ANALYSING THE IMPACT OF ISSUES' KINDS ON NEGOTIATION FEATURES IN AUTONOMOUS E-COMMERCE CONTEXTS

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ABSTRACT

Negotiation is being known as a main form of communication in contexts including multiple autonomous agents. One of these fundamental contexts would be autonomous e-commerce contexts in which human traders will be substituted by trader agents. In spite of ignorance of its role in previous researches, a prominent factor that can affect negotiation's features in such multi-agent contexts may be issues' kinds; by considering each issue (e.g. price, quality, guarantee, timing, …) as a beneficial issue for both sides of a negotiation or as a beneficial issue for one side, this paper introduces two kinds of issues- common and peripheral issues. To analyze the effect of this factor (issues' kinds) on negotiation's features, without being influenced by other factors, we will categorize negotiation methods based on kinds of issues. After investigating each method's features, next great deal would be selection of best method and the best opponent to negotiate with. Hence, this paper offers an architectural design to conduct this work properly.

Keywords: *E-Commerce, Artificial Intelligence, Intelligent Agents, Negotiation Methods, Negotiation Features, architectural design*

1. INTRODUCTION

Trade in all its dimensions plays an important role in people's life. Maybe this effect can be observed more clearly with the significant development of technologies such as internet. This valuable technology gradually opened new ways to the commerce world which, assuredly, e-commerce is the most famous one. Briefly, e-commerce with all its forms (B2B, C2C, and etc.) consists of buying and selling of products or services over electronic systems such as the internet and other computer networks [1].

In parallel with the emergence of e-commerce, intelligent software agents as entities capable of independent action in open, unpredictable environments have also matured into a promising new technology [2]. Intelligent agents' technology plays a decisive role in various electronic business applications [3]. Such agents can efficiently support tasks related to business models such as e-auction, e-mails, information brokers, and e-marketplace [4]. Their ability to provide functionalities in an autonomous, proactive, social, and adaptive fashion offers greater flexibility than traditional components when developing such applications.

Recently, combination of these two sciences (e-commerce and intelligent agents) with the main purpose of simplifying trades for human traders has changed in to a quite interesting subject [2, 3].

A big deal in all such multi-agent contexts is the way of communication between agents that negotiation is being known as one of the most beneficial ones [5, 6]. Negotiation is a process in which two or more parties (agents) with different criteria, constraints, and preferences, jointly reach an agreement on the terms of a transaction [7].

As might be expected, different negotiation methods, models and strategies have been offered by researchers [8, 9]. However, one still open way of investigation is analyzing the impact of different factors on negotiations' features. To analyze the effect of one of these factors, the authors have classified negotiation methods based on it (issues' kinds). Then, different negotiation methods have been compared in regard to their features (influenced by issues' kinds). This comparison provides the opportunity for agents to select the negotiation method that satisfies their concerned features in the best form. Another step towards our article goal is selection of best opponent to

negotiate with (when offered negotiation methods are being applied). Because of existence of different e-commerce types (B2B, B2C …) the opponent could be anything from different businesses to ordinary customers. However, by considering one side of a trade as a buyer and another side as a seller and by applying an architecture, each side tries to find the best competitor for negotiation.

The remainder of paper consists of following parts:
In addition to concept of optimal agenda, section 2 describes concepts of one-issue and multi-issue negotiations. Section 3 divides issues' kinds in to two groups: common issues and peripheral issues. Describing the problem, Section 4 illustrates our main motivation of providing this paper. To analyze the effect of issues' kinds on negotiation features, section 5 classifies negotiation methods based on issues' kinds. As an extra explanation to section 5, section 6 clarifies the essential criteria for each classified method. Section 7 demonstrates and compares features of different offered negotiation methods. Section 8 is dedicated to our proposed architecture to distinguish the best negotiation method and the best opponent. Section 9 attempts to show the algorithm way of operation through a simple scenario. Finally, conclusion and future works will be discussed in section 10.

2. ONE-ISSUE AND MULTI-ISSUE NEGOTIATION AND OPTIMAL AGENDA

The simplest form of negotiation involves two agents (seller agent and buyer agent- we sometimes call them simply seller and buyer) and a single-issue; For example consider sample scenario of seller and buyer who negotiate about price. To begin, two agents are likely to differ on the price at which they believe the trade should take place, but through a process of joint decision-making they either arrive at a price that is mutually acceptable or they fail to reach an agreement.

However, in most bilateral negotiations, the parties involved need to settle more than one issue. For example, agents may need to come to agreements about objects/services that are characterized by issues such as price, delivery time, guarantee, quality, reliability, timings, penalties, terms and conditions and so on [10,11]. For such multi-issue negotiations, the outcome also depends on two additional factors [6, 10, 11, 12]:
  a) Negotiation procedure: Clarifies the issues to be negotiated as a package

simultaneously, or separately and in different times.
  b) Agenda: Identifies the set of issues that are under negotiation (we call it main agenda sometimes).

