

Preference Ordering in Agenda Based multi-issue negotiation for Service Level Agreement

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Abstract—This paper discusses multi-issue negotiation between agents such as providers and consumers in a group decision making environment. The outcome of such encounters depends on two key factors: the agenda (the set of issues associated with the service) and the negotiation procedure (how to settle the issues). In a multiple-issue negotiation process it is difficult to reach an optimal outcome when the two agents' preferences and the relative importance of the issues to them are not known to each other. This paper investigates the multi-issue decision making problem where preference information on issues associated with services are expressed in different formats by the consumers. A fuzzy preference concept is used to order the issues in the pre-negotiation stage to improve the efficiency of the outcome. Finally we propose an approach where the preference ordering is used in an agenda based multi-issue negotiation process for service level agreement.

Keywords-multi-issue negotiation; preference ordering; agenda; service level agreement;

I. INTRODUCTION

Negotiation is a well-known approach for resolving conflicts in human and agent societies. With the rapid growth of E-commerce, research in group negotiation has become increasingly important [1]. Multi agent multi-issue decision making problems arise in many real world situations since groups instead of individuals make more and more decisions in a fast changing world. Agents may bargain over a single issue associated with the service, but negotiations often involve bargaining over multiple issues [2]. Negotiating over multiple issues produces complex situations and makes it difficult for the providers and consumers to reach an agreement during the negotiation phase. In this paper we are going to propose an approach to minimize these complexities.

There are two issues that are important in a multi-issue decision making problem: one is to make negotiation strategy more efficient in order to deal with multiple issues, and the second is to design a mechanism such that a solution or agreement can be reached which will be agreed by the group. For technical considerations there are three factors which are important: information, protocol, procedure and strategy [3]. The approach of the paper is to present a pre-negotiation protocol or strategy which deals with the different preference information expressed by the consumers on the issues or attributes associated with the

service. Each consumer gives their own importance over the issues. The participating agents and the service provider have no prior knowledge about the preferences over the issues of the other agents. This situation is common in E-commerce negotiations, where the number and diversity of agents is so large that an agent may not have any estimate about the preferences of any particular agent it is negotiating with. This can end up with inefficient agreements [4]. In this situation aggregated preference information can be used to reach agreements beneficial for both agents. Preference ordering methods are used to obtain the aggregated result. In some real life scenario the negotiation issues can be interdependent to each other but in this paper we assumed that the issues are independent and are negotiated sequentially.

During the multi-issue pre-negotiation process a Service Level Agreement (SLA) structure can help to build a communication bridge between the providers and consumers. In a multi-issue negotiation scenario it is necessary to deal with different clients who have different requirements. So a provider can build a SLA template and use that template with the consumers during the process. The SLA makes the communication process much easier and more clearly structured for the agents [5]. In this paper we present a consensus process for multi-issue decision making problem using a SLA approach along with preference ordering in the pre-negotiation stage to help to build an effective negotiation protocol or strategy.

This paper is organized as follows: Section II presents the brief description of the related work. The proposed approach is discussed in Section III. In Section IV, an example is used to illustrate the proposed approach.

II. BACKGROUND STUDY

The factors that we will discuss in this paper are: the set of issues; the different formats of preference information expressed by consumers, and, the ordering of the negotiation issues. In multi-issue negotiation, the outcome depends on two key factors: the agenda (i.e., the set of issues under negotiation) and the negotiation procedure (i.e., whether the issues are discussed together or separately) [6]. The agenda specifies what issues should be included in the negotiation while the negotiation procedure specifies how the issues on the agenda will be settled. In the exiting

literature there are three ways of negotiating multiple issues: One approach is to settle each issue sequentially and independently of all the other issues. This is called issue-by-issue or sequential negotiation [2, 7]. The second approach in multi-issue negotiation is to bundle all the issues and discuss them simultaneously [2, 8]. Another approach is to discuss all the issues together as a package deal where the issues are interdependent with each other. Although issue-by-issue negotiation minimizes the complexity of the negotiation procedure, an important question that arises is the order in which the issues are bargained. The equilibrium outcome strongly depends on the order in which the agreements are arrived at. This ordering is called the negotiation agenda. The order in which issues are negotiated in issue-by-issue negotiation is specified by the agenda, There are two ways of defining the agenda: exogenously or endogenously. If the agenda is determined before the actual negotiation over the issues begins, then it is said to be exogenous [9, 10]. On the other hand, for the endogenous agenda, the agents decide what issue they will settle next during the process of negotiation [10].

