"AN INTRODUCTION TO GROUP DECISION AND NEGOTIATION SUPPORT"

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ABSTRACT

Group decision making and negotiation are important managerial activities, yet difficult to understand and support. The associated complexity is due to the multi-person, dynamic, and ill-structured environment in which these activities take place. Recent advances in information technology create new opportunities for supporting group decision and negotiation processes.

This paper first reviews formal models for group decision making and negotiation. It then presents the different classes of multi-person decision situations. A discussion of the relationships, similarities, and differences between multi-criteria decision making and negotiation follows. The last part of the paper focuses on the notion of computer support and provides examples of conceptual frameworks and actual implementations of group decision and negotiation support systems.

KEY WORDS AND EXPRESSIONS:

Group Decision Making; Negotiation; Conflict Resolution; Group Decision Support Systems; Computer-Assisted Negotiation.

CONTENTS

1. INTRODUCTION

Group decision making and negotiation are multi-person processes which are complex and ill-structured. They are dynamic in nature due to changing information, aspiration levels of the participants, preferences and tactics. Moreover, decision-makers rarely conform to classical models of rational behavior (Tversky and Kahneman, 1981; MacLean, 1985). They do not want to unveil their real interests (Fisher and Ury, 1983) and may change their strategies as the process evolves over time (Lockhart, 1979; Schaffers, 1985).

The importance of group decision making and negotiation has stimulated a large volume of research. At one end of the spectrum, behavioral scientists (e.g., Druckman, 1977; Gouran, 1979; Lewicki and Litterer, 1985a and 1985b) have examined special cases or aspects of individual behaviors in prescribed settings in an attempt to discover the importance of specific factors on the overall process. At the other end, formal attempts to understand group decision making and negotiation have utilized various forms of mathematical or logic-based representation. However, these efforts have often been at such a level of abstraction that they are rarely applied to specific real-world instances. **While the behavioral approach has attempted to discover a particular rationality which may be generalized, the formal approach has assumed a general rationality which could be applied to specific problems.**

This paper provides an overview of formal models for group decision making and negotiation with a special focus on those that can be used in developing computer-based support systems. Section 2 discusses the main features of group decision making and negotiation and introduces four classes of multi-person decision situations. Section 3 briefly describes some formal models suggested in economics and game theory. Section 4 presents the relationships, similarities and differences between multiple-criteria decision making and negotiation. Computer support for multi-person decision situations and bargaining is introduced in Section 5. Then conceptual frameworks and actual implementations of group decision and negotiation support systems are discussed. A summary of the paper and some concluding remarks are provided in Section 6.

2. GROUP DECISION MAKING AND NEGOTIATION

2.1 Classes of Multi-Person Decisions

Multi-person decision-making covers a wide range of processes. In an attempt to model such processes, one should take into account their basic features. In this section we discuss the main differences between group decision making and negotiation. We see these two types of processes as different and as members of a more general class.

We distinguish four types of multi-person decision-making situations:

(i) Individual decision-making in a group setting. The decision maker utilizes knowledge of experts, advisers or stakeholders during the process. All group members participate in the process, but only one person is responsible for the decision made. An example of such a case is that of two regional authorities, one dealing with the ecological situation and the other responsible for the industrial development (Goncalves, 1985).

(ii) Hierarchical or bureaucratic decision-making. There are two cases to consider here: In the centralized one, it is assumed that there is one set of objectives representing the top-level decision maker, and also that he has full control over the lower-levels group members. The formal model that corresponds to this situation is Dantzig and Wolfe's (1960) decomposition model. In the decentralized case, each participant independently controls subsets of the decision variables and objectives and is responsible for his decision which serves as input to the higher-level one. There is a coordination procedure assuring the optimality of the overall decision.

(iii) Group decision-making or one-party decision-making. Each group member participates in the process and is partly responsible for the final decision. There usually is an overall goal which is accepted by all the members, but they differ in the ways of how this goal should be achieved. The decision problem can be solved by an individual but a group possesses more resources than each of its members and the potential for making effective decision-making is greater (Gouran, 1979; Steiner, 1972).

