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An e-marketplace for agent-supported commerce negotiations[1]

Eva Chen [1], Gregory E. Kersten[1, 2] and Rustam Vahidov[1]

[1] J. Molson School of Business, Concordia University, Montreal
[2] School of Management, University of Ottawa, Ottawa

Abstract. The key requirements for customer-oriented e-marketplaces include the personalization and customization of products and services, and personalized fulfilment. Negotiations are at the core of these processes. In this paper an e-Agora marketplace is discussed. It allows buyers and sellers to engage in multi-issue negotiations. eAgora implements several protocols based on a negotiation phase model constructed for this system. Its services include a software agent that generates and critiques offers. Based on a small scale usability testing with participants who conducted negotiations with and without the agent, the agent's services were found useful. The users also requested additional agent's services including enhanced offer critique and partial negotiation automation.

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1. Introduction

Retail e-commerce sales in the USA increase 26-27% on a quarterly basis and, in the second quarter of 2003, approached 13 billion dollars (http://www.census.gov/mrts/www/current.html). Although this amount represents only 1.5% of the total sales the increase is over 500% higher than the total retail sales increase in the USA. This is an indication of the increasing significance of e-commerce and, in particular, customer-oriented e-markets.

The key requirements for customer-oriented e-marketplaces include the personalization and customization of products and services, and personalized fulfilment. These characteristics allow for the differentiation of the e-markets from the traditional markets. Successful matching of products and services to customers' requirements further strengthens e-commerce thus allowing for its increased role in retail as well as in supply chain management. Negotiations are at the core of the personalization and customization processes. Business negotiations are also necessary when the parties cannot define all relevant product or service attributes *a priori*, and need to exchange information to specify the attributes and their values.

Negotiation has been a research topic of anthropologists, psychologists, sociologists, economists and operation researchers. Anthropologists studied negotiations in various cultural settings and proposed their phase models [1]. Psychologists and sociologists have been concerned with the negotiators' behaviour, impact of their individual characteristics and biases on the process and outcomes [2]. Economists' contribution has been mainly in the construction of normative models [3] and their falsification [4]. Operations researchers constructed normative and prescriptive models to help analysts provide advice to the negotiators [5, 6].

Research on negotiation support has started at the beginning of the 80's [7, 8]. Until recently there have been few successful implementations of e-negotiation systems (eNSs). The successful eNSs were used by intermediaries rather than by negotiators [9, 10] and in education [11, 12].

The limited use of the early eNSs was due to: (1) limitations of information and communication technologies (ICTs); (2) limited computer literacy of managers and, therefore, the consideration of analysts as system users; (3) sophistication of the constructed models, often based on strong rationality principles, that required significant amount of users' input; and (4) insufficient consideration of psychological and sociological conditioning of negotiations.

New ICTs, including Internet, software architectures, and software development technologies, made rapid development of systems for millions of users possible. This led to two new streams of theoretical and applied research: (1) behavioural research on the use of communication technologies (mainly email) in negotiations [13, 14]; and (2) design of easy-to-use eNSs. The latter stream has been initiated by computer scientists who espoused the engineering approach to negotiations focusing on the users' limited capabilities and on the usefulness rather than the correctness of embedded preference elicitation and utility construction models [15]. Within this stream innovative approaches based on collaborative filtering to preference modelling have been proposed [16] and implemented (e.g., by Amazon.com).

Early research in e-commerce and e-markets concentrated on auction systems [17, 18]. Increasing sophistication of e-market systems and maturity of e-commerce led to the recognition of negotiation as an effective mechanism for business transactions [19-21]. Software firms now provide negotiation components in procurement and supply chain management systems (e.g., Oracle, SAP and PeopleSoft). Other developers introduced software agents to automate negotiation processes [22-24]; such

agents have been successfully used for bidding in well defined domains [25].

E-markets that provide buyers and sellers with auction mechanisms are well known and widely used (e.g., eBay, YahooActions and AmazonAuctions). Furthermore e-markets that provide individual buyers and sellers with bargaining and negotiation mechanisms have been proposed; Kasbah and Tete-a-Tete are two experimental markets that allow customers to use software agents to negotiate on their behalf [23, 26]. The delegation of the negotiation activities to agents imposes the requirement that the negotiation problem is well-defined. These two systems cannot be used in negotiations that evolve in time with new issues being added or dropped. Aspire is an eNS that combines decision support with software agents providing advice to negotiators [27]. Its limitation is its lack of connectivity to an e-marketplace.

In this paper we propose an e-marketplace, called e-Agora, which allows buyers and sellers to conduct multi-issue negotiations. Section 2 discusses eAgora's negotiation processes using a phase model of negotiation for negotiation activities and protocols. Section 3 examines the agent model for offer generation and critiquing. Section 4 describes the system architecture and design. An example of the use of eAgora is given in Section 5. In Section 6 we discuss the preliminary usability testing of eAgora and present directions for future research.

