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Genetic Algorithm Strategies and Tactics Model for Agent Negotiation in E-Commerce Systems

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Abstract

The negotiation is a fundamental human process conducted by individuals with different perspectives, skills and roles to accomplish and settle a certain matter and to reach a mutually acceptable agreement. With the development of e-commerce, the negotiation protocols have to be implemented within the e-commerce applications. The seller and the buyer will be represented on these applications as software agents. Consequently the seller and buyer do not have to be physically on the same place to conduct the negotiation process. In this paper an evolutionary approach is adopted where the strategies and tactics for automated negotiations in electronic commerce correspond to the genetic material in a genetic algorithm. This genetic algorithm is used to determine the best solutions in an e-commerce application; one for the seller and one for the buyer, after the final solutions have been obtained, the negotiation protocol time bound negotiation framework (TBNF) begins between them to reach a mutually acceptable agreement.

Keywords: Genetic algorithm, Agent, E-commerce, Negotiation.

Introduction

Negotiation is a means of communication where the buyer and the seller, in the electronic commerce, try to reach a certain settlement and agreement for a certain matter. During the negotiation process, the two parties try to attain what achieves their goals; the buyer wishes to get the maximum benefit while the seller wants to get the maximum profit.

Electronic commerce negotiation does not require the availability of the two parties in one physical place, i.e., the buyers and the sellers because negotiating agents will substitute them, and commercial procedures could be carried out through the internet. They negotiate to coordinate their activities in order to reach a mutually acceptable agreement (on behalf of the seller and the buyer). Moreover, they need to behave differently in a variety of different settings. Therefore, an agent with limited time needs to behave differently from the one who has no time pressure to reach a mutually acceptable agreement.

To try the process of electronic commerce negotiation there are certain procedures to be carried out: first negotiation parties need to identify themselves to each other and this process is initiated on the buyer's side by seeking for products and sellers, whereas

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on the seller side it is initiated whenever he seeks for buyers. The result of this process is a list of potential business parties.

Then negotiation procedure which aims at reaching a final work agreement begins by a suggested solution from one of the parties whereas the other part has four alternatives to respond: refusing the suggestion completely and giving reasons, presenting a counter offer, giving criticism on this offer to improve it, or accepting the offer completely and reaching an agreement.

On the other hand, if the two parties have not reached an agreement from the first negotiation trial, then a new negotiating trial with another part will be initiated from the same list and so forth.

In this paper, an approach to implement strategies for automated negotiations in electronic commerce is presented. It is based on genetic algorithms that involve simple principles: selection, crossover, and mutation.

Selection means that only the fittest individuals survive. To select the best individuals the fitness function, which gives a value that indicates how well an individual performs in comparison to others in the same population, is used[3,6]. Each negotiating agent has a function that provides his own benefit (profit) for each possible issue value during the negotiation.

The crossover is the ability to take two individuals (parents) from the current population to breed new offspring that share some attributes with each parent[3,6].

The mutation process changes randomly the new individuals (offspring), by switching a few randomly chosen bits from 0 to 1 or from 1 to 0 (in case of the binary encoding)[3].

The Negotiation Model:

In this paper the negotiation model that is used relies on strategies and tactics to define the agent's behaviour, this model has been developed and used by Noyda, Carles, and Jennings [1].

One negotiation issue is considered which is the price, and has a value between a specified range (i.e.: $X_j \in D_j = [MIN_j, MAX_j]$).

The value of this issue is generated by using a tactic based upon a single criterion: time remaining, resource remaining, or the opponent behavior.

All buyers employ the time dependent tactic, while all sellers employ the behaviour dependent tactics.

Time Dependent Tactics:

In these tactics the agent is likely to concede more rapidly as the negotiation deadline approaches [1]. The offer from agent A to agent B for the issue j at the time T is modeled by a function α_j depending on the time. The $X_{a \to b}[j]$, at time T is the value for issue j proposed by agent A to agent B.

The αj function, and the issue value are computed according to the following formula: [1] $X^t a \rightarrow b[j] = min^a j + (1 - \alpha j^a(t))(maxj^a - minj^a)$.

$\alpha j^a(t) = (minimum(t, tmax^a)/tmax^a)^\wedge(1/\beta j)$.

