

Building Negotiation Decision Support Systems by Integrating Game Theory and Heuristics

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Abstract

Negotiation is considered in general very context sensitive. Since our research laboratory has successfully developed decision support systems in Australian Family Law, we have used our domain expertise to construct a variety of Family Law negotiation support systems. Family_Winner uses point allocation and heuristics to advise upon structuring the mediation process and provides solutions based on trade-off and compensation strategies. Heuristic utility functions were developed from cases supplied to us by the Australian Institute of Family Studies. Family_Winner operates best when it is possible to allocate points to issues, and creative decision-making is not required. Whilst conducting an evaluation of the Family_Winner system, we observed that Family_Winner, in focusing upon providing advice with regard to bargaining, had neglected considering issues of justice. In a domain such as Family Law, issues of justice are of paramount concern. This indicates that use of negotiation support systems should be limited to domains in which principles of equity do not conflict with user satisfaction. When Family_Winner was used in a variety of other negotiation domains (international disputes, enterprise bargaining and company mergers) the advice offered strongly resembled the eventual negotiated outcome.

Keywords:

Decision Support Systems, Litigation, Negotiation

1. INTRODUCTION

(Ross 1980) states *'The principal institution of the law is not trial; it is settlement out of court'*. Nevertheless, judicial decision-making has a major influence on the outcome of negotiated settlements, because judicial decisions serve as the very basis from which negotiations commence (Williams 1983). Litigation can be damaging to both parties in a dispute. It is a zero-sum game; in that what one party wins the other loses.¹ Mediation can strive to reduce hostility between the parties, to fashion an agreement about tasks each party is willing to assume and to reach agreement on methods for ensuring certain tasks have been carried out. It can lead to a win-win result.²

The Harvard Negotiation Project (Fisher and Ury 1991) introduced the concept of principled negotiation, which advocates separating the problem from the people. 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: (1) Entering into an agreement that you would be better off rejecting; OR (2) Rejecting an agreement you would be better off entering into.

(Sycara 1998) notes that in developing real world negotiation support systems one must assume bounded rationality and the presence of incomplete information. (Searle *et al* 2001) observed bounded rationality in laboratory experiments on bargaining. Our model of legal negotiation assumes that all actors behave rationally, in their own economic best interests.

¹ It is actually worse than a zero-sum game and indeed can often lead to a lose-lose result. This is because of the large legal fees arising from litigation.

² For example if both parties value the list of items in dispute, it is not uncommon (as long as they do not value the items in an identical manner) for each party to receive 70% of their requested points.

(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.

Some recent work on negotiation concerns the area of discourse and argumentation theory. (Walton 1998) defines six main types of dialogues, of which negotiation is one: persuasion dialogue, negotiation, inquiry, deliberation, information seeking and eristic dialogue. Whilst we are aware of the importance of discourse and deliberation systems (especially for the domains of e-democracy and e-government), our aim is to provide negotiation decision support rather than model a negotiation discourse. Of significance to our research is the work of (Weiss *et al* 2002). They develop 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.

In this paper we discuss various approaches we have developed for building negotiation support systems. We confine ourselves to discussing two-party disputes. Since negotiation is domain dependent, we begin by a discussion of negotiation in Australian Family Law. Next we consider two early Family Law Systems we developed – DEUS and Split-Up. DEUS is a template-based system that helps mediators understand the extent of the issues in dispute. Split_Up is a knowledge-based system that advises upon BATNAs.

Family_Winner extends the game-theoretic principles developed by (Brams and Taylor 1996) through the use of trade-off rules and maps to proffer advice upon structuring a mediation and reaching an equitable outcome. Because we hope that the techniques we have developed in Australian Family Law can be generalized to other domains, we conducted two evaluations of the Family_Winner system:

Having family law domain experts analyse the operation of Family_Winner;

Using the Family_Winner system to advise upon non family law cases and then comparing the outcome derived by Family_Winner to the eventual negotiated outcome.