(iv) Multi-party decision-making or negotiation. One decision maker represents one party and is responsible for the decision before this party and not before the other one(s). There is a conflict of interests because parties have separate and conflicting objectives (Lewicki and Litterer, 1985a) and they have different needs which they want to satisfy (Nierenberg, 1973). Negotiation is the chosen way to resolve a conflict out of necessity and not out of effectiveness or efficiency.

2.2 The Group Decision Problem

People make a group decision when they face a **common problem** and they all are interested in its solution. This problem may be the choice of a vacation site, the purchase of a car, or the acquisition of a house by a family; it may also be the design of a new product or a production plan for a company. An important characteristic of this situation is that all involved individuals belong to **one organization** (family, firm, or government). They may differ in their perception of the problem, and have different interests, but they are all responsible for the organization's well-being and **share responsibility** for the implemented decision.

Although the features mentioned above characterize group decision making, they do not apply to negotiation settings. Organizations may have a different representation of the decision problem and their representatives need to negotiate in order to find a settlement. For example, a buyer's problem is different from, though complementary to, a seller's problem; the same applies to a company management and a trade union, or to a police department and a hostage-taker. The varying perceptions may be less relevant than the **different interests** and **goals** of the involved parties. The responsibility of a negotiator, who may be from outside the organization he represents, is solely to this organization and not to other negotiators. Negotiation takes place when one organization cannot make a decision without the consent of another. Because negotiation involves organizations, one can expect group decision making within the process of negotiation (e.g. when a negotiator asks for new directives).

2.3 Alternative Decisions and Compromise Solutions

In group decision making, there is one set of alternative solutions. During the decision process, this set may be expanded or contracted when, respectively, new options are added or non-efficient alternatives are dropped. Moreover, the considered and communicated alternatives are **feasible,** or at least subjectively feasible, i.e. perceived as such by the decision maker.

In negotiation, there may exist as many sets of alternatives as there are negotiating parties and alternatives may belong to different decision spaces. For example, in the free trade negotiations, alternatives considered by the Canadian government are different from those considered by the U.S. government. However, these different alternatives are **interdependent:** there is a transformation which converts an alternative from one set to an alternative in another one. Usually this transformation is a homomorphism or a quasi-morphism (Holland et al., 1987), i.e. an alternative corresponds to a subset of alternatives. (It seems that this is one of the reasons why negotiators try to negotiate in their opponents' decision spaces).

Negotiating parties often choose alternatives from different spaces. Then, each party presents its **compromise proposal.** The preparation of this proposal is a decision process in itself; on the basis of one alternative several proposals may be prepared differing in the consideration of the opponent's interests. In a single-issue negotiation, an alternative may be the first aspiration level (Tietz and Bartos, 1983) and the negotiator presents his first proposal higher than this level. This proposal may be unfeasible but the very nature of negotiation requires making concessions. In fact, presenting initial proposals which are feasible and close to the expected consensus is called negotiating in "bad faith" (Lewicki and Litterer, 1985a, page 13). Hence, in negotiations the initial proposals may be **unfeasible** because all parties expect **concessions.**

In group decision making, concessions are required because of **hard constraints** which determine the feasible alternatives (Kersten, 1988) and, if possible, they are avoided. For example, a marketing department expects an increase in the quality of a product but the finance department argues that funds should be channeled to paying off debts, and there is only a given amount of funds available. Hence, in group decision making, concessions are made to improve the overall quality of a decision, while in negotiation they are part of the procedure. Moreover, in the former case, concessions change the group decision while in the latter, they affect the communicated proposal and not necessarily the settlement itself. Moreover, in group decision making, hard constraints are known, or become known during the process, to all the participants. In negotiation, each decision maker tries to hide his constraints because revealing them would weaken his bargaining position.

3. FORMAL MODELS FOR GROUP DECISION MAKING AND NEGOTIATION

There are numerous attempts to solve conflicts using theoretical frameworks. The two classical ones are economic models of bargaining and game-theoretic models and both utilize the utility concept.