2. Negotiation process, support and services

2.1 Phase model of negotiations

The use of support systems and software agents in negotiations requires that a *process model* and a *protocol* be constructed [28]. The process model describes the sequence of the negotiation activities and phases. The protocol is a formal model, often represented by a set of rules, that governs software processing and communication tasks, and imposes restrictions on activities through the specification of permissible inputs [22].

Several negotiation phase models have been discussed in the negotiation literature, ranging from a two-phase model [29], to three [30], to an eight-phase model [1]. From the perspective of constructing an eNS a more detailed model is preferable because it allows for a better (finer) determination of activities and their processing requirements. From the eNS users' perspective a phase model is also required because it allows the negotiators to follow a methodologically sound approach [31].

Behavioural research on negotiations does not yet consider processes in which support systems and software agents are active participants. Therefore, we need to adapt a behavioural phase-model to reflect the requirements imposed by an eNS. In the eAgora system we adapted a model proposed by Kersten [32], which is based on Gulliver's eight-phase model [1]. This model is modified to allow for a wider range of negotiated decisions than the eight-phase model, including those which use eNSs. The model comprises the following five phases:

1. *Search for arena and selection of the communication mode*. The participants select and agree on the location where the decision process may occur. Selection of the communication mode includes choice of the synchronous or asynchronous exchange of information, discussions and negotiation on partial or complete offers, and joint use of experts, mediators and facilitators. While this phase is important to eNSs in general, in our situation it is ignored because we consider only one arena and one communication mode (via eAgora).

2. *Agenda setting.* Negotiators discuss and agree on the terminology and the issues to be decided

upon. The activities of this phase set the stage for subsequent phases. They involve the construction of at least a partial problem representation (e.g., specification of the decision attributes and the bargaining ranges).

3. *Exploring the field*. This phase involves further problem specification and its analysis. In negotiation, the parties try to establish limits to the issues, formulate their best alternatives to the negotiating agreement (BATNA), and establish reservation prices and aspiration levels for specific objectives. Support systems have been used in this phase for the purpose of simulation and analysis of the implications of decision alternatives.

4. *Narrowing the differences and search for agreement.* Exchange of offers, arguments, threats and other information are the key activities in this phase. These exchanges allow the parties (and/or software) to learn of the others' limitations, identify the key issues and critical areas of disagreement. During this phase the parties realize the potential for a compromise and can assess its main features. The analysis of a negotiation may focus on the selection and verification of strategies, the determination of concessions and revision of aspiration levels, and on the restriction of efficient solutions to those which may be acceptable to the parties. This phase ends with an agreement or, if the negotiations are unsuccessful, termination of the process.

5. *Agreement's assessment.* At this stage the negotiators have already agreed on a compromise. They evaluate it and consider its possible improvements. They also may discuss additional issues which, however, have no impact on the negotiations. For example, the seller may provide the buyer with several delivery options, insurance or additional warranty.

2.2 Negotiation activities

Activities that are undertaken by, and supported with, software have to be precisely defined. Activities that involve only people may be ill-defined and initially incomplete. In order to determine a negotiation protocol we need to know not only the permissible activities, required input and output, but also their sequence. For example, an offer construction activity precedes offer submission, or offer acceptance precedes analysis of the agreement efficiency. This activity sequencing can be obtained from a negotiation phase model.

In defining the set of permissible activities, the roles that the negotiators play are taken into account; in eAgora there are two roles: buyer and seller. Figure 1 depicts the four phases implemented in eAgora and the activities undertaken in each phase.

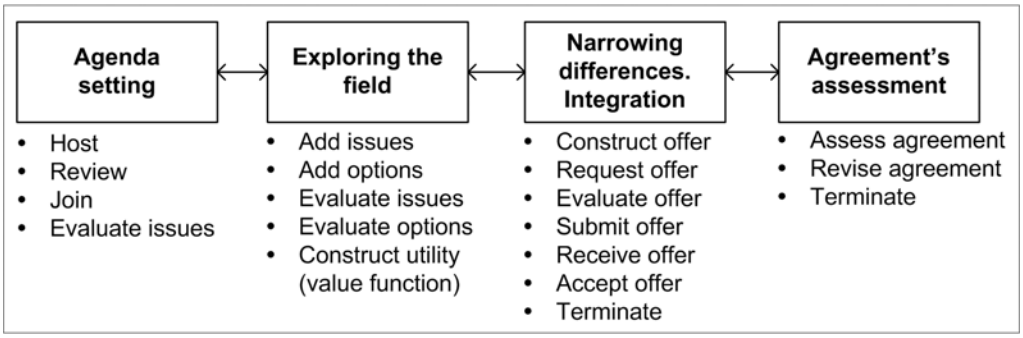

Figure 1. eAgora negotiation phase model and activities

Phase 1: Agenda setting. The negotiation is initiated by either a buyer or a seller; the person who ini-

tiates the process is the negotiation host (buyer_host, seller_host). The activity buyer_host (seller_host) requires the host to provide: (1) name of the host and her/his role; (2) product name and its short description; (3) selected product attributes (i.e., the negotiated issues), and their short descriptions; and (4) initial attribute values (i.e., issue options).

