Integrating artificial intelligence, argumentation and game theory to develop an Online Dispute Resolution Environment

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ABSTRACT

Current research in developing negotiation support systems focuses upon argumentation, artificial intelligence and game theory. These techniques are rarely used in tandem. We argue that truly intelligent negotiation support systems require the integration of such techniques.

In this paper we integrate the argumentation techniques of Lodder and the combined artificial intelligence/game theory approach of Bellucci and Zeleznikow to develop an on-line negotiation support environment.

The environment facilitates the following three steps that lead towards the resolution of the dispute. First, the disputants are advised what dispute resolution mechanisms are effective. In case our Dispute Resolution Environment is amongst those, the parties are invited to start with our online dialogue support tool. If they do not reach agreement on all points, as a next step parties are advised by the negotiation system on a possible sequencing and resolution of the dispute. The second and third steps are, if necessary, repeated recursively until either a solution is reached or a stalemate occurs.

INTRODUCTION

Alternative Dispute Resolution (ADR) refers to procedures for settling disputes by means other than litigation – such as arbitration and mediation. Arbitration is a process of dispute resolution in which a neutral third party (the arbitrator) renders a decision after a hearing at which both parties have an opportunity to be heard. Mediation is a private, informal dispute resolution process in which a neutral third party (the mediator) helps disputing parties to reach an agreement. The mediator has no power to impose a decision on the parties. Such procedures, which are usually less costly and more expeditious than litigation, are increasingly being used in civil, commercial, family and labour disputes.

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[Katsh and Rifkin 2001, p. 25] state that compared to litigation, Alternative Dispute Resolution (ADR) has the following advantages: a) Lower cost; b) Greater speed; c) More flexibility in outcomes; d) Less adversarial; e) More informal; f) Solution rather than blame-oriented; g) Private, and h) Fewer jurisdictional problems. We claim that On Line Dispute Resolution (ODR) has additional benefits: i) Disputants do not have to meet face-to-face: an important factor if the confrontation of parties works contra-productive, e.g. when there has been a history of violence; j) Online mediation can occur at any time, with participants located in different countries.

ADR has moved dispute resolution away from litigation and courts. ODR extends this trend [Clark and Hoyle 2002]. As [Katsh and Rifkin 2001, p. 26] state, the trend toward non-legalistic systems of settling conflict will push mediation and arbitration to the foreground and litigation into the background. Whilst ADR represents a move from a fixed and formal process, ODR, by designating cyberspace as a location for dispute resolution extends this process by moving ADR from a physical to virtual place.

ODR has primarily been developed to resolve e-commerce disputes. The major reason for this is that because the parties concerned already had on-line contact before the dispute arose, access to the internet is not a problem, and the information crucial for the dispute will, most of the time, be available electronically. SquareTrade, for example, has handled over a million of primarily eBay auction cases of which over 75% were settled after automated negotiation.

We believe the development of on-line legal and negotiation decision support systems has led to:

a. Consistency – by replicating the manner in which decisions are made, decision support systems are encouraging the spreading of consistency in legal decision-making.
b. Transparency – by demonstrating how legal decisions are made, legal decision support systems are leading to a better community understanding of legal domains. This has the desired benefit of decreasing the level of public criticism of judicial decision making[4].
c. Efficiency - One of the major benefits of decision support systems is to make firms more efficient.
d. Enhanced support for dispute resolution - Users of legal decision support systems are aware of the likely outcome of litigation and thus are encouraged to avoid the costs and emotional stress of legal proceedings.

The traditional approach towards providing negotiation decision support has been to use game theory. This approach was used by [Nash 1953] and is covered in detail in [Raiffa 1982]. [Jennings *et al* 2001] claim that negotiation theory incorporates a broad range of phenomena and makes use of many different approaches (such as from Artificial Intelligence, Social Psychology and Game Theory). They claim that given the wide variety of possibilities, it should be clear that there is no universally best approach or technique for automated negotiation. Rather, there is an eclectic bag of methods with properties and performance characteristics that vary significantly depending on the negotiation context. To this end, a generic framework for classifying and viewing automated negotiations has been developed. This framework was then used to discuss and analyse the three main methods of approach that have been adopted to automated negotiation; namely, game theoretic, heuristic and argumentation-based approaches.