As a result of our research in a), we have noticed that a fundamental conflict can arise when building negotiation support systems in legal domains – is our system concerned with supporting mediation or providing justice? When issues of justice influence the outcome of the mediation process, bargaining theory as developed in Family_Winner has its limitations. We illustrate this issue with examples from the domain of Australian Family Law.

We conclude by discussing how research on negotiation support systems is now focusing upon On Line Dispute Resolution. Examples of current research include plea-bargaining about sentencing in Australia.

2. NEGOTIATION SUPPORT SYSTEMS IN AUSTRALIAN FAMILY LAW

2.1 Negotiation in Australian Family Law

We chose as our domain to model Australian family disputes. Family Law (Ingleby 1993) varies from other legal domains in that in general:

1. There are no winners or losers - save for exceptional circumstances, since following a divorce both parents receive a portion of the property and have defined access to any children.
2. Parties to a family law case often need to communicate after the litigation has concluded. Hence the Family Court of Australia encourages negotiation rather than litigation.

The overriding principle in Australian Family Law is *the consideration of the paramount interests of the children*. Many men's rights groups have claimed Australian Family Law is feminist. Whilst there is no basis for such claims in any legislation, the incontrovertible fact is that following divorce, the place of primary residence for most children is with their mother. Given this fact, and that the Family Court of Australia is obliged to place the interests of children first, it is inevitable that primary caregiver mothers will receive a greater share of marital property than would other women. This is particularly the case in marriages that have minimal financial resources. These principles are significant in developing BATNAs for Australian Family Law Property distribution. They heavily influence bargaining strategies in Family Law mediation.

2.2 Template and knowledge based negotiation support systems

Our first attempt at building negotiation support systems was to build a template-based system, DEUS (Zelevnikow *et al* 1995). In building DEUS, we developed a model of family law property negotiation, which relies upon building a goal for each of the litigants, with the goals being supported by their beliefs. The model

calculates the agreement and disagreement between the litigants' goals at any given time. The agreement and disagreement are only in relation to the goals and hence do not resolve the negotiation. In order to reach a negotiated settlement, it is essential to reduce the difference between the goals to nil.

DEUS helps mediators understand what issues are in dispute and the extent of the dispute over these issues. Whilst DEUS does not perform belief revision nor indeed does not have any intelligent functions, it is very useful in informing disputants as to their level of disagreement. DEUS is not concerned with the principles of justice. Its goal is to indicate the range and significance of issues in dispute.

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 parties. For the example taken from (Bellucci and 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: Split_Up's determination of the Family Law example in (Bellucci and Zeleznikow 2001)

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).

2.3 Game theory based approaches for developing negotiation support systems

(Jennings *et al* 2001) developed a generic framework for classifying and viewing automated negotiations. It incorporates:

1. Game theory
2. Heuristics
3. Argumentation based approaches.

We have used all three techniques in building negotiation support systems. Family_Negotiator (Bellucci and Zeleznikow 1997) is a hybrid rule-based and case-based system which attempts to model Australian family law.

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 implementing 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;
2. 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.

Family_Winner (Bellucci and Zeleznikow 2001) uses both game theory and heuristics. It supports the process of negotiation by introducing importance values to indicate the degree to which each party desires to be awarded the issue being considered. The system uses this information to form trade-off rules.

As it is only at allocation that trade-offs are executed, the details of an allocation will have some input into the resulting changes. It was necessary to obtain some negotiation specific data to provide an insight into what change, and what amount of change was expected as a result of trade-off execution. 650 negotiated and litigated cases, provided by the Australian Institute of Family Studies, were analysed. It was hence discovered the shift in most issues appeared to be similar in number. We analysed the data and set numbers to each issue and position pair, which was then used to empirically develop functions used in trade-off and compensation calculations.

