GAMA (Genetic Algorithm driven Multi-Agents) for E-Commerce Integrative Negotiation

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ABSTRACT

Software agents help automate a variety of tasks including those involved in buying and selling products over the internet. The need for handling complex highly configurable products, together with presenting important merchant value-added services gave rise to integrative negotiation protocols. In this paper we introduce GAMA, an agent-mediated shopping system that allows shoppers to consider merchant offerings' full range of value in their buying decisions for complex products. The system helps shoppers through the two stages of product brokering and negotiation. Product Brokering is done through shopping agents adopting genetic algorithms to address the vast search space of product offerings. Integrative Negotiation is implemented using a "Collaborative GA" technique between both shopping and sales agents to satisfy the needs of both parties. The system has been simulated using the process of purchasing computers hardware. Results show that a high rate of satisfaction for both shoppers and merchants can be achieved using GAMA.

Categories and Subject Descriptors

D.2.2 [**Software Engineering**]: Design Tools and Techniques – *Evolutionary prototyping*. I.2.8 [**Artificial Intelligence**]: Problem Solving, Control Methods, and Search - *Heuristic methods*

General Terms: Algorithms, Design, Performance.

Keywords: E-Commerce, Genetic Algorithms, Multi-Agents, Multi-Attribute, Integrative Negotiation, Collaborative GA.

1. GAMA

GAMA is an agent-mediated shopping system that allows shoppers to consider merchant offerings' full range of value in their buying decisions for complex highly configurable products. The system mainly helps shoppers through the two stages: product brokering, and negotiation. This is done through shopping agents adopting Genetic Algorithms to come up with the set of product offerings that highly satisfy both shopper and merchant's set of criteria. Together with a decision support module based on Multi-Attribute Utility Theory [1], and an integrative negotiation protocol, GAMA creates an improved online shopping environment for both shoppers and merchants.

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1.1 Product Customization

As discussed at Tête-à-Tête [2] for complex highly configurable products, the number of product offerings grows exponentially, and the shopping agent would soon be overwhelmed with the computational burden of assessing the value of thousands upon thousands of these offerings!

At GAMA, a genetic approach is proposed to find best product offerings considering a shopper's specified criteria. At the first random population, each individual represents a specific product offering, and each gene represents an attribute of the product's different items. Fitness is calculated based on the user's given criteria of satisfaction. Then selection, crossover, and mutation operators are applied to the population to evolve the next generation.

Fitness is calculated using Multi-Attribute Utility Theory [MAUT], where each attribute must have both an offer value (defined by a product offering) and a criterion (defined through a shopper's expression of preferences) for evaluating the overall offer value. Given this data organization, GAMA assesses the average fitness of each product offering. Two factors contribute to the fitness assessment. The first factor x_j represents the shopper's satisfaction with an item *j*. It is computed as follows:

$$x_j = \frac{\sum_{i=1}^{n_j} w_i \times f_i(x_i)}{\sum_{i=1}^{n_j} w_i}$$

where n_j is the number of attributes defined for item *j*, x_i is the normalized utility of an attribute *i* computed based on shopper's preferences, $f_i(x_i)$ is the weighted utility function of attribute *i*, *and* w_i is the relative weight for attribute *i*. The second factor y_j represents the merchant's satisfaction with an item *j*. So far, the only merchant's preference taken into consideration is the availability of the item.

1.2 Integrative Negotiation Protocol using "Collaborative GA"

GAMA employs argumentation performatives asymmetrically to accurately model today's retail environment. GAMA's performatives are composed of information on product items/attributes. The negotiation protocol defines these items identically. Each item has a name (e.g., “Processor”). In addition, each item is comprised of one or more attributes. Each attribute also has a name (e.g., “Processor Speed” and “Cache”), together with a number indicating its relative weight, and a criterion indicating shopper’s preference.

For our application, GAMA has been applied to simulate the shopping experience of computer HW. Two ways are often used by sellers to convey their product offerings. The first way is using a price list for the different items. The second uses some sort of technical and financial proposal, where each item is fully specified in terms of attributes and price. Accordingly GAMA sales agents maintain a local price list together with a list of “Elite Product Offerings” (EPOs), where each offering is fully specified in terms of its items.

