in which the domain is divided for each existing variable v_i in the offers (6).

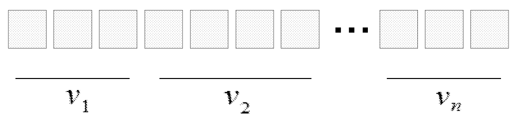

Figure 5: Applied Chromosome

$$\mathcal{L}_{chromosome} = \sum_{i=1}^{n} |\mathcal{C}_{vi}| \tag{6}$$

To provide an example, let us follow with the showed accommodation renting scenario at the end of the Section 3. In such an example, each offer presents four negotiated aspects and their domains are divided into the following fuzzy sets (see Table 1): rental rate (v_1) and Distance to the center of the town (v_4) in three fuzzy sets, lodging condition (v_2) in four fuzzy sets and lodging type (v_3) in five fuzzy sets. The length of the chain will be as follows:

$$\mathcal{L}_{chromosome} = 3 + 4 + 5 + 3 = 15$$

The alphabet for each element in chromosome is $\mathscr{A} = \{0, 1, \sharp\}$. The meaning of each element of the alphabet is: the symbol 1 is used to point out the presence of a variable label, the symbol 0, the absence of a variable label and the symbol $\sharp$ is to indicate the case in which a variable does not play part in a negotiation process. In this case, all the variable labels present this symbol $\sharp$. For example, the offer of the seller agent (A), $\mathcal{O}_A$*(cheap, average_bad, shared house, average)*, will be encoded as the following coded bitstring: $\mathcal{O}_A$ = (100 0100 01000 010) and if the variable "lodging condition" is out the negotiation process, the offer will be encoded as: $\mathcal{O}_A$ = (100 $\sharp\sharp\sharp\sharp$ 01000 010). A graphical representation of the offers that the seller agents (A,B and C) propose at step n of a negotiation process in the previous example is shown in Fig. 6 (where ■ simbolizes 1 and □ simbolizes 0).

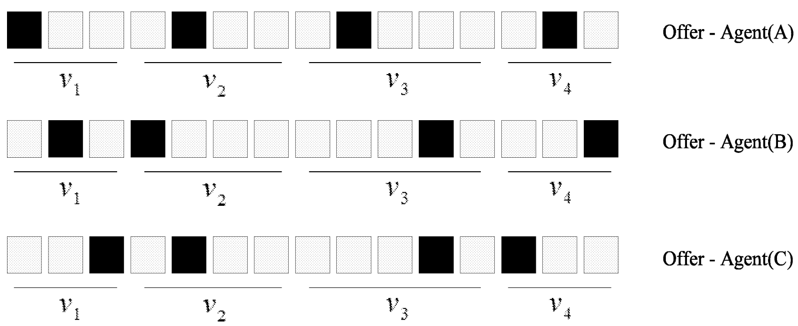

Figure 6: Representation of offers

The seller agent will have an initial population of $\mathcal{N}$ chromosomes. Each chromosome will represent a start point from which the negotiation could be initiated. This population will be taken as base at the beginning of a negotiation.

The crossover operation will lie in the random selection of both chromosomes and the variable from which this operation will be applied. This operation will carry out at the variable level to avoid any chromosome of the offspring presenting two selected labels for the same variable. An example of the aplication of this crossover operation is shown in Fig. 7 and, it is applied to the offers of the seller agents (A and B) (see Fig. 6) from the variable v_1.

The operation of mutation will be randomly applied to a chromosome of the offspring when a certain fixed threshold value ρ is beaten. The operation is based on the random selection of a variable that plays part in the negotiation and the

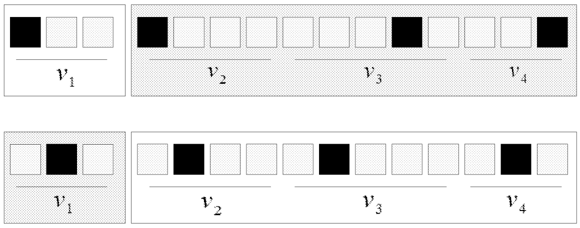

Figure 7: New offspring after crossover operation

selection of a label for the selected variable according to the tactic applied by the seller agent. Examples of this kind of tactics could be: conservative (it will be marked a contiguous label to the acutal one), aggressive (it will be selected the opposite one to the actual label) and poll (any label could be chosen). For example, if the mutation operation is applied to the rental rate variable of a new generated offer, the actual value is *expensive* and the tactic applied is conservative, the final value will be *average*.