3.1 Economic Models of Bargaining

Economic models are associated with Zeuthen's (1930) pioneering work and they treat bargaining as a process of convergence over time involving a sequence of offers and counter-offers. These models assume that the utility functions of the participants are fixed and known from the outset, and that a compromise zone exists, can be identified, and remains stable over time (Young, 1975). Moreover, the economic models deal with negotiations involving a single issue that is homogeneous and continuously divisible, such as money (Pen, 1952).

An important group of economic models emphasize the role of time as a bargaining factor (Cross, 1969). In the Cross model, bargaining is a routinized discovery process. The participant starts out with a set of expectations which he/she learns to correct on the basis of experience. The process produces determinate solutions given proper values governing the participants' behavior. If the participants are identical, the model yields the same result as the Nash solution (Cross, 1969, page 59). The Cross model and the one proposed by Rao and Shakun (1974) aim at providing normative recommendations for concession making. Though we are concerned here with both prescriptive and descriptive aspects of the process, with situations involving multiple criteria and "non-rational" aspects of the participants' behavior, the presented approach is partly based on the Cross model.

3.2 Game-Theoretical Models

The second type of approach is based on game theory (von Neumann and Morgerstern, 1947) and its extensions (see for example, Axelrod, 1984; Fraser and Hipel, 1984). The game models assume that the number and identity of players as well as the alternatives and utility functions are fixed and known, that players are fully rational, and that the communication takes place only within the model and it cannot affect either the form or the content of a game's payoff matrix (Luce and Raiffa, 1957).

While research built on game theory has generated important insights into the processes and outcomes of negotiation and bargaining strategies, the restrictive assumptions underlying this framework along with the computational difficulties that arise in all but the simplest cases, have meant that appropriate mathematical constructs are difficult to develop and apply. The limitations of this approach are inherent in the basic method **"... the answers provided by the theory of games are sometimes very puzzling and ambiguous"** (Simon et al., 1987, page 17).

3.3 Aggregation Models

Another often used type of approach recognizes the multiplicity of criteria underlying participants' behavior and aims at developing a decision rule(s). One assumes that the utility functions of each participant are stationary and may be first assessed separately, then aggregated by invoking the utility independence assumption. Under this assumption the bargaining process is reduced to specifying preferences and then combining them for each participant and for the whole group. The obtained group utility function (additive or multiplicative) is used to generate compromises.

The utility aggregation approach may be used in specific group decision making processes (e.g., project or scenario evaluation, joint model building) but not in typical bargaining situations where participants have conflicting objectives, display strategic behavior and withhold preferences and other information. The assumption of independent utility functions has been criticized, and an aggregate group consensus function which does not assume the existence of a von Neumann-Morgerstern utility function for each participant was proposed in the literature.

Other approaches do not require definition of a group utility or consensus function, but use decision rules defined on the alternatives themselves. An example here is ranking of alternatives by each participant and then determining compromise alternatives through expanding-contracting operations on the set of alternatives (Bui, 1985). Jarke et al. (1987) and Shakun (1988) propose another expanding-contracting procedure based on a goal/values referral process. Isermann (1985) assumes that the participants start from inferior alternatives and the negotiation process is a contracting procedure with participants determining the direction of changes. The Isermann model gives every participant the possibility to move from a worse to a better alternative so concessions are unnecessary. Another example of ranking is the use of Saaty's method in group decision making (Lockett et al., 1981).

3.4 Tactics Models

Out of analysis of labor and international negotiations, models that focus upon the tactics of bargaining have been developed (Schelling, 1966; Ikle, 1964). Tactics models lack the restrictive assumptions of the utility-based models. They do not assume that information is complete, nor that utility functions and alternatives are given from the outset and fixed. Manipulating these features of the bargaining situation is considered as one of the most important characteristics of the process.

The level of formalization in manipulative models is low. They cannot specify with determination bargaining outcomes, or attempt to represent negotiations as game-theoretic models. They also cannot provide a consistent account of concession making as in the economic models or most multiple criteria decision models. Heckarton (1980) considers these features as deficiencies, and they are indeed if a model is to be used to replace the process, to analyze it or verify its efficiency. However, this is not the case if the model is a support tool for a participant or a mediator, if it is used to analyze the current bargaining situation and to verify and determine tactics. Since we are concerned with the latter, we find manipulative models useful.