[Bellucci and Zeleznikow 2001] and [Zeleznikow and Bellucci 2003] have integrated game theory and artificial intelligence to advise upon structuring the mediation process and advising disputants upon possible trade-offs. [Lodder 1999] developed argumentation tools that support disputants to communicate about their conflict.

The negotiation systems of Bellucci and Zeleznikow do not facilitate discussion, whilst the dialogue tools of Lodder do not suggest solutions. Both systems are useful in what they offer to the user, but the weakness of one application is the strength of the other. We therefore combine the dialogical reasoning of Lodder with the game-theoretic based negotiation techniques of Bellucci and Zeleznikow to construct an online dispute resolution environment.

The online dispute resolution environment we are developing facilitates basically the following three steps that should lead towards the resolution of the dispute [Lodder and Zeleznikow 2005]. First, the disputants are advised what dispute resolution mechanisms are effective. In case our Dispute Resolution Environment is amongst those, the parties are invited to start with our online dialogue support tool. If they do not reach agreement on all points, as a next step parties are advised by the negotiation system on a possible sequencing and resolution of the dispute. The second and third steps are, if necessary, repeated recursively until either a solution is reached or a stalemate occurs.

2. APPROACHES TO CONSTRUCTING NEGOTIATION SUPPORT SYSTEMS

2.1 Artificial intelligence approaches

[Sycara 1998] notes that in developing real world negotiation support systems one must assume bounded rationality and the presence of incomplete information. Our model of legal negotiation assumes that all actors

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4 Judges of the Family Court of Australia are worried about criticism of the court, which has led to the death of judges, and physical attacks on courtrooms. They believe enhanced community understanding of the decision making process in Australian Family Law will lead to reduced conflict.

behave rationally. The model is predicated on economic bases, that is, it assumes that the protagonists act in their own economic best interests.

Over the past decade research systems have been developed which use artificial intelligence techniques to provide decision support to human negotiators. Recent work has revolved around modeling negotiation using agent-based methodologies and game-theoretic techniques. Agent-based theory refers to entities that can act independently of other agents. Distributed problem solving [Rosenschein and Zlotkin 1994] refers to systems made up of many agents that co-operate to solve a global problem. For our purposes, agent-based methodologies do not take into account the cooperative modeling aspect of negotiation as it assumes agents can independently resolve the global problem.

Traditional Negotiation Support Systems have been template-based with little attempt made to provide decision-making support. Little attention is given to the role the system should play in negotiations. [Eidelman 1993] discusses two template-based software systems that are available to help lawyers negotiate - NEGOTIATOR PRO and THE ART OF NEGOTIATING. INSPIRE [Kersten 1997] used utility functions to graph offers; while in DEUS [Zeleznikow *et al* 1995] the goals of parties (and their offers) were set on screen side by side. The primary role of these systems is to provide users with a guide to how close (or far) they are from a negotiated settlement.

The earliest negotiation support system that used artificial intelligence was LDS [Waterman and Peterson 1980], which assisted legal experts in settling product liability cases. SAL [Waterman *et al* 1986] helped insurance claims adjusters evaluate claims related to asbestos exposure. These two systems represented the first steps in recognising the virtue of settlement-oriented decision support systems.

MEDIATOR [Kolodner and Simpson 1989] used case retrieval and adaptation to propose solutions to international disputes. PERSUADER [Sycara 1990] integrated case-based reasoning and game theory to provide decision support with regard to United States' industrial disputes. NEGOPLAN was a logic based expert system shell for negotiation support. [Matwin *et al* 1989]. GENIE [Wilkenfield *et al* 1995] integrates rule based reasoning and multi-attribute analysis to advise upon international disputes.

2.2 Game theory and argumentation approaches

[Brams and Kilgour 2001] discuss fallback bargaining. Under fallback bargaining, bargainers begin by indicating their preference rankings over alternatives. They then fall back, in lockstep, to less and less preferred alternatives - starting with first choices, then adding second choices, and so on, until an alternative is found on which all bargainers agree. In this paper, we will discuss a generalisation of fallback bargaining.

Smartsettle [Thiessen and McMahon 2000] assists parties to overcome the challenges of conventional negotiation through a range of analytical tools to clarify interests, identify tradeoffs, recognise party satisfaction and generate optimal solutions. The aim is to better prepare parties for negotiation or to support them during the negotiation process.