A negotiation that is set-up by a buyer (seller) can be joined by one or more sellers (buyers). The join_as_seller activity involves: (1) selection of one or more buyers; and (2) review of the issues and options defined by each buyer.

Phase 2. Exploring the field. The seller who joins a negotiation may decide to add one or more new issues (add_issue). In this case s/he has to also provide one or more options (add_option) for each added issue. The activity of adding a new issue and its options may lead the negotiation counterpart to also add another issue and its options. If the seller adds new issues and options, then the buyer_host has to either accept or reject them. Rejection of an issue may be accepted by the person who proposed it or s/he may terminate the negotiation (terminate).

Once the sets of issues and options have been tentatively accepted, the buyer and the seller assess the subjective importance of the issues and options.

Phase 3. Narrowing the differences and search for integration. The key activities in this phase involve the formulation, submission and evaluation of offers and counter-offers. The construct_offer activity involves: (1) selection of issues; (2) selection of options for these issues; (3) assessment of the potential offer; and (4) rejection of the offer considered for submission. If the offer is rejected, then a new offer has to be constructed.

An offer that has been approved by the negotiator is submitted for consideration by her/his counterpart. The submit_offer activity may be very simple "send/submit action." It may also involve formulation of supporting arguments and reasons as to why the previous offer (if any) has been rejected.

The submitted offer is evaluated by its recipient who may accept it (accept_offer), reject and propose a counter-offer (this leads to construct_offer activity), or reject the offer and terminate the negotiation (terminate). If the offer is accepted, the negotiators move to Phase 4.

During this phase the negotiators may introduce new issues (this requires adding options for these issues) and/or adding new options to the existing issues. The addition of new issues and/or options may lead, as in phase 2, to the termination of the negotiation.

Phase 4. Agreement's assessment. The achieved agreement may be inefficient; there may be other alternatives that are better for one side and not worse for the other, or are better for both sides. The efficiency assessment is easy to conduct if both negotiators formulated their utility or value functions. In this case, the agreement's utilities (values) are compared with all feasible offers to formulate efficient solutions, which negotiators can assess (assess_agreement) and revise (revise_agreement) to achieve a better settlement. At present, eAgora does not provide users with efficiency assessments because this implies that both sides' utilities are revealed to each other, an aspect that can be uncomfortable for some negotiators. However, if both sides request such assessment, the agent will perform the efficiency analysis and generate efficient solutions.

2.3 Protocols

The purpose of the different negotiation phases is to provide the participants with a framework and rationale for activities conducted in each phase. It also allows to stress the importance of preparation

(phases 1 and 2) and the assessment of an agreement; these are often unappreciated by non-expert negotiators.

