Support for Group Decisions and Negotiations An Overview *

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Abstract. This paper discusses methods for the analysis and support of group decisions and negotiations from three perspectives. First, the continuation and outreach strategies are introduced; then methods and models are positioned within the modified process of negotiation proposed by Gulliver; and subsequently methods and systems developed within five areas of study are outlined.
Keywords. Group decisions, negotiations, negotiation/group analysis and support

1 Introduction

There is a significant and growing stream of research on analysis and support of group decisions and negotiations. It is usually published in general MS/OR/IS journals often with dedicated special issues (for example, *Annals of Operations Research*, *Control and Cybernetics*, *Decision Support Systems*, *EJOR*, *Management Sciences*, *Theory and Decisions*), area journals *Group Decision and Negotiation* and *Negotiation Journal*, and edited books (Jessup and Valacich, 1993; Munier and Shakun, 1988; Nagel, 1993; Young, 1991; Zartman, 1994). Recent reviews of the area concentrate on negotiation modelling and negotiation support systems (NSS), (Anson and Jelassi, 1990; Jelassi and Foroughi, 1989; Teich et al., 1994), MCDM approaches to group support (Iz and Gardiner, 1993), and a taxonomy of group decision support systems (GDSS), (Teng and Ramamurthy, 1993).

In this overview, we focus on methods and models of group decision and negotiation processes and on GDSS and NSS. Three hypotheses behind this review are that there is a need for:

- an analysis of the role of formal methods in GDSS/NSS,
- a review of the relationships between paradigms underlying approaches from different areas, and
- a comprehensive perspective of the role that social and behavioural studies can and should play in model and system development.

Comparative studies and detailed reviews should lead to formulation of unified frameworks and new avenues for applied and theoretical research in the area. This overview does not offer either. Instead it makes an attempt to present models and systems from two viewpoints:

* The author gratefully acknowledges Pam Norris' help and several discussions with Wojtek Michalowski and Sunil Noronha which have contributed to this paper. This work has been supported by the Natural Sciences and Engineering Research Council of Canada.

- the areas of study within which the models and systems are being developed, and
- the activities and phases of the group decision and negotiation process which can be analyzed and supported with the existing models and systems.

While only some models and systems are mentioned, the expectation is that this article will contribute to further and more comprehensive discussion on what can be supported and with what approaches and tools. Similarly, the review of the work conducted within specific areas is far from complete and more detailed comparative studies are required.

Within the MCDM community, there is an ongoing discussion on the roles of MCDM and its future, as exemplified by several articles contained in this book. A contribution to this discussion is attempted here by raising the questions of assumption falsification and strategies for GDSS/NSS development. These questions are considered in Section 2. Key issues of group decision and negotiation process and positioning of models and systems within this process are given in Section 3. In Section 4 MCDM approaches and areas most closely related to MCDM are discussed.

2 Two strategies

> *"The mathematical model is a set of assumptions. We know that every assumption is false. Nevertheless we make them, for our purpose at this point is not to make true assertions about human behaviour but to investigate consequences of assumptions, as in any simulation or experimental game."*
>
> A. Rapoport *Strategy and Conscience*, 1964, (p. 147)

The above quote, while controversial, suggests that formal models and support systems in which they are embedded may suffer from false assumptions or from assumptions that either seem unreasonable or are difficult to accept. This is a criticism that many social scientists as well as decision makers (including negotiators and mediators) voice with respect to both formal approaches and model-based GDSS/NSS. It may also be the main reason for many of the model-based GDSS/NSS never being applied to real-life situations. One possible response to this criticism is the continuation of studies on modelling and the development of support tools with only superficial consideration of the behavioural and social aspects of decision making and the needs and demands of decision makers. While this *continuation strategy* may contribute to maintaining a vibrant and lively area of study, the results will have very limited impact on both research in other areas and on real-life problem solving.

The continuation strategy will lead to isolation of the MCDM area. Notwithstanding its significant achievements which expanded applications domains and fostered research on representation of preferences, values and criteria, and on decision aids, its roots are deeply established in MS/OR with its traditional unifying perspective on modelling and aiding human endeavours. Although MCDM grew from discontent with certain assumptions underlying decision modelling and support, its mainstream remained firmly established within the MS/OR quantitative and analytical framework.