There is a common question among different researches on agenda which refers to defining the most beneficial issues for each agent. In other words, it evaluates what issues provide more utility for each agent and locate in its' optimal agenda? However, what is an optimal agenda and how it will be used? Based on [12], each participating agent in the negotiation process owns an optimal agenda which is a subset of main agenda and consists of the issues that are beneficial for that agent. It mean although different issues may attend the negotiation process, but all of them may not be beneficial for both agents. Based on this research, the participating agents in a negotiation may have or have not a zone of agreement for each issue in the main agenda.

In [12], the optimal agendas for two negotiating agents α and $\acute{\alpha}$, in situation where two issues B and C are under negotiation, are being shown by A_α and $A_{\acute{\alpha}}$ symbols, respectively (α and $\acute{\alpha}$ are two agents from two different types: seller and buyer). As a result of existence of two candidate issues for negotiation (B and C), four negotiation scenarios are possible (further information can be found in [12]):
− S_1: If both issues have a zone of agreement (both issues are beneficial for both agents). In this case optimal agendas are as follows:
$$A_\alpha = A_{\acute{\alpha}} = \{B, C\}$$
− S_2: If only issue B has a zone of agreement (just issue B is beneficial for both agents); Two cases are possible:
  a) If issue C has positive utility for none of the agents, optimal agendas are:
$$A_\alpha = A_{\acute{\alpha}} = \{B\}$$
  b) If issue C has positive utility for one of the agents, optimal agendas would be in one of these two forms:
$$A_\alpha = \{B, C\}, A_{\acute{\alpha}} = \{B\}$$
$$A_\alpha = \{B\}, A_{\acute{\alpha}} = \{B, C\}$$
− S_3: only issue C has a zone of agreement (similar to scenario S_2).
− S_4: neither issue B nor issue C has a zone of agreement. Two forms of optimal agendas are possible:
$$A_\alpha = A_{\acute{\alpha}} = \{A, B\}$$
$$A_\alpha = A_{\acute{\alpha}} = \emptyset$$

3. DIFFERENT KINDS OF ISSUES IN A NEGOTIATION

In this part we are going to study different relations between sets of issues which are under negotiation. As will be discussed, these issues maybe located in set of common issues (definition 1) or in set of peripheral issues (definition 2).

Consider figure 1 in which the left circle consists of the issues located in optimal agenda of α. Right circle also consists of the issues located in optimal agenda of $\acute{\alpha}$. Therefore, each issue is either located in A_α or in $A_{\acute{\alpha}}$ (or even both of them). The reason is that all the available issues are beneficial for one agent at least (if not, this issue will never be suggested by any of agents to enter to the negotiation process) and locate in its optimal agenda.
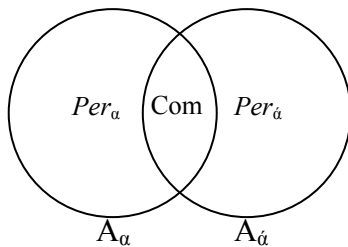

Figure 1. Possible relations between available issues in a negotiation

Location of each issue in optimal agenda of either of agents was depicted in figure 1. Therefore, it is the time to investigate relations of different issues together. Definitions 1 and 2 show two probable relations between negotiation features:

Definition 1:
There may be one or more issues that are common between both agents' optimal agendas (located in Com in figure 1); this also is clear in relation 1.

$$Com = A^\alpha_o \cap A^{\acute{\alpha}}_o \quad (1)$$

Such issues that can be beneficial for both sides (see table 1), are being called common issues. For example, issue A in part b of scenario S_2 (preceding section) is common issue of the negotiation and can be beneficial for both sides. For instance, price is an issue that always is important for both sides (it is a common issue). Apparently, seller prefers receiving more money and buyer prefers paying less money. However, they only reach agreement about this issue, when the offered price is beneficial and acceptable for both sides (table 1- utility is positive for both sides). Otherwise, they will quit the

negotiation. This is why we refer to common issues as beneficial issues of negotiation.

Note:
Common issues of a negotiation are inseparable part of each negotiation. The reason is that these issues can be beneficial for both sides. Consequently, both agents accept negotiating about such issues because there is a hope to reach agreement about this issue and benefit from it.

Table 1. Utilities of different kinds of issues for negotiating agents

	Com	*Per*$_\alpha$	*Per*$_{\acute{\alpha}}$
Agent $\underline{\alpha}$	+	+	
Agent $\underline{\acute{\alpha}}$	+		+

Definition 2:
Conversely, there may exist some issues, such as B in part b of scenario S_2, that are only located in one side's (agent) optimal agenda (issues located in *Per*$_\alpha$ or *Per*$_{\acute{\alpha}}$ in figure 1) and the other side receives negative utility after negotiating about them (they are beneficial for only one side of a negotiation). Hence, reaching agreement in such situation means each agent will receive positive utility from its own peripheral issues and other agent will receive negative utility from them (see table 1). Therefore, why and under what circumstances an agent will accept negotiating about peripheral issues of its opponent? This is a question which we will respond in sections 5 and 6.

Note:
Since in contrast to common issues, peripheral issues are just beneficial for one side of a trade, they are in second level of importance and even sometimes agents prefer not to negotiate about them at all (see section 5 and 6).

