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CONTEXT AWARE WIN-WIN SITUATION FOR AUTOMATIC NEGOTIATION IN INTELLIGENT AGENTS

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Abstract: - Negotiation is an important human activity in almost every matter of daily life to reach an agreement. Several automated negotiation support systems have been developed to help ease the negotiation process in human-to-human or human-to-agent negotiation. The major drawback of available systems is that they mainly focus on an agent-to-agent communication, which may not be suitable in an environment where humans make decisions, particularly in multi-literal negotiations. This research paper aims to present a Context-Aware Win-Win Situation for Automatic Negotiation (CAWSAN) for mutual negotiation between human and intelligent agents. Proposed system will be used for automated negotiations using a win-win strategy where preference elicitation will be performed by human negotiator while offer generation and offer evaluation will be handled by autonomous agent. In negotiation, a win-win strategy is a kind of compromise/cooperation where any negotiator generates an offer which is more acceptable for his/her counterpart by compromising claims on one matter to get extra benefit on other issues. A heuristic computational model is proposed in this research to simulate win-win strategy. The proposed computational model will employ a novel linear algorithm to estimate the preferences of other participants by using hill climbing approach to search the space of possible tradeoffs that are more acceptable by other negotiators.

Keywords: Electronic negotiation, Context-aware negotiation, Win-win situation, Intelligent agents

1 Introduction

Negotiation in our daily life is a fundamental approach to making vital decisions to reach an agreement between two persons or parties to accomplish their goals. People become engaged in negotiations in everyday life whenever they want to resolve a point of dispute [1]or to gain some advantage over others, like a bargain between a shopkeeper and a customer, a dialogue between an employer and an employee over raise in salary, position or other opportunities [2]. This helps the parties understand mutual interests and offer alternatives in the disputed areas where the negotiator generates offers to achieve maximum objectives [3]. Since negotiation is subjective to social, ethical and cultural conditions, it appears in various forms. In negotiation, a win-win [4] is a kind of compromise/cooperation where a partner generates an offer that is more acceptable for his/her counterpart by lowering his claim on one matter and getting extra profit on other issues [5]. This type of strategy is known as a win-win strategy in which various multiple negotiation decision issues win-win to each other [6] [7]. The role of a negotiator and negotiation situations has such immense diversity that it becomes a challenge for researchers in disciplines like economics, political science, law, applied mathematics, sociology, psychology and anthropology [8].
During the last decade, artificial intelligence and machine learning have emerged as promising fields to solve many real world problems [9] [10] [11] [12]. The growing interest in intelligent agents has significantly impacted electronic negotiations [13]. Different electronic negotiation systems are being developed for automatic auction and bargaining [14] to control the problems that become the reasons for unsatisfactory results. In automated negotiation systems, agents negotiate based on principals in which both parties define the agenda for negotiation [15] [16]. An agent can generate offers that satisfy or motivate another agent to resolve conflicts and accomplish a mutual agreement [17].
Previously several attempts have been made to develop automated negotiation systems such as two-pronged negotiation models [18] [19] [20] [21] group negotiation models [14] [22], and argument-based negotiation models [23]. A few more examples of intelligent agents being used for automated negotiations [24] are

Firefly [25], Bargain Finder [26], Kabash [27] and Person Logic [28]. Firefly and Person Logic is being used for product brokering which are helpful for the customers to find the product according to their requirements. Bargain finder [29] and Jango [29] are used for merchant brokering and are helpful for customers to find the best-offered prices. Intelligent software agents have also been deployed for the negotiation in e-commerce in business to the consumers, such as Tête-à-Tête [20], consumer-to-consumer negotiation, e.g., Kasbah and e-bay. The bidders or negotiators had to face many geographically collocated restrictions, but electronic negotiation has removed these restrictions and has become the source to reduce the business costs relevant to negotiations which may be too high for sellers or buyers [30] [31]. Auction Bot is used for online auctions among many members, whereas Tête-à-Tête and Kasbah provide bilateral negotiation. Kasbah is a web-based multiagent system to discuss prices between consumer-to-consumer transactions [32]. Tête-à-Tête is an advanced shopping assistant used to negotiate bilaterally over many dimensions like return policies, warranties on the product, delivery time etc. Tête-à-Tête agents exchange counteroffers or critiques, and this type of negotiation is called primitive argumentation.