The tactics models accept "non-rational" aspects of behavior which appear in negotiations. For example, negotiation and bargaining require communication among participants, but what is communicated is influenced by the act of communication. The sanction of communication implies that compromises may depend on the starting point rather than any underlying set of values (Raiffa, 1982, page 215). It further implies that players, while regarding their own behavior as rational, are not immune to strategies of other players (Satterthwaite, 1975). Another outcome of the importance of communication in these processes is that concessions of one player depend on concessions made by others (Komorita, 1973). There are other behaviors which may also not be seen as rational in the traditional sense because an essential part of negotiation and bargaining as a method of making decisions is the communication between players. Since players believe that such communications may be incomplete or inaccurate (at the minimum), their own behavior in response is unlikely to be rational in the traditional sense.

Tactics models assume that decisions, and thus compromises, are time, context, and strategy dependent in negotiation and bargaining settings. Even if the players' explicit utility functions are known, we may determine a compromise decision which they would not accept. This possibility arises because the decision was determined without taking into account the art of negotiation: skills of persuasion and argumentation, the ability to employ bargaining ploys, and the knowledge of how and when to use them. We have also overlooked learning effects; i.e., changes in the knowledge of the problem and of the players.

Kersten and Szapiro (1986, 1988) presented a tactics model of the negotiation process based on the information available to both players and mediators. This model assumes the dynamic nature of negotiation, varying strategies of players and the existence of secret and unveiled goals and interests. This paper is somewhat an extension of this approach and focuses on problems of supporting negotiators in their effort to determine compromise proposals.

4. MCDM AND NEGOTIATION SUPPORT

4.1 The Spaces Where Decisions Can Be Made

The models outlined in section 3 are aimed at describing and analyzing group decision and negotiation processes. Although some of them were computerized, their use was either incidental or limited to a very specific situation. There is an ongoing discussion about the usefulness and scope of use of group decision support systems (GDSS) and negotiation support systems (NSS). These systems with their underlying models and techniques are being developed, tested, and empirically validated. Therefore, generalizations cannot be drawn when answering questions such as: To what extent can GDSS be used for real-world group decision making? Is problem-oriented NSS better than process-oriented NSS? Is it possible to support ill-structured negotiation tasks? etc.

Multiple-Criteria Decision Making (MCDM) is one of the most dynamic areas of research oriented towards the understanding and support of decision making in general, and group decision and negotiation in particular. MCDM provides a framework for group decision and negotiation support. This framework may be oriented around the spaces where individuals can make decisions, in which the decisions can be evaluated and compared by an individual or by the group. More about the issues discussed here can be found in Keeney and Raiffa (1976) and Kersten et al. (1988).

4.2 The Decision Variable Space

The decision variables are the detailed actions that are taken, communicated, and when a compromise is reached, agreed upon. The level of decision variable may be coarse or fine, depending on the situation. For example, it may be the total number of sprockets produced in a month, or a total production time devoted to a class of products. The decision variable is a familiar concept in mathematical programming, where the **x** vector is the vector of decision variables. The decision variables together with their values which are considered at any point of time constitute a **decision** or a **compromise proposal**. Thus, group decision making may be reduced to an exchange of decisions between the group members, and negotiation - a similar exchange of compromise proposals.

The space of decision variables consists of feasible and unfeasible decisions. In the continuous case, there is a set of constraints which allow determination of the feasibility of a decision, and in the discrete case the feasible decisions can be enumerated. If all the participants in the decision process agree upon these constraints, then they are called **hard constraints**, in the sense that they are binding for each participant. In negotiations, often the hard constraints are discussed during the pre-negotiation phase when the parties determine the definitions of a particular decision variable, or its possible values.

An important feature of the decision variable space is its objectivity. The participants of the process are linked together only through a decision; the decision space provides the platform on which other spaces can be built. The participants differ in the evaluation of a decision but the requirement for the effective negotiation or group decision is the objectivity in understanding a decision.

