Artificial Intelligence and Law (2005) 13:233–271
DOI 10.1007/s10506-006-9013-1

Developing negotiation decision support systems that support mediators: A case study of the Family_Winner system

EMILIA BELLUCCI* and JOHN ZELEZNIKOW
School of Information Systems, Victoria University, 14428, Melbourne City, Victoria 8001, Australia
E-mail: emilia.bellucci@vu.edu.au; john.zeleznikow@vu.edu.au

Abstract. Negotiation Support Systems have traditionally modelled the process of negotiation. They often rely on mathematical optimisation techniques and ignore heuristics and other methods derived from practice. Our goal is to develop systems capable of decision support to help resolve a given dispute. A system we have constructed, Family_Winner, uses empirical evidence to dynamically modify initial preferences throughout the negotiation process. It sequentially allocates issues using trade-offs and compensation opportunities inherent in the dispute.

Key words: decision support, trade-offs, Negotiation Support Systems

1. Introduction

Negotiation is a process by which two or more parties conduct communications or conferences with the view to resolving differences between them. Parties are expected to act cooperatively to resolve issues. Cooperative negotiation describes the communication of parties when the outcomes are the result of coordinated behaviour of both participants (Robertson et al. 1990). Disputants are more likely to be satisfied with (and most importantly adhere to) the suggested result if they participated in reaching this result. Whilst the resulting settlement of a successful negotiation can indicate success, another indicator is the level of satisfaction parties find with the negotiation process.

This article will principally discuss providing decision support for mediators. We will focus upon Family_Winner, a Negotiation Decision Support System (NDSS) that advises upon trade-offs and compensation strategies. Whilst, Negotiation Support Systems (NSS) are programs that assist users in the negotiation process, NDSS extend the ability of a NSS to include an element of decision support.

Before we delve into the details surrounding the domain we have modelled and the system we have developed, we need to be aware of the reasons for developing NDSSs.

Hoffer (1996) discusses the use of decision analysis (in particular decision trees) in mediation, concluding that the mediator must decide on when and how the tool is used. Usually decision analysis tools are used during a particularly difficult mediation. Some of the benefits of their use include (Hoffer 1996):

- "Serving as a repository for information.
- Used to move beyond emotional issues and towards rational resolution of the dispute.
- Improve on communication by narrowing the issues, sharpening the arguments and improving understanding.

Although Family_Winner does not use decision analysis, it is a decision support aid since the outcome of the system is a solution that provides advice about the case at hand. The system serves as a repository of information, as it makes extensive use of a database that stores all case details. Bellucci (2004) has mentioned that there are substantial benefits in the use of a decision aid in negotiation or mediation, including the claim that a computer can help remove emotion from the dispute, and by doing so promote rationality. Family_Winner uses a numeral to distinguish preferences. We argue that this may help to sharpen and aid in a disputant's understanding of their priorities[1].

Obstacles to the use of decision analysis concern resistance by mediators, lawyers and parties to use the tool with respect to (Hoffer, 1996):

(1) Unfamiliarity with the tool's underlying concepts and theories,
(2) Discomfort with mathematics,
(3) Discomfort with computers,
(4) Unwillingness to concede 'control' to a model."

The theories that are embedded in the design of the Family_Winner system are based on norms and empirical evidence derived from practise. The mathematics involved in the development of Family_Winner is minimal in complexity. Point 3 is no longer relevant as the majority of knowledge workers in today's society regularly use computers. The fourth point is interesting as it is assumes the computer model has control over the dispute. We stress that Family_Winner should be used as a tool for advice and guidance and not as the sole decision maker.

We present a survey of existing NSS and NDSS in Section 3, including On-line Dispute Resolution (ODR) applications. ODR systems are web-enabled, primarily to provide parties who for various reasons cannot or should not meet face-to-face, with the opportunity to conduct negotiations and to facilitate easier and faster communication. Apart from complex negotiation dispute resolution, we will also discuss the emergence of systems capable of resolving disputes in electronic-commerce.

In our research, we did not find any computer systems that advise upon the use of trade-off manipulations to settle disputes, even though our research suggests that the use of trade-offs in negotiation is widespread. Hence, we have developed Family_Winner to advise upon trade-offs (among other structures) to suggest a resolution of the dispute at hand.

The majority of NSS use game theoretic and optimisation techniques to provide advice about optimal solutions. These systems use normative decision-making: they describe how decisions should be made (Raiffa et al. 2002). Examples of systems based on normative decision-making are SmartSettle (Thiessen et al. 2000) and INSPIRE (Kersten 1997). Another classification, descriptive decision-making is concerned with how and why decision makers act. An example of a descriptive decision making tool is Win Squared[2]. Prescriptive decision-making, a third classification, considers how a decision can be improved. We believe Family_Winner fits within this classification.

Data was collected from various sources of Family Law knowledge, including interviews with Family Law Mediators. The detail of this data collection is discussed in Section 5. After an extensive analysis of the data, we discovered several mediation practices that a computer system can readily support. These include a mediator's role in helping disputants allocate values to issues, her role in supporting the sequential resolution of issues and the recognition that disputants often change the manner in which they value issues following the allocation of an issue.

We next discuss Family_Winner (Bellucci 2004) a Negotiation Decision Support System that exploits the trade-off opportunities that are present (though often hidden) in a dispute. The system accepts numerical assignments (ratings) that each party gives to all issues in dispute. The sum of these ratings must be normalised to 100. If need be, issues can be divided into sub-issues and numerical assignments assigned. The system then forms trade-offs among issues. Once the system has extracted the trade-offs, it acts upon each one by allocating issues. Once an issue has been allocated, there may be a need to compensate parties for losses due to the recent allocation. The extent to which compensation is made is dependent on the value of issues to either party and to both parties.

Brams and Taylor (1996, 1999) advocate the use of numerical assignments to understand how disputants value an item. It is using these assignments that allocations are made. The use of numerical assignments leads to the essential question – can disputants use their knowledge of how the opposite side will rank their assignments to set their assignments strategically to gain a greater advantage? We argue in the negative. By trying to deny their adversary an item the adversary desires, the disputant greatly diminishes the prospect of their obtaining an item they greatly desire.

Whilst (Thiessen and McMahon 2000) focus upon obtaining Pareto optimal solutions, Family_Winner does not focus upon generating optimal

solutions. Rather it has as its goal the provision of useful negotiation decision support. Optimality is not considered vital, since disputants often have difficulty in numerically listing their priorities.

Family_Winner is we believe the first NDSS that uses theories based on empirical data. Whilst Family_Winner was initially developed in the domain of Australian Family Law, we argue that Family_Winner is not domain dependent. In Bellucci (2004), we demonstrated this by evaluating the system using case-studies in domains other than family law. Our conclusions were that Family_Winner suggested settlements similar to those achieved by face-to-face negotiations. Indeed, we argue that the integrative bargaining used in the development of the Family_Winner system conflicts with the concept of justice based negotiation used in Australian Family Law.

In our conclusion we note that Family_Winner is currently being trialled in industrial relations, plea bargaining and the negotiation of the outsourcing of Information Technology agreements.

Finally we foreshadow an On-line dispute environment of (Lodder and Zeleznikow 2005) that uses a dialog system and negotiation support system to support the resolution of a conflict. The NSS in Lodder and Zeleznikow's environment is based upon our research.

We conclude the article by mentioning our future directions in the development of On-line dispute resolution systems and other projects in the legal domain. The principles in Family_Winner are likely to be extended for use by mediators and negotiators.

2. Negotiation in Australian family law

Negotiations occur in a variety of political, economic and social settings, including Australian Family Law. Australian Family Law was chosen as the application in which our research was conducted because of our previous experience in modelling this domain[3]. Further, we had ready access to Family Law practitioners and relevant data.

Prior to a full hearing in the Family Court of Australia, couples who have dependant children are referred to family mediation[4]. Mediators are responsible for ensuring the negotiation improves, or at least, does not disintegrate the relationship between the husband and the wife.

In most legal conflicts, once a settlement is reached the parties are not required to have an on-going relationship. This is not the case in Australian Family Law. Family law varies from other legal domains in that in general:

- There are no total winners or total losers – in most common law domains one party to a legal dispute wins a case whilst the other loses. In civil matters, under the cost indemnity rule, the loser of a litigated case

pays the costs of the winner. Save for exceptional circumstances, following a divorce both parents receive a portion of the property and have defined access to any children.
- There are a vast amount of litigated Family law cases each year – in Australia there are approximately 50,000 divorces each year, of which 5,000 cases are litigated and 1,000 go to judgement.
- Parties to a family law case often need to communicate after the litigation has concluded.

Hence the Family Court of Australia[5] encourages negotiation rather than litigation.

Most disputes can be resolved through a variety of different techniques, including negotiation, mediation, arbitration and litigation. In a negotiation, parties attempt to resolve disputes on their own. Mediation differs to negotiation by the participation of a third party (a mediator), who acts as a neutral overseer in the negotiation process. A mediator may also assist by educating participants on the process of negotiation and in negotiation techniques particular to the dispute. For example, a mediator may discourage a disputant from making evaluative comments whilst the opposing disputant is listing the issues in dispute. This technique is believed to contribute to building confidence.

Arbitration and litigation represent dispute resolution that removes control and responsibility from the disputants to a third authoritarian person. In arbitration, it is an arbitrator who imposes decisions, whilst in litigation it is a judge. Precedent and legislation usually bind decisions made in litigation.

Arbitration is fairly rare in the family law domain. Whilst counselling reports do not carry the legal status of an arbitrated decision, they do in general carry great weight in a court and can thus be considered akin to arbitration.

One drawback to our use of integrative bargaining in Family Law is that Australian Family Law negotiation involves not only the interests of the parents, but more importantly the paramount interests of the children. (Fisher and Ury 1981) note that whilst interest based negotiation is desirable, there are also power-based and justice-based approaches to negotiation.

(Black 1990) views justice as the constant and perpetual disposition of legal matters or disputes to render every man his due. Our research is concerned with developing trade-off strategies to enhance negotiation about Family Law disputes. Whilst most negotiations aim to arrive at a settlement that satisfies all parties to the dispute, it should be noted that in some domains, including Australian Family Law, this aim may not be attainable. For example, this goal may conflict with the fundamental principle of Australian Family Law: the paramount interests of the child. If the wife's major concern is to be the primary care giver of their children, a negotiated

settlement may consist of giving the husband the bulk of the property in return for the wife 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[6].

To illustrate this point, our system Family_Winner was evaluated by a number of family law solicitors at Victoria Legal Aid (VLA). Whilst the solicitors were very impressed with the way Family_Winner suggested trade-offs and compromises, they had one major concern – that in focusing upon negotiation, the system had ignored the issues of justice. We acknowledge that any utility-based system based on interests cannot answer the fundamental question of justice. In light of this evaluation, we realise that we need to be careful in choosing domains that are amenable to the use of decision support systems. In our penultimate section, we will discuss Family_Winner's application to several domains other than Family Law, including enterprise bargaining, international disputes and business merger negotiations. It should also be noted that we are currently adapting Family_Winner to help with the resolution of Family Law disputes.