Fatima et al. [11] proposed an optimal agenda based framework for multi-issue negotiation to improve the utilities of both agents, by exploring the opportunities of joint gains, using a trusted mediator agent. They have considered the situation under incomplete information where one agent does not have complete information about other agents' preferences. The problem in this solution is to find a trusted mediator such that agents will feel free to reveal their true preferences. Also, this mediator has to be unbiased. In the real world, agents may not feel secure and comfortable in revealing information to any third party. Some other research has also proposed [12] the use of mediator agents for exploring an efficient agreement. In this paper we have proposed service level agreement approach to build the communication between the agents and exchange information without a mediator.

Fatima et al. in another paper [13] have proposed a model for multi-issue negotiation under time constraints in an incomplete information setting. In their agenda-based model, the order in which issues are bargained over and agreements are reached is determined endogenously, as part of the bargaining equilibrium. This allows the bargainers to decide which issue they will negotiate next during the process of negotiation. But in the research they have not used any specific mechanism to determine the ordering of the issues and this effects the efficiency of the equilibrium outcome in some scenarios. So when the conflicting preferences between the agents occur during the negotiation the proposed process delays the negotiation timeline and maximizes the search space. To improve this situation we have used preference ordering methods. In a multi-issue negotiation process, the information about the issues provided by the consumers can be of a diverse nature. As every consumer has their own ideas, attitudes, motivations and personality, it is quite natural to think that different

consumers will provide their preferences in different ways. The information can be represented by means of preference orderings, utility functions, linguistic variables, fuzzy selected subset of all the issues and fuzzy preference relations. The information has to be made uniform. Most of the existing models [14, 15, 16] have used fuzzy preference relations as the base element to make the information uniform. We have also used fuzzy preference relations in our model because the use of this concept in decision making situations to present consumer's opinion about issues, appears to be a useful tool in modeling decision processes.

In our proposed approach we consider agendas that are set entirely exogenously and in which all the issues are considered one by one. The negotiation should allow agents to express the issues that they want to negotiate. Multiple issues normally form a large and complex search space. In multi-issue negotiation it is difficult to reach an optimal outcome when the agent's preference and relative importance of the issues are not known to each other or when they have different opinions over the issues [11]. Different opinions among the agents can occur during the negotiation which delays the negotiation timeline. Preference ordering in agenda based negotiation can be a technique to minimize the negotiation delay time and the search space. It can be used in a pre-negotiation stage to overcome these problems.

In the exiting work on multi-issue negotiation research investigations have not used any specific mechanism or preference ordering method in an agenda based negotiation process to determine the ordering of the issues in different stages.

III. THE PROPOSED APPROACH

In a highly competitive business environment, quality of service is one of the substantial aspects for differentiating between similar service providers. The quality of service depends on several issues related to the service and also on the communication process between a provider and a consumer. Before starting the negotiation process, selecting the right party and gaining a good understanding among the providers and consumers became a major task. In a multi-agent multi-issue negotiation process there are various interaction and decision mechanisms such as game-theoretic analysis, heuristic based approaches and argumentation-based approaches [3]. But a well defined negotiation contract or agreement which identifies and defines the customer's requirements, provides a framework for understanding, simplifies complex issues, reduces areas of conflict, eliminates unrealistic expectations can be a useful communication technique [5]. Service Level Agreement can be used to fulfill these requirements. In the proposed approach the service providers start the pre-negotiation process with the service consumers by initializing a service level agreement. This illustrates the type of the service and it establishes an environment which lets the providers and