Decision making is about thinking of new situations and making choices among them. It involves the decision maker and other people. The decision process is about

changing the current situation to a new situation. This aspect may be more important than the decision outcome itself. Decision makers need to be able to determine what they can change, why they want to make a change, and how it may be introduced. Fisher, Kopelman and Schneider (1994, p. 9) wrote that:

> *Research driven by hard data … implicitly suggests that the value of research lies in the extent to which it enables us to predict something that is going to happen, or to show why a past event was inevitable. But, as the best experts in international relations have learned, the more that research focuses our attention on what is predictable, the more it diverts our attention from those things we can affect. If we want knowledge in order to improve the world, then predictability is the wrong standard. We need to turn from what is inevitable to those things we can change.*

This leads us to the *outreach strategy* in building models and developing systems. This strategy calls for challenging each and every assumption, multiple theoretical perspectives, and user and problem oriented research. The assumptions and simplifications are necessary but they need to be questioned. Accepting this, we can aid decision makers in the investigation of their own assumptions or those the analysts make for them. This will focus support on the analysis of consequences of assumptions rather than on providing a solution to the problem.

Methods for problem formulation, solution and analysis together with support tools, and design methodologies need to be developed from the users' and not the researchers' perspective. There are examples of systems that have successfully been used in real-life applications by analysts or decision makers themselves. These approaches typically address one specific aspect of the problem and/or process such as problem formulation, evaluation of issues, communication, or presentation. The challenges that researchers and developers face include research on approaches with weakened assumptions or assumptions that may be occasionally violated, and on ways to combine or integrate different approaches. This is one way to address decision makers' different and varying viewpoints and needs.

Negotiation and group decision processes are studied from multiple perspectives. We are convinced that in the development of analytical methods and support tools, social and behavioural theories must be considered to a larger extent and not as sporadically as they have been to-date. This includes organization theory with its focus on the organizational structure, cultural aspects, procedures and processes; small group theory focusing on group dynamics including interaction and process; political science with its research on power and forming coalitions; and management theory and leadership. That said, the space and the nature of this article does not allow us to discuss these diverse but complementary perspectives; we refer the reader to representative works of leading researchers in the respective theories (Fisher and Ury, 1983; Zartman, 1994; Kremenuk, 1991; Pruit, 1991; Lax and Sebenius, 1986).

Many analytical methods have their roots in economics where the first formal models of bargaining and negotiations were developed. We do not discuss the contributions of economics to bargaining and negotiations which has been widely discussed in the literature. While the contribution of economics is well recognized, it is often the case that developments in areas close to MCDM in which the researchers have

similar goals of developing methods for analysis and support are ignored. On the other hand, the scope of these methods is often too narrow or the underlying assumptions too restrictive to be effectively used in the actions undertaken in group decision and negotiation processes. Our argument is that coupling different methods based onsimilar paradigms will result in their enrichment and better adaptability to complex and dynamic social processes. Further, their enhancement with the results of the social and behavioural studies will lead to a comprehensive theory of analysis and support of group decisions and negotiations.

3 Negotiated decisions

3.1 Key aspects

Group decisions and negotiations involve two or more participants engaged in two types of complex activities: communication and decision making. Communication, or discourse of negotiations, includes passing, accepting and understanding (decoding) messages (Firth, 1995). While these activities play a significant role in processes involving multiple participants and efforts are made to construct computer systems for forming, representing and analyzing arguments (Binbasioglu et al, 1995; Chang and Woo, 1994) here the focus is on the decision making activities.

In group decisions there may be a single decision maker who has the power to decide while the other participants (e.g., analysts, experts) provide her with advice, interpretation, analysis, and so on. These types of groups are called *teams* (Holsapple, 1991) and they can be supported by meeting and conferencing systems and systems designed for cooperative work (Lewis, 1994; Nunamaker, 1991). In addition, the analysts and experts may use specialized group and individual DSS.

If the power to decide is shared among two or more participants, then decisions need to be *negotiated*. This does not imply that all such decisions are made through negotiation, but that they involve activities that are typical to negotiation processes. Therefore, we concentrate here on negotiations and their characteristics and features, indicating those activities which are similar to other types of group processes.

