Trade-off Manipulations in the development of Negotiation Decision Support Systems

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Abstract

Our model of negotiation for constructing Negotiation Decision Support Systems is based upon Principled Negotiation and uses trade-off manipulations in order to provide decision support.

A resulting system, Family_Winner, was constructed using several information systems techniques. Trade-off Maps (a variant of Constraint Diagrams) are used to represent trade-off opportunities, while an empirically derived formula calculates the amount of compensation given to the ratings of issues remaining in dispute. The Issue Decomposition Hierarchy embedded in the system allows for the incorporation of sub-issues.

Family_Winner was originally built for use in Australian Family Law. We believe our model can be extended for use in various other domains. Family_Winner has been evaluated in the areas of industrial relations, international disputation and company disputes. Results from our evaluation suggest the system works satisfactorily in these domains. We conclude this paper by describing future projects that will develop and extend Family_Winner's functions and applicability.

1. Introduction

Negotiation is a process by which two or more parties conduct communications or conferences with the view to resolving differences between them. Negotiation Support Systems (NSS) are programs that assist users in the negotiation process. In comparison, Negotiation Decision Support Systems (NDSS) extend the operation of NSS to include an element of decision support. In this paper, we present a system that we have implemented, Family_Winner, as a NDSS that uses trade-off manipulations to propose settlements to disputes.

We present a survey of existing NSS and NDSS. In the latter category, we did not find any systems that use trade-off manipulations to settle disputes, even though our research suggests that the use of trade-offs in negotiation is widespread[1].

We discuss Family_Winner [1] a Negotiation Decision Support System that uses Trade-off Maps (a variant of Constraint Diagrams) to represent trade-off opportunities inherent in the issues of a dispute. The system acts upon trade-offs once an issue has been allocated, resulting in compensation and rewards to the utilities of issues remaining in dispute. The amount by which a party is compensated is decided through a complex set of formulae that have been derived empirically. The Issue Decomposition Hierarchy embedded in the system allows for the incorporation of sub-issues, which forms our attempt to increase the number of issues in dispute. Family_Winner assumes a two-party dispute. Although Family_Winner was initially developed in the domain of Australian Family Law, we argue Family_Winner is not domain dependent, and is flexible with regard to the type of issues it is able to process. The system was evaluated against negotiation case studies from various domains. We conclude the paper by mentioning our future directions in the development of online dispute resolution systems and other projects involving the

[1] Data collected from interviews conducted with mediators from The Family Mediation Centre in August 1998 in Ringwood, Victoria Australia.

extension of Family_Winner to support online dispute resolution.

2. Negotiation theory

Numerous negotiation models have been developed from detailed studies involving observations of the way people negotiate. There is a significant difference between the formal models of negotiation and practical approaches to developing negotiation strategies. Formal models have been derived from game theory, multi-criteria decision making, negotiation analysis, and economics. Negotiation approaches, for example positional bargaining, collaboration and principled negotiation, have been derived from behavioural research. The difference between formal models and negotiation approaches is that the former use all or selected assumptions of economic rationalism while the latter is based on individual and social norms and behaviours, whether they be actual or postulated.

Our research has focused on behavioural negotiation approaches, and in particular we isolate principled negotiation as the theory most suited to our requirements. The Harvard Negotiation Project [6] has conceptualised value-based negotiation. It emphasises that parties look for mutual gains, wherever possible, and when interests conflict, parties should come to 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:

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.

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.

Invent options for mutual gain. There are a number of strategies that enable option generation. Expanding the pie is one strategy, where new issues are added to the dispute in an attempt to locate new resources. Another is compensation, in which payment is made through another issue or entirely new case and log-rolling, where disputants form an agreement by taking into account the differences between multiple issues. In providing decision support, Family_Winner uses a strategy integrating the principles of logrolling and compensation to support settlement. Family_Winner supports the concept of expanding the pie by increasing the number of issues in dispute. Disputants perform this task by decomposing issues into sub-issues and storing them in the Issue Decomposition Hierarchy.

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 is awarded, the less their opponent receives. In similar cases, unbiased independent evaluations of an item may provide guidance in setting a mutually agreeable settlement.