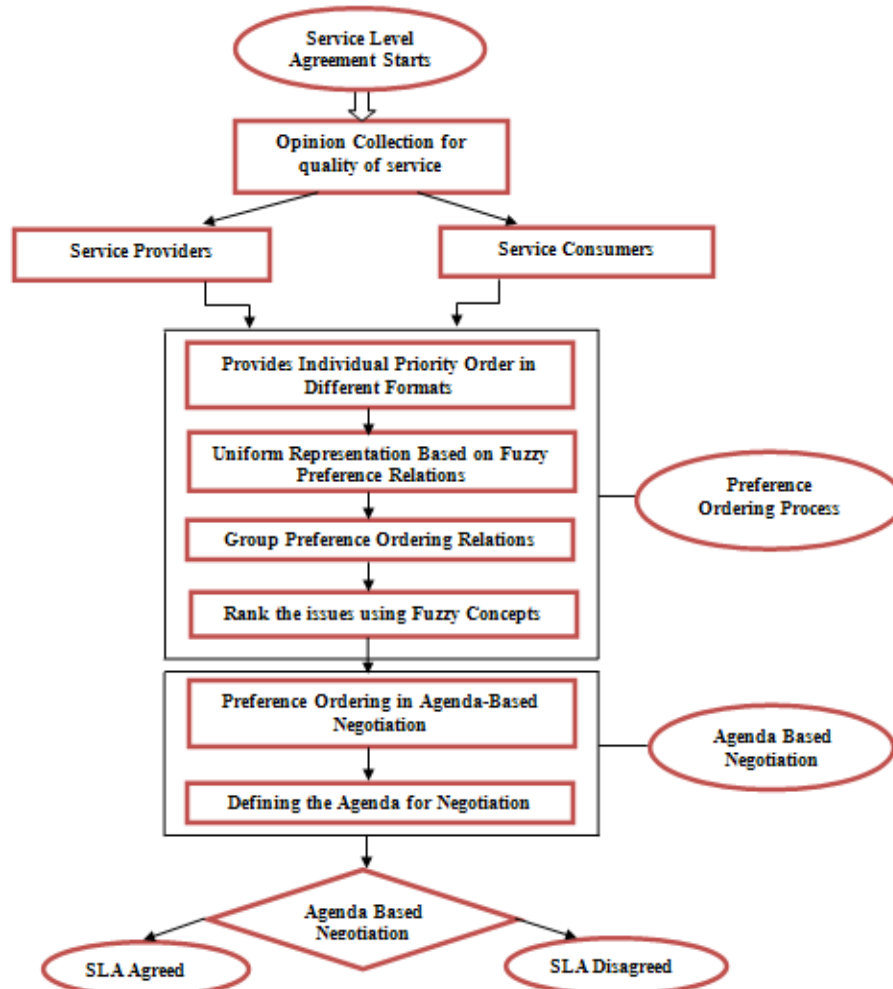


Figure 1. Proposed System

the consumers to participate in the group discussions more equally and actively [17].

After starting the SLA, a mediator on behalf of the provider collects the opinions from the consumers where each consumer expresses his/her priorities for the issues. The consumers may adjust their initial preferences according to their judgments and then present their individual preferences for group decision which is the major and important part in the preference ordering process. The proposed approach provides a mechanism for group decision makers to express their individual preferences in different formats based on their own attitude, motivation, personality and background. The preference formats provided to the consumers in the group decision making process are: preference ordering or ordered vector, utility vector, normal preference relation, fuzzy preference relation, fuzzy selected subset, selected subset, multiplicative preference relation [16]. In preference ordering or ordered vector the issues are ordered from best to worse. Each issue is assigned a numerical value between

[0, 1] by the consumer in utility vector format. Selected subset [16] is one of the individual preference formats where issues are selected from the basic issue set and compose a subset. In fuzzy preference relation [16] the consumer's preference relation is described by binary fuzzy relation where the binary relation denotes the preference degree of one issue over other the issue. Often the consumers use their subjective judgments to express their preferences. Fuzzy linguistic terms that contain various degrees of preferences are used to help the consumers to express their opinions more accurately when he/she is in complex or fuzzy situation. This kind of preference are called vector of linguistic variables [14].