[Aakhus 2003] investigates how dispute-mediators handle impasse in the negotiation of divorce decrees. Rather than examine the disputants' arguments, he examines the discussion procedures mediators use to craft the disputant's argumentation into a tool to solve conflict. [Hoz-Weiss *et al* 2002] developed an automated agent that can negotiate effectively with humans. The model used in constructing the agent is based on the formal analysis of their scenario, using game theoretic methods and heuristics for bargaining. [Faratin *et al* 2000] discuss trade-offs made by agents during automated negotiations.

Game theoretic techniques and decision theory were the basis for the AdjustedWinner algorithm [Bellucci and Zeleznikow 1998], which implemented the procedure of [Brams and Taylor 1996]. AdjustedWinner is a point allocation procedure that distributes items or issues to people on the premise of whoever values the item or issue more. The two players are required to distribute 100 points across the range of issues in dispute. The Adjusted Winner paradigm is a fair and equitable procedure. At the end of allocation of assets, each party accrues the same number of points, in a manner similar to that of the Nash equilibrium [Nash 1953]. It often leads to a win-win situation. Although the system suggests a suitable allocation of items or issues, it is up to the human mediators to finalise the agreement acceptable to both parties.

Arising from our work on the AdjustedWinner algorithm, we noted that

1) The more issues and sub-issues in dispute, the easier it is to form trade-offs and hence reach a negotiated agreement;

We should choose as the first issue to resolve the issue on which the disputants are furthest apart - one wants it greatly, the other considerably less so.

2.3 DiaLaw

DiaLaw is a two-payer dialogue game. A dialogue starts if a player introduces a statement she wants to justify. The dialogue ends if the opponent accepts the statement (justified) or if the statement is withdrawn (not justified). The rules of the game are rigid and the language used in the game is formal. This rigidness helps in presenting a clear picture of the relevant arguments. By using special language elements players can, under given circumstances, be forced to accept or withdraw statements. Due to its formal language, DiaLaw is not an easy game to play. However, the ideas underlying DiaLaw make it well suited for supporting a natural language exchange.

[Lodder and Huygen 2001] present an ODR-tool based on the principles behind the construction of DiaLaw. By structuring the entered information, the tool supports parties engaged in an arbitration procedure regarding domain names. They claimed that although the tool was primarily developed to support arbitration, it could be used for other types of ODR, such as negotiation and mediation.

The argument tool operates as follows. Statements are natural language sentences. A party using the argument tool can enter one the following three types of statements.

a) Issue – A statement that initiates a discussion. At the moment of introduction this statement is not connected to any other statement.
b) Supporting statement – Each statement entered by a party that supports statements of the same party.
c) Responding statement - Each statement entered by a party that responds to statements of the other party.

A statement that is entered by the parties is represented as follows: P(E, Q(C)), where P is the party who adds the statement, E is the entered statement, C is the statement connected to E and Q is the player who claimed C. If a statement is an issue, then we have P(E, P(E)). From the definition of the other statements above, it follows that:

P(E,Q(C)) is a supporting statement if and only if $P = Q$;

P(E,Q(C)) is a responding statement if and only if $P \neq Q$.

After a party enters a statement, an element P(E, Q(C)) is added to a set called the games board G. Because an issue is the only statement not connected to other statements at the moment of introduction, it is clear that the first statement added to the games board is always an issue. In the case of arbitration, the first party claims issues and provides support, and when she is finished he hands over the games board to the other party. This party can during her turn add any of the three statement types defined above.

The tool presented here differs from the tool of [Lodder and Huygen 2001], in that it is no longer a game in which parties take turns. Rather, parties can add statements at any given moment, and even simultaneously. We believe that in a mediation session, this is a more natural way of exchanging information, especially in an online environment.

We now illustrate the operation of DiaLaw through an example taken from Australian Family Law.

The implemented argument tool presents issues at the left of the screen, indents supporting statements under the statement they support, and places responding statements to the right side of the statement to which it reacts. For example, the set of G, with H(usband) and W(ife) as the parties:

{H("I want custody", H("I want custody")),

H("I would take good care", H("I want custody")),

W("I want custody", H("I want custody")),

W("I am a better parent", W("I want custody")),

H("In the past I have been good for the children", H("I want custody")),

W("You were working all the time", H("In the past I have been good for the children")}

is presented as follows.