3. NSS

Most NSS are primarily responsible for tracking past preferences and informing disputants about progress being made towards a solution to a conflict. We refer to these systems as template systems. We consider DEUS (Zeleznikow et al. 1995), INSPIRE (Kersten 1997), CBSS (Yuan et al. 1998), Negotiator Pro and The Art of Negotiating (Eidelman 1993), WinSquared as template based systems.

DEUS (Zeleznikow et al. 1995) represented our earliest attempt at building NSS in Australian Family Law. It is a template-based system. The model underpinning the program calculates the level of agreement and disagreement between the litigants' goals at any given time. The disputants reached negotiated settlement when the difference between the goals was reduced to nil. DEUS is useful to gain an understanding of what issues are in dispute and the extent of the dispute over these issues.

Negotiator Pro and The Art of Negotiating are two commercially available programs which help users prepare for negotiations. Negotiator Pro has two major features, a psychological profiling system and a negotiation planning system. The system is primarily used by lawyers to plan for business negotiations. The Art of Negotiating presents the user with a number of menus, so disputants can enter information regarding the issues, positions, interests and needs of parties. It also enables disputants to enter their preferred negotiating philosophy and strategies, whilst also supporting the generation of an

appropriate agenda. The system aims to develop a disputant's understanding of their opponent's needs, to enable the effective generation of strategies and counter-arguments.

INSPIRE (Kersten 1997) is a research tool that supports negotiations by modelling the three main stages of a negotiation; that of preparation, offer-exchange and post-settlement. While INSPIRE was initially implemented to collect data on cross-cultural negotiations and to study the impact of decision analysis on negotiations, the system has proven quite successful as a facilitator of negotiation across the Internet.

Template systems assume disputants take on a passive role after the initial intake of preferences and issues, since they fail to implement any strategies that incorporate change. Modelling the dynamic properties of negotiation infers the incorporation of decision support into a traditional negotiation support system.

A NDSS supports negotiation by modelling the properties of a template NSS, in addition to applying functions to interpret the goals, wants and needs of the parties to provide advice on how disputes can be settled.

Early decision-support negotiation systems primarily used Artificial Intelligence techniques to model negotiation. LDS (Peterson and Waterman 1985) used rule-based reasoning to assist legal experts in settling product liability cases. SAL (Waterman et al. 1986) also used rule-based reasoning to help insurance claim adjusters evaluate claims related to asbestos exposure.

NEGOPLAN (Matwin et al. 1989) is a rule based system written in PROLOG which advised upon industrial disputes in the Canadian paper industry. Mediator (Kolodner and Simpson 1989) used case retrieval and adaptation to propose solutions to international disputes, while PERSUADER (Sycara 1993) integrated case based reasoning and decision-theoretic techniques to provide decision support to United States' industrial disputes.

Our earliest NDSS was Family_Negotiator (Bellucci and Zeleznikow 1997). It utilises a hybrid rule-based and case-based system to provides disputants with advice on how to best resolve the issues in an Australian Family Law dispute. Whilst evaluating the Family_Negotiator system, we discovered that Family Law negotiation was not an appropriate domain in which to apply either Case-based or Rule-based Reasoning, due principally to the open textured nature[7], of the domain. Nor did the overall framework of Family_Negotiator provide in-depth solutions expected from real-life negotiations.

Our adaptation of AdjustWinner (Bellucci and Zeleznikow 1998), uses a utility function to achieve equal distribution, according to interests, of marital property following divorce[8]. The algorithm used in the system was the Adjusted Winner procedure (Brams and Taylor 1996). AdjustWinner resolves a dispute by dividing issues and items among disputants, through a mathematical manipulation of numeric preferences. Although not classed as

a NSS, AdjustWinner provided the framework for decision-making support that was later incorporated into Family_Winner.

Mediator, Persuader, NEGOPLAN and Family_Negotiator are considered to be intelligent systems since they can generate solutions using the system's internal knowledge as well as users input. All incorporate some level of negotiation support, together with a capability to provide users with a resolution to the current problem.

Artificial Intelligence techniques such as case-based, rule-based and hybrid reasoning have had mixed degrees of success in providing negotiation support. The Mediator proved quite successful in its retrieval and adaptation of previous cases. NEGOPLAN used rule-based reasoning to successfully model Canadian industrial disputes, while PERSUADER successfully modelled US industrial disputes through the use of a hybrid case and rule-based methodology. Family_Negotiator however, did not perform to its initial expectations, primarily due to its relatively simple modelling of the domain.

Apart from AdjustWinner, most of the systems surveyed above do not make allowances for measuring the fairness or justness of the settlement. Further, most of the systems discussed are rarely based on theories derived from practice or empirical studies. For example, INSPIRE (Kersten 1997) and SmartSettle (Thiessen and McMahon 2000) use Pareto Optimisation techniques to suggest optimal solutions. Our goal is to provide feasible suggested solutions (to the conflict) that are acceptable to the user, as opposed to providing them with the 'optimal' solution.

Raiffa et al. (2002) classifies decision-making support systems in three categories. He makes the distinction between normative, descriptive and prescriptive decision making tools. Normative decision-making makes no attempt to model how we actually make decisions, as it describes how ''idealised, rational, super-intelligent people should make decisions'' (Raiffa et al. 2002). Economic theories and game theory are used to model normative decision-making. Examples of normative NSS are SmartSettle and INSPIRE.

The second classification of decision-making tools is referred to as descriptive systems. These systems make suggestions based on behaviour, and make extensive use of behavioural decision theorists, such as psychologists who analyse how we make decisions. Tools based on this style of decision making predict actual behaviour, using analysis based on empirical or clinical study (Raiffa et al. 2002). WinSquared is an example of a negotiation support system we would classify as descriptive, since it provides negotiators with plans providing custom advice based on their ''style, goals and level of assertiveness'' (Acadian software 2004).

So how does Family_Winner fit into these classifications? (Raiffa et al. 2002) mentions a third classification of decision-making, prescriptive decision-making that considers how decisions can be improved. Prescriptive

analysts wrestle with "what a real person can do to make better decisions" Family_Winner can be described as prescriptive since (for example) it uses decision aids (trade-off maps) and novel perspectives (describing value through a numerical figure). In addition, (Raiffa et al. 2002) notes that prescriptive advice should be used to promote an understanding of the issues and problems at play. Family_Winner gives disputants the opportunity to describe their want of an issue through a numeral – quite a challenging prospect for most, but one that results in disputants understanding their priorities better.

Prescriptive decision-making tools make use of descriptive and normative theories (Raiffa et al. 2002). Family_Winner uses empirical data to form descriptive theories, whilst normative theories are employed in the game theoretic component of the system. Each of these techniques (together with others) is explained in Sections 6 and 7.

Essentially, it is difficult to compare Family_Winner to normative decision-making tools, such as Smartsettle or INSPIRE. Family_Winner assumes that people are able to make good decisions. Its' role is to improve the decision by introducing decision aids and alternative ways to support negotiation. Family_Winner's underlying assumption is that people may look for trade-offs and seek compensation when they do not obtain what they desire. In contrast, the Smartsettle system negotiates over a series of packages to seek the optimal package, which then becomes the suggested solution. But do we need an optimal solution? Perhaps not, when trying to optimise using vague concepts.

3.1. ON-LINE NSS

(Bichler et al. 2003) describes electronic negotiations as 'processes that involve computer and communication technologies in one or more negotiation activities'. These technologies include the use of e-mail and multimedia, databases, decision support systems and knowledge-based systems. On-line NSS can be classified into the following categories: Web-based NSS, Automated Negotiation and Automated Agent-based Negotiations. On-line auctions, automated negotiation and even some agent-based negotiation systems allow adequate support for most forms of e-commerce. On the whole, the major distinction between on-line and traditional forms of negotiation support is in the way each supports communication. Later in this section we discuss communication support as both an advantage and disadvantage to on-line negotiation support.

Web-based NSS refer to systems implementing the use of email and visual aids such as multimedia objects to facilitate effective communication between disputants. Negotiation support packages assist 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 (Thiessen and McMahon 2000). Their aim is to better prepare parties for negotiation or to support them during the negotiation process. A primary player in this area is SmartSettle[9] which uses graphs to illustrate the satisfaction ratings of disputants towards packages. INSPIRE (Kersten 1997) was among the first electronic NSS developed. INSPIRE enabled disputants to negotiate through the Internet, making extensive use of email and web browser facilities. Another example of a text-based electronic negotiation support system is CBSS (Yuan et al. 1998). The system enables 'full process support' by enabling communication in real-time through hot-line co-ordination, message exchange and the editing of common documents. WinSquared provides negotiators with templates to analyse the negotiation. It then will recommend approaches to communicate with disputants and to make proposals. INSPIRE, CBSS and WinSquared are examples of On-line Systems that fully support the standard processes of negotiation.

Automated negotiation involves a process of 'blind bidding', where parties submit settlement offers and a computer program automatically notifies them when a settlement is reached (Schultz et al. 2001). A major provider of automated negotiation is Cybersettle[10]. It is an example of on-line NSS in the area of legal claim settlement. It uses a blind bidding system to identify situations where there is overlap between what one party's offering and what the other party is willing to accept. The system arrives at a settlement by splitting the difference between parties offers' in the event of an overlap or if the final offers of the parties are within a predetermined distance from each other.

There are many advantages and disadvantages of using On-line NSS. One advantage includes the seemingly private submission of offers. Most systems allow party details, offers and demands to be kept confidential, so as to protect a parties' interest should negotiations fail. There is also a considerable reduction in time attending meetings, and settlements are often achieved faster as on-line facilities operate continuously. There may be an increase in compensation as the use of Internet technology tends to lower costs. Also, personality conflicts or human bias can be minimised using computer systems to facilitate negotiation (Bellucci 2004).

Disadvantages of using on-line dispute resolution include the necessary use of text-based communication methods, which may reduce important cues that can lead to misinterpretations, negative interpersonal behaviour and frustration.

3.2. NSS IN E-COMMERCE

(Weigand et al. 2003) introduces negotiation as a key component of electronic commerce. Electronic commerce is defined as 'doing business via

electronic networks such as the Internet and the World Wide Web (WWW)'. The trend in e-commerce is to support complete external business processes. These processes include access to services (special databases, chambers of commerce, WWW) that provide information on potential business partners, the support of electronic payment through credit facilities, and use of Electronic Data Interchange (EDI) messages to enable the management of orders.