Different types of preference information need to be made uniform or transformed into a common preference format to reach a group decision. The fuzzy preference relation has suitable qualities in aggregation and for generality [16]. That is the reason why the proposed approach uses the fuzzy preference relation as the base element of the uniform representation. There are various

transformation functions which are used to transform preference ordering or ordered vector, utility vector, normal preference relation, selected subset and multiplicative preference relation into a fuzzy preference relation [16].

Once the individual preference information of different preference formats are transformed into fuzzy preference relations, the next step is to aggregate these uniformed fuzzy preference relations. There are several ways to aggregate these individual fuzzy preference relations but the Ordered Weighting Operator (OWA) [18] is one of the most effective and common method used among them. From this set of relations, the collective fuzzy preference relation is derived. The aggregation phase, which is one of the steps of the selection process, defines a collective fuzzy preference relation. Using the concept of fuzzy majority represented by a fuzzy linguistic quantifier and applied in the aggregation operations by means of an OWA operator, a collective fuzzy preference ordering relation is obtained from the preference ordering relation set [19]. It indicates the global preferences between the issues to be ordered. In our approach a group preference matrix is obtained by using this OWA operator and fuzzy linguistic concept.

Next step of the process is the choice method. Two fuzzy quantifier-guided choice strategies are applied on the collective group preference matrix to rank the issues or order the issues. The two quantifier guided choice degrees of issues, based on fuzzy majority concept and OWA are: quantifier guided dominance degree and quantifier guided non-dominance degree [16]. Quantifier guided dominance degree (QGDD) is used to quantify the dominance that one issue has over all the others in a fuzzy majority sense. On the other hand quantifier guided non-dominance degree (QGNDD) presents degree in which each issue is not dominated by a fuzzy majority of the remaining issues. Once the QGDD and QGNDD are obtained a selected set of issues are obtained either applying both of them sequentially or a using conjunction selection process which is the intersection of the two sets or using any of them [16]. The ranking of the issues are then generated for the next negotiation phase.

Determining the agenda is one of the most important structural aspects of multi-issue negotiation as well as a significant determinant of negotiation power and influence [20]. Negotiation agenda impacts the outcome of the process [6]. So it is important to decide it before the actual negotiation. In the proposed system a pre-negotiation strategy is produced where the agenda is determined. The issues related to negotiation agenda are: the scope of the agenda, agenda sequence, framing the agenda and the agreement [20].

- The scope of the agenda: the list of the issues that the service provider and the consumers agree to discuss. The list of the issues can be drawn up by using the experience of the providers in their previous negotiations. In this proposed approach the issues associated with the service are determined at the start of the negotiation for the preference ordering method.

- Agenda sequence: once the issues are decided, they are then ordered. The issue-by-issue approach is chosen in this part. Among the two types of agendas: exogenous and endogenous; we select exogenous agenda where the issues are settled or ordered in the pre-negotiation stage.
- Framing the agenda: it is basically structuring the agenda or the presentation of the issues. In decision making problems this can help the consumers to avoid confusion and accept proposals which are seen as a potential gain rather than a likely loss.
- Agreement: this proposed approach determines a group consensus from the individual consumer's opinions. Then an agenda based process is performed. The group preference ordering or ranking of the issues may differ from the individual opinion. The way in which the order is arrived at however will minimize any problems caused by these differences.

This is how preference ordering is used along with agenda based negotiation to establish a pre-negotiation protocol.

IV. ILLUSTRATIVE EXAMPLE

The following example is used to illustrate the proposed approach. Suppose a set of consumers plan to buy or use a service from a service provider. The service provider provided a set of issues associated with the quality of service to the consumers to evaluate them. Suppose there are six consumers C_1, C_2, C_3, C_4, C_5 and C_6 who are asked to express their opinions on the following issues: price (I_1), availability (I_2), reliability (I_3) and performance (I_4). The service provider offers the consumers the various preference formats to express their opinions. The consumers can then use any one of the preference formats discussed above.

C_1 and C_2 give their opinion in preference ordering format: an ordered vector is used by C_1 and C_2 to express her/his preference on issues. These issues are ranked from the most important to the least important. In this example the issue I_2 is the highest rank for C_1 , while issue I_4 is the lowest. For C_2 the issue I_4 is the highest and I_3 is the lowest.