Where:

$X^t a \rightarrow b[j]$: is the value for issue j proposed by agent A to agent B at time t.

$minj^a$: the minimum value for the issue j accepted by agent A.

$maxj^a$: the maximum value for the issue j accepted by agent A.

$tmax^a$:the maximum time agent A has to negotiate.

ßj is a number. If ßj>1 this is called the conceder. This means that start produces ground quickly.

But if ßj<1 this is called the boulware. Where the agents don't concede till the deadline is almost up.

Behavior Dependent Tactics:

These tactics base their actions on the behavior of their negotiation opponent [1].

Relative Tit-For-Tat: reproduce the behavior that its opponent exhibited δj>=1 steps ago, (i.e., the behavior of one agent is ultimately dependent on the behavior of the opponent agent which has been behaved δj steps ago).

The value of the issue is obtained from the following formula [1]:

$X^{tn+1} a \rightarrow b[j] = min(max((X^{tn-2\delta j} b \rightarrow a[j] / X^{tn-2\delta j+2} b \rightarrow a[j]) * X^{tn-1} a \rightarrow b[j], minj^a), maxj^a)$.

Where:

δj : is integer. The number of steps into the past considered.

$X^{tn+1} a \rightarrow b[j]$: is the value for issue j proposed by agent A to agent B at time tn+1.

$X^{tn-2\delta j} b \rightarrow a[j]$: is the value for issue j proposed by agent B to agent A at time tn-2δj.

$min^a j$: the minimum value for the issue j accepted by agent A.

$max^a j$: the maximum value for the issue j accepted by agent A.

Algorithm steps:

The representation of the negotiation strategy:

The chromosome should contain information about the possible solutions they represent. This encoding depends heavily on the problem. In this work the binary encoding has been used, where every chromosome (individual) is a string of bits (0 or 1).

The individuals of the population are negotiating agents, and their genetic material is the parameters of the negotiating tactics. Each agent (strategy) is represented as a string of fixed length. The bits of the string (the genes) represent the parameters of the agent's negotiation strategy.

The Fitness Function determines the agent's chance of surviving to the next population. The greater the fitness, the more likely the agent is to reproduce.

The fitness function used for the seller is:

$$F(X) = Q * X + A$$

While the fitness function used for the buyer is:

$$F(X) = Q * X - A$$

Where:

Q : represent the quantity.

X: represent the price, generated by the tactic.

A: represent the fixed cost.

The Genetic algorithm operators used:

The Selection Operator:

A selection mechanism known to work well in such circumstances is tournament selection, which is one of the basic ways of determining the best interaction strategy, [3, 4] because of this reason, it is the mechanism that has been applied to select from buyer and seller populations. In this mechanism K individuals are randomly chosen from the population. The individual with the highest fitness among the selected K individuals is placed in the mating pool[5]. This process is repeated N times, where N is the size of the population. K is called the tournament size (K=2 in this work, and N=100).

The Crossover Operator:

In this paper the single point crossover has been applied in which, one crossover point within a chromosome is selected randomly, and binary string from the beginning of the chromosome to the crossover point is copied from the first parent, the rest is copied from the other parent. The crossover probability used (Pcross) is equal to 0.7.

The Mutation Operator:

The flip bit mutation operator was chosen in this work, which inverts the value of the chosen gene (0 goes to 1 and 1 goes to 0). The mutation probability (Pmute) used is equal to 0.02.

The stopping criteria:

The algorithm stops when the population converges, or the number of iteration is bigger than a predetermined maximum. (5000 in this work)

Negotiation Protocol (TBNF):

When the buyer and the seller reach to their best solutions, they exchange the negotiation messages in order to reach a mutually acceptable agreement. The negotiation protocol used is the time bound negotiation framework [2,7,8] that has at most five messages each with three possible commitment duration ($0, 0 < X < \infty$, and ∞).

In this paper only three messages are used according to the commitment durations that have been chosen.

1. The task announcement message from the buyer to the seller:

   When the buyer reaches to the best solution, this solution is send to the seller in a message with commitment duration equal to infinity, which means that the seller has only to submit the bid at any time, and the awarding is guaranteed (the automatic awarding)

2. The bid submission message from the seller to the buyer:

   In this message the seller asks the buyer to send the bid awarding message within a specified commitment duration equal to D, where $0 < D < \infty$.