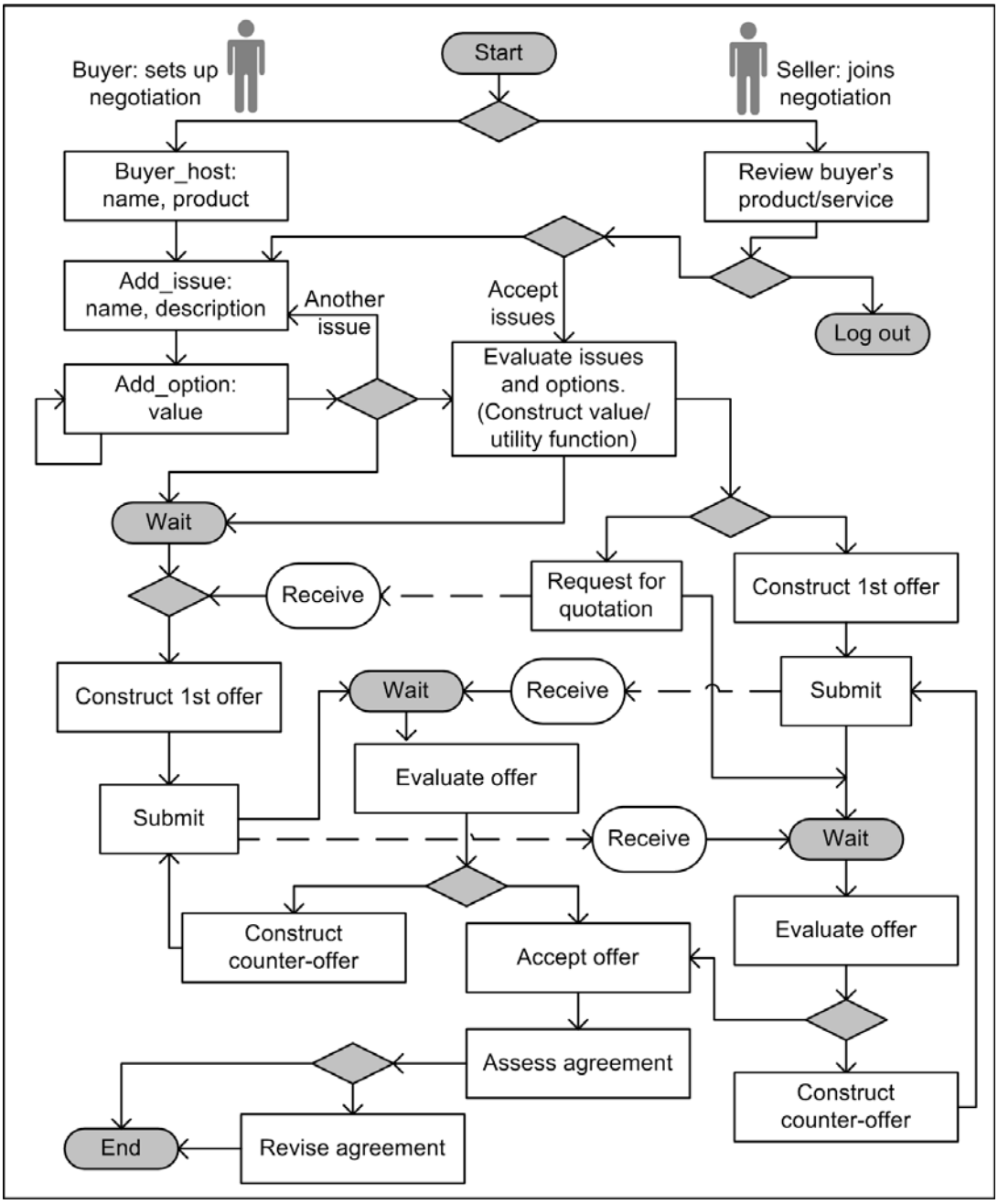

Figure 2. An example of the eAgora protocol

The consideration of phases helps to specify negotiation activities which are undertaken and the relationships among them. The activities are analyzed from the point of view of the required input and generated output. This analysis leads to: (1) specification of detailed actions and low-level processes which comprise an activity; and (2) assignment of these actions and processes to the negotiators and software.

Protocol design involves the specification of roles, actions and relationships among them. Often several protocols need to be designed; a different protocol may be required for the negotiation hosted by a buyer (buyer_host) and a different one for seller_host. Part of the protocol and its specific actions designed for buyer_host are presented in Figure 2.

3. Models

The design of an eNS can be expanded with consideration of the models and ideas proposed in closely related fields, including intelligent agents for automated negotiations and decision support. The fundamental problem of employing agents in the negotiation context is the conflict between autonomous character of agents and the ill-structured nature of real-life negotiations. While abandoning the notion of "eNS as an agent", we find it potentially fruitful to consider the use of embedded agents. In such a setup agents will have well-defined roles within the context, which is specified by the eNS protocol. The purpose of an agent is to act as a proactive assistant to the users.

The agent implemented in eAgora has three main objectives: (1) identifying alternative offers that may be attractive for the user; (2) critiquing an offer that the user is considering to submit; and (3) critiquing an offer that the user receives from his/her opponent.

Offer generation by an agent in eNS context is different from that of an automated negotiation, because the agent will generate a set of different candidate offers for human negotiator. This is because we cannot generally rely solely on the preference models of the negotiators, which may not be well-articulated.

Critiquing is an important activity that could be delegated to an agent as well [34]. The purpose of critiquing is to make sure the user does not make mistakes, e.g. making very large concessions. The origins of the use of critiquing capability in agents comes form the field of critiquing expert systems [33]. The idea is that such system will not only receive description of a problem as an input, but also the proposed solution and output critique of the solution in terms of actual and potential errors. Critiquing agents "watch over the shoulder" of human users and intervene when they sense an error.

3.1 Offer generation

Generating alternative offers is done in two steps. Because non-trivial negotiations involve multiple issues, the attractiveness of the offers may be assessed using a measure. In eAgora we used a simple linear value function of the form:

$$v(\boldsymbol{a}_l) = \Sigma\, w_i\, v_{ij}(a_{ijl}),\ (i = 1, .., n),$$

where: $\boldsymbol{a}_l$ is a feasible alternative ($\boldsymbol{a}_l \in \mathcal{A}$, $\mathcal{A}$ – the feasible set), a_{ijl} is the j-th value of the attribute i in alternative l, w_i represents the weight assigned to the i-th attribute, and $v_{ij}(a_{ijl})$ is the rating of the attribute i with value equal to a_{ijl}. Parameters w_i and $v_{ij}(a_{ij})$, (j = 1, …, m_i; $i = 1, .., n$), are determined with Swing method [35].

In negotiations the concession that negotiators are willing to make and/or accept influence their offer-making. The concession can be expressed in terms of the change (drop) in the value Δv_t ($\Delta v_t = v(\boldsymbol{a}_t) - v(\boldsymbol{a}_{t-1})$; $\boldsymbol{a}_t$, $\boldsymbol{a}_{t-1}$ – offer made in time t, t-1, respectively). Because a numerical value of a concession may be meaningless for the negotiator we used fuzzy sets to describe concession as very small, small, medium, etc.