C_3 provides an opinion in terms of a utility vector: a utility value between $[0, 1]$ is assigned to the issues by the customer C_3 .

C_4 and C_5 use linguistic terms: A set of fuzzy linguistic terms are used by the consumers which are provided by the providers. So the consumer is asked to select their priority from terms "very high", "high", "medium", "low", or "very low". Such linguistic values can be represented using fuzzy triangular numbers [16]. The support of the fuzzy numbers is a priority from zero to one. In this paper the following representations of the linguistic terms are used: "very high" $(0.8, 1, 1)$, "high" $(0.6, 0.75, 0.9)$, "medium" $(0.3, 0.5, 0.7)$, "low" $(0.045, 0.05, 0.25)$ and "very low" $(0, 0, 0.2)$.

C_6 express his/her preference by a binary fuzzy relation which denotes the preference degree of one issue over other. Therefore the information given by the consumers can be represented as:

$$C_1: O^1 = \{3, 1, 2, 4\}$$

$$C_2: O^2 = \{2, 3, 4, 1\}$$

$$C_3: U^3 = \{0.3, 0.7, 0.9, 0.6\}$$

$$C_4: L^4 = \{\text{“very high”}, \text{“medium”}, \text{“low”}, \text{“very high”}\}$$

$$C_5: L^5 = \{\text{“medium”}, \text{“very high”}, \text{“low”}, \text{“high”}\}$$

$$C_6: P^6 = \begin{pmatrix} 0.5 & 0.6 & 0.8 & 0.5 \\ 0.4 & 0.5 & 0.6 & 0.3 \\ 0.2 & 0.4 & 0.5 & 0.1 \\ 0.5 & 0.7 & 0.9 & 0.5 \end{pmatrix}$$

In order to aggregate individual preferences to group decision, different preference formats are standardized into a common format. Here a fuzzy preference relation is selected by the provider as the common format [16, 21]. Using various transformation functions the preference ordering, utility vector and linguistic vector are uniformed into fuzzy preference relation [16], so we have the following matrices:

$$P^1 = \begin{pmatrix} 0.5 & 0.16 & 0.33 & 0.66 \\ 0.83 & 0.5 & 0.66 & 1 \\ 0.66 & 0.33 & 0.5 & 0.83 \\ 0.66 & 1 & 0.83 & 0.5 \end{pmatrix}$$

$$P^2 = \begin{pmatrix} 0.5 & 0.66 & 0.83 & 0.33 \\ 0.33 & 0.5 & 0.66 & 0.16 \\ 0.16 & 0.33 & 0.5 & 0 \\ 0.33 & 0.16 & 0 & 0.5 \end{pmatrix}$$

$$P^3 = \begin{pmatrix} 0.5 & 0.15 & 0.1 & 0.2 \\ 0.84 & 0.5 & 0.37 & 0.57 \\ 0.9 & 0.62 & 0.5 & 0.69 \\ 0.8 & 0.42 & 0.30 & 0.5 \end{pmatrix}$$

$$P^4 = \begin{pmatrix} 0 & 0.8 & 0.94 & 0.5 \\ 0.2 & 0 & 0.8 & 0.2 \\ 0.05 & 0.2 & 0 & 0.05 \\ 0.5 & 0.8 & 0.94 & 0 \end{pmatrix}$$

$$P^5 = \begin{pmatrix} 0 & 0.2 & 0.8 & 0.30 \\ 0.8 & 0 & 0.94 & 0.64 \\ 0.2 & 0.05 & 0 & 0.1 \\ 0.69 & 0.36 & 0.9 & 0 \end{pmatrix}$$