When this operations will be applied, they might turn up side effects that can lay on the existing dependences among variables. A meaningful example could be: given an offer such as $\mathcal{O}_x$ = (*expensive, good, aparment, near*) which represents the typical features of a marvelous renting accomodation, it is not naturally in the negotiation process that after the aplication of the crossover or mutation operation, the value for the rental rate variable will take the value *cheap* because of this radical change will not take place in ordinary circumstances. Therefore, the seller agent must know this kind of dependences among variables to generate new offers. In such a case, these depedences could be represented by means of a set of linguistic "IF_THEN" rules $R = (R_1, R_2, R_3, ..., R_n)$. These rules would be formed by the attributes and values used during the negotiation and they would be expressed in the way the buyer and the sellers use them. This set of rules would hold constraints associated to each negotiable aspect. It could be used Mandani rules [3]. This information could be acquired in several ways, e.g. through machine learning algorithms [5]. The acquisition of all this information is out of the scope of this work. Examples of this kind of rules could be:

- R_0 : If lodging_type is ((not *apartment*) and (not *flat*)) and lodging_condition is *bad* then rental_rate is *cheap*
- R_1 : If lodging_condition is *good* and distance_to_center_town is *near* then rental_rate is not *cheap*.

The offer evaluation ($\mathcal{O}_x$) is based, on the one hand, on the proximity between the offer ($\mathcal{O}_x$) and the seller agent's optimum offer ($\mathcal{O}_{optimum}$) ($\mathcal{F}_{gen}(\mathcal{O}_x)$), which could be the same along the negotiation process or it could change depending on the negotiation circumstances but this is not usually the optimum solution for this process. On the other hand, it is based on the proximity between the offer ($\mathcal{O}_x$)

and the set of received offers (noted as B_o) from the buyer over the opponent sellers that negotiate the same product or service ($\mathcal{F}_{bo}(\mathcal{O}_x)$). The suggested evaluation function is described as:

$$\mathcal{F}(\mathcal{O}_x) = \mathcal{F}_{gen}(\mathcal{O}_x) + \mathcal{F}_{bo}(\mathcal{O}_x) \tag{7}$$

Both $\mathcal{F}_{gen}(\mathcal{O}_x)$ and $\mathcal{F}_{bo}(\mathcal{O}_x)$ are based on the application of (5), which is adapted to consider the assigned priority of each varible v_i that plays part in an offer (p_{v_i}). This adaptation is showed in (8).

$$\mathcal{D}(\mathcal{O}_x, \mathcal{O}_y) = \frac{\sum_{i=1}^{n} d_n(\mathcal{O}_x, \mathcal{O}_y, v_i) \cdot p_{v_i}}{n} \tag{8}$$

According to the above-mentioned, $\mathcal{F}_{gen}(\mathcal{O}_x)$ and $\mathcal{F}_{bo}(\mathcal{O}_x)$ are calculated by means of (9) and (10) respectively:

$$\mathcal{F}_{gen}(\mathcal{O}_x) = \mathcal{D}(\mathcal{O}_x, \mathcal{O}_{optimum}) \tag{9}$$

$$\mathcal{F}_{bo}(\mathcal{O}_x) = \frac{\sum_{i=1}^{|B_o|} \mathcal{D}(\mathcal{O}_x, \mathcal{O}_i) \cdot \phi_i}{|B_o|} \qquad \forall \mathcal{O}_i \in B_o \tag{10}$$

where ϕ_i captures the proximity to the up-to date received offers. The negotiation process is a dynamic process in which offers and counter-offers will change, so that, after n steps of negotiation, these will be placed around a certain area of the searching space or these could be moved to another area of such a searching space. By means of the application of the parameter ϕ_i it is expected that the calculated similarity between a new generated offer and a received offer will be weighed up by the proximity of the received offer to the actual area of the searching space, in which the negotiation process is moving, in other words, the relevance of such a received offer at the actual negotiation moment.

To model the evolution way of the negotiation process, firstly, it is associated a value to each received offer. This value $t(\mathcal{O}_i)$ represents the step or the moment in the negotiation process in which that offer is received. To capture that evolution it is applied a mechanism of updating this value. This mechanism is based on the calculus of the middle distance ($\overline{d}_m$) among all the received offers ($\mathcal{O}_i \in B_o$) just as (11), and, it is based on the updating of each received offer's value $\mathcal{O}_x$ to the actual negotation moment if the distance between that offer $\mathcal{O}_x$ and the lastest received offer $\mathcal{O}_n$ is less than the calculated middle distance. This updating will be carried out each time the seller agent gets new offers.

$$\overline{d}_m = \frac{\sum_{i=1}^{|B_o|} \sum_{j=i+1}^{|B_o|} \mathcal{D}(\mathcal{O}_i, \mathcal{O}_j)}{\sum_{k=1}^{|B_o|-1} k} \tag{11}$$

Finally, the parameter ϕ_i is calculated depending on the reception moment associated itself to each received offer $t(\mathcal{O}_i)$, which belongs to the set of received offers, (B_o) and depending on the current negotiation moment $(t_{current})$, with $t_{current}$ being a value taken for the interval $[1, n]$ and, it represents the timestamp in which the negotation process is.

$$\phi_i = \frac{t(\mathcal{O}_i)}{t_{current}} \tag{12}$$

The genetic algorithm modifies the population in each generation based on the associated value to each offer by means of (7). The population size $(\mathcal{N})$ is constant and those offers that hold worse values will be eliminated.