At any point in the negotiation the level of a concession depends on the strategy that the negotiator pursues, her/his reservation levels, the best alternative to the negotiated agreement (BATNA) and concessions made by both negotiators in the past [5]. In eAgora we used a simpler formula: a concession is determined by the negotiation strategy and the opponent's previous concession measured by the change in the negotiator's value function:

$$S \wedge M \rightarrow CON,$$

where S is the chosen strategy, and M is the opponent's move measured by the change in her or his value. The concession sets an upper boundary for a drop in the negotiator's value as a result of making an offer. We used fuzzy rules of the following form in order to determine concession:

If Strategy *is* S_i *and* Opponent_concession *is* A_j
then Concession is A_k.

where S_i is the concrete strategy selected by the user (e.g. "competitive", "collaborative"); A_j refers to fuzzy-defined concession level made by the opponent; and A_k is the proposed concession level.

The resulting value of concession sets an upper limit for the drop in value. In the second phase a heuristic optimization method is used to derive the alternative compositions of the offer that are close to the concession level derived as above. The algorithm generates five top offers that minimize the distance between the drop in value and the concession level, but keep the former a smaller number. More formally, we search for the composition of offer X that minimizes the distance:

$(CON - \Delta V) \rightarrow min$
subject to: $CON \geq \Delta V$.

Because many issues will be discrete (e.g. delivery, warranty, return options), this demands a combinatorial type of search. In vast majority of cases the drop in value will not be strictly equal to the concession level, but will be smaller. Because the preference model implemented in eAgora is linear and does not lead to local minima, an iterative improvement hill-climbing-like algorithm for the search is used [36]. Since the preference model is only an approximation of the user's true preferences, the five top alternatives are presented to the user rather then the best alternative. This also may provide the negotiator with a better understanding of good or satisficing counter-offers.

3.2 Offer critique

Critiquing of offers and assessment of counter-offers are activities conducted by the eAgora agent. The purpose of critiquing is to make sure the user does not make mistakes. The critiquing component C acts as a trigger. It is implemented in form of if-then rules and has the following general form:

$$C : S \wedge V \wedge CO \wedge M \rightarrow CM,$$

where: CM is critique messages, S is the user's strategy, V is user's preferences (value), CO is the contemplated offer, and M is the last opponent's concession. Concrete rules may include part or all of the above types of antecedents. For example, the rule for critiquing could be coded as:

If Strategy *is* Competitive *and* Opponent_concession *is* small
and Contemplated_offer *is* large
then Critique *is* Concession_too_large ("You are making an offer that is too generous ").

In essence, the antecedent parts of the above rules act as triggers for generating critique, i.e. when all

of the conditions are satisfied, the message is provided to the negotiator. If no conditions in any of the rules are met, the critique is not generated.

3.3 Offer generation process

This subsection describes how offer generation and critique are incorporated into offer construction process shown in Figure 3. Once the negotiator receives an offer he or she must decide weather to accept, or quit, or generate a counteroffer. In the latter case he or she might decide to update the preferences/negotiation strategy captured by eNS. The agent proceeds generating a list of candidate offers based on the adopted strategy and preferences. The user examines these recommendations and may also generate and evaluate his/her own trial offers in terms of the aggregate value and offer composition.

Once the user decides to proceed with the offer he or she will submit it to the system. At this point the agent starts examining the submitted offer in order to decide whether to interfere or not. If the agent is able to find a match between the offer characteristics and one of the agent's critiquing rules, the critique message is generated and displayed to the user as a warning signal. In this case the user may decide to ignore the message, or to go back to a new offer construction. If the agent sees no obvious reasons to interfere the offer will be submitted.

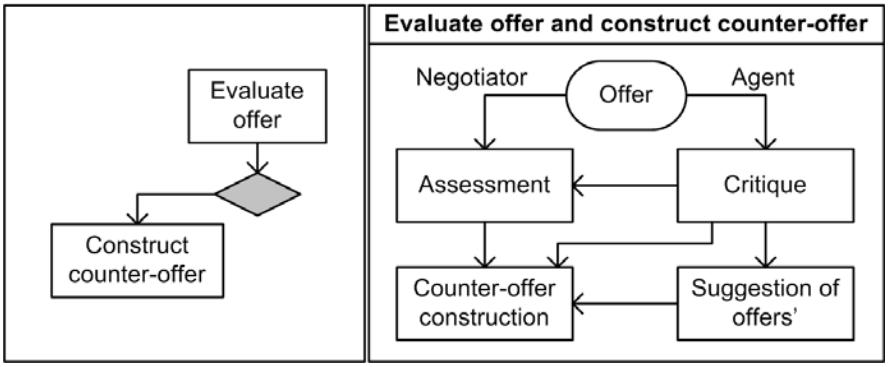

Figure 3. Decomposition of two protocol actions and their assignment to negotiator and agent

4. E-agora architecture

The architecture of eAgora follows the *n-tier* architectural design specification, used in *e*-business system development [37, 38]. The *n*-tier architecture is based on the software server concept. In eAgora the following servers are used: (1) an application server (Macromedia ColdFusion) for the construction of dynamic web pages and execution of applications, (2) a database server (Microsoft Access) for the execution of decision and negotiation protocols stored in a database, and the storage of users' and programs' inputs and outputs, and (3) a HTTP-server (Apache).