Consider figure 2 that shows a sample trade. Imagine that favorite issues of a buyer and seller (here buyer n and seller m) are the words written inside the ovals. Issues such as price and reliability in this figure are common issues between two trading agents. Accordingly, negotiating about them could be beneficial for both agents. Therefore, these issues are located in common set (*com*):

Com= {price, reliability}

On the other hand, issues such as timing, quality, and guarantee are just beneficial for one of the agents. These issues are located in peripheral set of

seller (we show it as $Per_{\text{seller m}}$) and peripheral set of buyer (we show it as $Per_{\text{buyer n}}$), respectively.

$$Per_{\text{seller m}} = \{timing\}$$
$$Per_{\text{buyer n}} = \{quality, guarantee\}$$

Based on table 1, seller agent receives positive utility after negotiating about issues in $Per_{\text{seller m}}$ set and receives negative utility after negotiating about issues available in $Per_{\text{buyer n}}$ set. This matter is vice versa for buyer agent.
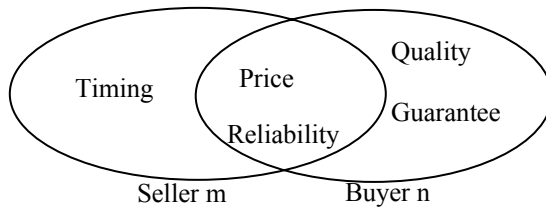

Figure 2. A real-world example

4. PROBLEM

Up to present times, different negotiation methods have been suggested by researchers. Nevertheless, one important pitfall in all the previous findings is that they do not pay enough attention to the impact of different factors on negotiations. Observing such challenges, we are going to analyze the impact of one important factor- issues' kinds- on negotiation process (Issues' kinds consist of common and peripheral issues that were discussed in the previous section). These effects are as follows:

i. Comparing to peripheral issues, agents reach quicker agreement after negotiating about common issues. The reason is that negotiating about peripheral issues of each side is not beneficial for the other side, at all. Therefore, some periods of time may be devoted to persuade the other agent to just accept negotiating about these issues. This process also consists of analyzing some complex criteria which will be discusses in section 6.

ii. Negotiating about common issues in a negotiation usually is securer. When negotiating about common issues, fewer messages should be exchanged to reach agreement. Hence, the security degree of negotiating about such issues is more. This feature stems from the fact that in contrast to common issues, peripheral issues are just beneficial for one side and lots of messages should be exchanged to persuade the other side to accept negotiating about such issues.

iii. While negotiating about peripheral issues, some complicated criteria should be checked. This matter provides that negotiating about such issues be too complex. On the contrary, negotiating about common issues is easily achievable (see section 6 for more information).

iv. While negotiating about common issues, no utility loss occurs (as discussed in section 3, agreement occurs only if both sides are satisfied). However, negotiating about peripheral issues of other agents provides that some utility loss occurs in some occasions (table 1). Therefore, to avoid such situation, some complicated criteria should be checked (section 6). This operation imposes a big overhead.

v. The total utility of each agent in a negotiation is the utility that it gains after negotiating about all the candidate issues (common and peripheral issues). However, negotiating about peripheral issues (even peripheral issues of both sides) does not always guarantee receiving more utility comparing to when just common issues are under negotiation. In other words, it is very probable that the utility of negotiating about peripheral issues of both sides be negative for agents. Hence, kinds of issues can firmly affect this feature.

vi. Kinds of issues usually can affect number of issues that can attend in the negotiation. For example, if just common issues are supposed in the negotiation, some other peripheral issues cannot attend the negotiation process. This means a decrease

in number of attending issues in the negotiation.

An important feature that can be influenced by number of issues is "satisfaction of agents' preferences". The more issues are allowed to attend in the negotiation process, the better the agents' preferences will be satisfied; each agent strongly likes negotiating about its favorite issues. As a result, the issues' kinds can indirectly affect the degree that agents' preferences will be satisfied.
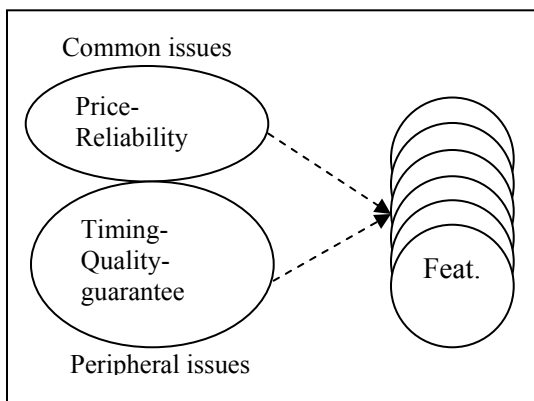

Figure 3. Effect of issues' kinds on negotiation features

Figure 3 shows how issues' kinds (common and peripheral) can affect the six mentioned negotiation features. In this figure, price and reliability are common issues of negotiation. On the other hand, Timing, quality, and guarantee are peripheral issues of negotiation (sample trade in section 3).

5. NEGOTIATION METHODS

As discussed, issues' kinds can affect negotiation features. Therefore, if we classify negotiation methods based on this factor, they will have different features. This matter provides that the negotiation method that mostly satisfies concerned features of agents be chosen. Hence, by considering its' importance, in this section we are going to start this classification process.