   The seller can use the bid submission with specified commitment duration for [2]:

   - Increasing the probability of getting the award from the buyer by providing a safe choice.
   - Maintaining internal consistency for itself and escaping the responsibility of the future possible rejection of the awards from the buyer.

3. The bid awarding message from the buyer to the seller with the commitment duration equal to infinity. This means that, the contract is completed and the seller agent does not have to reply to this.

The seller then checks to see if the bid awarding message is received before the specified bid submission commitment duration is expired. If that is satisfied, the seller gives his solution, the negotiation end and two graphs represent the relationship between the average of the fitness function and the time, one for the buyer and the other for the seller, appear. Otherwise, the buyer and the seller should suggest new solutions and repeat the negotiation.

Experiments and results:

The aim of this paper is to see the result of the evolution of the negotiation strategies for buying and selling agents using genetic algorithms. It has been considered that the buyers and sellers populations applying genetic algorithm to find the best solution for each, all buying agents employee a conceder tactic (time dependent tactic with $ßj>1$), and all selling agents employee a relative TFT tactic (one of the behaviour dependent tactic family).

The system has been run several times; the outputs are generated as a result of applying the genetic algorithm steps and using the negotiation model to generate the issue value, which can help negotiating agents to reach quickly a mutually beneficial agreement objectively.

The reason for using the commitment durations that have been chosen for the negotiation messages in this work, is that they reflect the semantics of the acceptance guaranteed protocol, which is:

- A simple protocol in the contract process.
- It is efficient in the negotiation.
- And the communication overhead in this protocol is low.

Conclusion:

In this paper, we have used genetic algorithm to implement strategies for automatic negotiation in e-commerce systems, since the GA solves problems with multiple solutions, and is easily transferred to existing simulations and models.

In our implementation the strategies and tactics correspond to the genetic material (represented in the population) of the genetic algorithm. Each individual in the population is a negotiating agent encoding negotiation parameters as genes in a genetic algorithm. The overall objective of an agent (buyer agent or seller agent) is to find a solution that maximizes the agent's utility at the highest possible level of constraint satisfaction subject to its acceptability by other agent. When the buyer and the seller get the best solutions, the TBNF begins between them in order to reach a mutually acceptable agreement.

Through the application of this model, we can find that the program is being optimized with the increase in the number of iteration, and the goal for the seller and the buyer finally achieved. Also by using software agents high benefits result from reduced transaction costs due to the avoidance of human intervention. By using genetic algorithm the negotiating agents can reach quickly to a mutually beneficial agreement. The merits of TBNF are provides more informative framework with richer semantics, and provides the background for efficient and effective multi-agent coordination. The commitment durations that have been used in this work for the negotiation messages reflect the semantics of the acceptance guaranteed protocol, that is simple, efficient, and the communication overhead is low.

استخدام الخوارزمية الجينية Genetic Algorithm في التجارة الالكترونية

أمل أبوناصر

ملخص

يهدف هذا البحث إلى دراسة مدى فاعلية استخدام الخوارزمية الجينية في إيجاد أفضل الحلول في التجارة الالكترونية وذلك كونها مناسبة لاختيار افضل حل في المسائل متعددة الحلول. حيث تم تمثيل كل من البائع والمشتري ببرنامج الوكلاء (software agents) وبالتالي ليس من الضروري وجود الطرفين (البائع والمشتري) في نفس المكان.كما أن الاستراتيجيات والتكتيكات للمفاوضات في التجارة الالكترونية تم تمثيلها باستخدام المادة الوراثية (genetic material) في الخوارزمية الجينية.ولتطبيق المفاوضات تم استخدام نموذج المفاوضات المقيد بالوقت (TBNF) و الهدف من هذه المفاوضات هي ان يصل كل طرف من الأطراف (البائع والمشتري) إلى الحل الذي يحقق أقصى فائدة له ضمن الظروف المتاحة. وفي نهاية البحث أثبتت هذه الخوارزمية أنها قادرة على إيجاد أفضل حل من الحلول المتوفرة مع تحقيق عدد من الميزات للمفاوضات باستخدام برامج الوكلاء وتطبيق نموذج المفاوضات المقيد بالوقت.

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