The trade-off rules are used to allocate issues according to the logrolling strategy. The system makes this analysis by transforming user input into trade-off values, used directly on trade-off maps, which show the effect of an issue's allocation on all unallocated issues.

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 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 a decomposition hierarchy, with all links to existing issues 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, as the possibility of trade-offs increases. This may seem counter intuitive, but 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 each of the party's respective trade-off maps, and makes appropriate numerical adjustments to 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 are made in the allocation of issues. When all issues are allocated at the one level, then decomposition of issues continues, re-commencing from the top level in a sequential manner.

3. EVALUATING FAMILY_WINNER

3.1 Law and Negotiation

On Tuesday December 3 2003, we met with a number of family law solicitors at Victoria Legal Aid (VLA) to evaluate the performance of the Family_Winner system. We used the Context, Criteria, Contingency evaluation framework of (Hall *et al* 2003). Whilst the solicitors were very impressed with how Family_Winner suggested trade-offs and compromises, they had one major concern – that Family_Winner in focusing upon mediation had ignored issues of justice.

(Alexander 1992) has illustrated that women tend to be more reluctant than men to continue conflict and are more likely to waive their legal rights in a mediation session. If their major goal is to be the primary care giver for their children, they may reach a negotiated settlement, which whilst acceptable to them is patently unjust. The wife may for example, give the husband the bulk of the property, in return for her being granted the

primary care of the children. Whilst such an arrangement may meet the goals of both parents, it does not meet the paramount interests of the children, who will be deprived of subsequent financial resources. Family Law is one domain where mediation conflicts with notions of justice. In such domains, the use of negotiation support systems that attempt to equally satisfy both parties is limited.

Similarly, suppose two parents both want primary residence of their children, to the exclusion of any other matters or indeed, the interests of the children. Although a compromise, acceptable to both parents, might be to have the children move households every night, no judge would sanction such a course of action, since it would be detrimental to the welfare of the children. The judge (who is the final arbiter on what constitutes the paramount interests of the children) can over-ride an agreement negotiated by the parents. Indeed, since legal professionals are aware that judges are unlikely to approve a settlement where children move house every night, they would caution their clients against even proposing such a solution.

Family_Winner is a system that has no boundaries with regard to the types of dispute it can process. Family Law is a domain fraught with emotive arguments, which if allowed to frame the negotiation, can lead to irrational and unsatisfactory solutions. As the origins of Family_Winner are in this domain, we chose to base our system on accepting disputes in which most elements of human emotion has been removed. Family_Winner models disputes by requesting the issues entered are not emotionally sensitive, as the system is not capable of judging such issues nor of understanding their context. The importance weight (represented by a rating) assigned to an issue by the disputants, is the source from which the computer models the dispute. It is the responsibility of users to enter issues and appropriate associated weights to enable adequate modelling of the dispute.

Hence, bargaining theory has its limitation in providing decision support for family law negotiation. However, we have noticed that various negotiation domains are far more suitable than family law, which include enterprise bargaining and international disputation.

3.1 Using Family_Winner in a variety of negotiation domains

Given our research on compensation strategies for developing negotiation support systems, and the VLA evaluation of the Family_Winner system, we realised that we need to be careful in choosing negotiation domains that are amenable to the use of our systems. Further, we need to be careful that principles of justice do not conflict with the advice provided by our negotiation support systems.

Since Family_Winner has been designed with a view to being utilised in many negotiation domains, there are no domain-specific requirements that prospective cases need to exhibit. In (Bellucci 2003) we discuss how Family_Winner has been used in a variety of negotiation domains. These examples include:

1. Family Law – This example taken from (Brams and Taylor 1996) concerns the real-life case of *Jolis v Jolis* which commenced in the state of New York on October 30 1981. New York assumes a default distribution of property on an equal basis, quite unlike Australian Family Law. The dispute was solely about property and included New York and Paris apartments, a farm, cash, securities a profit-sharing plan and life insurance.