As discussed, each issue in the negotiation is either a common issue between two sides or is a peripheral issue of one side. As a result, negotiation can take place in one of the following forms (we call them notion):

1. Negotiating about common issues
2. Negotiating about peripheral issues
3. Negotiating about common and peripheral issues

In the first notion, some of the common issues (issues that are common between two sides) are under negotiation. Therefore, first notion results in formation of first negotiation method (figure 4).
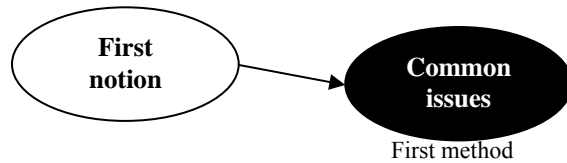

Figure 4. Creation of first negotiation methods

In contrast to first notion, in the second notion peripheral issues are under negotiation. Thus, the question is that which peripheral issues (peripheral issues of seller, buyer or both of them)? The answer to this question is the third option. Since peripheral issues of each side bring negative utility for other side, none of the agents accept to negotiate just about other agent's peripheral issues. However, if both sides accept to negotiate about peripheral issues of each others in a way that their total utility is positive, a negotiation is possible. The reason is that agents are self-interested creatures and will never accept utility loss. Therefore, the second negotiation notion results in formation of second negotiation method in which peripheral issues of both sides are under negotiation (figure 5).
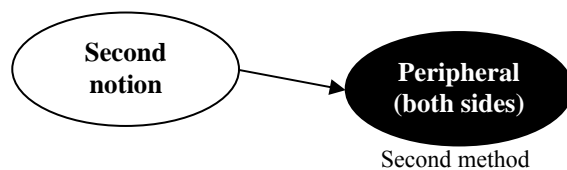

Figure 5. Creation of second negotiation method

Again in the third notion, common and peripheral issues are under negotiation. Therefore, it may seem that the only way to a successful negotiation is negotiating about peripheral issues of both sides (third method in figure 6). However, since common issues also attend into this negotiation notion another option is also imaginable [13]:

The option is that only peripheral issues of one side attend into negotiation technique. Instead, the other side receives more positive utility from common issues. This will be done in a way that the

negative utility of negotiating about one side's peripheral issues can be compensated for the other side and none of the agents face with utility loss (fourth method in figure 6).

For instance, agent α that its peripheral issues are going to be negotiated will concede some parts of its common issues' utility to agent ά. Apparently, in this case the utility that agent α receives after negotiating about common issues will decrease and the utility that agent ά receives from common issues will increase. Therefore, if $U(α, Com)$ is the utility that agent α receives from its common issues in ordinary cases, it will change into $U_{decrease}(α, Com)$ in this negotiation method and relation 2 would be satisfied. On the other hand, $U(ά, Com)$ will also change into $U_{increase}(ά, Com)$ and relation 3 will be satisfied.

$$U_{decrease}(α, Com) >= U(α, Com) \quad \textbf{(2)}$$
$$U_{increase}(ά, Com) >= U(ά, Com) \quad \textbf{(3)}$$

Hence, as illustrated in figure 6, third negotiation notion results in formation of two negotiation methods (black ovals).
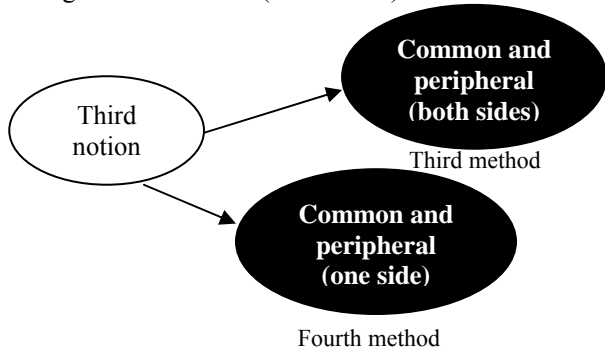

Figure 6. Creation of third and fourth negotiation methods

In figure 7, four negotiation methods (black ovals) that came from the three mentioned notions are illustrated. The kinds of issues that are under negotiation in each technique are written inside the ovals. The dashed arrow shows an extension to the third method. This situation is a special case of third method in which all the common and peripheral issues (all the issues) are under the negotiation.

Note:
Present e-commerce trades usually take place around all the issues (like the dashed oval). However, the difference is that entrance of common and peripheral issues to the negotiation process (in the dashed oval) occurs after satisfaction of some

criteria (section 6). While, in present e-commerce trades both sides accept negotiating about all the issues available in agenda, unconditionally; this is a big challenge because this operation may cause utility loss for one of the agents or both of them.
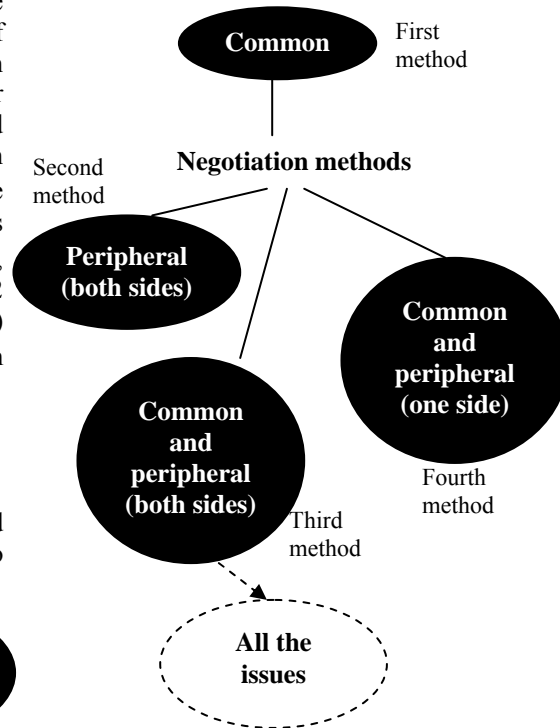