Know your best alternative to a negotiated agreement - BATNA The reason you negotiate with someone is to produce better results than would otherwise occur. If you are unaware of what results you could obtain if the negotiations are unsuccessful, you run the risk of:

- Entering into an agreement that you would be better off rejecting; or
- Rejecting an agreement you would be better off entering into.

When a person is wishing 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 negotiator then decides the value they wish to place on a car. BATNAs in negotiations are therefore generally used to form a basis on which fair agreements can be argued.

Family_Winner uses Principled Negotiation as its' foundation negotiation theory. In providing decision support, it uses a trade-off and compensation strategy to invent options for mutual gain.

3. An analysis of current NSS and NDSS

The majority of traditional NSS have been restricted to informing parties of past and present preferences and on the progress made within the negotiation. We have classed these as template-based NSS. Examples of such NSS include Negotiator Pro, The Art Of Negotiating [5] and DEUS [24]. Web-enabled NSS include Smartsettle [19], INSPIRE [9] and CBSS [22].

The aim of this paper is to demonstrate use of decision-making support in negotiation, in particular through our system, Family_Winner. NSS that extend the primary role of template-based systems to incorporate a decision-making aspect are classified as Negotiation Decision Support Systems (NDSS). NDSS extend the primary notion of a NSS to include the ability to propose sample solutions.

Early decision-support negotiation systems primarily used Artificial Intelligence techniques to model negotiation. Examples include LDS [13], SAL [20], NEGOPLAN [11], Mediator [10], PERSUADER [18] and Family_Negotiator [2].

AdjustWinner ([3],[4]) uses a utility function to achieve equal distribution of the pool being distributed. AdjustWinner resolves a dispute by dividing issues and items among disputants, through a mathematical manipulation of numeric preferences.

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 the ability to provide users with a resolution to the current problem.

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

A grid comparing systems mentioned above against specific criteria can be found in [1].

4. Negotiation decision support through Trade-Off manipulation

Decision-making is a knowledge-intensive activity that alters an organisation's state of knowledge. A decision is defined 'a piece of knowledge indicating a commitment to some course of action' [8]. 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. Decision support in negotiation involves a number of complex variables, which include the number of issues, the number of parties to the dispute, and to some extent, the complexities inherent in the domain.

Family_Winner's method of decision support involves a complex number of techniques:

1. Implementation of an Issue Decomposition Hierarchy;
2. Trade-off Strategy;
3. Compensation Strategy;
4. Fairness and equality principles; and
5. Allocation Strategy.

An Issue Decomposition Hierarchy was incorporated into Family_Winner. It enabled 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 Process (AHP) [17]. Although it may not appear intuitive, the number of issues involved will influence the success of the negotiation, as it is assumed, 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' [12] and [21] as a method of option generation.

Point 2 refers to trade-off capabilities. Family_Winner accepts as input a list of issues and importance ratings that represent a concise evaluation of a disputant's preferences. In forming these ratings, we assume disputants have conducted a level of comparison between the issues. [18] notes bargainers are constantly asked if they prefer one set of outcomes to another. The system [18] suggests is to consider two issues at a time, assuming all others are fixed. Family_Winner uses a similar system in which pair-wise comparisons are used to form trade-off strategies between two issues.

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. The value of a trade-off relationship is determined by analysing the differences between the parties [12].

Compensation is considered as an external reward, one that is not related to the issues on the table. 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 [1].

Point 4 refers to Family_Winner's allocation strategy. We have interpreted the allocation of an issue based on a trade-off as form of logrolling. [15] describes log-rolling as the process where participants look collectively at multiple issues to find issues that one party considers more important than the opposing party's evaluation of the issue. Logrolling is successful if the parties concede issues to which they give low importance values.

Brams and Taylor view fairness in a negotiation as giving both parties to a dispute an equal percentage of their priorities. The Adjusted Winner algorithm [4] 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 [4] and [14] are sustainable. However, our goal of providing negotiation support does not easily lend itself to fairness assessment, due primarily 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 fair outcome. The theories promoted in this paper 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.