For some problems, it may be difficult to determine decision variables or it may be convenient not to distinguish between them. A decision about the management strategy for a large corporation often involves too many decision variables to make effective choices. Even in simpler problems, it may be difficult to distinguish between a decision and an objective, as in the case of union/management salary negotiations.

4.3 The Objective Function and Weight Spaces

A second space to consider is the objective function space. The objects in this space are obtained through transformation of the decisions with the use of the objective functions. It is usually a space of lower dimension than the decision variable space which makes it easier to analyze and evaluate different alternative decisions. While the objects in the decision space are neutral, these objects when transformed into the objective function space can be evaluated. We may say, for example, that one value is better than another because it is higher and we are interested in obtaining as high a value as it is possible. Such a statement cannot be formulated about values of a decision variable.

Introduction of the objective function space makes it possible to define a **non-dominated** or efficient decision. A non-dominated decision is a feasible decision for which there is no other feasible decision which yields better values of one or more of the objective functions. Note that we say that a decision is, or is not, non-dominated, but say that we have to perform analysis in the objective function space.

The third space is the weight space, the space of linear positive (non-negative, for convenience) weights. Weights are used to aggregate the objective functions values into one value determining the goodness or the utility of alternative decisions. This aggregate is called the utility function.

There is a relation between the dimension of the weight space and the objective function space. This relation depends on the type of the utility function which is used to describe preferences of a particular decision maker. For example, this function may be linear, or multilinear with weights assigned both to individual objective functions and to their multiplications, or polynomial. In the simple, linear case the weight space is equal to the objective function space; one weight is assigned to one objective so the dimension is equal to the objective function space. (In this case the space of weights may be one dimension less than the objective function space because, without loss of generality, any set of weights may be normalized.)

Both the objective function and weight spaces are used in individual decision support systems. The support provided by, for example, VIG (Korhonen et al., 1986) is in the objective function space, while TRIMAP (Climaco and Antunes, 1990) and VISA (Belton and Vickers, 1990) support decision making with the use of the weight space.

4.4 The Party Utility and Weight Spaces

The three considered spaces refer to the decision problem or to the multiple criteria of one party. The party utility and weight spaces are introduced because of the multiple agents. The party space has as many dimensions as there are parties and one dimension refers to one individual in the group decision or one party involved in the negotiation. That dimension refers to the utility function of a given individual or party.

There is an analogy between the objective function space and the party space. Therefore one can introduce a concept similar to the non-dominated (efficient) solution. It is the Pareto optimality solutions in the party space. We say that a solution is Pareto optimal if and only if there does not exist another solution for which every party is at least as well off and at least one party is strictly better off. Pareto optimal solutions are considered to be desirable in negotiations. If a solution is not Pareto optimal, that means that one or more parties can negotiate gains at no cost to the other parties. This is possible if the utility functions are mutually independent and this assumption reflects rational behavior of the parties, i.e. one party's increase in its utility does not imply another party's decrease.

Continuing the analogy between the multiple objectives of an individual and multiple individuals, we may define the party weight space. Remarks given with respect to the (individual) weight space do hold here. The party weight space could be introduced, if we were to assume a societal utility function (social welfare function) or a "supra decision maker" (Keeney and Raiffa, 1976).

The party weight space may be used in the mixed "MCDM/voting" support systems. The party utility space is used in, for example MEDIATOR (Jarke et al., 1987) and it is also further discussed in Raiffa (1985). Note that instead of using the party utility space explicitly, one can also use the Cartesian product of the objective function spaces (it is called the Cartesian product). Here the difference between group decision and negotiation is that in the former case, all the dimensions are known to all the individuals, while in the latter one, a negotiating party would know only its own subspace. It would be only the computer (acting as a facilitator or mediator) which would have access to all the information. An extension of VIG from individual to group decision or negotiation would be an example of a support system in the objective function spaces. Another example is NEGO (Kersten, 1985).