H: I want custody	W: I want custody
H: I will take good care of the children	W: I am a better parent
H: In the past I have been good for the children	W: You were working all the time

The statement "I want custody" is claimed both by H and W. The introduction of identical statements is not unique in negotiation. In existing formal systems, e.g. DiaLaw, this is modeled in two different steps. First W claims that she does not want H to have custody for the kids, and consecutively claims in support of this statement that she wants to have the custody herself. This sequence might be necessary from a formal point of view, but if natural language is used, one cannot expect that the parties will enter the statement in such an unnatural way. In DiaLaw, the dialogue is:

H: custody(h)

W: not(custody(h))

H: ?

W: custody(w)

To our knowledge, in existing formal systems the following dialogue cannot take place.

H: custody(h)

W: custody(w)

The argument tool can handle this sequence of moves, due to the use of natural language (anything can be entered in reaction to a statement by the other party). The tool still helps in showing the structure of the dialogue. Hence, the statement of W is a response to the statement of H; both players can provide support for the statements they introduced.

Another statement that players can claim is similar to that of a question in dialogue games. For example, in response to the previous statements, a player could add the statement “I do not understand why you should get custody”.

Yet another possible response is OK, or I agree. While the parties will notice that agreement has been reached, the tool will not recognize this agreement. This is unnecessary for most statements. However, if the tool is merged with the negotiation support system, it is important to identify any agreement regarding the issues. We do not, however, want to restrict the parties by requiring specific formats for the statements they enter. In the implementation, each introduced issue is accompanied by an OK-button. If a party clicks the OK-button, then the system recognizes that agreement is reached. The following element is then added:

P(OK, Q(C)), given that Q(C, Q(C)) is an element of G.

2.4 Family-Winner

Family-Winner uses Principled Negotiation as the underlying negotiation strategy, in which decision-making is supported by trade-off and compensation strategies. The Issue Decomposition Hierarchy imbedded in the system allows for the incorporation of sub-issues, which forms our attempt to increase the number of issues in dispute. Principled Negotiation Theory advocates ‘Expanding the Pie’ as a strategy to reach agreement. Input is in the form of issues and numerical utilities, which represent the importance disputants’ place on issues. Family-Winner output consists of a list of allocations the system has made.

Family-Winner’s uses Trade-off Maps (a variant of Constraint Diagrams) to represent trade-off opportunities inherent in the issues of a dispute. The system acts upon trade-offs once an issue has been allocated, resulting in both compensation and rewards to the utilities of issues remaining in dispute. The amount by which a party is compensated is decided through a complex set of formulae that have been derived empirically from mediation transcripts provided by the Australian Institute of Family Studies. We analysed the transcripts by setting importance numbers (ratings) to each issue and position pair, from which we were able to developed generalised trade-off rules.

To use Family-Winner, we must assume:

(1) The dispute can be modeled using Principled Negotiation,

(2) That weights can be assigned to each of the issues in dispute; and

(3) That sufficient issues are in contention to allow each side to be compensated for losing an issue.

Users of the Family-Winner system enter information such as the issues in dispute, indications of each issue’s importance to the respective parties and how the issues relate to each other. An analysis of the information is compiled, which is then translated into graphical trade-off maps. The maps illustrate the relevant issues, their importance to each party and the trade-off capabilities of each issue. The system takes into account the dynamics of negotiation by representing the relations that exist between issues. Maps are developed by the system to show the disputant's preferences and relation strengths between the issues. It is from these maps that trade-offs and compromises can be enacted, resulting in changes to the initial values placed on issues.

The user is asked if the issues can be resolved in its current form. If this is the case, the system then proceeds to allocate the issue as desired by the parties. Otherwise, the user is asked to decompose an issue chosen by the system as the least contentious. Essentially the issue on which there is the least disagreement (one party requires it greatly whilst the other party expresses little interest in the issue) is chosen to be the issue first considered. Users are asked to enter sub-issues. As issues are decomposed, they are stored in the Issue Decomposition Hierarchy, with all links intact. This structure has been utilised because we recognise there may be sub-issues within issues on which agreement can be attained. It is important to note that the greater the number of issues in dispute, the easier it may be to allocate issues, since the possibility of trade-offs increases. While this may seem counter intuitive, we argue that if only one issue needs to be resolved, then suggesting trade-offs is not possible.