The recommendations made by Family_Winner were identical to those made by the judge (admittedly this was a judicial rather than a negotiated settlement).

2. Family Law is a less suitable domain for building Negotiation Support Systems than is Enterprise Bargaining. We considered the Enterprise Bargaining Agreements of VLA for the period 2000-3. Issues in dispute were pay, the use of technology, flexitime, overtime, pre-natal leave, childcare, working from home and performance management.

The solution generated by Family_Winner was very similar to that eventually concluded by VLA and its employees.

Both negotiations 1) and 2) involved the sharing of a pie. As it was possible to allocate points to issues, and creative decision-making was not required, the solutions suggested by Family_Winner were similar to the eventual settlements.

The next two examples come from the domain of International disputes: an analysis of the Panama Canal treaty of 1974 (Raiffa 1982) and a negotiation held with terrorists (Fisher and Ury 1991).

1. The Panama Canal treaty involved a lengthy series of negotiations between the United States of America and the Panamanian Government. Issues in dispute were considerable: defence rights, use rights, land and water, expansion rights, duration and compensation. The negotiations continued from early in the twentieth century until 1974. A treaty was concluded in 1974. (Raiffa 1982) listed and

assigned points to the issues in contention. He explained that the negotiations failed to resolve all the issues.

Family_Winner's advice varied considerably from the settlement obtained from negotiations held between the parties. As Family_Winner only has the ability to allocate issues to one of the parties, a comparison based upon creative settlements is not possible. Also, there needs to be a better understanding of exactly what issues are in contention, and how these issue definitions can be translated into issues ready for allocation by Family_Winner. The Panama Canal treaty was particularly difficult to resolve, since the disputants changed their goals during the dispute. Unfortunately, Family_Winner has no temporal aspects.

2. The terrorist negotiation example showed that even critical situations could benefit from the use of an automated negotiation system. The example involved the 1988 hijacking of Kuwait Airlines flight 422. The hijackers were protesting the conviction of Shiites for committing acts of terrorism. The Cypriot and Algerian governments negotiated with the hijackers, allowing the plane to land on their territory, and providing the hijackers with deliveries of food and access to the media.

Family_Winner advised upon negotiations between the Kuwaiti government and the hijackers. Issues covered were allowing the plane to land, fuel, food, access to media, release of hostages, release of convicted terrorists and the possible conviction of the terrorists. Family_Winner's advice coincided with the eventual outcome of the siege.

3. An example taken from (Brams and Taylor 1996) considered a negotiation held between two companies discussing a company merger. Issues in dispute were, name, headquarters, chairman, chief executive officer and layoffs. The settlement reached by Brams and Taylor was identical to that achieved using Family_Winner. The results obtained from this example demonstrate the effectiveness of point assignments to show the importance value of an issue to a party, coupled with trade-off equations to assist in the allocation of issues valued closely by the respective parties.

An investigation of these five examples has shown the benefit of Family_Winner for advising upon trade-offs, compensation and the sequencing of negotiations as long as the issues can be described and remain static and points can be allocated to issues. The system cannot develop creative solutions nor (currently) deal with temporal changes. In addition, problems can occur in legal domains where a negotiated settlement conflicts with our notion of justice.

4. DEVELOPING ON LINE DISPUTE RESOLUTION

4.1 The benefits of On Line Dispute Resolution

Alternative Dispute Resolution has moved dispute resolution away from litigation and courts. Online Dispute Resolution extends this trend (Clark and Hoyle 2002). As (Katsh and Rifkin 2001) state, the trend toward non-legalistic systems of settling conflict will push mediation and arbitration to the foreground and litigation into the background. Whilst Alternative Dispute Resolution represents a move from a fixed and formal process, Online Dispute Resolution, by designating cyberspace as a location for dispute resolution extends this process by moving Alternative Dispute Resolution from a physical to a virtual place. Or, as (Karamon 1996) puts it:

While, originally, Alternative Dispute Resolution took the resolution of disputes outside of the courtroom, the Internet has brought Alternative Dispute Resolution directly to each individual's personal computer.