Figure 1 shows a typical scenario of integrative negotiation. A first handshaking occurs between both agents where the shopper’s set of criterion –excluding Price- are sent to the sales agent, and the merchant’s price list is sent to the shopping agent.

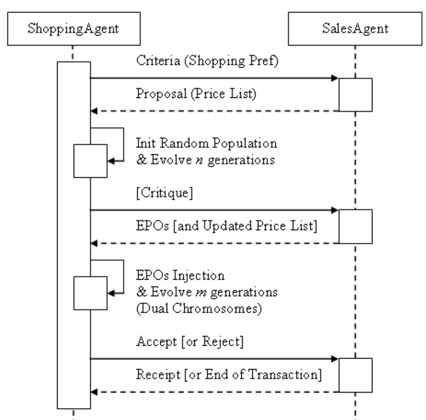

Figure 1: GAMA’s Scenario

After this introductory handshaking, a GA is run at the shopping agent’s side to evolve offerings that best meet its preferences. After establishing the first random population, we allow the evolution of “*n*” generations. Possible critiques are then sent to sales agent.

The sales agent responds with EPOs and price list updated according to received critiques, if any. These EPOs are then injected into the shopper’s GA population, and used as some sort of “Attraction Points” to guide the evolution for another number “*m”* of generations. This is done using “Dual Chromosomes” where an offspring is created by coupling parents coming from different sources, one from the elites evolved at the shopping agent side, and the other from the injected EPOs (sales elites). This has the impact of evolving individuals that meet both shopping and sales agents’ criteria, thus satisfaction.

2. EXPERIMENTAL RESULTS

To evaluate the proposed collaborative GA, two experiments were done: Traditional -non-collaborative- GA vs. Collaborative GA experiments.

At the “Traditional GA” experiment, the genetic algorithm is run only at the shopping agent after getting the sales agent’s price list. Evolution is only governed by the shopper’s set of preferences and the initial price list received from the sales agent. The experiment is done using single point crossover & mutation operators. While at the “Collaborative GA” experiment, the shopper and merchant co-operate together to come up with products that highly satisfy both parties without revealing one’s preferences –specially related to price and profit- to the other party. As discussed in section 1.2, this is done through the injection of merchant's EPOs after *n* generations, keeping the total number of generations the same in all experiments.

A performance analysis has been conducted [3]. For the two experiments, 100 runs were evolved independently. Experiment I was carried out using traditional non-collaborative GA; while four trials -Experiment II to V- used collaborative GA approach with *n* equal to 25, 50, 75, and 99 respectively, using the same GA parameter set.

Figure 2 illustrates how average satisfaction rate changes in response to different probabilities of success if only one run is performed. It shows that the collaborative GA is more successful in achieving a much higher average satisfaction rate, especially at higher success probabilities. On the other hand, the same satisfaction rate can be obtained by a higher probability when using collaborative GA than when using non-collaborative. E.g. 90% satisfaction rate can be obtained with 50% success probability in the case of non-collaborative GA while the probability jumps to 99% in the case of collaborative GA.

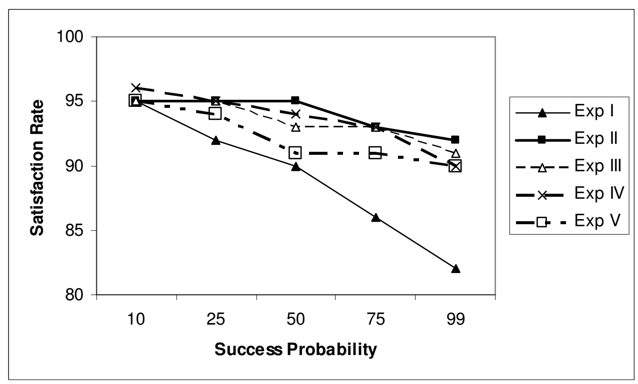

Figure 2: GAMA’s Performance Analysis

3. REFERENCES

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