One major drawback of existing agents is that they mainly focus on an agent-to-agent communication, which may not be suitable in a business environment where humans make decisions [33]. In bilateral, multilateral negotiation, one human participant may negotiate himself, but on the other hand, the other participants may prefer to negotiate with an intelligent agent on his/her behalf [32]. This research uses a heuristics model approach for a context-aware win-win situation for automatic negotiation among human and intelligent agents.

2 Proposed Methodology

The main objective of this research is to develop the CAWSAN system that can be used to negotiate with a software agent and a human for multilateral negotiation issues.

In automated negotiation, there is no particular or universal approach suitable for every problem domain. Regarding environment and agents' interaction, each approach may have different assumptions. For instance, an agent may have corrected and complete knowledge about the opponent in an austere environment. Therefore, the decision-making will involve some action sequence to achieve some particular goals. On the other hand, in complex state negotiation, an agent needs to focus on numerous factors for appropriate decisions. For instance, in the business environment, agent knowledge about the opponent might be uncertain and incomplete, and the decision may also depend on the opponent's behaviour. Therefore, it is suggested in this research that the agent must be aware of the context and situation in which negotiation is required.

This CAWSAN situation during negotiation is implemented using a heuristic computational model to maximize the benefits for participants. For this purpose, a novel linear algorithm is presented to estimate the other participant's preferences and uses a hill-climbing procedure to search the space for possible win-wins that are more acceptable to another negotiator. The negotiator does not reduce his/her pay-off while creating a win-win. In a win-win mechanism, the heuristic function is used for offering generation, which maps the counterpart's current offer and the agent's introductory offer to create a new offer sent to the counterpart. It is supposed that two agents, "x" and "y", negotiate with one another, and "x" wishes to generate an exchange offer for "y". Therefore, the win-win mechanism can be described formally as below.

- Choose a set of contracts that have a similar utility $to\ x$'s last offer. That is known as $x's$ aspirational level.
- Choose a contract () from this set; agent x thinks it is more suitable $for\ y\ than\ x$. This contract maximizes the chance that agents y accept this contract.

These two rules can mathematically be stated as the agent x thinks that $V^b(x') > V^b(x)$ and $V^a(x) = V^a(x')$ so, $V^a(x') + V^b(x') > V^a(x) + V^b(x)$ and x' enhances the joint utility of contract. The preference structure of the agent is based on the desirability of the opponent, which is estimated by considering the agent's previous offer. The win-win contract generation utilizes a heuristic technique to generate an analogous contract. The heuristic technique produces a domain model that encourages the opponent's same preferences. A fuzzy similarity technique is used to compute the similarity between two contracts. The vague resemblance specifies the idea of closeness between two agreements. The resemblance of every issue is computed individually. In order to obtain overall similarity between two contracts, the individual similarity of issues is added, which results in complete resemblance among contracts. The resemblance presents the nearness among values of a problem besides a few assessment criterions. This assessment is presented as an assessment that functions on a particular problem and verifies the criteria of the issue and how it is coped with. The assessment criteria are the fuzzy resemblance constraint on a problem or issue. The fuzzy resemblance technique matches intrinsic uncertainties during the negotiation procedure.

This mechanism is used in continuous and discrete negotiation problems. Using the win-win mechanism, the automated negotiation simulations display that participant achieve an agreement that maximizes the joint utility [34] of both parties and is therefore advantageous for participants. The agent gains high utility using the win-win mechanism compared to the responsive mechanism. The simulated outcome of the win-win strategy reveals that the best win-wins are sought if the negotiation space is searched in detail. For the computation of similarity between the adversary's previous contract and the complete generated offer, the weight of every issue is also defined in the algorithm of the opponent's preference. The simulated outcomes show that accurate knowledge about an adversary's preferences directly affects exploring the best offer. Four scenarios define the adversary's weight preferences for issues.

- Correct information in the perfect information scenario.
- Correct information in the partial information scenario.
- Erroneous information about the adversary's weighted preferences in the imperfect scenario.
- Every issue has equal importance in uncertain information scenarios.

