Computer-Mediated e-Negotiation Support System

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Abstract

Ensuring adequate involvement of stakeholders is an important element in a participatory decision-making. Previous efforts to incorporate the preferences from stakeholders mostly focused on providing adequate communication between decision makers and stakeholders, not among stakeholders themselves. A different approach to involve stakeholders in planning and decision making is by providing them with an interaction platform to enable them interact in a negotiation-based decision making. In this paper, we introduce a new method to develop a Computer-Mediated Negotiation Support System, where stakeholders do not interact directly, but mediated by a computer system. The negotiation protocol in our system is as follows; in each round of negotiation, stakeholders made their proposals. Based on the proposals of other stakeholders, the system suggests a new proposal for each stakeholder using Orthogonal Strategy. Stakeholders then have a choice to use this proposal or use his own for the next negotiation round. Negotiation then continues until reaching an agreement or time limit.

1. Introduction

Recognition of the importance of stakeholders' involvement in planning and decision making processes has grown rapidly in the last two decades, especially since the formulation of the Local Agenda 21 (LA21) during the 1992 Rio Summit. According to LA21, participation that can ensure stakeholders involvement is an important element of decision making. We can distinguish two forms of relationship between government and stakeholders in urban planning and decision making, which are "consultation", where government seems open for suggestions but simply rejects the ones that do not meet their preferences, and "participation", where there is a certain degree of power sharing between government and stakeholders (Bickerstaff, Tolley et al. 2002).

Previous efforts to involve stakeholders mainly evolved in the "communicative paradigm" (Healey 1992), which assumes decision making will be improved if decision makers communicate better with stakeholders (Appleton and Lovett 2005). This approach of learning and listening is still not enough to improve stakeholder involvement (Fischler 2000). Thus, it is necessary to develop a method of stakeholders involvement in decision making which allows stakeholders to communicate their difference through equal participation in the process of decision making (Ataov 2007).Planners can provide an interaction platform based on the problem stakeholders are facing, so they can independently, collectively and cooperatively develop solutions.

The starting point of any effort to provide stakeholders with an interaction platform is to define the type of decision making. Three types of decision making(Raiffa 1982): Individual, Separate and Interactive, and Joint Decision Making. The latter two types can be considered as a Plural Decision making, as seen in Figure 1.

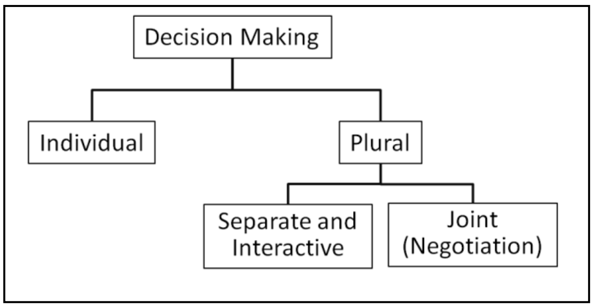

Fig. 1. Decision Making Perspectives (Raiffa 1982)

In Individual Decision Making, each stakeholder decides individually. This may result in a conflict between decision makers. Individual Decision making can also produce a single decision set by a supra decision-maker such as government institution or planner. The main drawback of this type of decision making is that stakeholders' preferences are summarized by the supra-decision maker, making it difficult to trace back, relate, or compare the final decision to the preference of each individual Stakeholder. The second type of decision making is Separate and Interactive decision making. In this case, stakeholders made their own decision based on their preferences and interaction with other stakeholders, which may lead to different decisions. The most common example of this type of decision making is Game Theory.

The last type of decision making is Joint Decision Making, where a single final decision is produced as the result of negotiation among the stakeholders. The main advantage of this approach is that stakeholders are well aware about their own initial preferences, differences between them, and how their preferences are converging along the negotiation. This is very useful if we want to explore the behavior of stakeholders involved in the decision making process and use this information to improve negotiation processes. For example, a supra decision maker such as planners and government institutions can approach certain stakeholders who became a stumbling block during the negotiation. Based on the above discussions, we consider that negotiation-based planning and decision making is the most promising method to improve stakeholders' involvement.

Recent advances in computer science offer a better way to support multi-issue, multi-stakeholder negotiation processes, especially by significantly reducing the time required for negotiation. Beginning in the late 1980s, researchers have explored a new field of study, namely Negotiation Support Systems (NSS) with applications in a variety of domains, such as economics, social science, psychology, and even artificial intelligence (Lao, et al., 2010). NSS is designed to assist negotiators in reaching decisions by providing a means of communication and providing tools of analysis (Bui, et al., 2004). NSS is a special class of group support systems designed to assist negotiating parties in reaching mutually satisfactory decisions by supporting information analysis and communication protocols (Guo, et al., 2007). When developing a Negotiation Support System, two approaches can be applied (Kersten and Lai 2007).