This process of decomposition continues through the one issue, until the users decide the current level is the lowest decomposition possible. At this point, the system calculates which issue to allocate to each party, then removes this issue from the each of the party's respective trade-off maps, and makes appropriate numerical adjustments to the remaining issues linked to the issue just allocated. The resulting trade-off maps are displayed to the users, so they can see what trade-offs have been made in the allocation of issues. Once all issues at the current level are allocated,, then the decomposition of issues continues in a sequential manner, re-commencing from the top level.

The algorithms implemented in the system support the process of negotiation by introducing importance values to indicate the degree to which each party desires to be awarded each issue. It is assumed that the importance value of an issue is directly related to how much the disputant wants the issue to be awarded to her. The system uses this information to form trade-off rules.

Given that we want an integrated system that provides for both communication and intelligent decision support, it is logical for us to integrate the strategies developed in the construction of both DiaLaw and Family-Winner.

3. THE INTEGRATED TOOL

The proposed integrated tool is described in more detail in [Lodder and Zeleznikow 2005].

3.1 Step one – calculating the BATNA

Some proponents of mediation consider ADR as superior to litigation. On the other hand, some opponents of mediation believe parties should litigate because only then can fundamental rights such as a fair trial be truly guaranteed [Alexander 1992]. We do not consider mediation superior to litigation. For some disputes litigation is the best procedure, for others mediation. The challenge is to develop systems that can advise people on what is the most effective procedure given their dispute type, their intentions and their background, amongst other issues.

A decision to either go to court or to mediate is ideally based on a well-informed choice. Currently the necessary information to make such a decision is often lacking. One of our aims is to provide litigants with information about the expected outcome of court proceedings; in the legal negotiation literature this is called a BATNA. Data mining techniques or Semantic Web Technology can be used to determine a BATNA. At this moment there is no generic tool available for determining BATNAs.

The Harvard Negotiation Project introduced the concept of principled negotiation, which advocates separating the problem from the people [Fisher and Ury 1981]. Fundamental to the concept of principled negotiation is the notion of *Know your best alternative to a negotiated agreement (BATNA)*. The reason you negotiate with someone is to produce better results than would otherwise occur. If you are unaware of what results you could obtain if the negotiations are unsuccessful, you run the risk of:

Entering into an agreement that you would be better off rejecting; or

(2) Rejecting an agreement you would be better off entering into.

The first stage of our integrated tool is the provision of a decision support system which advises upon appropriate BATNAs. For example, Split-Up [Stranieri *et al* 1999] is a hybrid rule-based/neural network systems that advises upon property distribution following divorce in Australia. A separate system of justification, using Toulmin Argument Structures [Toulmin 1958] is provided. Whilst Split-Up is not a negotiation support system, it can be used to determine one's BATNA for a negotiation and hence provides an important starting point for negotiations. Split-Up first shows both litigants what they would be expected to be awarded by a court if their relative claims were accepted. It gives them relevant advice as to what would happen if some or all of their claims were rejected. Users are then able to have dialogues with the system to explore hypothetical situations to establish clear ideas about the strengths and weaknesses of their claims.

Suppose the disputants' goals are entered into the system to determine the asset distributions for both W(ife) and H(usband) in a hypothetical example. For the example taken from [Bellucci & Zeleznikow 2001], the Split-Up system provided the following answers as to the percentages of the marital assets received by each party:

	W's %	H's %
Given one accepts W's beliefs	65	35
Given one accepts H's beliefs	42	58
Given one accepts H's beliefs but gives W custody of the children	60	40

Table 1: Disputant goals from hypothetical example

Clearly custody of the children is very significant in determining the husband's property distribution. If he were unlikely to win custody of the children, the husband would be well advised to accept 40% of the common pool (otherwise he would also risk paying large legal fees and having on-going conflict).

Whilst Split-Up is a decision support system rather than a negotiation support system, it does provide disputants with their respective BATNAs and hence provides an important starting point for negotiations. However, more is required of negotiation support systems. Namely they should model the structure of an argument and also provide useful advice on how to sequence the negotiation and propose solutions.