In the aggregation phase a collective preference relation $P^c = (p^c_{ij})$ is obtained by means of the aggregation of all individual fuzzy preference relations $\{P^1, P^2, P^3, P^4, P^5, P^6\}$, which specifies the overall preference between every ordered pair of issues. Here $p^c_{ij} \in [0, 1]$ is the individual value in the matrix, represents the degree to which one issue has over another issue. Fuzzy linguistic quantifier that represents the concept of fuzzy majority and OWA operator is used to aggregate the consumers' individual opinions [18]. Fuzzy majority can be expressed by a fuzzy linguistic quantifier, such as “most”, “at least half”, “as many as possible” with the pairs or parameters (0.3, 0.8), (0, 0.5) and (0.5, 1) respectively [15]. The corresponding weight vector is calculated from these quantifiers. In this example we

illustrate the “most” fuzzy quantifier and the corresponding OWA operator with the weighting vector, $W = [0, 0.066666667, 0.333333333, 0.333333333, 0.266666667, 0]$ to obtain the collective fuzzy preference relation:

$$P^c = \begin{pmatrix} p^c_{ij} & & & \\ 0.5 & 0.35 & 0.67 & 0.39 \\ 0.54 & 0.5 & 0.65 & 0.38 \\ 0.22 & 0.30 & 0.5 & 0.12 \\ 0.56 & 0.52 & 0.71 & 0.5 \end{pmatrix}$$

The next step is the selection process. In this phase the group preference about the issues is transformed into a global ranking. The provider can use different selection approaches to obtain the order of the issues. In our approach the provider decided to use two fuzzy quantifier-guided choice strategies to select the issues, based on the concept of fuzzy majority and OWA operator. The QGDD and QGNDD are calculated for the issues from the collective preference matrix P^c and the weighting vector $W = [0.066666667, 0.666666667, 0.266666667]$, which is generated from the corresponding OWA operator. We have chosen the “most” criteria. It may be the best choice here. The QGDD and QGNDD of the issues acting over the collective fuzzy preference relation supplies the following values:

	price	availability	reliability	performance
QGDD	0.40	0.51	0.20	0.56
Rank	3	2	4	1
QGNDD	0.83	0.96	0.51	1
Rank	3	2	4	1

Here QGDD may be interpreted as the degree to which an issue dominates “most” issues when compared against “most” criteria. On the other hand, QGNDD may be interpreted as the degree to which an issue is not dominated by “most” issues when computed against “most” criteria [15]. QGDD and QGNDD give the preference orders respectively:

$$\text{performance} > \text{availability} > \text{price} > \text{reliability}$$

$$\text{performance} > \text{availability} > \text{price} > \text{reliability}$$

When the information is consistent we get the same ordered vector of issues using QGDD and QNGDD, which are independent of the linguistic quantifier used. In this example both results came out same. On the other hand, when the information is not consistent then both can give a different ordered vector of issues. In that situation it depends on the provider's attitude which sequence is chosen. The QGDD reflects the positive attitude of the consumers where reward is given to as many as possible opinions. On the other hand QNGDD process is applied if the provider decides to offend as few people as possible. That means fewer people may disagree with it. The provider may also have his/her own opinion on the issues. Suppose the priority order is {“high”, “medium”, “medium”, “very high”}. This set of preferences can be added to the set of consumer opinions. Reworking the above calculations the following preference order can be derived:

performance > price > availability > reliability

So the provider can compare this preference order with consumers collective preference order, which will also allow the provider to participate in the group consensus. The provider, collects the opinions and then decides the agenda which would be offered to the consumers based on the calculations he/she has done.

CONCLUSION AND FUTURE WORK

This paper presents an approach to build a pre-negotiation protocol which includes preference ordering and agenda based negotiation process. This approach gives the decision makers flexibility to express their opinions on the issues in different preference formats. The different preference formats are then transformed into a unique format which is fuzzy preference relation. Fuzzy concepts are used to aggregate the individual preferences into a group preference ordering relation. Then finally to determine the global ranking of the issues, two fuzzy quantifier guided selection processes: dominance degree and non-dominance degree are applied. This preference ordering of the issues helps to build up an agenda based negotiation process which leads the consumers and the providers towards a Service Level Agreement. The future work has several directions. In this paper we have assumed that all the consumers have the same importance on giving their opinions over the issues. But such scenarios may occur where relative importance might be given to the individual consumer as well as the provider. The consumers' opinions mainly influence the group decision in this particular example. So in future we plan to design a mechanism that allows both the consumer and the provider to express their opinions with relative importance. These steps will be then available for a complete agenda based negotiation process.

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