Figure 7. Different possible negotiation methods (based on issues' kinds)

6. CRITERIA

Four main groups of negotiation methods were discussed in the previous section. However, in negotiation methods in which peripheral issues are under the negotiation (second, third and fourth methods in figure 7), some complicated criteria should be checked. The reason is that peripheral issues of each side bring negative utility for other sides. Hence, it should be guaranteed that, totally, negotiating about peripheral issues that are under negotiation does not cause utility loss for neither of agents. In this part, main criteria of each negotiation method will be analyzed:

a. Criteria for the first method:

The only criterion to use first technique of negotiation is that agents have at least one issue in common. Otherwise, this negotiation technique is not applicable, in practice. Hence, criterion 1 would be too simple and as follows:

Criterion 1: Existence of at least one common issue.

b. Criteria for the second method:

As discussed, in the second technique peripheral issues of both sides are under the negotiation. Therefore, if only one agent owns peripheral issues, using this negotiation method will not be possible. Furthermore, the total utility that agents receive after negotiating about peripheral issues should be positive (see section 5). For instance, according to criterion 2.α, agent $\underline{\alpha}$ accepts to negotiate about those peripheral issues of agent $\underline{\acute{\alpha}}$ ($P_{\acute{\alpha}y}$) that their negative utility ($\sum_1^{y \leq n} U(\alpha, P_{\acute{\alpha}y,2})$) can be compensated by the positive utility of its own peripheral issues ($\sum_1^{x \leq n} U(\alpha, P_{\alpha x,2})$). Number 2 in this algebraic formula shows that this relation is related to second negotiation method. Criterion 2.$\acute{\alpha}$ shows this situation for agent $\underline{\acute{\alpha}}$.

Criterion 2.α:
    Existence of at least one peripheral issue for each agent,

$$\forall \; P_{\acute{\alpha}y} \; \in \; Per_{\acute{\alpha},2} \Big| \; \exists \; \sum_1^{x \leq n} U(\alpha, \; P_{\alpha x,2}) \; + \; \sum_1^{y \leq n} U(\alpha, P_{\acute{\alpha}y,2}) >= 0$$

Criterion 2.$\acute{\alpha}$:
    Existence of at least one peripheral issue for each agent,

$$\forall \; P_{\alpha x} \; \in \; Per_{\alpha,2} \Big| \; \exists \; \sum_1^{x \leq n} U(\acute{\alpha}, \; P_{\alpha x,2}) \; + \; \sum_1^{y \leq n} U(\acute{\alpha}, P_{\acute{\alpha}y,2}) >= 0$$

c. Criteria for the third method:

In the third method of negotiation common issues and peripheral issues of both sides are under negotiation. However, if just common issues exist (no peripheral issues exist at all), this technique will be done similar to first method. Similarly, if just peripheral issues of two sides exist (no common issues exist), this technique will be done similar to second method (if criterion 2.α or criterion 2.$\acute{\alpha}$ are satisfied). The last possible option is that common issues and peripheral issues of one side exist. In this case, third method will be done similar to fourth method (if criterion 4.α or criterion 4.$\acute{\alpha}$ is satisfied).

Hence, the only situation in which this negotiation method can be done completely (as it is) is when common issues and peripheral issues of both sides attend in to negotiation process (see criterion 3.α and criterion 3.$\acute{\alpha}$).

Again like the previous method, the total utility that agents receive after negotiating about peripheral issues in this technique should be positive (otherwise agents will not accept negotiating about them). This matter is the second essential factor for the method to be applicable (see criterion 3.a and criterion 3.b). Therefore, the algebraic relations for this method would be similar to the second method.

Altogether, agents $\underline{\alpha}$ and $\underline{\acute{\alpha}}$ accept negotiating about other side peripheral issues if criterion 3.α and criterion 3.$\acute{\alpha}$ are satisfied, respectively.