5. Family_Winner

This section outlines the major components of Family_Winner through a discussion of the comprehensive flow chart, displayed in Figure 1. The input data consists of several variables (including issue names and associated ratings), which all directly contribute to the outcome of the current case. The system uses the Issue Decomposition Hierarchy in which to store all issues (and sub-issues) and makes ample use of Trade-off Maps to mimic a compensation strategy. The output consists of a list of allocations, which forms the basis of the advice provided by the system.

The flowchart in Figure 1 identifies the sequence of actions, decisions and branching points in the negotiation process implemented in Family_Winner. The system accepts input from both parties involved in the dispute. This data is then analysed and transformed into information required by the functions inherent in the system.

The first major process is that of forming and displaying Trade-off Maps. 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. 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.

Issues are labelled by their name and current rating. The value of an issue can be directly entered by the party, or a rating modified as the result of a previous allocation.

The trade-off relationships between pairs of issues are labelled by the numerical difference between the two ratings. This newly devised numeral is used in calculations, to determine appropriate compensation awarded to the parties after the allocation of an issue.

As the program progresses, the parties are asked to build on an Issue Decomposition Hierarchy by decomposing issues, which allows for the current pool of issues to be expanded. The parties are asked if the issues should be sub-divided into smaller issues. If the disputants answer yes, then the system suggests the first issue to be decomposed. This recommendation has been based on the understanding that a large difference between the ratings of parties is indicative of an issue that is most likely to be resolved quickly[3].

Once the issue to be decomposed has been decided upon, parties are required to enter new sub-issues in the same format as parent issues were entered. When this task is completed, the new details are stored in the Issue Decomposition Hierarchy under the appropriate primary (parent) issue. On the flowchart, development of the hierarchy is shown by the line labelled *level + 1 issues to be input.*

If an issue does not require decomposition, or has been sub-divided appropriately, the issue is allocated according to the issue's importance rating. The ratings of issues are hence compared. The party that values the issue more highly is most likely to receive the issue.

After an allocation, the ratings of the remaining issues may be modified through compensation, to influence future issue allocations. The amount of compensation awarded is calculated through graphs that were derived from data obtained from domain experts, and is explained in full in [1].

Once Family_Winner allocates an issue, a summary outlining the allocation is presented to users. Information presented at this time includes the allocated issue and the party to whom it is allocated, previously allocated issues (and the parties they have been allocated to), and the value of rating changes made to the subsequent issues. This information enables users to gain an insight into the reasoning behind the allocation and the relative impact of the allocation on the remaining issues in dispute.

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

[3] With the exception of Family Law, where Family Law practitioners involved in our study suggested Child-related issues should be resolved foremost.

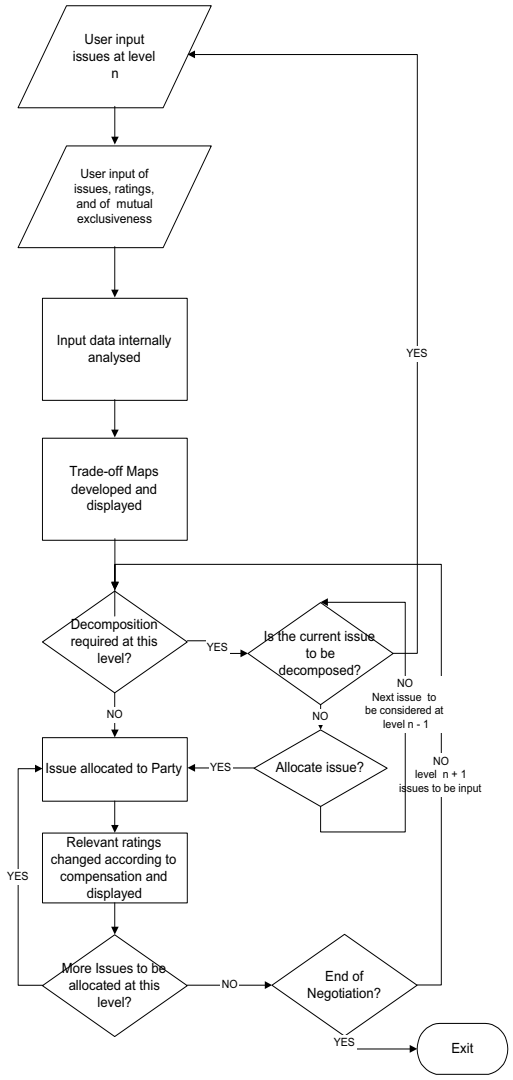

Figure 1. Flowchart of Family_Winner

6. Family_Winner in Operation

We now detail a hypothetical family law trial case using Family_Winner to provide negotiation support. This exercise demonstrates the system's operation in practice.