1.1. Computer-Supported Negotiation

The first type of NSS is Computer-supported negotiation, where stakeholders rely on a computer system to reduce the cognitive efforts required in negotiation, thus expanding stakeholders' ability to assess available alternatives and their possible implications. The purpose of a computer system in this type of negotiation is to provide stakeholders with information required for negotiation, which they do not have nor may not able to obtain without computer support, enabling them to have a better understanding of negotiation issues (Kersten and Lai 2007). This type of negotiation requires direct interaction among stakeholders, because the final decision still relies on human cognitive and social interaction. Although direct negotiation offers a better flow of information among the negotiating parties (Galin et al. 2007), this type of negotiation often leads to an ineffective outcome(Rangaswamy and Shell 1997).

1.2. Computer-Mediated Negotiation (e-Negotiation)

The second type of NSS is Computer-Mediated Negotiation or e-Negotiation, where the computer system acts as a human mediator, which actively influences the negotiation process. In this type of negotiation, the computer system identifies differences among stakeholders and possible conflicts, and then suggests directions to reduce them. It also offers potential compromises and proposes concessions which may lead towards an agreement by explaining counterparts' moves and predict their concessions (Kersten and Lai 2007). It has been argued that e-negotiation offers a more direct approach to support negotiation, mainly because e-negotiation helps stakeholders to reach a higher degree of objectivity by separating negotiation issues from the personalities of the stakeholders involved (Carmel et al. 1993).

In this paper, we suggest a Computer-Mediated Negotiation Support System, based on the concept of Orthogonal Strategy. The main advantage of Orthogonal Strategy is its capability to handle multi-issue, multi-stakeholders negotiation in an efficient fashion compared to other negotiation models.

2. Orthogonal Strategy

Previous work related to NSS has used various negotiation models such as The Nash Bargaining Solution (Aggarwal and Dupont 2001; Chan 1988; Liu and Andersson 2004; Rangaswamy and Shell 1997; Sánchez-Anguix et al. 2010), Utility Theory (Faratin et al. 2002; Fatima et al. 2004; Soh and Li 2004), and Bayesian Learning (Buffett and Spencer 2007; Devisch et al. 2006). Although those models have proven to be useful in developing a NSS, they shared a drawback that only a limited number of stakeholders and/or issues can be handled. For example, The Nash Bargaining Solution was specifically designed to handle two stakeholders with one negotiation issue. Utility Theory and Bayesian Learning, on the other hand, are capable to handle multi-issue negotiation but with a limited stakeholders.

We propose the implementation of Pareto-optimal search method, namely Orthogonal Bidding Strategy (Wu et al. 2009), to develop a NSS with built-in capability to evaluate stakeholders' proposals, and suggest a counter-proposal to enable stakeholders reaching an agreement.Orthogonal Strategy is based on the principle that when a stakeholder makes a proposal, he always chooses the value on his current indifferent curve which is closest to a reference point. More specifically, Orthogonal Strategy enables stakeholders to compromise by moving their proposals towards one another. Each stakeholder's proposal can be directly used to guide his opponent's proposal towards an agreement. The orthogonal strategy operates on utility functions (Somefun et al. 2004) of stakeholders involved in the negotiation process. Implementation of the orthogonal strategy will enable a stakeholder to determine which proposal will yield the highest payoff, based on the proposals of other stakeholders and their current desired payoff (Ma et al. 2010). Given a desired utility level and indifference curves, the orthogonal bidding strategy lets an stakeholder choose the proposal which is closest (measured in the Euclidean distance) to the reference point introduced by the last proposal of each opponent on the indifference curve.