Formal Model of Win-win: Let $\boldsymbol{i}$ ($\boldsymbol{i} \in \{\boldsymbol{a}, \boldsymbol{b}\}$) correspond to the negotiation agents, and $\boldsymbol{j}$ ($\boldsymbol{j} \in \{\mathbf{1}, \dots, \boldsymbol{n}\}$) are the variables for the decision which are discussed in negotiation. Both qualitative and quantitative decision variables can be discussed. Quantitative variables are described on a real domain ($\boldsymbol{i.e.}\, \boldsymbol{x_j^i} \in \boldsymbol{D_j^i} = [\boldsymbol{min_j^i}, \boldsymbol{max_j^i}]$) while qualitative decision variables are described on incompletely order set($\boldsymbol{i.e.}\, \boldsymbol{x_j^i} \in \boldsymbol{D_j^i} = [\boldsymbol{q_1}, \boldsymbol{q_2}, \dots, \boldsymbol{q_p}]$). Every agent has a function for scoring($\boldsymbol{V_j^i}\colon \boldsymbol{D_j^i} \rightarrow [\mathbf{0}, \mathbf{1}]$). For ease, scores have an interval($[\mathbf{0}, \mathbf{1}]$). The agent assigns relative importance to every decision variable in negotiation and has a weight $\boldsymbol{w_j^i}$ that gives the importance of decision variable $\boldsymbol{j}$ for agent $\boldsymbol{i}$. Then normalize both agent's weights, $\boldsymbol{i.e.} \sum_{\mathbf{1} \le \boldsymbol{j} \le \boldsymbol{n}} \boldsymbol{w_j^i} = \mathbf{1}$, for all $\boldsymbol{i} \in \{\boldsymbol{a}, \boldsymbol{b}\}$. The scoring function of an agent for an agreement, that is, for a value in multi-dimensional space defined by the decision variables' value ranges, is then defined as:

$$V^i(x) = \sum_{1 \le j \le n} w_j^i \, . V_j^i(x_j) \tag{1}$$

Now we define the definition of the similarity.

Definition 1 Give a domain of values D_j , a similarity between two values $x_j, y_j \in D_j$ is defined as:

$$Sim_j(x_j, y_j) = \sum_{1 \le j \le m} w_i \,.\left(h_i(x_j) \leftrightarrow h_i(y_j)\right) \qquad (2)$$

Where $h_i(x_j) \leftrightarrow h_i(y_j) = 1 - |h(x_j) - h(y_j)$ and $1 - |h(x_j) - h(y_j)$ is the equality operator, the resemblance between two contracts is the combination of weight for the decision variables.

Definition 2 The similarity between two contracts $\boldsymbol{x}$ and $\boldsymbol{y}$ over the set of decision variables $\boldsymbol{J}$ is defined as:

$$Sim(x, y) = \sum_{j \in J} w_j^a \,. Sim_j(x_j, y_j) \qquad (3)$$

An agent may decide to do a win-win activity while it does not want to reduce its aspiration level (referred to as θ) during a service-oriented negotiation (the objective level is the assessment of its preceding offer x, which is $\theta = V(x)$. Therefore, firstly, the agent must create a few or all feasible contracts that produce the score of θ. Theoretically, it wants to create such contracts which lie on the iso-value curve θ. Since all these feasible contracts have a similar value to make a win-win for the agent, it is uncaring between them. According to this information, the win-win mechanism's purpose is to seek the contract on this scenario which is primarily preferable and is also accepted by the other negotiator. More appropriately, an iso-curve is described as:

***Definition* 3** Given an aspirational scoring value θ, the iso curve at level θ for the agent a

is defined as:

$$iso_a(\theta) = \{x \mid V^a(x) = \theta\} \qquad (4)$$

In this set, the agent will choose a similar contract to agent a's earlier offer. The win-win is described as:

Definition 4 Given an offer, **x**, from an agent a to b and a subsequent counter offer, **y**, from b to a,

with $\theta = V^a(x)$, a win − win agent a co*ncerning* $\boldsymbol{y}$ is defined as:

$$the\ tradeoff \quad (is\ y) = arg_{z \in iso_a(\theta)} \{Sim(z, y)\} \qquad (5)$$

The value function V_i^aused by agent for decision variable i is a linear scoring function is defined in eq. 6

$$V_i^a(x_i) = \begin{cases} \frac{max_i^a - x_i}{max_i^a - min_i^a} & if\ decreasing \\ \frac{x_i - max_i^a}{max_i^a - min_i^a} & if\ increasing \end{cases} \qquad (6)$$