Two key aspects of negotiated decisions are *conflict* and *interdependence*. Conflict occurs because people have separate and conflicting interests (objectives, goals). This situation is well recognized in the MCDM community. Negotiation introduces an additional level of complexity to the conflicting objectives. This is because not only may one participant have conflicting objectives, but there are multiple participants each with their own objectives and only limited knowledge about the objectives and individual conflicts of the others.

Conflict also arises because the decision makers are interdependent. Realization of the objectives of one depends on the others and conversely, she can influence their outcomes. Interdependence can arise directly at the objective level as is often the case in bargaining. It can also be at the resource (constraints) level when different individuals control complementary resources or both at objective and resource levels.

Conflict and interdependence often lead to *calculated behaviour* which is based on the premise that the more information one has about the others, the better the

calculations are and thus the better her position can be. This type of behaviour is directly related to another key aspect of negotiation and other decisions made by groups, namely *formulation of messages*. This involves definition of the issues or decision attributes, constraints and possibly certain objectives and goals. Though joint problem definition is critical in negotiations, it is unusual that a complete problem representation can be obtained. This is because of the use of strategies and some degree of concealment and mistrust. In less competitive or conflicting situations, a significant effort may be on the joint problem definition. Recently, several support systems have been introduced that focus on this aspect of the decision process (Eden, 1992; Hitchcock et al., 1994; Friend, 1989).

The exchange of information also involves exchange of offers or compromise proposals. These can be a complete proposal, that is a decision alternative, or a partial proposal in which values of only some attributes are given. The latter type of exchange is typical in, for example, intra-organizational decisions involving individuals and groups from different functional areas. Formulation of the partial proposals and their integration into a complete alternative can be effectively supported with the same above-mentioned brainstorming and meeting systems that are used for joint problem formulation.

3.2 Process

In outlining the main aspects of group decisions and negotiations, we mentioned several types of systems which can be used for support. To further delineate the possibilities of support in making negotiated decisions and to position the support systems in the decision process with multiple participants, we outline phases and activities in which the decision makers are involved. They are based on the eight-phase process model of negotiations proposed by Gulliver (1979). The model is modified to include activities typical for group decisions, to allow for a wider range of negotiated decisions than those discussed by Gulliver (1979), and to allow for the present and future use of computing and communication technologies.

1. *Search for arena and selection of the communication mode*. The participants select and agree on the location where the decision process may occur. Communication technologies allow for the use of the wide area networks bringing together participants from remote locations and local area networks for inter-office exchange of information. Thus, the location may be a physical or a virtual setting. Selection of the communication mode includes choice of synchronous or asynchronous exchange of information, discussions and negotiation on partial or complete offers, and joint use of experts, mediators and facilitators. This phase is often neglected by researchers and GDSS/NSS developers despite the fact that any formal method or support tool imposes a particular mode of communication and defines information requirements.

2. *Agenda setting.* Decision makers discuss and agree on the terminology and the issues to be decided upon. These include discussion on decision attributes and hard which are acceptable by all and possibly on certain goals and objectives. The activities of this phase set the stage for subsequent phases. They involve the construction of at least a partial problem representation and are considered key to “correct”

decision processes (Buchanan and Henig, 1995). Recently, interesting techniques borrowed from Artificial Intelligence have been proposed to establish similarities between concepts (terms) presented by different decision makers and to categorize these concepts into consistent and meaningful groups.

3. *Exploring the field*. This phase involves further problem specification and its analysis. In negotiation, the parties try to establish limits to the issues, formulate their best alternatives to the negotiating agreement (BATNA), establish reservation prices and aspiration levels for specific objectives (Raiffa, 1982), assess the opponent and the nature (strength) of opposition, and decide on the initial strategies to use. In group decisions, the limits and aspiration levels may be jointly formulated. The differences in problem understanding and specification of the areas of contribution of particular decision makers takes place here. Computer-based support, in addition to the meeting and brainstorming systems mentioned above, has a significant potential here. In fact, early support systems were used in this phase for the purpose of simulation and analysis of the implications of decision alternatives. Analytical and simulation models allow for the assessment of the decision situation, the participants' behaviour and possible process evolution. This analysis includes determination of efficient solutions and the critical constraints and objectives.