An example of Orthogonal Strategy-Based negotiation, involving three stakeholders negotiating over two issues, is explained in (Wu et al. 2009). In the initial state of negotiation, stakeholders do not have the minimum accepted proposal values such as required in other negotiation models, but rather they have to calculate their reference points based on others' proposals. A simple implementation of Orthogonal Strategy can be illustrated as follows:

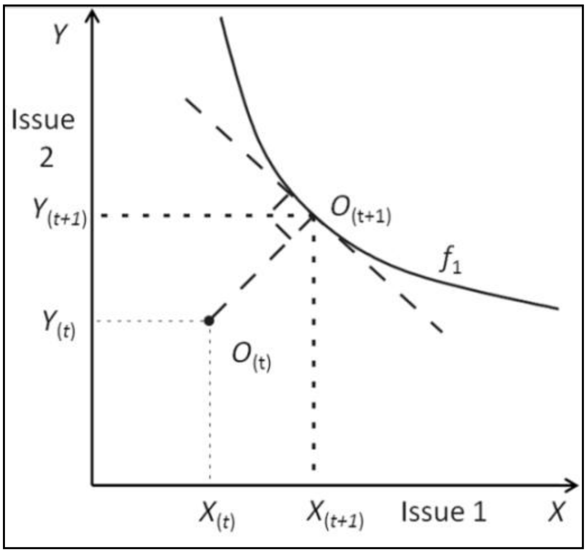

Fig. 2. Orthogonal Strategy (Gerding 2004)

Suppose $(t)^{th}$ proposal, represented by point :

$$O_{(t)} = \left(X_{(t)}, Y_{(t)}\right)$$

Stakeholder 1 will seek for a point on his Indifference Curve f_1 which is closest to $O_{(t)}$, which can be represented as

$$O_{(t+1)} = \left(X_{(t+1)}, Y_{(t+1)}\right)$$

If we consider that negotiation occurs among three or more stakeholders, the proposal for each stakeholder is represented by a reference point based on opponents' proposals. Given the proposals of other stakeholders in negotiation in round (*t*), a stakeholder puts a new proposal in his indifference curve in a sequential manner as follows;

1. Stakeholders put their proposal on their own indifference curve.
2. The system calculates a unique reference point for each stakeholder based on the proposals of other stakeholders.
3. The stakeholders made a counter proposal, which is a point on their indifference curve which lies closest to their unique reference point.
4. The next round of negotiation starts with stakeholders' new proposals, and a new reference point is calculated for each stakeholder.

3. Negotiation Protocol

Before negotiation starts, stakeholders declare their preferences about negotiation issues. These preferences are then used to generate Indifference Curves which represent different utility levels for each bundle of negotiation issues. Negotiation starts by stakeholders selecting a proposal on their indifference curves. The main task of the NSS is to suggest a new proposal to each stakeholder in such a way that stakeholders' proposals are becoming closer to one another. Whenever the system produced a new proposal, stakeholders have the option to accept this proposal or insist on their own proposal. This is to ensure that human negotiators still have some degree of control in the negotiation process. The Negotiation protocol in the proposed system is displayed in Figure 3.