3.2 Step Two – attempting to resolve the dispute through a dialogue

The starting point for the mediation is to form the set of issues in dispute, formally denoted as $D = X \cup Y$ where

$X = \{X_1, X_2, \dots, X_n\}$ is the set of issues that H sees as in dispute; and

$Y = \{Y_1, Y_2, \dots, Y_m\}$ is the set of issues that W sees as in dispute.

The disputants can discuss any of the issues in D. The first statement added to games board is always an issue, $G_1 = \{H(D_1, H(D_1))\}$ or $G_1 = \{W(D_1, W(D_1))\}$.

Following the dialogue they will agree on some issues, say

$A = \{D_1, D_2, \dots, D_r\}$ and disagree on others $N = D \backslash A = \{D_{r+1}, D_{r+2}, \dots, D_k\}$.

So, if $H(OK, W(D_i))$ or $W(OK, H(D_i))$ is an element of G, then D is added to A.

Based on [Bellucci & Zeleznikow 1999], we give an example of a dialog in which agreement is reached. Tom and Mary have decided to divorce. They have two children. The relevant issues can be divided into child-related issues and property and monetary issues. When the operation of the Family-Winner system was demonstrated, the child-related issues were split into the following sub-issues:

- Private school;

- Residency of the children;
- Religion;
- Visitation rights.

Tom starts the discussion by introducing the private school issue. Mary does not understand why the children should go to a private school and therefore asks Tom why this is so important to him. Tom explains that he wants the children to be well educated, and he is afraid that public schools provide an inferior education. After hearing Tom's explanation, Mary says it is okay if the children attend a private school. The current state of the negotiation is as follows, with the sequence of the information exchange being indicated between the brackets.

Tom: Children should go to a private school (1)	Mary: I do not understand why they should (2)
	Mary: OK (5)
Tom: Children should be well educated (3)	
Tom:Public schools provide an inferior education (4)	

Note that Tom introduced support for his position only after Mary asked him to do so, because Tom expected that Mary would automatically accept his position. The dialogue also shows that Tom did not wait for Mary's reaction after introducing the first supporting statement, but introduced the two supporting statements consecutively.

The issue concerning private schools can be placed in the resolution set, and we now use negotiation techniques to resolve the issues in N, which is a subset of D. We use the techniques of [Bellucci and Zeleznikow 2001] to distribute the issues in N.

3.3 Step Three – negotiation support through the use of compensation strategies and trade-offs

If the dialogue turns out to be not entirely successful, H and W are asked to give a significance value to each of the issues in $D = \{D_1, D_2, \ldots, D_k\}$ where $m, n \leq k \leq m + n$ and the sum of significance values for both H and W is 100.

We hence have two sets

$X_D = \{X_{D1}, X_{D2}, \ldots, X_{Dk}\}$ and $Y_D = \{Y_{D1}, Y_{D2}, \ldots, Y_{Dk}\}$ where $\Sigma X_{Di} = \Sigma Y_{Di}$

This information is necessary to initiate the negotiation part of our system.

The final proposed solution might involve sharing some issues (such as selling a property and distributing money or sharing the residency of children) to ensure that each of the disputants receives an equal number of points for the issues in N. It should however be noted, that unlike the situation in [Bellucci and Zeleznikow

2001], the points may not be equally distributed over N. This situation arises because the disputants have resolved issues in A, independently of distributing the issues as advised by the negotiation support system. The reason this is acceptable is because both parties have supported such action in the dialogue model. Whilst such an approach might not distribute points equally, this is not the major goal of our system. Our aim is to have both parties reasonably satisfied, or at least "equally dissatisfied".

[Zeleznikow and Bellucci 2003] decided that rather than using the AdjustedWinner algorithm to distribute points, importance values should be introduced which can then be used to advise upon trade-offs. These values indicate the degree to which each party desires to be awarded the issue being considered. The distribution algorithm is basically as follows.

We first calculate $d_1 = \max \{| X_{Di} - Y_{Di} |\}$

Let us say this value i1 occurs where $X_{Di1} >= Y_{Di1}$ so that X receives the item to be distributed.