The above considerations and the sequence of the geometrical spaces leading from the neutral decision space, possibly with many dimensions to one dimensional supra utility or welfare function, are general in that they do not restrict the possible approaches to NSS and GDSS design. Only one assumption should hold, which is the economic rationality of the involved individuals or parties. Hence, one can incorporate the aspirations which may cause the objective functions or the utility functions to be defined for the aspiration levels intervals. The reservation prices (the lowest/highest acceptable values), shifts in negotiation tactics, and context dependent concessions can also be introduced. The paradigm is, however, that a Pareto optimal solution is desirable, and that the decision problem can be expressed as a problem of identifying acceptable Pareto optimal solutions.

5. COMPUTER SUPPORT FOR GROUP DECISION MAKING AND NEGOTIATION

One of the issues this paper tries to address is defining the type of computer-based information systems that has the potential to support group decision making and facilitate negotiation processes. The first part of this section describes some conceptual frameworks for GDSS and NSS that were proposed in the literature and summarizes their key features. The second part presents illustrative examples of system implementations in the area of group decision and negotiation support.

5.1 Conceptual Frameworks for GDSS and NSS

DeSanctis and Gallupe (1985) categorized GDSS technology into four separate areas: decision room, local decision network, linked decision rooms, and remote decision networks. They distinguished between the four models in terms of proximity of participants and duration of the decision making session. Their categorization helped define GDSS, their possible configurations and potential applications.

Bui and Jarke (1986) analyzed the communication requirements of various group decision settings. They also suggested an architecture for defining and enforcing dynamic application-level protocols that organize group interaction.

DeSanctis and Gallupe (1987) introduced a typology for GDSS based on three levels representing varying degrees of intervention into the decision process. Level 1 GDSS aim at facilitating communication between decision makers. Level 2 GDSS use decision modelling techniques to support involved parties. Such techniques may include multiple-criteria decision models, multi-attribute utility techniques, decision trees, etc. Level 3 GDSS have built-in knowledge and can provide advice and explanation through the use of expert systems technology. The authors also identified three environmental contingencies as critical to GDSS design: group size, member proximity, and the task confronting the group.

Jelassi and Beauclair (1987) suggested a comprehensive framework that integrates the behavioral characteristics of group decision making with the technical specifications that drive GDSS. Behavioral issues in GDSS include diffusion of responsibility, deindividuation, pressure toward group consensus, and problems of coordination. These issues should be taken into account when designing GDSS "shells". The intervention of such systems aims at reducing the negative impact of these behavioral issues.

Based on the experiments conducted at the University of Arizona, Nunamaker et al. (1989) discussed the interaction of task and technology to support decision groups. They presented several perspectives for studying group environments, including systems theory, communication, decision making, and management science. They argued that a multi-disciplinary approach is necessary for studying such environments.

Pinsonneault and Kraemer (1990) analyzed the empirical research on the impacts of electronic meetings on group processes and outcomes. This analysis is based on a framework developed from the literature on organizational behavior and group psychology. Two specific technologies that facilitate electronic meetings were studied: GDSS and Group Communication Support Systems. Issues that have affected previous research and implications for future work were discussed.

In the NSS Area, a number of conceptual frameworks have been suggested in the literature. The one proposed by Jarke et al. (1987) set the stage for several research efforts. It viewed negotiation as an evolutionary process of problem definition and solution design. In this context, information sharing and exchange coupled with concession making lead the bargaining parties, with the help of a human mediator, toward consensus.

Bui (1985) proposed a consensus-seeking algorithm called the "Negotiable Alternatives Identifier" which could be used in conjunction with preference aggregation techniques. The algorithm is characterized by a triple operation: expansion, contraction, and intersection.

Sycara (1987) developed a general approach for structuring and modelling negotiations. The main emphasis of the approach is on the use of case-based reasoning. The suggested model has been implemented in a computer program for labor-management negotiations.

Kersten (1988) suggested an interactive procedure for group decision making and negotiation. It is based on the aspiration theory and utilizes both satisficing and optimizing approaches. The outcome of the modelled process is a compromise decision which can fulfil fairness and equity criteria and may also be an efficient solution.

Jelassi and Jones (1988) addressed two general questions associated with NSS: How can computers support negotiations? What acceptable systems can we develop to help in such complicated scenarios as multi-party, multi-issue negotiations? These questions were addressed using the analytical mediation process.