On-line Auctions are not characterised as ODR systems, as they facilitate markets, not resolve disputes. In a dispute, the parties are tied to each other, while in an action they can walk away at any time. Notwithstanding, it is certainly a growing area of e-commerce. On-line auctions operate in a similar manner to that of physical auctions. Sellers publish the prices at which they wish to deliver services. Buyers offer to purchase the service at a stipulated price. In an English Auction, the buyer who offers the highest price is given first preference to purchase the item at the price they have offered. In a Dutch action, the auctioneer starts the bidding at a top price and then lowers the amount sequentially with the first person to raise his hand 'winning' the item (Raiffa et al. 2002). Examples of on-line auction houses that use the English auction model include http://www.ebay.com and http://www.auction-port.com.

Electronic commerce has also been applied to Agent-based Negotiations. (Lomuscio et al. 2003) introduces electronic commerce as a merchant transaction in which the buyer and seller are replaced by electronic entities, represented by Agents. (Blanning and Bui 2000) discusses an example of an Agent-based Decision Support System to support Air Cargo Market Transactions in Electronic Markets.

4. Negotiation theory

Numerous models have been developed from detailed studies of how people negotiate. Formal models, such as Game theory, rely upon a mathematical concept of optimal convergence. But do such models realistically simulate human behaviour? (Kalai and Stanford 1988) notes 'humans are more correctly modelled as having bounded rationality, that is choosing strategies from less-than-complete considerations and striving for satisfactory rather than optimal levels of utility'. Game theory, for example, seems to ignore disputant satisfaction as an indicator of a mutually acceptable outcome. It supports a win-lose approach contrary to promoting cooperation among the parties.

Principled Negotiation (Fisher and Ury 1981) essentially emphasises that parties look for mutual gains. When interests conflict, Principled Negotiation advocates parties arrive at a ruling that is independent of the beliefs of either

side. The essential features of Principled Negotiation as a problem-solving task are as follows:

4.1. SEPARATE THE PEOPLE FROM THE PROBLEM

This is to ensure that persons with stronger personalities cannot influence others into a decision that is biased towards a party or group of parties. This aspect is perhaps most relevant in disputes between people who are involved in an on-going relationship, for example in family law disputes.

4.2. FOCUS ON INTERESTS, NOT ON POSITIONS

Participants must distinguish and make known their underlying values in order to justify their position. In most negotiations, each party will have interests they would like satisfied by settlement, and it is important these be understood as separate from their positions. By isolating the reasons why a position is most appealing, participants in a negotiation will increase the chance of achieving agreement.

4.3. INVENT OPTIONS FOR MUTUAL GAIN

Even if the parties' interests differ, there may be bargaining outcomes that will advance the interests of both parties. Once interests have been ranked to determine the relative importance of each, a range of options is discussed before deciding on an outcome. The negotiators now invent options for mutual gain. This is what constitutes the decision-making aspect of the strategy. (Wertheim et al. 1992) maintains brainstorming as one way of encouraging cooperative decision-making. Other approaches include Expanding the pie, awarding Compensation and Log-rolling.

Compensation and Log-rolling are similar in that both seek to resolve differences between disputants in their interests and preferences. An interest is defined as what a person truly desires from a situation, consisting of a person's wants, needs, concerns and fears. An agreement is far more likely if at least some of these interests are satisfied in the final agreement. Compensation allows for parties to be rewarded as a method to promote fairness in the final settlement. Log-rolling does not assume compensation, entirely resting on considering priorities (and the differences between them) to form an agreement.

The algorithm implemented in Family_Winner uses a combination of log-rolling and compensation strategies to support the trade-off strategy.

4.4. INSIST ON OBJECTIVE CRITERIA

Some negotiations are not susceptible to a win–win situation. The most obvious of these is haggling over the price of an item: since the more money one side negotiates, the less their opponent receives. In these cases, unbiased independent evaluations of an item will guide a price for the item that both parties will agree on.

4.5. KNOW YOUR BEST ALTERNATIVE TO A NEGOTIATED AGREEMENT – BATNA (BEST ALTERNATIVE TO A NEGOTIATED AGREEMENT)

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.

For example, when a person wishes to buy a used car, they will usually refer to a commonly accepted set of approximate automotive prices. Using this initial figure and considering other variables such as new components, the distance travelled by the car and its current condition, the buyer then decides the value they wish to place on a car. If the seller is not willing to sell the car at this price, then you can argue the merits of your valuation, in an attempt to persuade the seller to accept your BATNA. Generally, BATNAs are used to form a basis from which fair agreements can be obtained.

The remainder of this article will discuss the development and use of the Family_Winner system. We found that in existing systems, little mention was made of implementations based on actual common-place practises in negotiation and mediation. Hence we decided to analyse differences between the requirements and processes used in software and face-to-face negotiation. From interviews conducted at the Family Mediation Centre we observed that the practise of priority ranking and trade-off manipulation was prominent. We hence investigated how the use of priority listing of issues and trade-offs can be implemented in a NSS to successfully provide decision support.

5. Data analysis and modelling requirements for the Family_Winner system

Data in the Family_Winner project was obtained from different sources in varying forms. These included interview transcripts, surveys from questionnaires and statistics sourced from different organisations.

We found access to negotiated data difficult to obtain, as negotiations are usually held in secret. Notwithstanding, we were fortunate to gain access to 36 negotiated case studies and conducted interviews with disputants and mediators. Data collection consisted of access to four major sources in legal mediation and legal support. Mediator questionnaires obtained from the department of Law and Legal Studies at La Trobe University[11], were suitability analysed. From the 36 surveys at our disposal, we observed that the majority of issues discussed fell into three major topics: Property Issues, Child-related Issues and Monetary Issues. It was also evident that disputants were encouraged to divide these issues into sub-issues, which would essentially reflect their interpretation of the underlying (parent) issues in dispute. We have hence provided a facility in Family_Winner to assist in the support of sub-issues.

Our second source of legal mediation data was a series of interviews conducted with four Family Law mediators from the Family Mediation Centres in both Noble Park and Ringwood, Victoria, Australia. Transcripts recording the interviews revealed that in the majority of cases, disputing parties were very hostile to each other both before and during mediation. We also discovered the importance of an initial meeting held between disputants and the mediator, referred to as an intake interview. During this session, disputants are asked to prioritise issues. In addition, interviews revealed that all mediators from the Family Mediation Service advocate and practise interest-based negotiation principles. This data source reinforced our original understanding of family law mediation, and emphasised what aspects of a negotiation a computer representation should support. In particular, we noted that in most mediations, each issue is discussed and resolved separately in a sequential manner. Mediators often require disputants provide some measure to describe their desire to be granted an issue. Most mediators agreed that the assignment of these importance values is instrumental to the success of the mediation as a win–win approach to conflict resolution.

In addition, we noticed from our data sets, that divorcing couples frequently changed their preferences. This usually occurred as the result of an allocation (assuming issues are resolved sequentially). The mediators questioned in our interviews certainly concurred with our observations and confirmed these findings.

The third source of data is a set of mediation transcripts provided by the Australian Institute of Family Studies (AIFS)[12]. The AIFS asked a group of mediators to participate in a survey of Family Law cases in which they were involved. An analysis of the data revealed that no two mediations involved identical issues and positions. Hence, any representation meant to describe the domain, needs to be flexible enough to accept any number of positions on a seemingly infinite number of issues.

The final source of data was collected from Family Law negotiation simulations, held in conjunction with the Law School at Monash University, Melbourne, Australia and with the Graduate School of Business at Bar-Ilan University in Ramat Gan, Israel. These simulations were conducted with final year law and management students and lawyers, and resulted in ten negotiated transcripts from each group. Importance ratings were recorded on the transcripts, as was the timing of any changes to ratings. From this study, we discovered people change their preferences (represented by ratings) in response to either an allocation of issues or a change in the importance of a related issue. This observation concurs with our belief that it is realistic to implement trade-off strategies that change issue preferences during the course of a negotiation. During interviews, mediators agreed that trade-off manipulation was a common method of attaining agreement among their clients.

The data analysis detailed above provided us with both theoretical and empirical evidence to incorporate into the development of the Family_Winner system. In the next section we will discuss the decision support aspect of the system, which will incorporate most of the analysis we derived from the data collection.

6. Decision support in the Family_Winner system

The NSS we have surveyed certainly support the process of decision support, though rarely offer solutions. A decision is defined as 'a piece of knowledge indicating a commitment to some course of action' (Holsapple and Whinston 1996). The decision support process not only introduces a new piece of knowledge (the decision), but the process itself may result in the addition of new knowledge, for example, complexities hidden in the variables of the dispute. Family_Winner aims to use trade-off values (which were previously hidden from the disputant's awareness) to provide support to resolve the dispute. Family_Winner suggests a settlement by sequentially allocating items issues to disputants based on the value of ratings. A rating is a numeral that represent a disputant's want of an item or issue. An important innovation in Family_Winner is suggesting allocations based on the changing values of ratings. Ratings often change in response to a previous allocation. All issues remaining in dispute may be affected by changes to their respective ratings. It is here that Family_Winner attempts to mimic the way negotiators (particularly in Family Law) frequently change their initial ratings during the negotiation.

Family_Winner's method of decision support uses the following techniques:

(1) Implementation of an Issue Decomposition Hierarchy;
(2) A Trade-off Strategy;

(3) A Compensation Strategy;
(4) Fairness and equality principles; and
(5) An Allocation Strategy.

An Issue Decomposition Hierarchy enables disputants to increase the number of issues in dispute by allowing issues to be sub-divided into smaller issues, to any required level of specification. We have adopted our structure from that of Analytical Hierarchy Processes (Saaty 1980). We assume, based on observations and results from data analysis, that the greater the number of issues, the greater the scope and opportunity for a mutual agreement. Principled Negotiation advocates use of 'Expanding the pie' (Mnookin et al. 2000) and (Wertheim et al. 1992) as a method of option generation. In Family_Winner, we use the concept of 'expanding the pie' to assist in generating an increasing number issues[13].

The trade-off strategy uses ratings provided by disputants to reflect their desire to be granted an issue, to assist in forming trade-offs relationships. These trade-offs are acted upon once an issue has been allocated. The trade-offs pertaining to a disputant are graphically displayed through a series of trade-off maps. Their incorporation into the system enables disputants to visually understand trade-off opportunities relevant to their side of the dispute.

A trade-off is formed after a comparison between the ratings of two issues has been conducted. (Sycara 1993) notes bargainers are constantly asked if they prefer one set of outcomes to another. (Sycara 1993) suggests that negotiators should consider two issues at a time, assuming all other issues remain fixed.

We have chosen to define compensation as a form of reward for conceding other issues in dispute. Family_Winner awards compensation to parties that have either lost an issue they regard as valuable, or have been allocated an issue of little importance. The system implements compensation by either increasing or decreasing a party's rating. It is then expected that changes made to a rating will influence the decision of a future allocation. The amount of any compensation resulting from the triggering a trade-off has been empirically determined from an analysis of data.

In Section 1, we described the Raiffa et al. (2002) classification of decision-making (support) systems. We concluded that Family_Winner can be described as a prescriptive decision making tool. This is because it describes how a decision can be improved, using empirical studies to justify the advice provided. The equations that Family_Winner uses to change the value of ratings during the course of the negotiation are empirically derived from data concerning Family law mediation cases. We believe using empirically derived equations is a valid method used in prescriptive decision support systems.