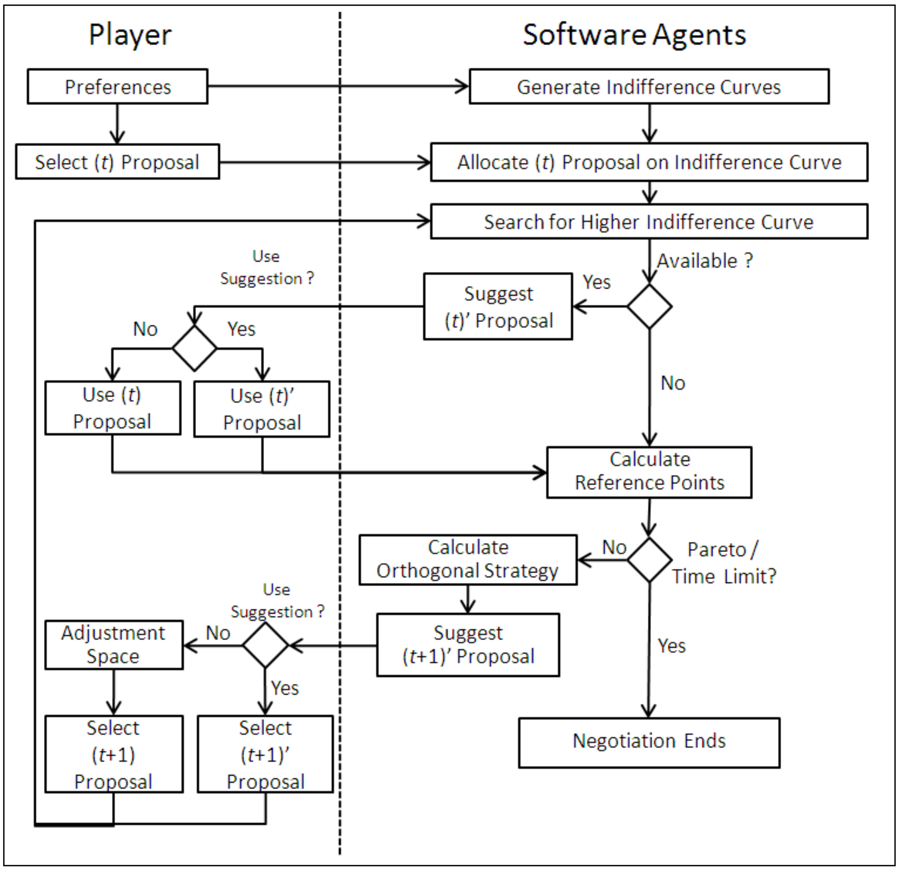

Fig. 3. Negotiation Protocol

3.1. Indifference Curves

Orthogonal Strategy requires stakeholders to have different levels of indifference curves. These curves can be generated by asking them to choose between different options that are systematically varied according to an experimental design. The shape of the curve will depend on the order of the estimated utility function.

Stakeholders may have different indifference curves, due to stakeholders' different opinions regarding negotiation issues. A stakeholder may considers a higher value of an issue to yield a higher payoff, while another stakeholder considers the higher value of the same issue to reduce his payoff.

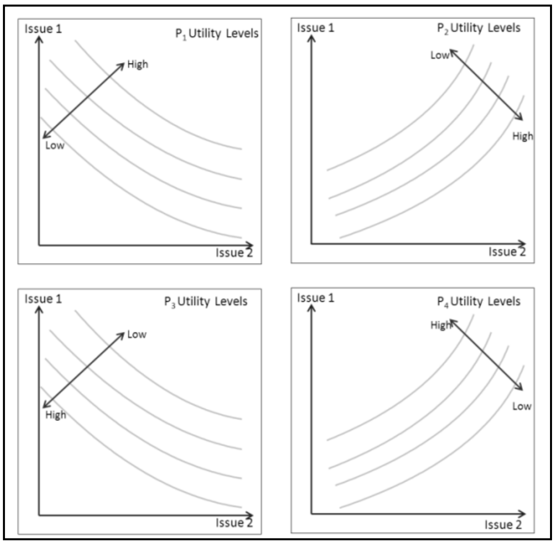

Fig. 4. Different Types of Indifference Curves

Figure 4 shows the four possible combinations of indifference curves, based on stakeholders' opinions regarding the negotiation issues. A stakeholder may consider both negotiation issues will yield a higher payoff if the values of these two issues are increasing (P1), while another stakeholder considers that they will reduce his payoff (P3). Stakeholders can also consider that an increase of value in one negotiation issue will result in a higher payoffs while an increase of value in the other negotiation issue will reduces their payoffs (P2, P4). Before negotiation started, stakeholders put their most preferred proposal on a selected indifference curve, thus allowing the system to calculate their initial differences about negotiation issues.

The main challenge of this approach is stakeholders are required to declare their preferences before negotiation started. Preferences are an inherent requirement for Computer-Mediated Negotiation, because the main role of the computer system is providing suggestions to reduce the differences among stakeholders (Kersten and Lai 2007). Therefore, conflicts or at least some degree of difference among stakeholders must be well-defined before negotiation can take place. This requirement also applies when using Orthogonal Strategy. However, in real-world decision making, stakeholders sometimes withhold their preferences. Therefore, they have to be aware that in Computer-Mediated Negotiation, their preferences are an inherent requirement as the starting point of negotiation.

3.2. Higher Indifference Curves

After stakeholders formulate their proposals and have articulated their preferences or indifference curves, the computer searches for a higher indifference curve without an intersection. If this non-intersecting higher utility indifference curve is found, the computer suggests a stakeholder to move to this indifference curve. The logic behind this step is that in theory, a stakeholder should have no objection to move to a higher utility level because the utility would be higher. However, because human stakeholders need to have a certain degree of control in the negotiation process, they will be provided the option to move to this point or keep their original proposal.