The agent's score will increase if the decision variable's value increases and vice versa. For example, if a product price is increased, then the dealer's score will be increased, but the score of the customer will be decreased in this scenario where, the discriminatory power is the magnitude of the difference between the input and output as shown in eq. 7.

$$h(x) = \frac{1}{\pi} \operatorname{atan} \left[\left(\frac{2|x - min|}{x - min} \,.\, | \frac{x - min}{max - min} |^{\propto} - 1 \right) \tan \left(\pi \left(\frac{1}{2} - \varepsilon \right) \right) \right] + \frac{\pi}{2} \qquad (7)$$

2.1 The Win-win Algorithm

$inputs: y^j;$ /* $last\ step\ best\ contract.\ y^0 = y$ */
$E;$ /* $step\ utility\ increase$ */
$V_i();$ /* $value\ scoring\ functions\ for\ the\ decision\ variables$ */
$w_i;$ /* $importance\ weights\ for\ the\ decision\ variables$ */
$output: y^{j+1}$ /* $child\ of\ y^j$ */
$\textbf{begin}$
$\textbf{for}\ each\ decision\ variable\ i\ \textbf{do}$
$\textbf{if}\ i\ is\ discrete$
$\textbf{then}\ \overline{E}_i := \{\Delta_u(q) | q \in D_i, \Delta_u(q) = V_i(q) - V_i(y_i^j) > 0\}$
$\textbf{else}\ \overline{E}_i := \{0, 1 - V_i(y_i^j)\}$
$\textbf{end for};$

$E_{max} := \sum_i w_i\ .\ max(\overline{E}_i);$
$\delta := 0.01\ .E_{max};$
$\textbf{if}\ (E_{max} > E + \delta)\ \textbf{then}$
$\textbf{begin}$
$k := 0;\ E_n := 0;$
$\textbf{while}\ (E_n < E)\ \textbf{do}$
$k := k + 1;$
$\textbf{for}\ each\ decision\ variable\ i\ \textbf{do}$
$\textbf{if}\ (E_n < E)$
$\textbf{then if}\ i\ is\ qualitative$
$\textbf{then}\ r_i^k := random\left(\left\{\Delta_u(q) \middle| \Delta_u(q) \in \overline{E}_i, \Delta_u(q) \le \frac{E - E_n}{w_i}\right\} \cup \{0\}\right)$
$\textbf{else}\ r_i^k := \min\left(random(\overline{E}_i), \frac{E - E_n}{w_i}\right)$
$\textbf{else}\ r_i^k := 0;$
$E_n := E_n + w_i\ .r_i^k;$
$\textbf{if}\ i\ is\ qualitative$
$\textbf{then}\ \overline{E}_i := \{\Delta_u(q) | q \in D_i, \Delta_u(q) = V_i(q) - (V_i(y_i^j) + \sum_{i \le j \le k} r_i^j) > 0\}$
$\textbf{else}\ \overline{E}_i := \{0, max(\overline{E}_i) - r_i^k\}$
$\textbf{end for}$
$\textbf{end while};$
$\textbf{for}\ each\ decision\ variable\ i\ \textbf{do}$
$E_i := \sum_{j=1}^{k} r_i^j;$
$y_i^{j+1} = V_i^{-1}(V_i(y_i^j) + E_i)$
$\textbf{end for}$
$\textbf{end}$
$\textbf{else}\ raise\ error\ no\ step\ can\ be\ performed$
$\textbf{end}$

3 Implementation and Discussion

Three participants are involved in the negotiation. For automated negotiation, the agent and its principal will negotiate. On the other hand, the human participant is involved in the negotiation. The system is designed for multilateral negotiation. On one side buyer and the other side seller are negotiating. We design the system flexibly so that the software agent can negotiate on behalf of its principal, and the principal can be the buyer or seller. Human negotiators will elicit preference while software agent handles offer generation and offer evaluation. Now we describe the architecture of the e-negotiation system briefly. The human principal defines the negotiation agenda of how many negotiation issues will be discussed during negotiation.