Jelassi and Foroughi (1989) examined the issues involved in NSS design based on a review of previous literature. They also discussed current systems that could be used to support the negotiation process. The article laid the foundation for the development of a wide range of individual and group support tools for use in negotiation. After contrasting between "hard" (zero-sum) and "soft" (win-win) negotiations, the authors outlined five factors important to the design of NSS. These factors are: 1) Separate the people from the problem; 2) Provide communication between negotiators; 3) Help negotiators identify their real interests; 4) Generate options for mutual gain; and 5) Use objective criteria. In a subsequent paper, Foroughi and Jelassi (1990) focused on the major stumbling blocks to successful negotiation and suggested ways for alleviating or overcoming them.

In a recent article, Anson and Jelassi (1990) provided a conceptual framework for developing computer-supported conflict resolution. It addressed the following obstacles to integrative bargaining in a mediation setting: cognitive biases of negotiators, socio-emotional factors, and analytical processing difficulties. A number of practical design issues and implementation guidelines were suggested in order to build NSS capable of overcoming the above obstacles.

The conceptual frameworks outlined above and others suggested in the literature are based on different perspectives: management science, operations research, information systems, computer science, organizational behavior, communication, etc. They help advance the concepts of GDSS and NSS by providing enriching and complementary views of group decision and negotiation processes. The next step for researchers in the field is to build computer-based support systems using these frameworks and to empirically test their effectiveness.

5.2 Examples of GDSS and NSS Implementations

An increasing number of researchers are investing considerable time and effort in designing and implementing computer-based information systems for group decision and negotiation support. Anson and Jelassi (1990), Jelassi and Foroughi (1989), Jelassi and Jones (1988), DeSanctis and Gallupe (1987), Kersten (1987), Nyhart and Goeltner (1987) and Kraemer and King (1986) have identified some sixty GDSS and NSS. In the GDSS area, significant experiments took place in North American university laboratories, in particular at the University of Arizona where the PLEXSYS system was developed and at the University of Minnesota, home of the SAMM system.

The University of Arizona has two GDSS rooms in operation. The smaller system (Nunamaker et al., 1987) provides 16 personal computers whose screens are imbedded in a U-shaped table (see Figure 1). A public screen can be used to show what is on the facilitator's screen. The system's program and data reside on a data server that is also used as the facilitator's workstation. The second, larger system provides 24 workstations and two projection screens arranged in amphitheatre style (see Figure 2). This system, which became operational in November 1987, uses the same software. PLEXSYS provides a large number of tools that support brainstorming, issue analysis, voting, stakeholder identification, assumption surfacing, and recording what happened during a meeting. The facilitator's station provides access to and control over the group support tools. The system uses pop-up menus, cursor selection from menus, and keyboard instructions to communicate with the user.

-- Insert Figures 1 and 2 here --

The University of Minnesota GDSS uses 4 microcomputer terminals and its software consists of a public program to manage what appears on each screen and private programs for individual participants. The public program receives all communications from the participants' private programs during the meeting and acts on them. The private program initially presents each participant with a general purpose agenda that includes choices such as problem formulation, criteria/alternatives definition or selection, rating, ranking, and voting. Any participant can ask to view the current state of the decision on the screen, without having to go through the facilitator. Notice that the personal screens face toward the public screen rather than being built into the table (see Figure 3). [For more details on these and other GDSS implementations, the reader is referred to (Gray and Olfman, 1989)].

-- Insert Figure 3 here --

In the NSS area, existing implementations differ widely in the type and amount of support they can provide. At one end of the spectrum, NSS consist of a computerized model that performs computations or quantitative analysis used during the negotiation process. Such systems serve as "backroom processors" and thus play a rather passive role. Examples of these NSS include DECISION TREE (Winter, 1985) and DECISION MAKER (Fraser and Hipel, 1984). [For a detailed discussion of these systems, see Jelassi and Foroughi, 1989].

Toward the middle of the spectrum of NSS implementations are interactive systems that support a human mediator and/or the negotiating parties. Examples of such implementations include MEDIATOR (Jarke et al., 1987) and GDS1 (Kersten, 1987) which use multicriteria decision making methods, preference elicitation techniques, and electronic communication features.