4. *Narrowing the differences and search for integration.*[1] Learning of the others' limitations, aspirations and objectives, and knowledge about efficient solutions and their outcomes, is refined in this phase through intensive exchange of information. In negotiations, the parties realize the potential of a compromise and can assess its main features. This allows them to identify the key issues, critical areas of disagreement and exchange specific and substantive proposals. Analysis of negotiation may focus on the selection and verification of strategies, the determination of concessions and revision of aspiration levels, and on the restriction of efficient solutions to these which may be acceptable to the parties. This can be supported with systems using MCDM-based methods (for example, Korhonen and Wallenius, 1988; Bui, 1994; Ethamo et al. 1996) and those utilizing MAUT (Rangaswamy and Shell, 1994).

In group decisions, common threads are sought for partial decisions and analysis of the implications of these decisions is performed. This allows for the identification of the critical issues for all members of the group. During this phase, the negotiating parties and group members may also identify the critical constraints or interrelationships. Softening the limitations may allow expansion of the set of feasible alternatives or new alternatives may be explicitly formulated and subjected to discussion. Analysis and support tools may be used to identify the critical constraints, demands, and degree of opposition between parties (Kersten and Noronha, 1996).

5. *Search for agreement and improvements.* Successful identification of the

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[1] We integrated two phases proposed by Gulliver ("Narrowing the differences" and "Final bargaining") into one because in many negotiations these phases are indisguishable and because the use of analytic and support tools should allow for the exchange of substantive proposals already in the "Narrowing the differences" phase. Also, the preceeding phase has been expanded to include assessment of the feasible and efficient alternatives which allows the parties to move into the phase of the exchange of proposals.

critical issues and areas of disagreement, development of joint proposals or joint softening of limitations, leads the parties or group members to identification of a limited number of possible compromises. At this stage, the parties or group members may have already agreed on some issues with few issues remaining outstanding.

If the achieved compromise is non-efficient, then the analytical tools may be used to identify efficient ones that benefit all the parties. The same methods which are used in phase 4 can be used to determine an efficient alternative to the achieved compromise, that is, "post-settlement settlement".

4 Models and systems

4.1 Game theory

Many theories of negotiation and group decision have a common heritage in game theory which focuses on the strategic interactions of rational decision makers. The game theoretic assumptions of perfect rationality and perfect or near perfect knowledge of all parties, led to the prescriptive/prescriptive approach (dictating what all the parties should do to achieve a stable compromise).

Game models assume that the number and identity of players, and alternatives and preferences are fixed and known, and that communication takes place only within the model and does not affect either the form or the content of a game's payoff matrix. The usual division of games is between cooperative and non-cooperative games. Cooperative games assume that a binding agreement can be imposed on the parties and posit the question of the division of the value of the game. Cooperative game theory is axiomatic and concentrates its efforts on the search for efficient solutions and the rules for choice from among different efficient solutions (e.g., stability, fairness, equity). The difficulty is, however, that cooperative games assume some form of collective (social) rationality and lack a coherent, unifying framework (Siebe, 1992).

The theory of non-cooperative games assumes that an agreement can be achieved only if it is in the parties' interests and the question is one of the rational strategies that parties choose in the situation of conflict. The focus is on a solution which is self-enforcing in the sense that a party cannot get an advantage by unilaterally defecting from this solution. That is, the agreement among parties should possess a self-stabilizing character or self-enforcing elements. This leads to the concept of the equilibrium point as stipulated by Nash (1954) within the context of non-cooperative game theory. Further research in game theory expanded the solution concepts to other types of stability that differ in their foresight and disimprovement ability (for a review of different solution concepts, see Fang, Hipel and Kilgour, 1993). The difficulty here is that efficient solutions seldom have an equilibrium property, in other words, a stable solution may often be improved for all the parties.

Specification and analysis of the equilibria lies at the roots of the Graph Model for Conflict Resolution (GMCR) developed by Fang, Hipel and Kilgour (1993) who also developed a computer-based system for conflict analysis based on the GMCR method. Other refinements of the Nash equilibria have been proposed within the context of dynamic games (Hämäläinen, 1995).