In Family_Winner, trade-offs (as a form of log-rolling) are acted upon once issues have been allocated. (Pruitt 1981) describes log-rolling as the process where participants look collectively at multiple issues to find those issues that one party considers more important than the opposing party's equivalent evaluation.

Brams and Taylor equate fairness in a negotiation to giving both parties to a dispute an equal percentage of their priorities. The Adjusted Winner algorithm (Brams and Taylor 1996) guarantee fairness and equitability by ensuring an equal number of points (represented by issue ratings) are awarded to each party through a distribution of issues or items.

In an ideal environment, where fairness can be applied with definite certainty, the theories of (Brams and Taylor 1996) and (Pruitt and Carnevale 1993) are sustainable. However, our goal of providing negotiation support does not easily lend itself to fairness assessment, due to:

(i) The difficulty in assessing fairness to a system whose numerical values fluctuate during the course of negotiation; and
(ii) A lack of data on which to base comparisons.

Family_Winner does not employ any of the fairness principles mentioned above. It interprets fairness as promoting satisfaction between the disputants. We argue a disputant's satisfaction is more important than their need for a supposedly fair outcome. The theories promoted in this article support satisfaction by allocating issues based on an issue's value to the party. Trade-offs are utilised to enable compensation, satisfying the system's attempt to make the allocation equally satisfactory to both parties.

7. The Family_Winner system

Family_Winner accepts as input issues or items for division. The program proceeds to form Trade-off Maps and displays these to the disputants. Family_Winner continues by considering each issue for either direct allocation or sub-division. Each issue can be divided into sub-issues at this point. Allocation of either sub-issues or top-level issues proceeds in the same manner, by firstly determining the party to receive the issue, and then using trade-offs to award compensation or reward appropriately.

The system makes an assumption that all participants act rationally. It is also assumed that parties can demonstrate an issue's importance sufficiently through the assignment of numbers.

The program has been implemented in Microsoft Visual Basic. It is a programming environment that lends itself to easy manipulation and rapid development of a program. It provides a facility to extend its environment to include add-in applications. Applications such as Microsoft Visio and ABC

Flowcharter were utilised by the program to draw graphs and to illustrate Trade-off Maps.

At the moment Family_Winner resides as a single Microsoft executable for the Windows operating system. A web-based version is currently being constructed, the current status of which may be obtained by contacting the authors.

7.1. A DISCUSSION OF THE FAMILY_WINNER STRUCTURE CHART

This section will outline, through a comprehensive structure chart displayed in Figure 1, the major components of the Family_Winner system. The input data consists of several variables, which all directly contribute to the outcome of the current case.

The input consists of:

- *Issues in dispute*. Both disputants are requested to enter the issues in dispute.
- *Ratings*. Once the issues have been established, the user enters numbers that reflect the importance of an issue (a rating).
- *Mutual Exclusiveness*. An issue is mutually exclusive of another issue, if as a result of allocating one issue, both issues are allocated simultaneously. For example, the issues of primary residency and visitation rights to children are mutually exclusive, since if one parent has residency, then the other, save for exceptional circumstances, is allocated visitation rights.

Unlike the case of input, the method by which output is presented by the system is not characterised by a sequential standard process. These outputs include:

- *Trade-off Maps*. Once new information has been entered into the system, or changes occur in the negotiation (for example to ratings following an allocation), the system displays two Trade-off Maps. Each map represents the preferences and trade-offs pertaining to a party. These diagrams provide disputants with an opportunity to diagrammatically assess their position in relation to all other issues.
- *Summary Report*. Once an issue has been allocated to a party, a summary report describing the current state of issue allocation with respect to the preferences of both parties is displayed. The summary report lists the issue recently allocated and the party to which it is allocated, all prior allocations, the value of issues before allocation and their current value, and a hierarchical map of all issues yet to be resolved.

Family_Winner uses the Issue Decomposition Hierarchy to store all issues (and sub-issues) and makes use of Trade-off Maps to deliver a compensation

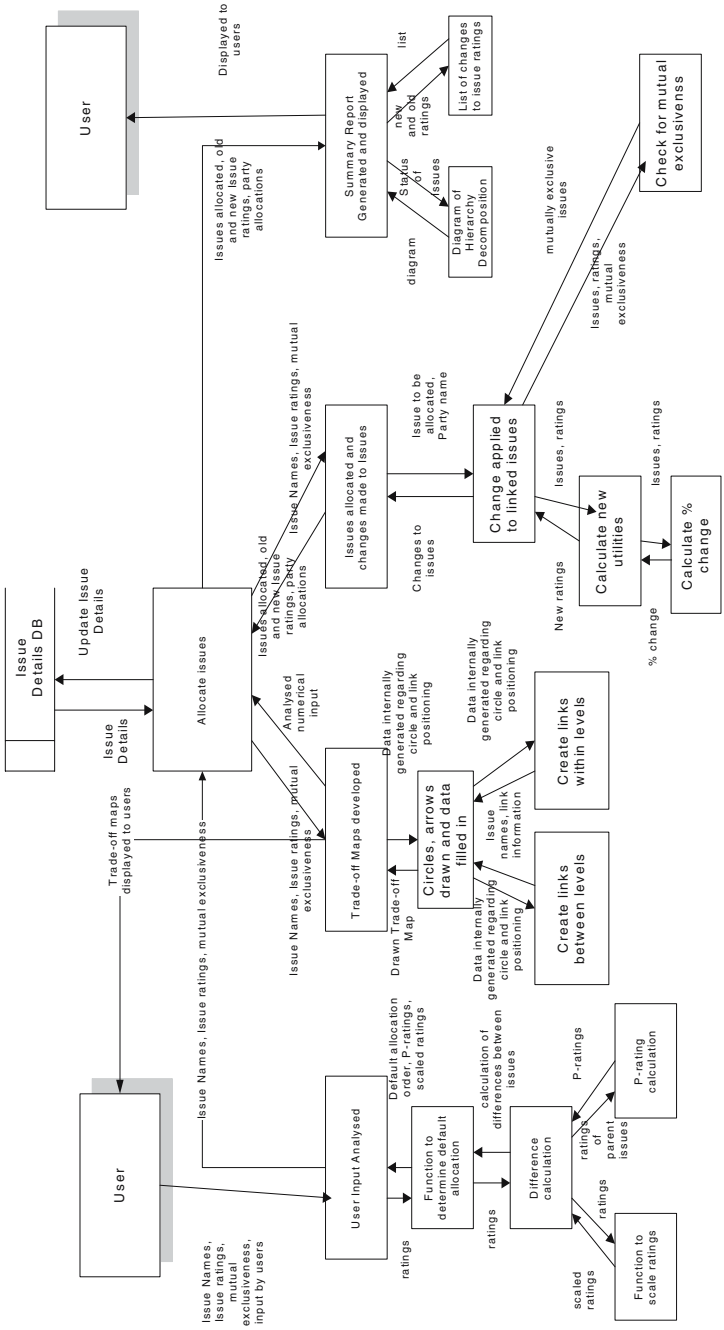

Figure 1. Family_Winner's structure chart.

strategy. The output consists of a list of allocations, which form the basis of the advice provided by the system.

The structure chart displays all the major modules, functions and information flow of the system. The program commences by accepting the user input. When the user input has been suitability analysed, the program proceeds to the allocation module. Trade-off maps are developed and displayed, at which point sequential issue allocation commences. Still under the allocation module, following an issue allocation, changes are made to the ratings of remaining issues. This new information is then transferred to another module responsible for the generation and display of a summary report. This summary report describes the current state of the negotiation, and is displayed to the user for their information

7.2. A FORMALISM FOR DEVELOPING FAMILY_WINNERS TRADE-OFFS

The starting point for the negotiation is to form the set of issues in dispute: $D = X \cup Y$ where $X = \{X_1, X_2, ..., X_n\}$ is the set of issues that H sees as in dispute and $Y = \{Y_1, Y_2, ..., Y_m\}$ is the set of issues that W sees as in dispute. H and W are then asked to give a significance value (rating) to each of the issues in $D = \{D_1, D_2, ..., D_k\}$ 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 $x_D = \{x_{D1}, x_{D2},..., x_{Dk}\}$ and $y_D = \{y_{D1}, y_{D2},..., y_{Dk}\}$ where $\Sigma\, x_{Di} = \Sigma\, y_{Di} = 100.00$. The X_i and Y_i are the issues whilst the x_i and the y_i are the values given to the issues.

So, two sets of ratings x_D and y_D are accepted by the system, each one representing a party's preferences. Disputants are asked to enter these numbers so that their sum equates to 100. A function checks whether the sum of a party's ratings adds to 100. If this is not the case, the function will suitably scale each party's ratings to sum to one hundred. Equation (1) formally presents this calculation.

If $\Sigma\, x_{Di} <> 100$ and/or $\Sigma\, y_{Di} <> 100$.

$$\text{Then NEW}x_{Di} = (x^*_{Di}100)/\Sigma x_{Di} \text{ and /or NEW}y_{Di} = (y^*_{Di}100)/\Sigma y_{Di} \quad \text{where } i \in \{1, 2, \ldots, k\} \tag{1}$$

Throughoutthis article, the rating of an issue refers to the value of an issue to a party. The rating of a parent issue is its numerical rating provided by disputants, while the rating of a sub-issue is represented by a percentage of the parent issue's rating.

The value of sub-issues, with respect to the rating of their parent issues is calculated next. *P*-ratings incorporate the influence of a parent issue to form the rating of a sub-issue. *P*-ratings are calculated according to the following equation:

Suppose $X = \{ X_{D1},..., X_{Dn}\}$ is the set of issues in dispute. The ratings are defined by $\{x_{D1},..., x_{Dn}\}$. Each issue can be decomposed into sub-issues $X_{di} = \{X_{di,1}, ..., X_{di,m}\}$.

Further each sub-issue is given a *p*-rating $\{x_{di,1}, ..., x_{di,m}\}$

$$\text{where } \sum_{k=1}^{m} x_{di,k} = 100 \text{ then the } p\text{-rating for } \mathrm{X}_{di,k} \text{ is } \mathrm{x}^{*}_{di} x_{di,k}/100 \tag{2}$$

For instance, Party A gives issue1 a rating of 60, and issue2 a rating of 40. Issue11 has a *p*-rating of 10 (10% of 60) = 6, and Issue12 a *p*-rating of 90 (90% of 60) = 54. The *p*-ratings are then copied to the appropriate table in the negotiation database.

The order by which issues should be considered for decomposition or allocation is then calculated. Specifically, the function calculates the numerical difference between the ratings set by both parties towards the same issues.