Criterion 3.α:
    Existence of at least one common issues and at least one peripheral issue for each agent,

$$\forall \; P_{\acute{\alpha}y} \; \in \; Per_{\acute{\alpha},2} \Big| \; \exists \; \sum_1^{x \leq n} U(\alpha, \; P_{\alpha x,2}) \; + \; \sum_1^{y \leq n} U(\alpha, P_{\acute{\alpha}y,2}) >= 0$$

Criterion 3.$\acute{\alpha}$:
    Existence of at least one common issues or at least one peripheral issue for each agent,

$$\forall \; P_{\alpha x} \; \in \; Per_{\alpha,2} \Big| \; \exists \; \sum_1^{x \leq n} U(\acute{\alpha}, \; P_{\alpha x,2}) \; + \; \sum_1^{y \leq n} U(\acute{\alpha}, P_{\acute{\alpha}y,2}) >= 0$$

d. Criteria for the fourth method:

In the fourth method of negotiation, common issues and peripheral issues of one side are under the negotiation. Therefore, if no issues exist in common between two sides, applying this negotiation method is not possible; because in this case just peripheral issues of one side can attend in to negotiation process and this matter is not possible (see explanation for second method's criteria). Thus, existing of common issues is an essential factor for this method to be applicable.

On the other hand, existence of peripheral issues for at least one side could help the method to work completely. Otherwise, if no sides own peripheral issues, this method will be done similar to first method (negotiation happens around common issues). Therefore, existence of at least one peripheral issue can be considered as a factor that helps the fourth method to be done completely and as it is.

Another important factor for this negotiation method to be applicable is that one agent will accept negotiating about peripheral issues of other agent, if the negative utility of this matter can be compensated for it with an increase in utility of

common issues. For instance, consider first relation in criterion 4.α in which peripheral issues of agent $\underline{\alpha}$ are under the negotiation. In this case, agent $\underline{\acute{\alpha}}$ will accept negotiating about peripheral issues of agent $\underline{\alpha}$, if the negative utility of this matter ($\sum_1^{x \leq n} U(\acute{\alpha}, P_{\alpha x,4})$) can be compensated for it with an increase in utility of common issues ($\sum_1^{y \leq n} U_{increase}(\acute{\alpha}, Com_4)$).

Note:

Our intention by the word "compensating" is that summation of these utilities, totally, is positive for agents and benefits them (see first and second algebraic relations in criterion 4.α and criterion 4.ά).

As mentioned, The increase in utility of common issues for one side means a decrease in other side's utility (e.g. if buyer accepts to pay more money, seller will benefit and buyer encounter a decrease in its utility). Again consider criterion 4.α:

To persuade other side to accept negotiating about its peripheral issues, agent $\underline{\alpha}$ decreases its common issues' utility partially and concedes it to agent $\underline{\acute{\alpha}}$. However, based on second relation in criterion 4.α, agent $\underline{\alpha}$ decreases its utility ($\sum_1^{y \leq n} U_{decrease}(\alpha, Com_4)$) as much as positive utility of negotiating about its own peripheral issues can compensate this loss for it ($\sum_1^{x \leq n} U(\alpha, P_{\alpha x,4})$).

Another important point is that the total utility (utility of peripheral issues plus utility of common issues) in criterion 4.a and criterion 4.b should be greater than utility of common issues in ordinary situation; otherwise, the agents will prefer not to negotiate about peripheral issues at all; because just by negotiating about common issues they will receive more utility.

Note:

Criterion 4.ά shows all the above operation for the other agent.

Criterion 4.α:

Existence of at least one common issue, Existence of at least one peripheral issue for each agent,

$$\forall\ P_{\alpha x}\ \in\ Per_{\alpha,4} \Big|\ \exists\ \sum_1^{x \leq n} U_t(\acute{\alpha},\ P_{\alpha x,4})\ + \sum_1^{y \leq n} U_{increase}(\acute{\alpha}, Com_4) \geq \sum_1^{y \leq n} U\ (\acute{\alpha}, Com_4) \geq 0$$

$$\sum_1^{y \leq n} U_{increase}(\acute{\alpha}, Com_4) \Big|\ \exists\ \sum_1^{x \leq n} U_t(\alpha, P_{\alpha x,4})\ + \sum_1^{y \leq n} U_{decrease}(\acute{\alpha}, Com_4) \geq \sum_1^{y \leq n} U\ (\alpha, Com_4) \geq 0$$

Criterion 4.ά:

Existence of at least one common issue, Existence of at least one peripheral issue for each agent,

$$\forall\ P_{\acute{\alpha}y}\ \in\ Per_{\acute{\alpha},4} \Big|\ \exists\ \sum_1^{x \leq n} U(\alpha,\ P_{\acute{\alpha}y,4})\ + \sum_1^{y \leq n} U_{increase}(\alpha, Com_{y,4}) \geq \sum_1^{y \leq n} U(\alpha, Com_{y,4}) \geq 0$$

$$\sum_1^{y \leq n} U_{increase}(\alpha, Com_4) \Big|\ \exists\ \sum_1^{x \leq n} U(\acute{\alpha}, P_{\alpha x,4})\ + \sum_1^{y \leq n} U_{decrease}(\alpha, Com_4) \geq \sum_1^{y \leq n} U\ (\acute{\alpha}, Com_4) \geq 0$$

7. RANKING THE METHODS IN REGARD TO FEATURES

Different negotiation methods (based on issues' kinds) and features of each one were explained. However, the main question is that what negotiation method should be used in each situation? To answer this question we should compare different negotiation methods in regard to their features. As a result, in each situation the negotiation method which satisfies the determined features will be chosen (this operation forms the first step of architecture in section 8).