6.1 A hypothetical Family Law case

Suppose Cassandra (Wife) and Paul (Husband) Jones have been married for fifteen years and have two sons aged thirteen and eleven. 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.

6.2 Input to Family_Winner system

In Family_Winner, the disputants enter information regarding the dispute at hand. Disputants do not enter the issues in any particular order. Since issues will be stored in a hierarchy, it is important that issues on the same level of decomposition should be entered at the same time. Equally as important, are indications of the importance of an issue to each party, represented in the form of a numerical rating between 0 and 100 inclusive. The case is presented to Family_Winner, using the following data as input.

Table 1. 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

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.

6.3 Trade-off Maps

Once the user has entered the data appropriately, the next screen displays Trade-off Maps generated by the system. The elements of a Trade-off Map are:

(i) The nodes (or issues in this case);

(ii) The strength of connections between these nodes (reflective of the trade-off opportunities); and

(iii) A rating figure for each issue.

The issues and their ratings are retrieved directly from user input. Figures 2 and 3 are the Trade-off Maps displayed to disputants following the input of issues listed in Table 1.

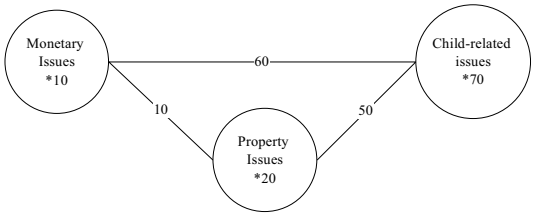

Figure 2. The Husband's Trade-off Map after the initial input of the primary issues.

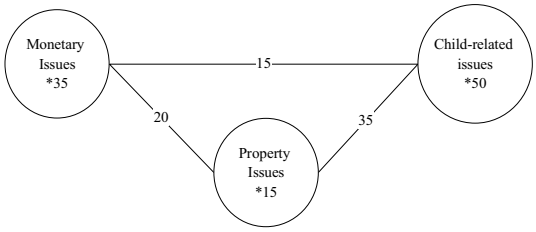

Figure 3. The Wife's Trade-off Map after the initial input of the primary issues.

6.4 Formation of the Issue Decomposition Hierarchy

The disputants are asked to decompose 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 2 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:2. Ratings and p-ratings for the sub-issues of *Child-Related Issues*.

Issue	Husband's ratings and p-ratings		Wife's ratings and 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 4 and 5.

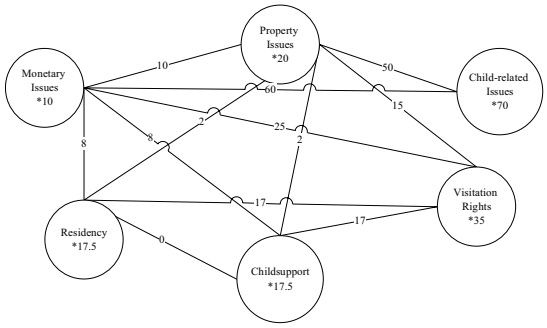

Figure 4. The Husband's Trade-off Map incorporating the sub-issues of *Child-related Issues*.

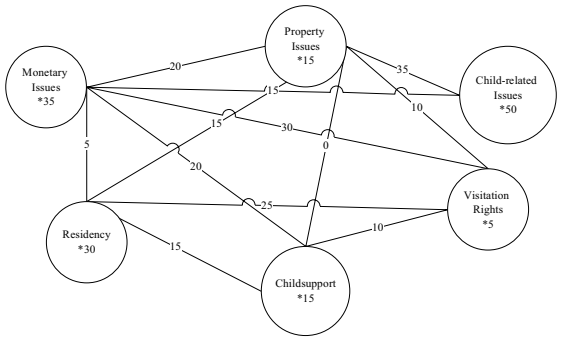

Figure 5. The Wife's Trade off Map incorporating the sub-issues of *Child-Related Issues.*

Family_Winner allocates a parent issue through the allocation of its sub-issues. Therefore, in this example, one of the issues listed in Table 2 will be allocated next. All the sub-issues of *Child-related Issues* will be allocated before the negotiation moves to consider other issues.