Then $X^* = X_{Di1}$ and $Y^* = 0$

Choose $d_2 = \max \{(Y_{Di} - X_{Di}) : i \text{ not equal to } i1\}$, the issue ($D_{i2}$) goes to Y and $X^* = X_{Di1}$ and $Y^* = Y_{Di2}$

Now, If $X^* >= Y^*$, then choose $d_3 = \max \{(Y_{Di} - X_{Di}) : i \text{ not equal to } i1 \text{ or } i2\}$, the issue ($D_{i3}$) goes to Y and $X^* = X_{Di1}$ and $Y^* = Y_{Di2} + Y_{Di3}$

ELSE choose $d_3 = \max \{(X_{Di} - Y_{Di}) : i \text{ not equal to } i1 \text{ or } i2\}$, the issue ($D_{i3}$) goes to X and $X^* = X_{Di1} + Y_{Di3}$ and $Y^* = Y_{Di2}$

This procedure is repeated recursively until the last issue to be distributed is reached. This last issue is distributed equally so that $X^* = Y^*$.

The algorithm is an adaptation of the AdjustedWinner algorithm of [Brams and Taylor 1996] who prove the validity of the algorithm.

3.4 The outcome of the ODR process

If the advice suggested by the negotiation support system is acceptable to the parties, then the dispute is resolved. Otherwise, the parties agree to those issues resolved through the use of the negotiation support system and then return the remaining issues in dispute to the dialogue system.

This process continues until either all issues are resolved or a stalemate is reached. A stalemate occurs when no further issues are resolved on moving from the argumentation tool to the negation support system, or vice versa.

The following scenarios can arise through the use of our online dispute resolution environment:

1. No issues are resolved after use of either the argumentation tool or the negotiation support system and total failure is reported;

2. Some issues are resolved, but a stalemate occurs. One of two scenarios can then occur

   a) Either the parties do not agree to accept the partial resolution of the issues resolved during the process and no progress is reported, or

   b) The parties agree to some or all of the issues resolved during the process and partial success is reported

3. The dispute is resolved and success is reported.

We have suggested that the parties commence with an argument tool. If the parties do not reach agreement on all issues, they can then use the negotiation support system. If the proposal suggested by the negotiation support system is not acceptable, then the argument tool can be used again, to provide additional support, or a response. Moreover, the issues that were introduced when using the negotiation support system can be further discussed.

We could have suggested that the parties commence with the negotiation support system phase. If the system does not suggest an acceptable proposal, then the parties can use the argument tool and discuss one or more (sub)-issues. In case agreement is reached on one or more (sub-)issues, the negotiation support system can be further consulted.

The reason we commenced with the use of the dialogue tool is that if a negotiation support tool is used first the parties are discouraged from conducting a dialogue. It is important that the parties discuss the issues in dispute and become aware of the opposing side's arguments prior to trade-offs being suggested. An important task of a mediator is to have the parties communicate with each other. This task is hindered if a decision support system automatically suggests trade-offs before any attempt at communication or conciliation occurs.

We can imagine, however, that ultimately both the negotiation support system and the argument tool will be offered in the online environment, and it will be left to the parties to decide upon their order of use.

4. Conclusion

Many commentators argue that the most important aspect of ADR is face-to-face communication [Eisen 1998]. However, there are many circumstances where this is either not feasible or not desirable. Examples include but are not limited to:

- Parties that have a history of violent conflict;
- Prisoners in jail, for example complaining about treatment;
- Parties for whom the costs of being in the same room are exorbitant;
- Parties who are in different time zones;

➢ Parties who cannot agree upon a joint meeting time.

In such circumstances, Online Dispute Resolution systems can prove very useful.

The judiciary is faced with enormous case-loads. Therefore, alternative dispute resolution mechanisms such as online mediation are very welcome. This is in particular so if ODR providers can inform the parties about the pros and cons of either going to court or engaging in mediation or arbitration.

In this paper an ongoing project on the development of an online dispute resolution environment based on a three step model was described. The dialog tool as well as the negotiation system described in this paper are of a general nature and can be used in any jurisdiction, for basically any dispute. The first step, calculating the BATNA, is not yet represented in a generic tool. This first step is probably the most difficult one for the development of ODR applications. But it is a really important one.

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