Game theory is the most rigorous approach to conflict resolution. It allows for formal problem analysis and the specification of well-defined solutions and can therefore be used for an extensive evaluation of the scenarios and specific moves of the parties, their strategies, and the determination of the characteristics of the potential compromise solutions (Sakawa and Nishizaki, 1996).

The weaknesses of game-theoretic approaches include the treatment of the process and its impact on the game itself, and strict rationality assumptions which, for numerous reasons, rarely hold (e.g., imperfect information, parties' cognitive limitations, deception). Game theorists recognize these weaknesses and interesting extensions have been proposed. However, they often regard communication as neither central nor problematic. Negotiations may be characterized as communication superimposed on a game or a new "transcended" game where communicative acts are moves of the game (Jönsson, 1991). Thus, while game-theoretic methods have a significant role to play in the prior or posterior analysis of the group decision or negotiation problems, their usefulness as a support tool during the process is limited.

4.2 Decision analysis and MCDM

Decision analysis has its roots in economics and game theory. Extensions of decision analytic methods to group decisions and negotiations are based on either explicit or implicit creation of a supra decision maker whose aggregate utility is constructed from group members or the parties' individual utilities (Keeney and Raiffa, 1976). This allows the introduction an additional step to methods based on multiattribute utility theory (MAUT) which is the construction of an aggregate utility (value) function. Several support tools adapting the existing methods to group situations have been proposed. These include the Negotiation Assistant (Rangaswamy and Shell, 1994) and ICANS (Thiessen et al., 1996), extensions of the analytic hierarchy process (AHP), (Saaty, 1989; Saaty and Alexander, 1989) to multiplicative AHP (Van den Honert and Lootsma, 1995), interval AHP (IAHP) which is the core of the HIPRE-3+ Group Link system (Hämäläinen and Kettunen, 1994), use of AHP together with the Tchebycheff distance measure (Iz, 1992) and the simple multiattribute rating technique (SMART), (Edwards, 1977; Lootsma, 1995).

The difficulty with the specification of one compromise decision lies in the assessment of weights of the aggregate utility function which reflects the parties' power, intensity or convictions. One possibility is to resort to a voting procedure. Another is to focus on the set of possible compromises or identify the contract curve. For two-party negotiations, Angur and Lofti (1994) use a bi-criteria optimization problem to develop the efficient set.

Specification of the utility (value) functions is not necessary to determine the efficient set or a contract curve. RAMONA and NORA (Teich, 1991; Korhonen et al., 1994) are systems that allow to identify the contract curve either directly or within an envelope formed by the decision makers' preferences. Methods that allow to determine and analyze the efficient frontier are also proposed by Korhonen and Wallenius (1988) and Teich et al., 1995). These methods either guide users in their concession making actions so that they are getting progressively closer to the efficient set, or provide a single negotiation text which the users can modify in order to increase their

joint gains.

Another extension of MCDM methods to group decisions and negotiations is the use of goal programming (Iz and Krajewski, 1992; Kersten, 1988). The role of the method is to provide users with feasible compromise proposals determined through minimization of distance between solutions selected by individual users. A similar approach, but based on user defined reservation and aspiration levels, has been proposed by Reeves and Bordetski (1995) and by Bronisz et al. (1988) in MCBARG system.

The main contributions of MCDM to negotiation analysis and support are: consideration of the negotiation process in addition to negotiation outcome which is the predominant focus of game theory; the use of criteria which is more meaningful for decision makers than utilities; search for the set of efficient compromise solutions rather than one solution; and, interactivity which allows decision makers to participate in and control the decision process. Many MCDM approaches are more intuitive and easier to use than those based on MAUT, and thus they can be used directly by the decision makers themselves. On the other hand, the process of finding a compromise decision is often prolonged and requires many iterations. As in decision analysis, the axiomatic rationality is also assumed in MCDM although, due to interactivity and generation of complete decisions (compromise proposals), the decision makers may terminate the process selecting an inefficient compromise.