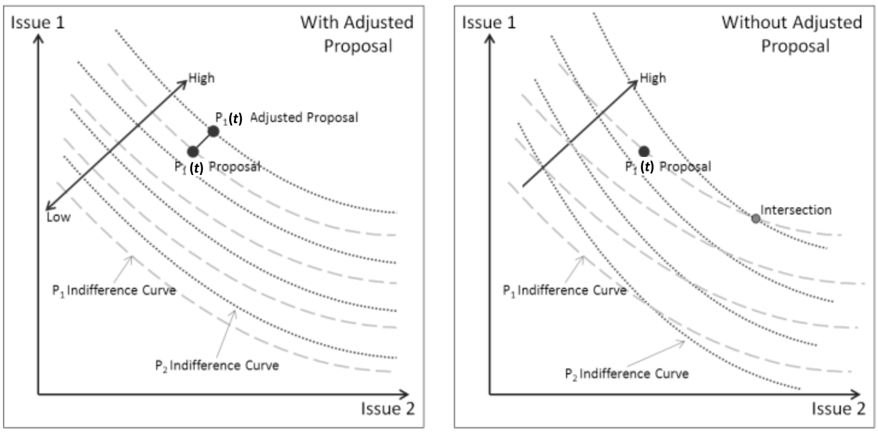

Fig. 5. Search for Non-Intersecting Higher Indifference Curves

3.3. Reference Points

After all stakeholders have submitted their proposals, the next step is to calculate a reference point for each stakeholder. A stakeholder's reference point is defined as a point that has a minimum distance to all other stakeholders' proposals. Thus, the main goal of negotiation is to move reference points as close to one another as possible until reaching a Pareto or time limit. Figure 6 shows how the reference point is calculated. For each stakeholder, the computer will search a point that has a minimum distance from his proposal to all other proposals.

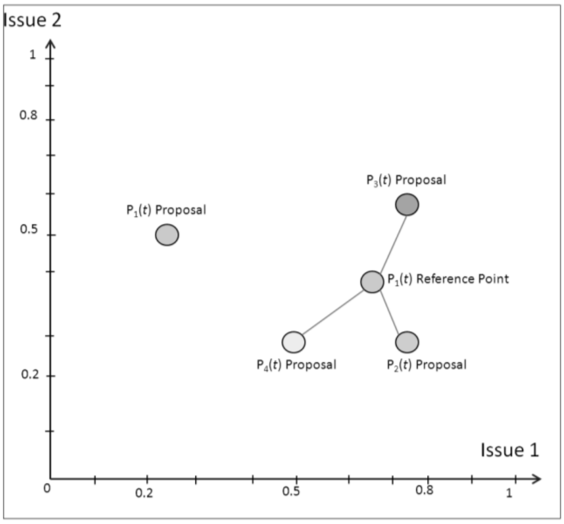

Fig. 6. Reference Point Calculation

For stakeholder i in negotiation round (t), the computer will calculate a point which satisfies;

$$R_{(i)}(t) = min\{\sum d_{(j)}(t)\};\ \forall j$$

$R_i(t)$ = Reference Point for Stakeholder i in negotiation round t
$d_{(j)}(t)$ = Distance between $R_i(t)$ and stakeholder j's proposal in negotiation round t

3.4. Orthogonal Strategy

After the negotiation support system has calculated the reference points for all stakeholders, it derives a proposal for negotiation, which is a point on a stakeholder's indifference curve that lies closest to its corresponding reference point. Human stakeholders then select a proposal for (*t+1*) round of negotiation.

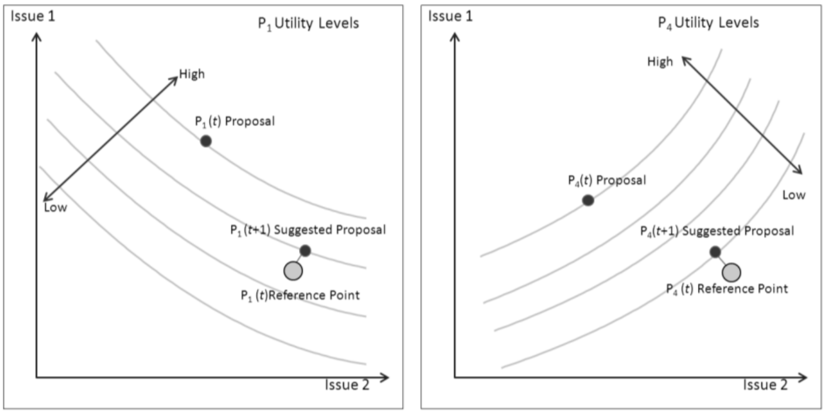

Fig. 7. Suggested Proposal

Figure 7 shows how the suggested proposal is calculated.