The 4-tier architecture implemented in eAgora is presented in Figure 4; in addition to the servers comprising three tiers, the 4th tier is the client's browser. The eAgora applications are implemented using the Fusebox development methodology [39] which provides a high level of modularity and flexibility. The applications are independent components (fuses). The components are linked through the Fusebox engine (see Figure 4). The Fusebox engine also parses elements of the web pages and passes them to the ColdFusion server, which sends them to the HTTP server.

The business, negotiation and agent fuses are the functional components comprising HTML code, da-

tabase queries, and algorithms. The business fuses determine activities allowing users to manage their negotiations. For example, the business fuse, display_current shows users all their current negotiations. The negotiation fuses perform actions discussed in Section 2; the agent fuses perform actions discussed in Section 3.

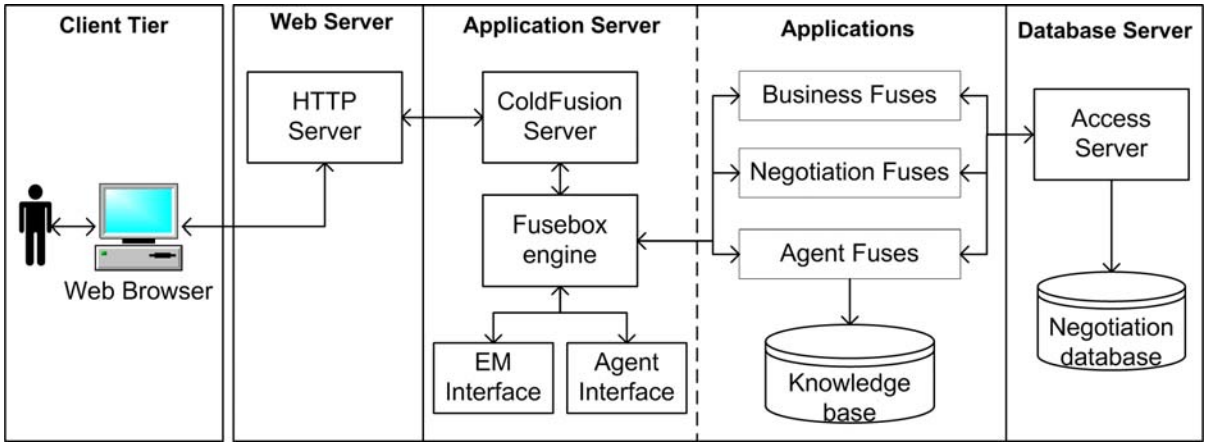

Figure 4. eAgora 4-tier architecture

The knowledge-base consists of the rules that govern the agent's behaviour. For example, they implement the fuzzy logic analysis in offer generation. The negotiation database contains the tables and relationships used to store the data required for and generated by the site.

The unification of all these parts in the 4-tiers has created eAgora: an e-marketplace for buyers and sellers to negotiate with or without the support of an intelligent agent. The following section illustrates the concepts described by providing a concrete example of a negotiation on eAgora.

5. An example of a simple negotiation

In order to illustrate eAgora, this section describes a simple negotiation; it does not include all implemented activities. The purpose of the example is to present the flow of the process and selected activities undertaken by the negotiators and the agent.

Maria, the seller, registers the product name (car), provides the product description (2000 Toyota, Corolla), specifies her role, and requests the agent's assistance (enabled). She continues by specifying issues (except for price which is a default issue) and options. The two additional issues are: warranty and winter tires.

The involvement of the agent requires that Maria enters her preferences for the three issues. The preference elicitation form is shown in Figure 5. This completes the preliminary steps and Maria waits for a potential buyer.

Bob enters eAgora and reviews products for sale. He is interested in buying a car and joins the negotiation established by Maria. Then, rather than making an offer, he asks Maria to make the first offer. Maria, as illustrated in Figure 6, reviews her current negotiation and realizes that Bob is waiting for her offer.