4.3 Negotiation analysis

Negotiation analysis describes a stream of studies on conflict resolution based on decision analysis and MAUT. While this area is not well defined and some of the MCDM approaches can be positioned here, there are several underlying principles following from the overly restrictive assumptions and requirements of decision analysis and, to a lesser extent, MCDM. Both decision analysis and MCDM focused on supporting all decision makers. In education and training, involvement of all parties can be achieved and provide them with relevant knowledge and skills. In real-life negotiations, having all parties use the same system is rarely possible. Therefore, negotiation analysis seeks to advise one party given predictions of the other party's behaviour.

As a result of complexity of negotiation processes and mix of political, psychological, sociological and organizational aspects, which influence the decision process but often cannot be formally represented, causes the axiomatic rationality assumptions rarely hold. Negotiation analysis, in the attempt to provide advice and support, is based on principles of "asymmetrically prescriptive/descriptive" orientation, introduced by Raiffa (1982). This is in contrast with game theory which uses the symmetrically prescriptive approach with fully rational players being analyzed in terms of optimal strategies. That is the decision makers are assumed to be intelligent and goal seeking individuals, rather than exhibiting full game-theoretical rationality (Sebenius, 1992).

One of the consequences of the rejection of the axiomatic rationality is that the decision makers may not achieve an efficient compromise. Negotiation analysis attempts to focus on the "zone of feasible agreements" without restriction as to its effi-

ciency. The presumption is that parties can assess the attractiveness of the no-agreement situation and select those possible agreements which yield higher utility. This is achieved with the specification of the best alternative to negotiated agreement (BATNA) which serves as a benchmark for compromise decisions.

Agreement on an inefficient compromise does not terminate the process. The prescriptive aspect of negotiation analysis is seen in the concept of "post-settlement settlement" in which the analyst or mediator suggests one or more alternatives which all the parties prefer more than the achieved compromise.

Most of the existing analytical approaches assume a well-defined and fixed situation (issues, parties, feasible alternatives) that is being modelled and analyzed. This allows construction of mappings between the structure of the problem, preferences and criteria, and the ultimate outcome which is a compromise or a set of efficient solutions. However, purposive behaviour of the parties can change the problem structure and other elements of the situation and hence the outcomes. The situation has similar effects on the outcomes when the problem is not completely specified. Negotiation analysis attempts to take the evolving nature of the process into account through "negotiation arithmetics, adding and subtracting issues and parties, attitudinal restructuring and investigation of the changes in the parties' perceptions" (Lax and Sebenius, 1986).

Negotiation analysis is more of a framework of thought in which some analytical methods are used than a unified formal approach to negotiations. Its contribution lies in the consideration of aspects and features which were disregarded in game theory and decision analysis but which take place in real-life situations. Some of these aspects were introduced in formal models and support systems. For example, the evolutionary aspect has been incorporated into NEGO (Kersten, 1988) and MEDIATOR systems (Shakun, 1988); and management of the process has been analyzed by Nyhard and Samarasan (1987).

4.4 Cognitive theory

Cognitive processes, among decision makers, assume special significance when the choice situation is characterized by "structural uncertainty". This is the case when the situation is: (i) new and without familiar clues; (ii) complex with many clues to be taken into account; or (iii) contradictory and with different elements suggesting different interpretations. Many group decision and negotiation situations are eminent examples of structural uncertainty.

Applying a cognitive approach focuses analysis on perception and interpretation leading to the construction of representations and the use of heuristics. Problems are recognized and interpreted through references to pre-existing knowledge structures (schemata or belief systems). Specific issues and behaviours of people are categorized and interpreted with the use of judgmental heuristics that reduce complex inferential tasks to simple operations. Thus formation of an innate representation, which for complex and difficult problems can only be partial, has its roots in the individual's past experience and her knowledge of similar situations (Bazerman and Neale, 1991),.

Group decisions and negotiations are characterized by the co-existence of both

cooperative and conflicting issues. A prerequisite for success is that the interests which are common outweigh those which are divergent. Cognitive theory may contribute to a better understanding of the issues, contradictions and negative perceptions (Bonham, 1993). For example, it may be used to explain the persistence of negative images of the adversaries and perception of conflicts suggesting possible modifications of conflictual perceptions.