Note that $\Sigma x_{Di} = \Sigma y_{Di} = 100$.

$$\text{Let set D be the difference between ratings of issues in dispute, described by } \{d_1, d_2, \ldots, d_k\} \quad \text{where } d_i = |X_{Di} - Y_{Di}| \text{ with } i \in \{1, 2, \ldots, k\} \tag{3}$$

The issue with the highest d_i value will be presented first. Mediators and disputants can choose to either decompose the issue into sub-issues or directly allocate it.

The set *D* consists of the numerical differences between the ratings of both parties with regards to the same issues. For example, Party A has issue1 with value of 20, and issue2 with value of 50. Party B has issue1 with a value of 60 and issue2 with a value of 30. The difference calculation for issue1 is 40, while the corresponding calculation for issue2 is 20. Therefore *D* is the set {40,20}. Since issue1 has the highest value of 40 in set *D*, the system will suggest to the disputants that they negotiate over Issue1 first. We use the numerical difference between ratings (equation (3)) to reflect the level of discourse surrounding an issue. Since the numerical difference of Issue1 is greater than that of Issue2, we believe Issue1 to be comparatively easier to resolve.

Once User Input has been analysed, the next major process is that of allocating issues. Within this process, Trade-off Maps are developed by the program and then displayed. These diagrams are indicative of possible trade-offs between pairs of issues. Two maps are drawn side by side, each one representing a party's view of the negotiation. Visually, they consist of a series of circles (indicating issues) and lines connecting two issues together, (indicating a trade-off relationship). Trade-off relationships translate to a trade-off opportunity acted upon when an issue has been allocated.

The next function performed by Family_Winner is to form trade-off relationships connecting issues across one level of division. These relationships link either parent issues or sub-issues together. The function calculates

differences between the ratings of parent issues or the *p*-ratings of sub-issues using a pair-wise comparison of issues, to form a matrix of comparisons. Calculations are performed according to equation (4).

P-ratings (the ratings of sub-issues) are represented by P_{pi} while ratings are represented by x_{Di}.

M defines the $n(n-1)/2$ row where $m_{i,j} = |x_{Di} - x_{Dj}|$ (for each rating level) or

$$m_{i,j} = |P_{pi} - P_{pj}|(\text{for each sub-rating level}) \quad \text{where } i,j \in \{1,2,\ldots,n\} \text{ and } i<j \tag{4}$$

where n is the number of issues or sub-issues across one level.

For instance, party H assigns issue1 a rating of 50, issue2 a rating of 10 and issue3 a rating of 40. The relationship between issue1 and issue2 is given a numerical value of 40, while the relationship figure between issue1 and issue3 is given a value of 10, and between issue2 and issue3, a relationship figure of 30 is determined. Therefore row $M = \{40, 10, 30\}$. Similarly party W's M_i row is calculated from her ratings. The numerals indicate the strength of trade-off capabilities between respective issues. Together with other information analysed by the system, the numerals in *M* are used in calculating the amount of compensation given to parties after allocation of an issue.

The next function performs a similar calculation to that expressed in equation (4), in that it creates links between issues present on different levels in the Issue Hierarchy. Hence the issues involved in these relationships will be parent issues and sub-issues. In forming relationship figures, the rating of a parent issue will be compared against the *p*-rating of a sub-issue. Links are formed between parent issues and sub-issues not related to the parent issue forming the link. We believe it is necessary to incorporate the influence of the parent rating (and hence use the *p*-rating of a sub-issue) to form a valid comparison between parent issues and sub-issues present in the dispute. The following equation formally describes this operation:

P-ratings (the ratings of sub-issues) are represented by P_{pi} while ratings are represented by x_{Di}.

$$N \text{ defines the } n(n-1)/2 \text{ matrix where } n_{i,j} = |P_{pi} - x_{Dj}| \quad \text{where } i,j \in \{1,2,\ldots,n\} \text{ and } i<j \tag{5}$$

where*n* is the number of issues.

For instance, Party H assigns issue1 a rating of 60, and issue2 a rating of 40. Issue11 has a *p*-rating of 6, and Issue12 a *p*-rating of 54. Issue21 has a *p*-rating of 30 and Issue22 a *p*-rating of 10. The relationship figures between parent issues and sub-issues are: issue2 and issue11 a value of 34, issue2 and

issue12 a value of 14, issue 21 and issue1 a value of 30 and issue22 and issue1 a value of 50. Therefore the corresponding row is {34, 14, 30, 50}.

Essentially, a Trade-off Map consists of circles (representing issues), directed lines connecting these circles (representing a relationship), and a relationship figure (numerals calculated from equations (4) and (5)) to indicate the strength of a trade-off relationship. Two maps are drawn to represent each party's view of the negotiation.

If an issue does not require to be divided further, the issue is allocated according the issue's importance rating. The ratings of issues are hence compared. Essentially, the party whose rating is greatest is allocated the issue. If the ratings are of equal value, then the next issue to be considered for allocation is presented. Formally, this algorithm is presented as follows:

$$\text{If } x_{Di} \geq y_{Di} \text{ then issue } i \text{ is allocated to party } X. \text{ If } x_{Di} < y_{Di} \text{ then issue } i \text{ is allocated to Party } Y, \text{ where } i \in \{1, 2, \ldots, k\} \tag{6}$$

Oncean issue (or issues) has been allocated, the remaining issues are affected to varying degrees, according to trade-offs executed as a result of the allocation. The extent to which the ratings of issues change is dependent on whether an issue is lost or gained, the ratings of issues forming trade-offs, and strength of the trade-off (represented by relationship figures). The values of these variables combined to form a series of graphs, used to extract the amount of change affecting ratings.

Data analysis revealed several heuristics relevant to our investigation on the development of Family_Winner's allocation strategy. For example, if the issue lost is very important, and the strength of relationship is very significant, then the values of the relevant issue will increase. If a very important issue is allocated to a party, and the strength of relationships are very significant, then the ratings of relevant issues will not change. A relationship is considered very significant if the relationship factor is high.

Results from the above-mentioned analysis were used to form a series of 10 graphs, found in (Bellucci 2004). Each graph illustrates the change to issues following an issue's allocation. Each graph symbolises a different scenario based on whether the issue was gained or lost, and the importance exhibited by the rating of the allocated issue. Graphs are consulted to determine the appropriate level of compensation awarded following an allocation. Specifically, graphs provide the percentage change to be applied (Y-axis) given the level of discourse surrounding an issue (X-axis). Values on the X-axis represent the difference between the ratings of each issue, calculated according to equations (4) and (5). The range of the X-axis is from 0 to 100, where 0 indicates issues of minimal argument, and 100 indicating a greater level of discourse exhibited by the issue. The Y-Axis indicates the

amount of change resulting from an allocation. It has values ranging from 100 to −100, to indicate the most negative change to the most positive change applied to the value of a rating.

To illustrate how Family_Winner uses these graphs, suppose party H lost Issue1, assigned a rating of 70. Since Issue1 is valued Very Important (according to a linguistic assignment to ratings, given in Table I), then a graph GraphLost4 (Figure 2) is consulted to retrieve compensation figures. Assume the following issues exist, where Issue2 exhibits a rating of 20, and Issue3 is valued by 10. The relationship factors are in the amounts of 50 (for trade-off between Issue 1 and issue 2) and 60 (for trade-off between Issue 1 and Issue 3). These numbers, corresponding to X-axis values, are then applied to the graph. The corresponding Y-axis recommends 75% change to Issue 2 and 50% change to Issue 3.

We have included one graph, GraphLose4 as Figure 2. There are in total 10 diagrams, each one representing the compensation levels for every category (determined by the value of the issue), and whether it is lost or gained. The remaining graphs can be found in (Bellucci 2004, pp.108–117).

The amount of compensation awarded is calculated by graphs that were derived from data obtained from domain experts. The example graph in Figure 2 indicates the level of compensation, to be awarded based on the value of ratings, the strength of the trade-off relationship and whether the issue has been lost or gained by a disputant. Whilst it is obvious why a party losing an issue should be compensated, it is equally important to reward a party for being allocated an issue that she did not value importantly[14].

The manner in which compensation is awarded is dependent upon the value of a percentage change, applied to relevant ratings. Once the percentage change of all affected issues has been derived (from the graph functions), the values of new ratings are calculated. To form new ratings, the percentage change relevant to an issue is retrieved and incorporated according to the following equation:

D is assumed to be the union of the issues that have been raised by the disputants. C_j is assumed to be the union of all issues connected to an

Table I. Linguistic importance assignments to rating ranges

Rating range	Linguistic importance assignment
≤10	Not important
11–20	Moderately important
21–35	Important
36–55	Quite important
>55	Very important

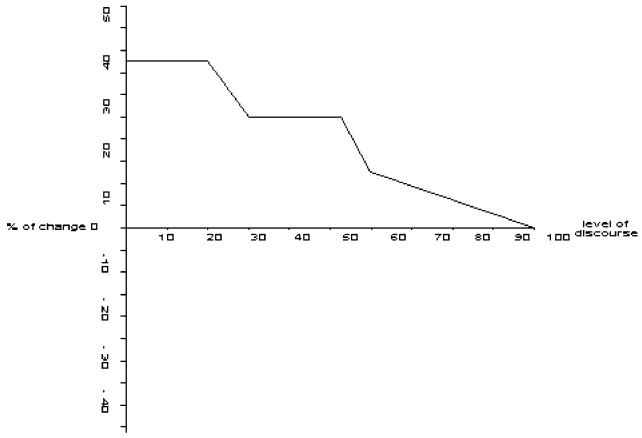

Figure 2. GraphLose4: a sample taken from graphs used in the calculation of compensation figures.

allocated issue, j. For each $d_i \in D$, a set X is defined as the numerical rating calculated on behalf of a party, to each of the issues in D. For each $c_i \in C$, a set Y is defined as the percentage of change, obtained from relevant graph function f. Thus $X = \{x_1, x_2, ..., x_k\}$ and $Y = \{f(x_1), f(x_2), \ldots, f(x_k)\}$.

$$xDi = x_i + x_i^* f(x_i)/100 \quad \text{where } i \in \{1, 2, \ldots, k\} \text{ and } F \text{ is determined empirically.} \tag{7}$$

Subsequent to allocation, the ratings of remaining issues may be modified due to compensation, to influence issue allocation in the following rounds of allocation.

These new ratings (x_{Di}) replace existing rating values (x_i). x_{Di} values are then used to decide the outcome of the next round of allocation. The program then displays a summary report to notify disputants on the current status of the negotiation. The summary page displays the issues and parties to which the issues are allocated, both diagrammatically through the Issue Decomposition Hierarchy, and by generating a complete list of issues. Both the old and new values of ratings, as a result of the recent allocation, are listed.

The process of allocation and issue decomposition continues until there are no more issues to allocate, at which point the program ceases execution.