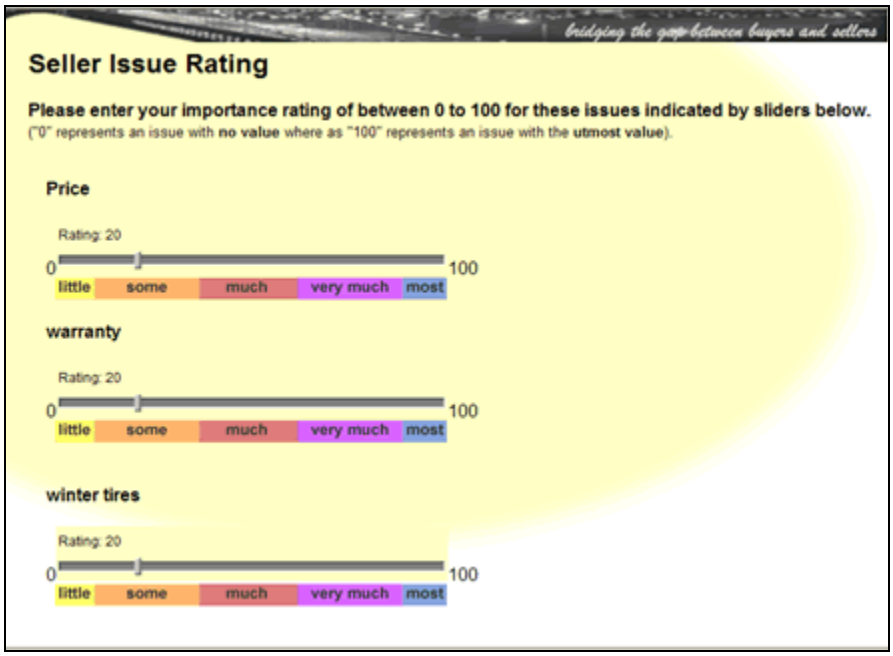

Figure 5. An example of preference elicitation

Figure 6. List of Maria's current negotiations

Figure 7 illustrates the offer construction activity. The agent has suggested five possible offers, of which she can propose any one to Bob or she can formulate her own offer. The value, associated with each suggestion, tells Maria how well the agent's recommendation corresponds to her ideal settlement (rated at 100) and reservation point (rated at 0). These packages are based on calculations using the negotiator's strategy, previous offers, latest offers received from the opponent and the number of negotiation rounds. In order to support her during offer formation, the agent also reminds Maria of Bob's last offer and its value.

Once Maria's offer is sent to Bob, the agent critiques the offer, as shown in Figure 8. The critique refers to the value of the offer based on Bob's ratings; the agent advises Bob to make a counter-offer because Maria's proposal does not meet his reservation point.