6.5 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 current rating of issues connected to the issue allocated is revised, based on mathematical functions derived empirically from data used in our study. [1] details the source of this data and subsequent functions used in Family_Winner. 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. The following table lists all existing issues, their updated ratings and the percentage change resulting from the allocation of *Visitation Rights* to the Husband.

Table 3. 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)

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

6.6 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-off relationships.

The resulting Trade-off Maps following the allocation of *Visitation Rights* are demonstrated in Figures 6 and 7.

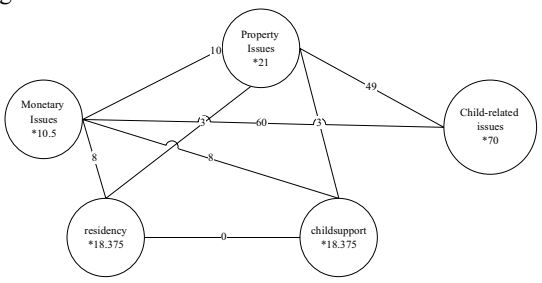

Figure 6. Husband's Trade off Map after the allocation of *Visitation Rights*.

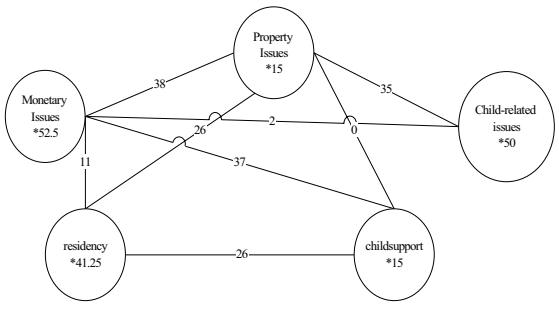

Figure 7. Wife's Trade-off Map after the allocation of *Visitation Rights*.

The system continues to traverse the hierarchy, by either allocating or decomposing issues, until all issues

have been allocated. A summary of subsequent allocations is found in table 4.

Table 4. 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	

Family_Winner was evaluated using the Context, Criteria, Contingency Evaluation Framework [7] for evaluating legal 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 requirements. Family_Winner is a negotiation decision support system that was initially built to resolve disputes in Australian Family Law. From the system's evaluation, we concluded its' use is of greater significance in domains other than Family Law.

In [1] we discuss how Family_Winner has been used in a variety of negotiation domains; for example in Family Law, Enterprise Bargaining Agreements, International disputation and company negotiations. An investigation of these examples [23], has shown the benefit of Family_Winner for advising upon trade-offs, compensation and the sequencing of negotiations; as long as the issues can be described and points can be allocated to issues.

7. Conclusions

Our survey of existing Negotiation Support Systems isolated two major streams of negotiation support: template-based systems and decision support systems. The major role of a template system is to provide tools and graphical aids for keeping parties informed on past preferences and other issues concerning progress made in a negotiation. Whilst most template systems successfully support the negotiation, they assume the negotiation continues passively after the initial intake of preferences and issues. Negotiated Decision Support Systems attempt to model the negotiation dynamically, through the incorporation of decision support.

We have presented Family_Winner as a Negotiated Decision Support System that provides a step-by-step approach to a negotiated settlement, based on a series of trade-offs and compensation to provide decision support. In addition, the system utilises the principles of Principled Negotiation to model the negotiation process.

Smartsettle [19] assists parties to overcome the challenges of conventional negotiation through a range of analytical tools to clarify interests, identify tradeoffs, recognise party satisfaction and generate optimal solutions. The aim is to better prepare parties for negotiation or to support them during the negotiation process. We are working at incorporating Smartsettle strategies into the Family_Winner system.

Our evaluation of the system resulted in positive feedback regarding its use in domains other than family law. We have obtained a grant to extend the applicability of the Family_Winner system by developing an on-line version.

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