It is important to note that the formulas mentioned in this section (equations (1–7)) were derived from our observation of data analysis, as opposed to representing proven mathematical formulae. We believe negotiation is an art and not a science. In addition, negotiation is characterised by changing ratings, which makes it difficult to arrive at a theoretical function. We argue a theoretical function cannot exist, otherwise there would always be a perfect solution for each negotiation. Nevertheless, (Bellucci 2004)

discusses in great depth the validity of the formulae through an analysis of case studies and in the formal evaluation of Family_Winner.

7.3. AN ILLUSTRATION OF HOW FAMILY_WINNER HANDLES A FAMILY LAW DISPUTE

In this section we aim to demonstrate the manner Family_Winner operates with reference to a worked example.

Suppose Cassandra (Wife) and Paul (Husband) Jones have been married for 15 years and have two sons aged 13 and 11. Cassandra wants a divorce and an immediate property settlement. She also believes that although she received income from employment throughout her marriage, her principal role was as a homemaker and a nurturer.

Both agree to the distribution of the joint marital property consisting of a house, his Mitsubishi car, and her Holden car. In addition, she believes she is entitled to a portion of her Husband's share in his share portfolio and of his superannuation entitlements. She wishes to retain the house and the Holden car, while Paul wishes to retain his Mitsubishi car and agrees on an equal share of the share portfolio and his superannuation entitlements.

Cassandra believes she should receive primary residency of the children. She consults a lawyer who advises her that as the parent with current primary residency of the children, she should seek 60% of the marital property and adequate child allowance. The 60% mainly consists of the matrimonial home and the holiday house. She wishes to retain both of these properties.

The above case will be used to highlight several important theories used by Family_Winner in determining negotiation advice about this case. These include the areas of input, the Issue Decomposition Hierarchy's development, the display of Trade-off Maps, the allocation of issues and their effect on issue ratings and Trade-off Maps.

7.3.1. *Information input into Family_Winner*

The case is presented to Family_Winner, using the following data as input.

This information is then analysed by a number of functions. These functions include the translation of data into Trade-off Maps, the relaying of information to the database, forming issue allocations and modifying the ratings of the issues in the negotiation to reflect allocations.

7.3.2. *Trade-off Maps*

Once the user has entered the data appropriately, the next screen displays Trade-off Maps generated by the system. Figures 3 and 4 are the Trade-off Maps displayed to disputants following the input of issues listed in Table II.

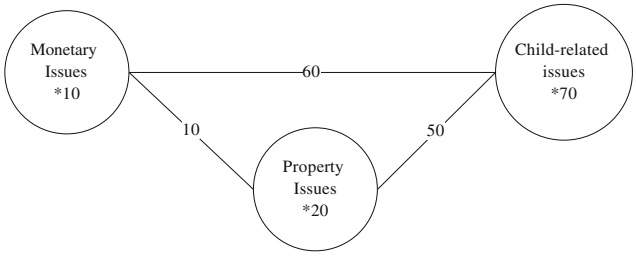

Figure 3. The Husband's Trade-off Map after the initial input of the primary issues.

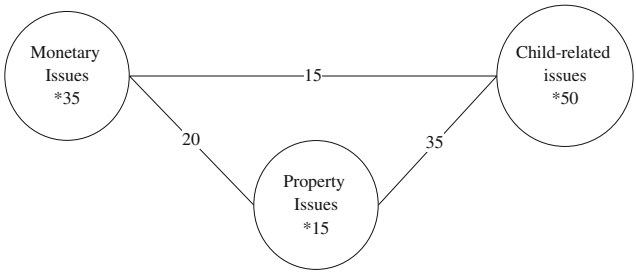

Figure 4. The Wife's Trade-off Map after the initial input of the primary issues.

7.3.3. *Formation of the Issue Decomposition Hierarchy*

The disputants are asked whether they want to divide an issue into many smaller sub-issues. Sub-issues are then incorporated into the dispute through the formation of an Issue Decomposition Hierarchy.

Child-related Issues is the first issue to be considered for decomposition or allocation. Table III lists the point allocations (ratings) given to each issue by the Husband and the Wife, and the ratings used in the dispute (*p*-ratings), which represent the influence of Child-Related Issues on the sub-issue's initial point allocation. *P*-ratings are calculated as a ratio of the parent issue's rating. For instance, Party A gives issue1 a rating of 60, and issue2 a rating of 40. Issue11 has a *p*-rating of 10 (10% of 60) = 6, and Issue12 a *p*-rating of 90 (90% of 60) = 54.

Table II. Initial input of Issues and ratings for use in the hypothetical Family Law Negotiation

Issue	Husband's ratings	Wife's ratings
Child-related issues	70	50
Property issues	20	15
Monetary issues	10	35

Table III. Ratings and *p*-ratings for the sub-issues of Child-Related Issues

Issue	Husband's ratings	*p*-ratings	Wife's ratings	*p*-ratings
Residency	25	17.5	60	30
Visitation rights	50	35	10	5
Child support	25	17.5	30	15

The Trade-off Map is now altered to include the sub-issues of the primary issues. The modified Trade-off Maps of both parties are detailed in Figures 5 and 6.

Family_Winner allocates a parent issue through the allocation of its sub-issues. Therefore, in this example, one of the issues listed in Table II will be allocated next. All the sub-issues of *Child-related Issues* will be allocated before the negotiation moves to consider other issues.

7.3.4. *Commencing the allocation of issues*

The system allocates an issue to one of the parties. The party whose rating is greatest for the issue is allocated the issue. If the issue is valued equally (by the disputants), then the next issue to be allocated replaces the issue in question. The rating of issues connected to the issue just allocated is revised, based on mathematical functions derived empirically from data used in our study. The allocation of an issue involves removal of the issue from the Trade-off Maps, and making appropriate changes to the ratings of affected issues.

The first issue in this example to be allocated is *Visitation Rights*. It is awarded to the Husband, as his rating of 35 is greater than the Wife's equivalent of 5. As a result of the Husband's allocation, the ratings of remaining issues are changed. Table IV lists all remaining issues, their

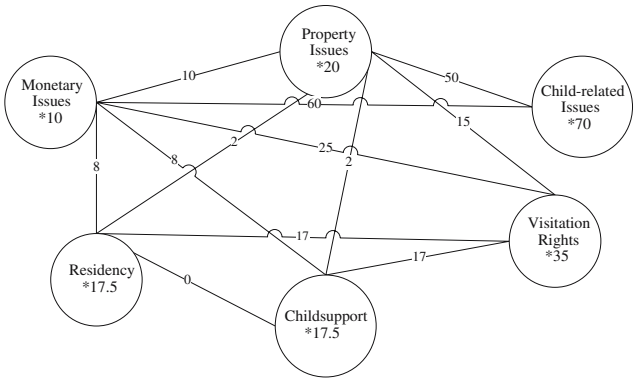

Figure 5. The Husband's Trade-off Map incorporating the sub-issues of Child-related Issues.

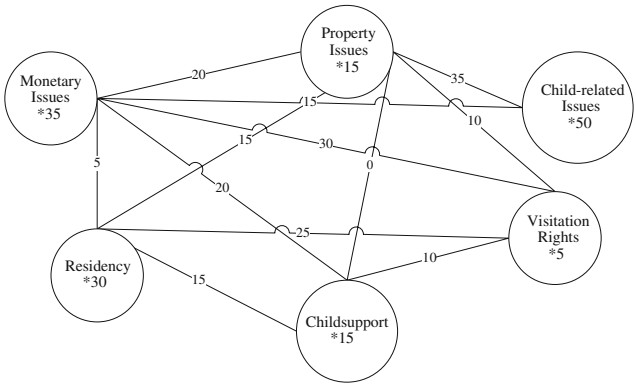

Figure 6. The Wife's Trade off Map incorporating the sub-issues of Child-Related Issues.

updated ratings and the percentage change resulting from the allocation of *Visitation Rights* to the Husband.

As a result of the Husband's allocation of an issue he considered important (valued at 35 points), his ratings did not change considerably. The Wife was compensated for her loss of *Visitation Rights*, valued relatively unimportant at 5 points.

The relative Trade-off Maps of each party, shown in Figures 6 and 7, can be interpreted to explain the amount of change each rating experienced as a result of the allocation. The Husband's ratings experienced little change as the issue's rating was considered by the system to be of great importance to the Husband. All ratings experienced an increase of 5%, as the relationship figures between the issues and *Visitation Rights* were all similar in number. Their relationship figures were 17 between *Child Support*, 17 between *Residency*, 25 between *Monetary Issues* and 15 between *Property*.

The Wife was compensated for her loss of *Visitation Rights* (valued at 5 points), through those issues whose relationship with Visitation Rights is of relatively greater significance. The trade-offs between *Visitation Rights* and *Monetary Issues*, and *Visitation Rights* and *Residency* held relationship values of 30 and 25 respectively. These issues were the only ones whose ratings increased, with increases of 50% and 37.5% respectively. *Property Issues* and

Table IV. Changes made to the ratings of issues following the allocation of visitation rights to the husband

Issue name	Husband's ratings	Wife's ratings
Child support	18.375 (5% change)	15 (0% change)
Residency	18.375 (5% change)	41.25 (37.5% change)
Monetary issues	10.5 (5% change)	52.5 (50% change)
Property issues	21 (5% change)	15 (0% change)

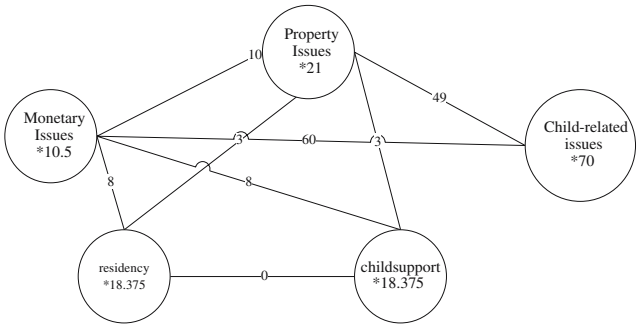

Figure 7. Husband's Trade off Map after the allocation of Visitation Rights.

Residency did not change their ratings, as their relationships with *Visitation Rights* were valued at 10 points each.

7.3.5. *Changes to Trade-off Maps as a result of the allocation of issues*

Trade-off maps display the trade-offs currently applicable to the dispute. Once an issue is removed from a dispute through allocation, the Trade-off Map is modified to reflect this change. The issue is removed from the map, and the ratings of the remaining issues are re-calculated according to the values dictated by the applicable trade-offs.

The resulting Trade-off Maps following the allocation of *Visitation Rights* are demonstrated in Figures 7 and 8.

The system continues to traverse the hierarchy, by either allocating or dividing issues, until all issues have been allocated. A summary of subsequent allocations is found in Table V.