On the other hand, a human negotiator also selects the negotiation agenda and negotiation issue which he/she wants to discuss during the negotiation. After defining the negotiation agenda, the agent and human negotiator can set their preferences. All this information will store in the database. After defining the negotiation agenda and preferences, the agent's principal generates the first offer manually because the tradeoff mechanism requires the negotiator's last offer. Now negotiation starts between the software agent and human negotiator. Human negotiators generate offers manually. On the other hand, a software agent generates the offer using an algorithm. All offers are stored in a database which will be used for offer evaluation and future use.

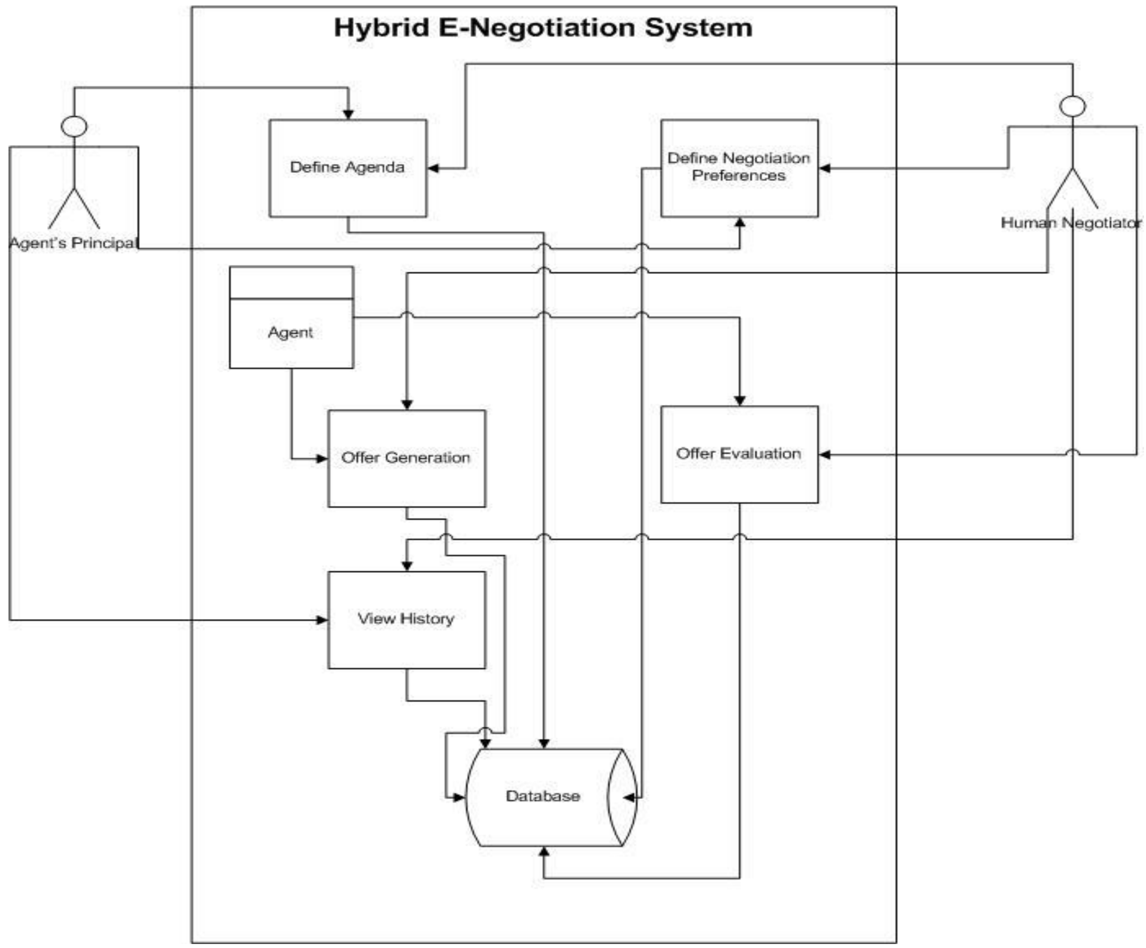

Figure 1: The architecture of the proposed negotiation System

3.1 Hybrid E-Negotiation System

First of all, the human negotiator and agent's principal will be registered and can also define their roles. The role of "Agent" will be used for the agent's principal, while the role of "Human" is used for the human negotiator. Agent’s principal and human negotiator can also update their information.