Table 2 shows our offered ranking of negotiation methods in regard to their features. As illustrated, second negotiation method is removed from this table. This matter has two main reasons:

a. Because of existence of various benefits for common issues (see section 4), agents usually prefer negotiating about such issues (while second negotiation method suffers from absence of common issues).

b. Although our classification conducted us to second negotiation method (consisting peripheral issues), but in real world trades there always exist some issues that are in common between two sides (E.g. price is an issue which plays an important role for both sides). Therefore, ignoring such issues role in a negotiation will not be a sensible action.

Now, it is the time to investigate each row in table 2 in details:

• By throwing a glance to each method's criterion, apparently, first technique is the simplest one. Third technique is also simpler than the fourth.

- Since just common issues are under the negotiation in the first technique, it has no risk of utility loss. On the other hand, although peripheral issues attend in the third and fourth techniques, the defined criteria avoid any kind of utility loss. Thus, these two techniques also do not cause any utility loss.

- First negotiation method is the most secure and applicable method for trades with time limits (see section 4); just common issues are under the negotiation. Moreover, fourth technique not only is securer than third technique but also is more applicable for trades with time limits. The reason is that in the third technique common and peripheral issues of both sides are under the negotiation. Besides the need to devote longer times for such trades, it probably means attending of more issues in the negotiation. Therefore, more messages may be exchanged to negotiate about all the issues and negotiation would be less secure.

- Third negotiation method can satisfy agents' preference in the best form; since common and peripheral issues of both sides are under the negotiation. Furthermore, based on figure 7, in some situations even all the issues can attend the negotiation. On the other hand, in the fourth technique common and peripheral issues of one side are under the negotiation. Hence, it satisfies agents' preferences more than first negotiation technique.

- The last feature that we are going to analyze is "gained utility". Although peripheral issues of each side bring a negative utility for the other side, they bring a positive utility for agents that own them. Therefore, third negotiation method in which common and peripheral issues of both sides are under the negotiation can bring highest relative utility for each agent (especially if negative utility of negotiating about other agent's peripheral issues is not considerable). While in the fourth negotiation method, except for common issues, just one side will be utilized of its peripheral issues.

Finally, in the first method of negotiation just common issues are under the negotiation and the total utility of this method would be the least (it cannot benefit from peripheral issues' utility).

- Each column in the last row of table 2 shows summation of rankings in the corresponding column. Since lower ranks in each row show better methods, lower total also shows the method which is better, totally. However, if just some of the listed features are important for an agent (to select its proper negotiation method), it is enough to simply compute the summation of rankings in related columns and ignore the others.

Table 2.Comparison table

	First method	Third method	Fourth method
Algorithm simplicity	1	2	3
Risk of utility loss	1	1	1
Applicability for trades with time limits	1	3	2
Security	1	3	2
Satisfaction of agents' preferences	3	1	2
Gained utility	3	1	2
Total	10	11	12

8. ARCHITECTURAL DESIGN

In this section, the proposed architecture of this paper to choose the most qualified opponent to negotiate with will be illustrated. Figure 8 shows the situation that a new buyer decides to enter the negotiation. As depicted, this architecture consists of five main steps:

Step 1:
At first, based on buyer's preferences (features) and using a knowledge base, the dominant negotiation method that satisfies agent's willingness in the best form will be suggested (the buyer is shown by B_n); this will be done based on table 2 and the features that are mostly important for agent.

Other fixed information (such as agent's name and agent's ID) also is accessible using local database of agent.

Note:
Such operation has already been done (or will be done) in sellers' side.

Step 2:
All the discovered information in the previous step will be added to a broker. Broker can be used as a repository to introduce different trader agents to each other. The available information in the broker consists of Agent's type (seller or buyer), Agent's ID, the item which is going to be traded, issues which are important for agent, and the dominant negotiation mechanism that already has been specified in step 1.

Note:
Such operation has already be done (or will be done) in sellers' side.

Step 3:
Buyer's dominant negotiation method was determined in the first step. Therefore, B_n will just accept negotiating with opponents (here sellers) that accept negotiating using that technique. As a result, in the third step and using the information saved in the broker the opponents that use the same negotiation method will be identified.

Step 4:
Some qualified sellers were identified in the previous step. Therefore, it may be a good idea to start negotiation with all of them simultaneously and finally reach agreement with the best one. However, this matter usually needs lots of resources to be involved. Furthermore, it provides high computational overhead. Hence, in the fourth step and by applying an inference engine, we will choose the best opponents among the suggested ones. In other words, we again do the analyzing process to choose the bests among offered opponents. To do so, the engine selects the opponents that have all the required types of issues for the specified negotiation method. For instance, if the determined negotiation method is the third method, the engine will choose opponents that have some issues in common with buyer and some peripheral issues. This process will be illustrated using a sample scenario in the section 9.