7.4. USING FAMILY_WINNER IN NON FAMILY LAW DOMAINS

Family_Winner was formally evaluated using the Context, Criteria, Contingency Evaluation Framework (Hall et al. 2003) for evaluating legal

Table V. Allocation table for the hypothetical family law dispute

Husband's allocations	Wife's allocations
Visitation rights	Residency
Shares	Superannuation
Child support	Matrimonial Home
Investment unit	Holiday house
Mitsubishi car	Holden car
Boat	

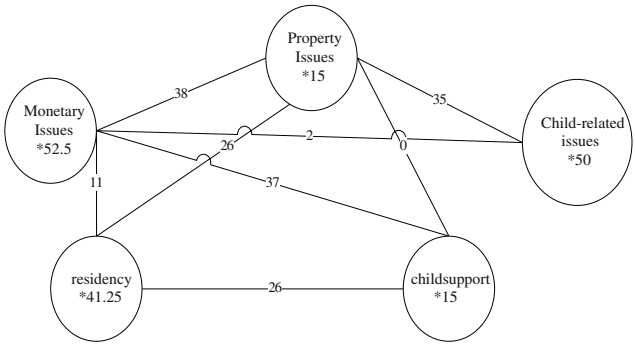

Figure 8. Wife's Trade-off Map after the allocation of Visitation Rights.

knowledge-based systems. Although the strategy has components specifically developed for the requirements of legal systems, we were able to develop an evaluative strategy suited to Family_Winner's attributes. Family_Winner is a negotiation decision support system that was initially built to resolve disputes in Australian Family Law. From the system evaluation, we concluded its use is of greater significance in other legal domains.

In (Bellucci 2004) we discussed how Family_Winner has been used in a variety of negotiation domains: for example in Family Law, Enterprise Bargaining Agreements, International disputation and negotiations about company mergers. An investigation of these examples in (Zeleznikow and Bellucci 2003), has shown the benefits Family_Winner provides for advising upon trade-offs, compensation and the sequencing of negotiations; as long as points can be allocated to issues.

When Family_Winner was trialed at Victoria Legal Aid's offices in December 2002, we observed that the system, in focusing upon providing advice with regard to bargaining, had neglected 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.

(a) Family Law is a less suitable domain for building Negotiation Support Systems than is Enterprise Bargaining. We considered the Enterprise Bargaining Agreements of Victoria Legal Aid (VLA) for the period 2000–2003. Issues in dispute were pay, the use of technology, flexi-time, overtime, pre-natal leave, childcare, working from home and performance management. The solution advocated by

Family_Winner was very similar to that eventually concluded by VLA and its employees.Our experience with modelling enterprise bargaining and the introduction of new Industrial Relations legislation in Australia[15] has led to our development of an interested based NDSS in the domain of Australian Enterprise Bargaining.

(b) The terrorist negotiation example cited by (Raiffa et al. 1982) showed that even in time critical and fraught situations, NDSS can prove useful. 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 provided 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.

(c) An example taken from (Brams and Taylor 1996) considered a negotiation held between two companies discussing a company merger. Issues in dispute were the name of the merged company, location of the headquarters of the company, chairman of the company, chief executive officer of the company and how to handle the layoff of staff in the merged company. The settlement cited by Brams and Taylor was identical to that suggested by Family_Winner. The results obtained from this example demonstrate the effectiveness of trade-off equations in assisting appropriate allocation of issues valued closely.

An investigation of these 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, remain static and points can be allocated to issues.

8. Future research and conclusion

8.1. COMMERCIALISING FAMILY_WINNER

Family_Winner has recently received considerable media publicity[16]. As a result, we have been approached to commercialise the program. Two specific projects are taking place.

(a) In conjunction with a commercial partner (Creative Binary Engineering) we are developing a generic web-based system to provide advice about dispute resolution using an interest-based approach. The Australian Workplace Relations Amendment (Work Choices) Bill 2005 encourages employers and employees to conduct direct negotiations about employment conditions. Previously, under a centralised decision-making process, the Australian Industrial Relations Commission made ruling on disputes[17]. Whilst the new legislation creates a Fair Pay Commission to ensure that all agreements meet five basic principles, the new legislation encourages interest-based negotiation rather than arbitrated or judicial decisions. It is thus an excellent domain in which to provide Negotiation Decision Support. In conjunction with the School of Applied Economics at Victoria University, we are building a tailored system adapted from our generic web-based system to advise upon enterprise bargaining. In conjunction with a commercial partner (Creative Binary Engineering) we are developing a generic web-based system to provide advice about dispute resolution using an interest-based approach.
(b) In conjunction with the Queensland Branch of Relationships Australia, we are developing a NDSS using both interested-based and justice-based negotiation. For example, in the case of the Jones family discussed in Section 7.3, the family mediator might advise that that if Mrs. Jones is to have primary care of the children, then she should receive 60% of the property (or let us say 60% of her desires). Our adaptation will advise the parties upon how to best meet their interests, given such a split.

8.2. AN ONLINE DISPUTE RESOLUTION ENVIRONMENT

(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.

Our NDSSs 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. (Lodder and Zeleznikow 2005) therefore combine the dialogical reasoning of Lodder with our game-theoretic based negotiation techniques to construct an online dispute resolution environment.

The on-line environment (Lodder and Zeleznikow 2005) propose suggests use of the dialog system in the first instance. If use of the dialog system has

not facilitated agreement on all issues, then a negotiation support system such as ours can provide decision support about trade-offs and negotiation. The environment (Lodder and Zeleznikow 2005) propose benefits from the observation that what one system lacks the other employs. It is assumed participants to an on-line dispute resolution process such as the one being proposed will achieve at least equal or better results than if using only one negotiation support technique.

The online dispute resolution environment (Lodder and Zeleznikow 2005) facilitates 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. (Bellucci et al. 2004).

8.3. CURRENT RESEARCH

In Zeleznikow (2005) we have described how Toulmin's treatise (Toulmin 1958) on the uses of argument can be gainfully employed to construct legal decision support systems. This is particularly so in discretionary domains, which we decide to model using knowledge discovery techniques, which do not provide adequate explanations or arguments. The Toulmin structure also allows use of a hybrid of different inferencing techniques.

We illustrated how Toulmin's theory has been applied in disparate domains such as family law, eligibility for legal aid, copyright, refugee law, evaluation of eyewitness evidence and sentencing.

We are using this environment to provide negotiation support for:

(1) Plea bargaining – using our sentencing decision support system to learn how to determine BATNAs in the domain, and may be used by defence lawyers at Victoria Legal Aid to hold discussions with the Office of Public Prosecutions;
(2) Family Law – parties to a family dispute can receive advice about possible outcomes, exchange arguments and receive mediation advice about how best they can attain their objectives.
(3) The negotiation of Information Technology Outsourcing Agreements.

8.4. CONCLUSION

Rather than focusing upon how to model the process of negotiation, we have concentrated upon providing decision support for mediators through the use

of trade-offs and compensation strategies. The resulting system, Family_Winner, provides advice in the domain of Australian Family Law.

We have collected data from various sources, to decide upon a unique approach to computerised negotiation support. Most of the techniques implemented by Family_Winner are commensurate with the practises of family mediators. For example, Family_Winner can only operate on the assignment of ratings by disputants (which indicate the relative importance of each issue to a disputant) and supports the sequential resolution of issues. The system implements a well known phenomena in mediation, that disputants often change their initial values (defined as ratings in Family_Winner) in light of an issue's allocation. The system revises ratings according to a predetermined empirically derived formula, following the allocation of an issue. It utilises trade-off manipulation and compensation strategies in modelling change.

We believe that there is a market for systems such as Family_Winner. Mediators for example are concerned with using our process to make clients aware of their interests and to expose them to potential trade-offs they should accept. Divorcing couples may use the system to help them define their interests in the negotiation; as well as be interested in the ensuing advice. This information should be used in conjunction with advice sought from professional mediators and lawyers.

Notes

[1] In ongoing research we are developing the notation that rather than give points to each issue in dispute, they need merely linearly order the issues. This can occur by saying for any two issues A and B, A is much more/more/same/less/much less important than B.

[2] See http://www.winxwin.com, accessed January 26 2006.

[3] See for example (Stranieri et al. 1999) where we use machine learning techniques to mimic the manner in which Australian Family Law judges distribute marital property.

[4] There are also compulsory Section 24 conferences for the mediation of property disputes. Legislation currently before the Australian Parliament will mandate compulsory mediation at a much earlier stage in the Family Law Dispute Resolution process.

[5] Australia has a federal system of government. The Australian Constitution divides authority between the States and the Commonwealth. s.51 of the Commonwealth of Australia Constitution Act 1900 (Cth) gives the Federal Parliament the power to make laws about:

(xx) Marriage; and

(xxi) Divorce and matrimonial causes; and in relation thereto, parental rights, and the custody and guardianship of infants. Prior to 1959 there were varying state laws about divorce. The *Matrimonial Causes Act 1959 (Cth)* introduced the first uniform divorce laws for Australia. The principal aim of the *Family Law Act* (1975) was to reform the law governing the dissolution of marriage. The new Act replaced the *Matrimonial Causes Act 1959 (Cth)* and superseding State and Territory laws about 'guardianship, custody, access and maintenance' of children of a marriage.The *Family Law Act 1975 (Cth)* as well as making

significant changes to the law relating to divorce in Australia, created the Family Court of Australia to interpret and apply that law to individual cases..

S 21(1)A court, to be known as the Family Court of Australia is created by this Act.

(2) The Court is a superior court of record (3) The Court consists of:

(a) A Chief Judge who shall be called the Chief Justice of the Court;

(b) a Deputy Chief Judge who shall be called the Deputy Chief Justice of the Court; and

(c) Judge Administrators, Senior Judges and other~Judges, not exceeding, in total, such number as is prescribed.Appeals from a first instance decision of a Family Court judge are ordinarily heard by a Full Court of the Family Court, which must be composed of at least three Family Court Judges (Dickey 1990). There are currently 52 judges of the Family Court of Australia. For administrative reasons only, the Family Court of Australia is divided into four regions. Each region has a Judge Administrator. Each region has a number of registries. Whilst each of the judges of the Family Court of Australia is assigned to a registry, he/she regularly hears cases in other registries. An appeal from a decision of the Full Court of the Family Court can be made to the High Court of Australia.Prior to a case regarding the welfare of children being heard by the Family Court, the parties are required to attend confidential mediation.

[6] As we shall discuss in our concluding section, we are conducting ongoing research with the Queensland Branch of Relationships Australia to integrate interest-based and justice-based negotiation into the Family_Winner system. In particular our resulting system will ensure the justice based notion that 'the parent caring for the children will be provided with adequate resources to complete this task'.

[7] Open textured legal predicates contain questions that cannot be structured in the form of production rules or logical propositions and which require some legal knowledge on the part of the user in order to answer.

[8] In the Split-Up project (Stranieri et al. 1999) wished to model how Australian Family Court judges exercise discretion in distributing marital property following divorce. Section 79(1) of the *Family Law Act (1975)* empowers judges of the Family Court to make orders altering the property interests of parties to the marriage but does not lay down procedural guidelines for judicial decision makers. In practice, judges of the Family Court follow a five-step process in order to arrive at a property order: (1) Ascertain the property of the parties. (2) Value all property of both parties. (3) Determine which assets will be paramount in property considerations. This is referred to as common pool property. (4) Determine a percentage of the property to be awarded to each party. (5) Create an order altering property interest to realise the percentage. The Split-Up system implements steps 3 and 4 above, the common pool determination and the prediction of a percentage split.