3.1.1 Negotiation Agenda

The first step is to define the negotiation agenda and number of issues to be discussed during the negotiation. The agent also defines the issue's name and agenda title. The human negotiator can select the agenda title to negotiate alongwith the number of issues.

Figure 2: Screen image of the proposed system for the human negotiation agenda

3.1.2 Negotiation Preferences

The next step is to set preferences for both human and the agent. Therefore, the agent-principal defines the preference elicitation of each qualitative and quantitative issue as mentioned in Fig. 3

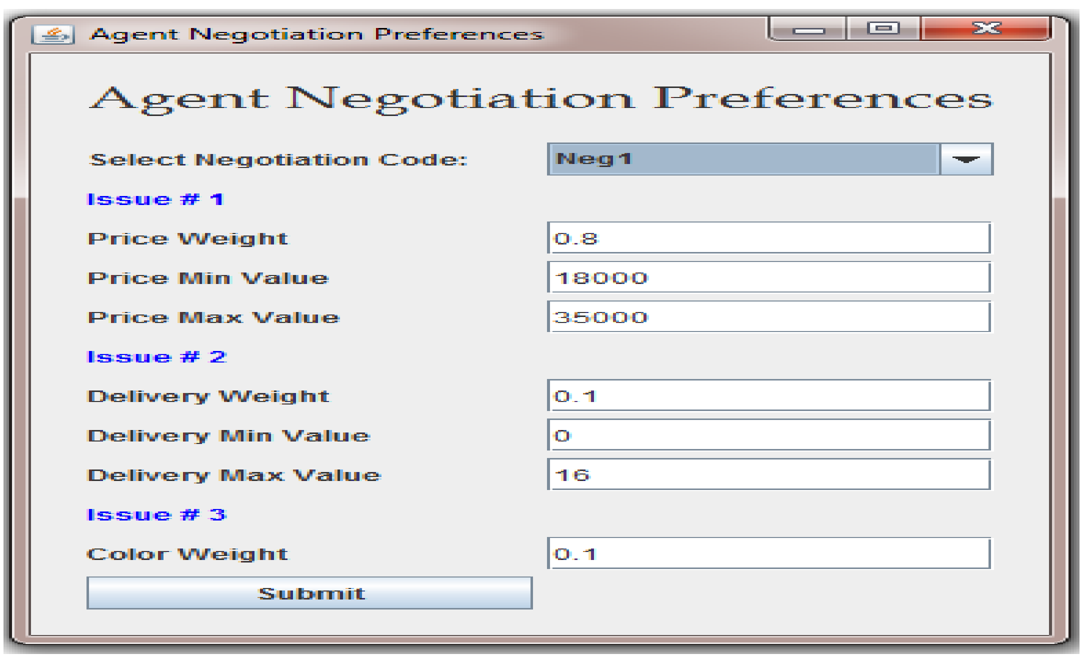

Figure 3: Screen image of the proposed system for agent negotiation preferences

Similarly, the human negotiator can define their preferences as mentioned in Fig 4.

Figure 4: Screen image of the proposed system for human negotiation preferences

3.1.3 Offer Generation

Once the negotiation preferences are set the agent principal generates the offer manually because the tradeoff mechanism generates a new offer on the player's last offer, an opponent's current offer. So, agent-principal has to define the first offer manually. Once the offer is generated the role of the agent principal's is finished. Now negotiation starts between the human negotiator and software agent on behalf of the human principal using a tradeoff mechanism. Human negotiators view the offer; if this offer is beneficial for him/her, he/she accepts the offer. If not suitable, he/she sends the counteroffer or rejects it. On the other side, the software agent views the counteroffer; if this offer meets the aspiration level, then the software agent accepts the offer; if it does not meet, he/she sends the counteroffer using the tradeoff mechanism.

3.1.4 Offer History

Human principals and negotiators can see the history of contracts, as shown in figure 5.