Tools that are based on cognitive theory are used for the development of structural problem representations, and in that sense, their main contribution is to reduce the structural uncertainty. COPE developed by Eden and his associates (1992) and Strategic Choice (Friend, 1992) are examples of systems that allow for the development of cognitive maps reflecting problem perception of one or more participants. The ability to formulate a problem in a form of a map which can be easily reviewed and analyzed, already provides a significant support. In addition, these systems allow for map manipulation, analysis of its consistency and focus on specific aspects of the problem, its implications and determinants.

The difficulty in the integration of techniques based on cognitive maps and normative or prescriptive methods, lies in the main difference between intuitive and scientific theories. Intuitive theories are used to make maps but they are implicit and often used below the level of awareness. Therefore, they are both user and problem context specific and are not easily amenable to formal models derived from scientific theories which are generic in that they can be applied to a wide range of problems. One of the challenges for the developers of analytical GDSS/NSS is to determine ways of using cognitive mapping techniques to build and manipulate representations which can then be analyzed and solved.

4.5 Artificial intelligence

Cognitive mapping techniques involve symbol manipulation which is defined by the map constructor. Symbol manipulation controlled by reasoning mechanisms embedded in a computer system is conducted by knowledge-based systems (expert systems). Classical knowledge-based systems contain destilled and compiled knowledge about a specific problem or a class of problems and are used to provide expertise to their users. For negotiation support, Vedder and Mason (1987) developed a Hostage-taking Information and Tactics (HIT) system to facilitate the assessment of the hostage taking situation and suggest negotiation tactics for police negotiators. Eliasberg et al. (1992) developed NEGOTEX, a rule-based system for preparation of international negotiation including the cultural aspects of the negotiating parties. These systems use knowledge obtained from the experts and academic and practitioner publications.

Another approach to analyze a specific negotiation situation and provide recommendations is through the use of past cases. Sycara (1990, 1991) introduces case-based reasoning to planning and support of labor negotiations. Through the manipulation and merger of case elements, representation of a given negotiation problem is obtained. The construction of a new case which represents the negotiation that the user faces is guided by predefined utility values assigned to elements of past cases. The cases are also used to obtain argumentation for particular proposals, to determine

interrelationships between elements of representations, and to specify options for problem restructuring.

Knowledge-based systems rarely allow for the generation and selection of alternatives or for the evolving nature of problem solving and decision making. Restructurable modelling is an attempt to incorporate these two characteristics (Kersten et al., 1991). The Negoplan system which is based on restructurable modelling, has been applied in trade negotiations, labour negotiations (Matwin et al., 1989), and negotiations with a hostage taker (Kersten and Michalowski, 1989).

An interesting approach to determine and evaluate negotiation tactics has been proposed by Matwin et al. (1991) with the use of genetic-based learning algorithms. The prototype system GBML allows the user to specify the relevant issues which are used for simulation of the negotiation problem and generation of negotiation rules with genetic operations of reproduction, crossover and activation. GBML and Negoplan are examples of systems that combine a symbolic and quantitative representation, and aim at merging analytical and knowledge-based approaches.

5 Future work

We reviewed models and systems for group decision and negotiation analysis and support from two perspectives: the process and the areas of study. In the first perspective, the main activities of decision makers are considered. In that way, we took into account the users' needs but only partially. Further studies are needed to define the requirements of specific activities, to delineate the role of a support system and consider decision makers with different abilities and needs.

The second perspective is the continuation of the work of Teich et al. (1994) aiming at presentation of different studies about the same social phenomenon. It is far from complete. Many models and systems are not mentioned and behavioural and social studies are not discussed. More detailed and more comprehensive discussion is obviously needed. It should set the grounds for cross-fertilization of the MCDM field and development of systems in which different perspectives and paradigms can be included. If one accepts that the outreach strategy should be chosen, then one should follow the MCDM pioneers who went outside of their own fields to expand their decision modelling paradigms. They succeeded and developed formal decision models based on multiple criteria, which were discussed in the context of accounting, organizational behaviour and marketing. This led them and their students to conduct research on conflicting objectives, efficient solutions, interactive methods and, more recently, group decisions and negotiations. To continue their "outreach" efforts is to challenge our assumptions, study new paradigms and enrich the MCDM methodologies.

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