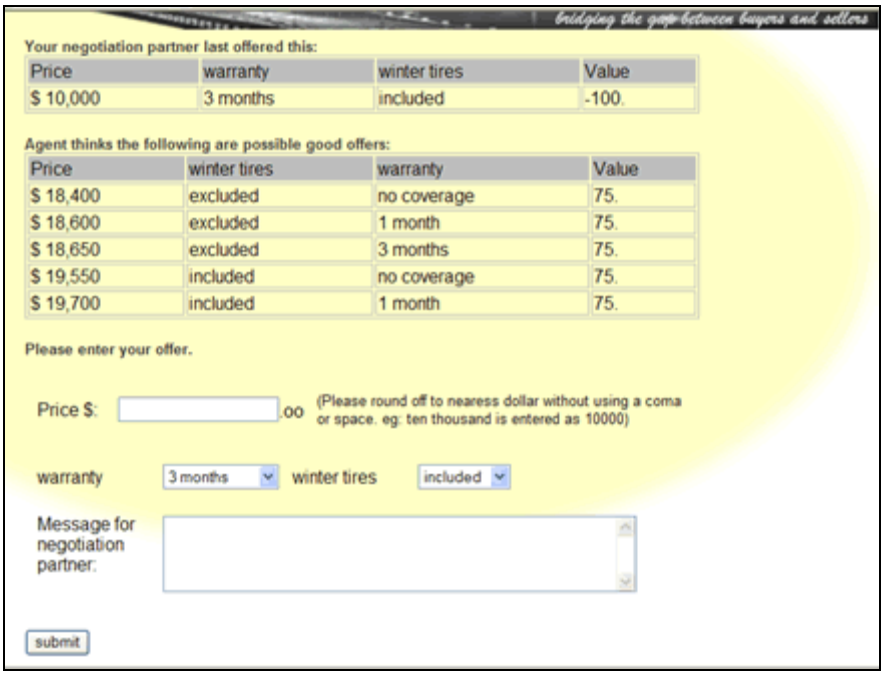

Figure 7. Screenshot of Maria's offer construction

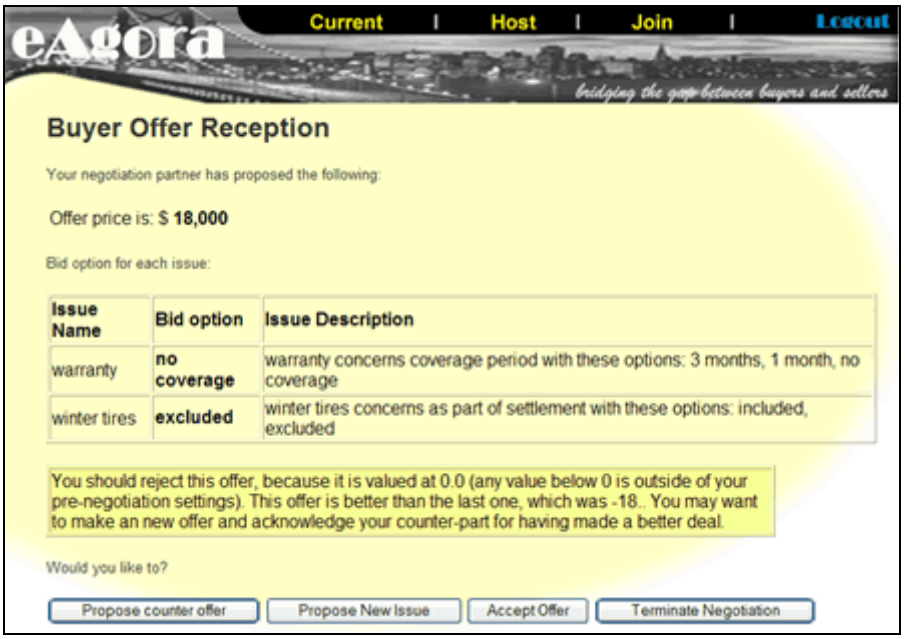

Figure 8. The agent's critique of a received offer

At one point, mistakenly, Maria decides to accept Bob's offer. The agent notes this action and warns her that the offer violates her reservation point. This situation is illustrated in Figure 9. Note that, in addition to the two issues specified at the beginning of the negotiation (warranty and winter tires), issue "inspection" has been added by one of the sides during their negotiations.

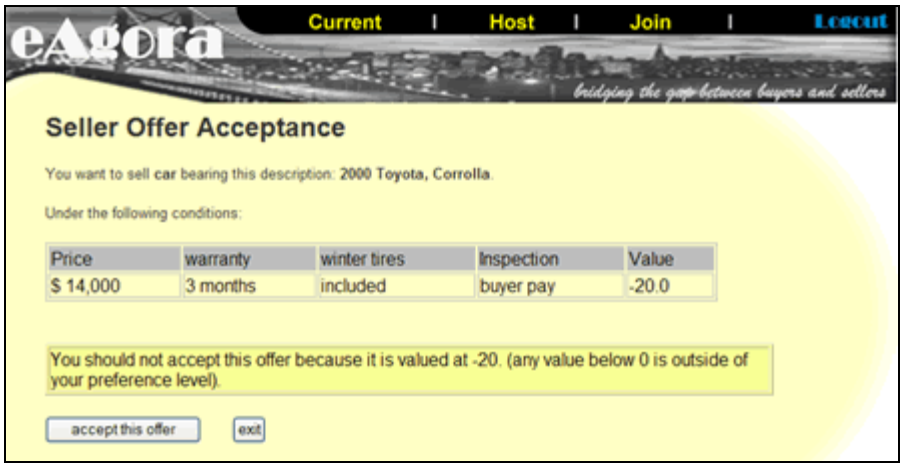

Figure 9. Screenshot of Agent's warning in offer acceptance

Negotiation in eAgora can be concluded in two ways, either the negotiator accepts an offer made by the opponent or one party walks away from the bargaining table.

6. Discussion and future research

The evaluation of eAgora consists of a preliminary usability test to determine the value of the system. We were interested in the role of the agent and the users' perception of its usefulness, therefore the agent was active in one series of tests and inactive in the second series. We need to note that the test results are tentative because of the small sample size; this size was also the reason for not following the experimental design methodology.

A convenient sample of twelve individuals was gathered for testing. They were divided into six buyer-seller pairs. A pre-test questionnaire was filled out by the participants to determine their expertise level in e-negotiation and Internet usage. Next, a demonstration of eAgora was given to show all the features and functionalities of the system, after which participants were asked to first conduct a negotiation using eAgora without an agent, and then they were requested to start a new negotiation with an agent. During the process, comments and questions were recorded, and after each negotiation, a questionnaire was completed based on their experience with and without the agent.

The results show that 92% of the participants are in favour of employing eAgora to buy and sell products over the Web. They liked the fact that issues can be added during negotiation, and that eAgora is easy to use. In addition 83% of individuals claimed that the agent provided helpful advice and suggestions in their negotiations, and everyone expressed that with the agent; they felt in control of negotiations at all times. The agent's presence is positively correlated with an increase of 17% in successful settlements. However, the preliminary test also found that users would like the possibility of having different protocols that would allow using different strategies and tactics. The participants also requested that the agent suggests negotiation strategies rather than accept the one selected by the user, and uses possible strategies to formulate critiques and suggest offers.

In order to evaluate the potential of eAgora, further testing is required with different user groups and products described by a few and by many attributes. This will include a full-scale laboratory experiment involving control and treatment groups with eAgora, with and without the use of the agent. A variety of outcome, process and perceptive measures should be used in such experiments in order to

assess the effectiveness of agent-based negotiation support. Our aim is to employ eAgora as a medium to study behavioural, commercial and social aspects of e-marketplaces and e-negotiation processes. Another topic for future research is to investigate new ways of enhancing agent capabilities. Different possibilities in this respect include: incorporating real-time information search on demand by an agent; adaptive tracking of user profile based on the offers made; and profiling the opponent in order to infer the most likely directions for compromise and mutual benefits. Other directions include the implementation of various negotiation and auction mechanisms and the study of their efficacy in different contexts defined by problem complexity and users' characteristics.

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