[9] See http://www.Smartsettle.com. Accessed January 26 2006.

[10] See http://www.cybersettle.com. Accessed January 26 2006.

[11] These surveys where originally used in mediator service evaluations conducted in 1994 by the Attorney-General's Department and the National Centre for Socio-legal studies at La Trobe University.

[12] Mr. Bruce Smythe of the Australian Institute of Family Studies provided us with 650 negotiated and litigated cases.

[13] As opposed to distributive procedures such as a zero-sum game; in that what one party wins the other loses.

[14] This scenario is highly unlikely to occur as the systems' primary focus is to allocate issues to parties who value them the most.

[15] The new legislation basically eliminates many safeguards provided to employees and encourages employers and employees to negotiate on an individual and case-by-case basic.

Previously, workplace decisions were made by Judges of the Australian Industrial Court, following litigation between unions and employers' group.

[16] See for example: (a) February 2005: Article in MIT Technology Review: Logging on to your lawyer http://www.technologyreview.com/articles/05/02/issue/forward_lawyer.asp;(b) March 2005: Article in the Economist: AI am the Law http://www.odr.info/comments.php?id = 1480_0_1_20_C;(c) September 11 2005: Publication in the Boston Globe: Robo-Justice: Do we have the technology to do a better legal system. See http://www.boston.com/news/globe/ideas/articles/2005/09/11/robo_justice/;(d) September 21 2005: Publication in Sydney Morning Herald (shorter version in the Age) Divorce? Let the computer be the judge http://www.smh.com.au/articles/2005/09/20/1126982062322.html and http://www.theage.com.au/articles/2005/09/20/1126982061855.html;(e) September and October 2005: Over a dozen radio interviews in all Australian states and on BBC Radio 5 and separately the BBC World Service;(f) September 29 2005: Airing of a segment about our research on the Seven Network's Today Tonight Show. See http://www.seven.com.au/todaytonight/story/?id = 24784;(g) October 4 2005: See http://www.timesonline.co.uk/article/0,,8163-1806165,00.html Times of London, for a discussion of our work on using game theory for negotiation support; (h) October 17 2005 – ABC TV midday news;(i) October 17 2005 – Age Education Supplement, page 10: Campus Chatter Article on Dispute Divorce on PC;(j) November 15 2005 – Age IT article, Game theory for negotiators http://www.theage.com.au/news/next/game-theory-for-negotiators/2005/11/14/1131816858584.html and – Sydney Morning Herald IT article, Game theory for negotiators http://www.smh.com.au/news/next/game-theory-for-negotiators/2005/11/14/1131816858584.html;(k) November 16 – ABC TV 2 New Inventors Program: Family Winner http://www.abc.net.au/newinventors/txt/s1504763.htm.

[17] Generally conducted between unions and employer groups.

References

Acadian software (2004). http://www.winxwin.com.

Bellucci, E. (2004). Developing Compensation Strategies for the Construction of Negotiation Decision Support Systems. PHD thesis, La Trobe University, Bundoora 3086, Victoria, Australia.

Bellucci, E., Lodder, A. R. and Zeleznikow, J. (2004). Integrating Artificial Intelligence, Argumentation and Game Theory to Develop an Online Dispute Resolution Environment. *The Proceedings of 16th IEEE International Conference on Tools with Artificial Intelligence*, (ICTAI'04), 749–754.

Bellucci, E. and Zeleznikow, J. (1997). Family-Negotiator: An Intelligent Decision Support System for Negotiation in Australian Family Law. *Proceedings of the Fourth Conference of the International Society for Decision Support Systems*, Lausanne, International Society for Decision Support Systems, 359–373.

Bellucci, E. and Zeleznikow, J. (1998). A Comparative Study of Negotiation Decision Support Systems. *Proceedings of the Thirty-First Hawaii International Conference on System Sciences*. IEEE Computer Society, Los Alamitos, Cal, 254–262.

Bellucci, E. and Zeleznikow, J. (2001). Representations for decision making support in negotiation, Journal of Decision Support 10(3–4): 449–479.

Bichler, M., Kesten, G. and Weinhardt, C. (2003). Electronic Negotiations: Foundations, Systems, and Experiments – Introduction to the Special Issue, Group Decision and Negotiation 12: 85–88.

Black, H. C. (1990). Black's Law Dictionary. West Publishing Company, St. Paul: Minnesota.
Blanning, R. W. and Bui, T. X. (2000). Decision Support Systems and Internet Commerce. In Shaw, M., Blanning, R., Strader T. and Whinston A. (eds.), Handbook on Electronic Commerce, 53–75, Springer-Verlag.
Brams, S. J. and Taylor, A. D. (1996). Fair Division, from Cake Cutting to Dispute Resolution. Cambridge University Press: Cambridge, UK.
Brams, S. J. and Taylor, A. D. (1999). The Win–Win Solution: Guaranteeing fair Shares to Everybody. W.W Norton: New York NY.
Dickey, A. (1990). Family Law. The Law Book Company: Sydney.
Eidelman, J. A. (1993). Software for Negotiations, Law Practice Management 19(7): 50–55.
Fisher, R. and Ury, W. (1981). Getting to YES: Negotiating Agreement Without Giving In. Boston: Haughton Mifflin.
Hall, M. J. J., Hall, R. and Zeleznikow, J. (2003). A Method for Evaluating Legal Knowledge-based Systems based Upon the Context Criteria Contingency-guidelines Framework. Proceedings of the Ninth International Conference on Artificial Intelligence and Law, 274–283, Edinburgh, Scotland: ACM Press.
Holsapple, C. W. and Whinston, A. B. (1996). Decision Support Systems – A Knowledge Based Approach. West Publishing Company, St. Paul: Minnesota.
Hoffer, D. (1996). Decision Analysis as a Mediator's Tool, Harvard Negotiation Law Review 1: 113.
Kalai, E. and Stanford, W. (1988). Finite Rationality and Interpersonal Complexity in Repeated Games, Econometrica.
Kersten, G. E. (1997). Support for Group Decisions and Negotiations: In Climaco, J. (ed.), An Overview, in Multiple Criteria Decision Making and Support. Springer-Verlag:Heidelberg.
Kolodner, J. L. and Simpson, R. L. (1989). The Mediator: Analysis of an Early Case-Based Problem Solver, Cognitive Science 13: 507–549.
Lodder, A. R. (1999). DiaLaw – On Legal Justification and Dialogical Models of Argumentation (LAPS Vol. 42). Kluwer Academic Publishers: Dordrecht.
Lodder, A. R. and Zeleznikow, J. (2005). Developing an Online Dispute Resolution Environment: Dialogue Tools and Negotiation Systems in a Three Step Model, The Harvard Negotiation Law Review 10: 287–338.
Lomuscio, A. R., Wooldridge, M. and Jennings, N. R. (2003). A Classification Scheme for Negotiation in Electronic Commerce, Group Decision and Negotiations 12: 31–56.
Matwin, S., Szpakowicz, S., Koperczak, Z., Kersten, G. E. and Michalowski, G. (1989). NEGOPLAN: An Expert System Shell for Negotiation Support, IEEE Expert 4: 50–62.
Mnookin, R., Peppet, S. R. and Tulumello, A. S. (2000). Beyond Winning: Negotiating to Create Value in Deals and Disputes. The Belnap Press of Harvard University Press.
Peterson, M. and Waterman, D. (1985). Evaluating Civil Claims: An Expert Systems Approach to Evaluating Product Liability Cases. In Walter, C. (ed.) Computer Power and Legal Reasoning, 627–659. West Publishing Company.
Pruitt, D. G. (1981). Negotiation Behaviour. Academic Press Inc.
Pruitt, D. G. and Carnevale, P. J. (1993). Negotiation in Social Conflict. Open University Press: Buckingham.
Raiffa, H. (1982). The Art and Science of Negotiation. Harvard University Press: Cambridge, Massachusetts.
Raiffa, H., Richardson, J. and Metcalfe, D. (2002). Negotiation Analysis: The Science and Art of Collaborative Decision Making. The Belknap Press of Harvard University Press: Cambridge Massachusetts.
Robertson, S., Zachary, W. and Black, J. (1990). Cognition, Computing and Cooperation. Ablex Publishing Cooperation: New Jersey.

Saaty, T. (1980). The Analytical Hierarchy Process: Planning, Priority, Allocation. Mac-Graw Hill: New York.

Schultz, T., Kaufmann-Kohler, G., Langer, D. and Bonnet, V. (2001). In E-Com Research Project of the University of Geneva.

Stranieri, A., Zeleznikow, J., Gawler, M. and Lewis, B. (1999). A Hybrid – Neural Approach to the Automation of Legal Reasoning in the Discretionary Domain of Family Law in Australia, Artificial Intelligence and Law 7(2–3): 153–183.

Sycara, K. (1993). Machine Learning for Intelligent Support of Conflict Resolution, Decision Support Systems 10: 121–136.

Thiessen, E. M. and McMahon, J. P. (2000). Beyond Win–Win in Cyberspace, Ohio State Journal on Dispute Resolution 15: 643.

Toulmin, S. (1958). The Uses of Argument. Cambridge University Press: Cambridge, UK.

Weigand, H., Moor, A.De, Schoop, M. and Dignum, F. (2003). B2B Negotiation: The Need for a Communication Perspective, Group Decision and Negotiation 12: 3–29.

Waterman, D. A., Paul, J. and Peterson, M. (1986). Expert systems for legal decision making, Expert Systems 3(4): 212–226.

Wertheim, E., Love, A., Littlefield, L. and Peck, C. (1992). I Win: You Win, 130–135. Penguin Books, Ringwood, Victoria.

Yuan, Y., Rose, B. J., Archer, N. and Suarga, H. (1998). A Web-Based Negotiation Support System, EM – Electronic Markets, 8.

Zeleznikow, J. (2005). Using Toulmin Argumentation to Develop an On Line Dispute Resolution Environment. To Appear in Proceedings of Ontario Society for the Study of Argumentation Conference on the Uses of Argument, McMaster University, Hamilton, Ontario, Canada, May 18–21.

Zeleznikow, J. and Bellucci, E. (2003). Family_Winner: Integrating Game Theory and Heuristics to Provide Negotiation Support. Proceedings of Sixteenth International Conference on Legal Knowledge Based System, 21–30. IOS Publications, Amsterdam, Netherlands.

Zeleznikow, J., Meersman, R., Hunter, D. and van Helvoort, E. (1995). Computer Tools for Aiding Legal Negotiation, 231–251. ACIS95 – Sixth Australasian Conference on Information Systems, Curtin University of Technology, Perth, Western Australia.