Step 5:
In the fifth step, B_n sends an offer to start the negotiation. These offers will be sent to each specified opponents in the fourth step. Those sellers

that accept negotiating with this buyer will send and acceptance message to it. Finally, negotiation with those opponents will start.
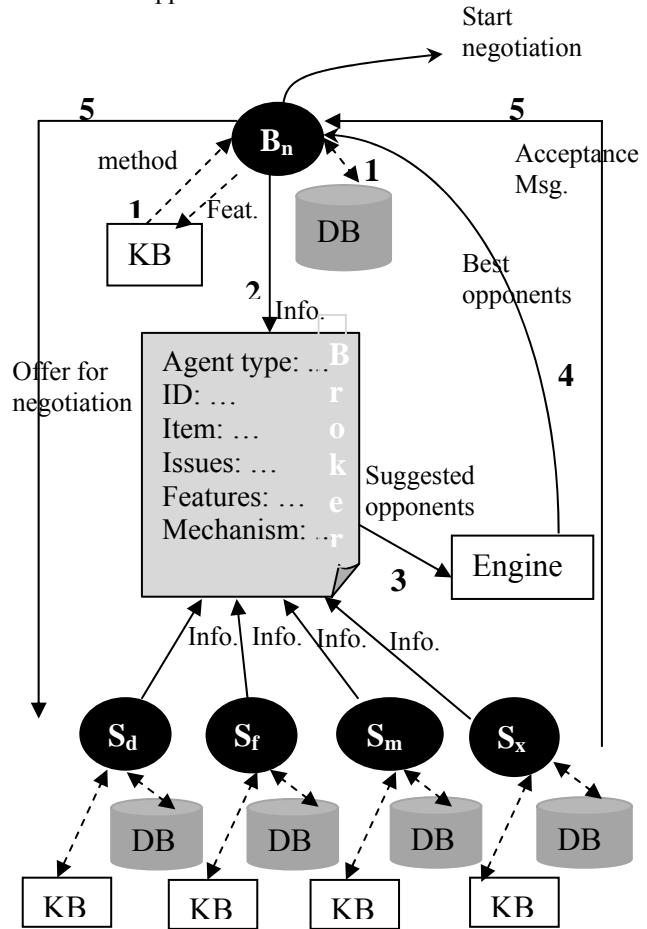

Figure 8. Proposed architecture

Note:
All the above operations also can be started by sellers.

9. A SAMPLE SCENARIO

In this section, we will attempt to demonstrate how the suggested algorithm works in practice. To do so, a sample scenario will be considered:

Imagine that part of the registered information in the broker is as illustrated in table 3. As discussed, the features and issues will be entered either by agents (e.g. using an UI) or through accessing the databases. Based on the determined features, the appropriate negotiation method for each agent will be suggested and will be inserted into the broker.

In this example, buyer B_n prefers negotiating using third technique. Therefore, sellers S_d, S_m, and

S_x can be selected for negotiation. Then, these three suggested opponents will be analyzed using the inference engine (table 4).

Table 3. Some part of the information saved in broker.

Agents	features	method	issues
B_n	Gained utility- Risk of utility loss	3	Price-reliability-guarantee-quality
S_d	Simplicity-Gained utility-Satisfaction of prefer.	3	Price-quality-
S_f	Simplicity-Risk of utility loss-Applicability for trades with time limits	2	Price-quality
S_m	Risk of utility loss-Satisfaction of prefer.	3	Price-reliability-timing
S_x	Gained utility-Security-Satisfaction of prefer.	3	Price-timing-Delivery type

Table 4. Selecting the best opponents to negotiate with.

Suggested opponents	Common issues with B_n	Peripheral Issues B_n	Peripheral Issues opponents	Best opponent
S_d	Price-quality	Reliability-guarantee	-	No
S_m	Price-reliability	Guarantee-quality	timing	Yes
S_x	Price	Reliability-Guarantee-quality	Timing-delivery type	Yes

Selecting the best opponents (sellers), the engine needs to extract common or peripheral issues of each seller. In this scenario, the third negotiation method is going to be applied. Hence, the engine will analyze common issues and peripheral issues of both sides (B_n and three sellers). As depicted, although seller S_d has some issues in common with buyer B_n, but it has no peripheral issues. Therefore,

this opponent does not satisfy criteria 3 and is not the best opponent to start negotiation with. On the other hand, Sellers S_m and S_x both have some peripheral issues and common issues. Therefore, they satisfy the pre-requisites (criteria) for the third method.

10. CONCLUSION

In this paper the impact of issues' kinds on features of negotiation methods has been analyzed. To have a sensible analysis, we have categorized negotiation methods based on the kind of issues that can attend in each one. Therefore, we could easily investigate how each one would be different with others in regard to its features. After extracting each method's features, we concentrated on the fact that methods' features can be considered as a determining factor for choosing the best method. In other words, each agent prefers the negotiation method that mostly adapts with its considered features. In addition to choosing the dominant negotiation method, the proposed architecture of this paper focused on finding the most suitable opponent for each agent. To do so, by applying an inference engine, the opponents that accept negotiating with the selected negotiation method and finally those that satisfy the method's criteria will be chosen.

It is worth to mention that this work can be extended in several directions:
First, the impact of other effective factors on negotiation process can also be analyzed. A more sophisticated branch of work could be where the impact of all the factors will be analyzed together, simultaneously, and in a unique context.
Second, in contrast to static ranking of this paper, it could be possible to consider different weights for various features. For instance, if importance of one feature is twice the other features, a weight (here 2) will be multiplied by that feature's rank in table 2.
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