Not surprisingly, Online Dispute Resolution has primarily been developed to resolve e-commerce disputes or at least internet related issues. (Bordone 1998) argues:

that there is a crucial role for Alternative Dispute Resolution specialists and designers of dispute resolution systems to play in the development of a comprehensive and optimal system of dispute resolution for the Internet.

He introduces a proposal for an integrated conflict resolution system for online disputes.

The major reason for the popularity of handling e-commerce or internet related disputes online is that because the parties concerned already had online 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.

(Katsh and Rifkin 2001) state that compared to litigation, Alternative Dispute Resolution 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; and g) Private.

On Line Dispute Resolution has the following additional benefits: g) Disputants do not have to meet face-to-face: an important factor if there has been a history of violence; and h) Mediation can occur at any time, with participants located in different countries.

We are now focusing upon developing various on-line dispute resolution systems, including developing on-line versions of Split_Up and Family_Winner.

4.2 Current Research

A joint project in Victoria Australia, between Victoria University, La Trobe University, JUSTSYS and Victoria Legal Aid is developing an On Line Plea Bargaining system to allow prosecutors and defence barristers to negotiate pleas and sentences with regard to criminal offences. A model of sentencing has been developed using Knowledge Discovery from Database techniques (Hall *et al* 2004).

(Hall *et al* 2004) reports on a project undertaken to support decision-making in discretionary legal domains by referring to a recently created model that involves the interplay and weighting of relevant rule based and discretionary factors used in a decisional process. The case study used in the modeling process is the Victorian Lower Court Criminal Jurisdiction in Australia, where the handing down of an appropriate custodial or non-custodial sentence requires consideration of many factors. Tools and techniques used to capture relevant expert knowledge and display it both as a paper model and as an on-line prototype application are discussed. Models of sentencing decision-making with rule-based and discretionary elements are presented and analysed. The paper discusses the benefits and disadvantages of such technology and considers some potential appropriate uses of the model and web-based prototype application.

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. We are working at incorporating Smartsettle strategies into the Family_Winner system.

(Lodder and Zeleznikow 2004) combine the dialogical reasoning of (Lodder 1999) with the game-theoretic based negotiation techniques of (Bellucci and Zeleznikow 2003) to construct an online dispute resolution environment. The online dispute resolution environment they developed facilitates basically the following three steps that should lead towards the resolution of the dispute. First, the disputants are advised what dispute resolution mechanisms are effective. In case the Dispute Resolution Environment is amongst those, the parties are invited to start with the 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.

5. CONCLUSION

For the past decade, we have developed negotiation support systems in the domain of Australian Family Law. In this article we first discussed our template-based system (DEUS) that informs mediators of the issues in the conflict and the extent of disputation. Split_Up is a knowledge-based system that advises upon BATNAs whilst Family_Negotiator is a hybrid rule-based/case-based system that models Family Law negotiations.

AdjustedWinner is a point allocation procedure that distributes items or issues to the parties that most value the issues in dispute. Family_Winner extends the point allocation procedure through the use of importance values in forming trade-offs and performing compensation. It provides advice upon structuring a negotiation, and an equitable outcome, given the disputant's preferences.

In evaluating Family_Winner, we noted that disputant's preferences might well conflict with notions of justice. This is particularly true in Family Law, where the interests of children are paramount.

We hence realized certain limitations of bargaining-type negotiation support systems such as Family_Winner. An evaluation of Family_Winner in diverse domains such as enterprise bargaining, company mergers and international disputes has shown that it is useful for advising on solutions given trade-offs and compensation strategies are used. The system cannot develop creative solutions nor (currently) deal with temporal changes.

We conclude by discussing how research on negotiation support systems is now focusing upon On Line Dispute Resolution. Examples of current research include the UK building industry and plea-bargaining about sentencing in Australia.

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