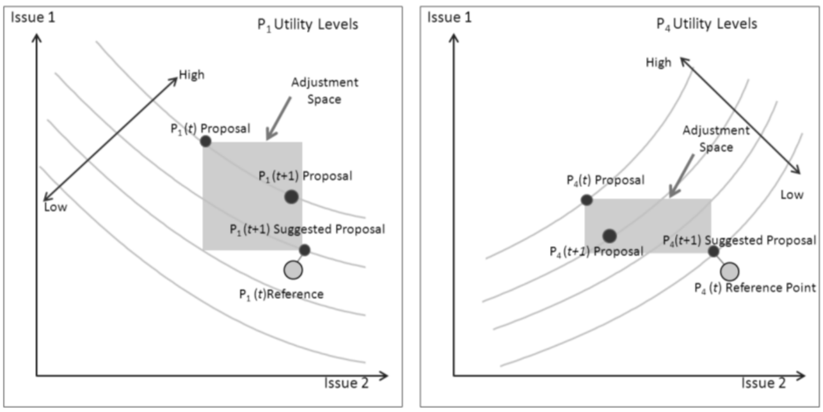

Fig. 8. Proposal Selection.

Although the suggested proposal in theory can improve the outcome of the negotiation, stakeholders have the option to accept the suggested proposal or keep their own for the next round of negotiation. However, to maintain the purpose of negotiation, which is to move stakeholders' proposals closer to one another, stakeholders are required to propose a new proposal within a pre-specified adjustment space.

3.5. Agreement

For each round of negotiation, a Global Reference G(t) is calculated, which is the optimum point for all stakeholders' Reference Points where;

$$G(t) = min\{\sum d_i(t)\}$$

G(t) = Global Reference for negotiation round t
$d_i(t)$ = Distance between Stakeholders i's Reference Point to the Global Reference in negotiation round t

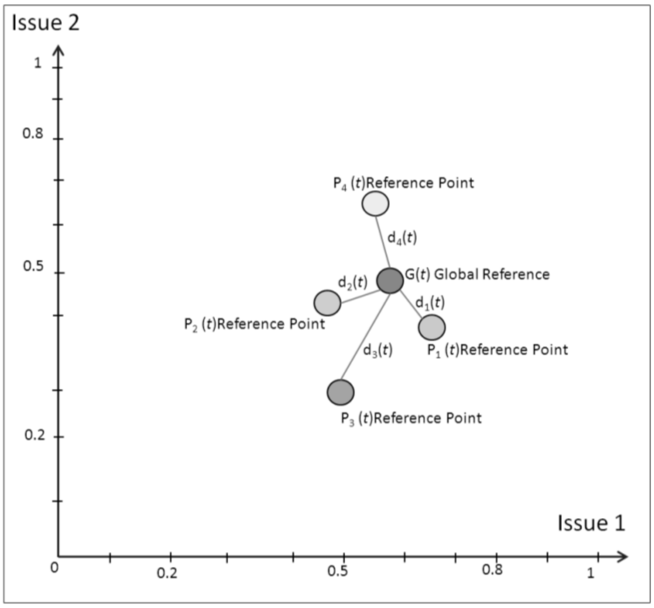

Fig. 9. Global Reference

Because the aim of negotiation process is to minimize $\sum d_i(t)$, the negotiation ends when all stakeholders agree on the same value, thus $\sum d_i(t) = 0$. Negotiation also ends when the value $\sum d_i(t+1)$ is same or higher than the value of $\sum d_i(t)$, or the negotiation process reaches a time limit, in which case it has been unsuccessful.

4. Conclusions and Future Work

In this paper, we have shown how to implement an Orthogonal Strategy in a multi-issue, multi-stakeholder Negotiation Support System. Negotiation in this approach is based on stakeholders compromising their utility until all stakeholders have as equal utility as possible. However, by using Orthogonal Strategy, stakeholders are not always required to lower their utility level, but instead, sometimes they can move to a higher utility level to reach agreement. In each round of negotiation, the negotiation support system seeks for a better proposal for every stakeholder. Because we want that human negotiators still have a certain degree of control in the negotiation, we propose that they should have the option to accept proposals suggested by computer or stay with their own proposal. However, stakeholders are only allowed to make their proposals within a pre-specified adjustment space. In this adjustment space, stakeholders' proposals for the next round of negotiation will move towards convergence. This is different with previous works on e-negotiation, where negotiation mostly is done by computer stakeholders until a Pareto optimum or the time limit is reached. Negotiation ends when the time limit is reached or negotiation reaches Pareto, in a sense that the next round of negotiation cannot move stakeholders' proposal closer one another. Values when negotiation ends then selected as the final decision. To explore how our proposed e-Negotiation Support System works with real life decision making, we need to set-up an experiment involving human decision makers as stakeholders.

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