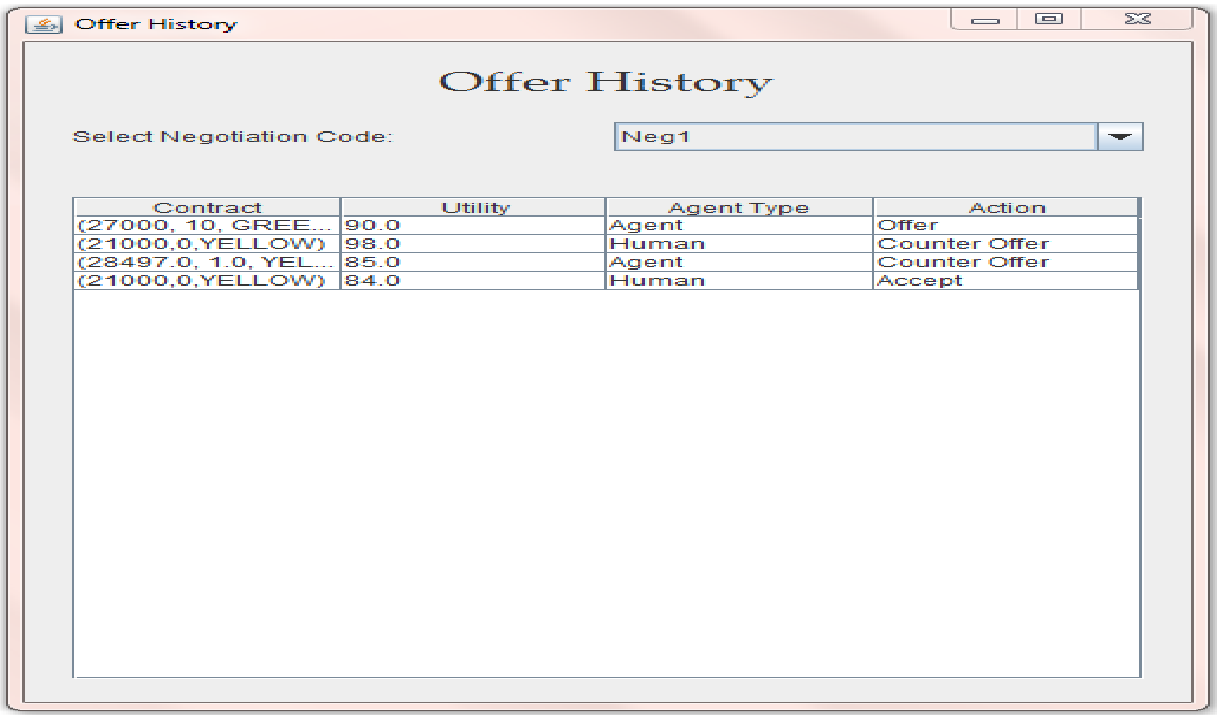

Figure 5:Screen image of the proposed system for offering history

The experiment supports the claim that win-win negotiation outcomes (such as profit) and psychological negotiation outcomes (such as satisfaction) do not effectively reflect the relationship effects of various negotiation techniques. However, negotiating interactions based on proposed win-win situation appear to have a greater impact on the continuing customer-seller relationship as shown in Table. 1.

Table 1: Comparison of Win-Win and No Win-Win Situation

Win Win Strategy	Value	Negotiator	Mean	SE
No Win-Win Situation	Increasing	Human	2.464	0.275
		Agent	2.425	0.282
	Decreasing	Human	3.511	0.263
		Agent	4.807	0.269
Win-Win Situation	Increasing	Human	3.869	0.261
		Agent	4.088	0.268

	Decreasing	Human	4.076	0.250
		Agent	5.398	0.255

4 Conclusion

NSS are the source of perspective support such as showing the utilities of offers and counteroffers, allowing preference elicitation, providing graphs for negotiation analysis and offering Pareto optimal solution, etc., which is helpful for planned decision making. Though, during negotiation, negotiators are free in their decisions. They may demonstrate ridiculous behavior and have made agreements that are not better for them and their partners. Automated negotiation is performed via software agents on behalf of their counterparts due to their autonomous nature, rationality and efficiency. In this research, we present a hybrid e-negotiation system. Agents will negotiate rationally and autonomously, and humans will participate where the litheness is necessary. In an automated negotiation, preference elicitation and the scheduled situation will be handled manually, and the agents will create and exchange offers. The human negotiator can adopt any negation behavior, but on the other hand, negotiation agents can adopt only particular behaviors. The human-agent negotiation protocol defines the rules for interaction between two different negotiators. From the decision-making point of view, we select the tradeoff strategy. This strategy generates the offers to represent actual coordinative behavior. The linear additive utility function helps offer an evaluation.

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