In each negotiation step, the seller agent will apply the above-mentioned algorithm to generate a new offer. Initially this population is based on a set of initial offers. This population will evolve in m generations. The selected offer in each negotiation step will be that one whose value will be the best one according to (7).

5 Structure of the Seller Agent

The suggested seller agent is directed to automate the negotiation stage in competitive B2B or B2C frameworks where negotiations are held between a buyer and many sellers, that is to say, many-to-one negotiation scenarios. In this buyer dominated negotiation scenarios, the buyer starts a negotiation process with those sellers that offer the desired product or service with the aim of taking advantage from the competition among sellers. To favour this competition, the buyer analyzes the received offers from the sellers in each step of the negotiation to find those with equally beneficial offers. Then, the buyer asks these sellers for improving their offers after making the other equally offers known to each one. This process is played until a suitable deal is reached according to the owner requirements.

In this context, the seller agent will carry out the following actions:

- When the negotiation is started, give an initial offer that represents the most benefial situation to the seller
- In each step of negotiation:
  - To receive the equally benefical offers of the other opponent sellers from the buyer

– To analyze the received offers in order to generate a new counter-offer that improves its last offer to take advantage from the other opponent sellers
– If the new counter-offer is suitable for the seller, send it to the buyer.

To perform these actions, it is necessary that the seller agent will initially have information about the product or service which will be negotiated. This required information will be: negotiated aspects of the product or service, dependences between them, the priority of each one and its possible initial, reserved and optimum set of offers. With this whole information, the agent will automatically generate offers according to above-mentioned sections, up to the negotiation will finalize.

The fact that the seller agent owns information about the opponent offers in each step of the negotiation process makes it possible the optimization of the automatic generated offers. As these offers arrive they are stored in the agent's *binnacle of offers (B_o)*. This binnacle will be started at the beginning of a negotiation process. As it was said in Section (4), each received offer will have associated a value that represents the negotiation time in which it was received. This associated value will be update in each negotiation step by the seller agent when it receives the new counter-offers of the opponent sellers. The seller agent's behaviour is described in Algorithm 2.

Algorithm 2 Seller Agent's Behaviour

1. Start negotiation of a product or service
   (a) Initializate the population of offers (P_{gen}) to start with for that product or service from the based set of start offers.
   (b) Initializate the binnacle (B_o) to $\emptyset$
   (c) Initializate the negotiation time ($t_{current}$) to 0
2. Send a start offer

while (negotiation exists) **do**
   4. Receive counter-offers and increase the time ($t_{current}$)
   5. Update binnacle of offers (B_o)
      (a) Analyze if the distance of each offer is null with each existing one. If true the offer will not be added to the binnacle.
      (b) Refresh $t(\mathcal{O}_i)$ of offers according to (11)
   6. Check if a new variable will play in negotiation. If true, to each offer of the population (P_{gen}) will be assigned in such variable the current value that a randomly selected offer of the based set of start offers presents.
   7. Generate a new offer making use of the suggested evolutionary mechanism
   8. If the existing distance between the new generated offer and the desertion point is lower than a certain threshold (σ) then the participation of the seller is required.

end while

The application of a negotiation protocol that leads the interaction between agents is not a discussed aspect in this work. It is obvious the need of defining a set of rules that describe the different negotiation states, the events that unleash the transitions among states, the allowed actions in each state, etc. This negotiation protocol will be researched in future works.

6 Conclusions

In this work, it is proposed a possible solution to the automation problem of the seller participation in a competitive automatic negotiation framework. On the one hand, in the suggested design, the independence and the autonomy ability of the seller figure is represented via the concept of intelligent agent [10]. On the other hand, the negotiation strategy is mainly based on the application of exploration and optimization techniques, such as Genetic Algorithms [2] together with fuzzy techniques [9], with the aim of generating offers that will improve or will be close to the opponent offers and will contribute the biggest benefit too.

Nevertheless, there are many topics in our current seller agent that must be investigated in-depth. Thus, our main research for future will be the following: to apply ontologies in an automatic negotiation framework, to model negotiation strategies and negotiation protocols that govern the interaction between buyers and sellers in a competitive market.

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