MEDIATOR is a database-centered, micro-mainframe NSS used to support negotiators and human mediators in solving conflicts. It is applicable during the pre-negotiation stage where players formulate their initial bargaining position. It is also employed in the negotiation stage to help select and evaluate alternatives. MEDIATOR handles subjective (qualitative) and objective (quantitative) data and analyzes decision-maker preferences for possible solutions (agreements). Each negotiating party uses PREFCALC (Euro-Decision, 1986; Lauer and Jelassi, 1987), a single-user multicriteria DSS, to establish their individual preferences and problem representation, which are transferred then to the common (mainframe) database. The human mediator integrates these individual problem representations using relational query language capabilities to form an initial group joint problem representation (Jarke and Jelassi, 1986). Negotiations are undergone by consensus seeking through exchange of information and compromise. MEDIATOR is useful for multi-player, multi-criteria, ill-structured, dynamic problems.

Proceeding along the spectrum, we find two recently proposed systems: the KAJ NSS (Anson and Jelassi, 1990) and MEDIANSS (Carmel and Herniter, 1989). These NSS provide interactive support for the entire negotiation process through the use of GDSS features such as electronic communication and group process structuring techniques, in addition to the employment of quantitative analysis methods and game-theoretical models for conflict resolution. MEDIANSS was strongly influenced by the KAJ model. Negotiating teams are guided by the mediator through a structured set of computerized steps. These consist of the following: rule setting, role reversal, issues and reason identification, issue consolidation, ranking, package creation, proposal presentation, linking, house trading, and agreement wording.

At the extreme end of the spectrum are rule-based NSS which use expert systems techniques to play an active role in the negotiation process (Sycara, 1987). An example of such NSS is RUNE (Kersten et al., 1988) which employs an artificial intelligence approach to problem representation and solution by evaluating bargaining positions and modelling negotiating strategies. However, RUNE supports only one stage of the process, pre-negotiation planning. DeSanctis and Gallupe (1987) as well as Anson and Jelassi (1990) suggested that rule-based intervention in negotiations could potentially include: 1) analysis of conflict contingencies, 2) suggestion of appropriate process structuring formats or analytical models, 3) monitoring of the semantic content of electronic communications in order to enforce pre-programmed, mutually agreeable interaction norms, 4) suggestion of settlements with high joint benefits, 5) automatic mediation, and 6) automated parlimentary procedure.

Recent research in applying artificial intelligence to decision making (Jelassi et al., 1987) and negotiation (Kersten et al., 1988; Kersten and Szpakowicz, 1990; Sycara, 1987) opens up new possibilities for providing effective support to decision makers as well as bargaining parties. Negotiators' knowledge is one of the forces shaping the process and influencing its outcome. This knowledge increases and dynamically evolves over time and therefore artificial intelligence may well provide the appropriate techniques and tools for its representation and manipulation. The ultimate objective here is to offer negotiating parties a means by which they can **directly** define and evaluate possible settlements. Hence the support system will allow negotiators to act as their own mediator, rather than having to go through a third party, human or machine-based, which is quite often imposed on them. Achieving this objective would be a significant step toward improving the efficiency and effectiveness of the negotiation process.

6. CONCLUDING REMARKS

The aim of this paper was to introduce some formal models of group decision making and negotiation and discuss ways in which recent advances in information technology can be applied to these managerial activities. A special focus was on the concept of computer support for such multi-person, complex, dynamic, and ill-structured processes.

As can be noticed from the sections on conceptual frameworks and actual implementations of group decision and negotiation support systems, significant developments have taken place in the field in spite of its infancy. However, although the potential of GDSS and NSS has been recognized, there is still very little empirical evidence about **how and under what circumstances computer-based tools can best assist decision makers and negotiators.** [For examples of empirical assessments of GDSS and NSS, see respectively (Nunamaker et al., 1989) and (Jones and Jelassi, 1990)].

There is a need for more rigorous research on the role computers can play in group decisions and conflicts and their impact on the process outcomes as well as on the participants' attitudes. Further conceptual studies are needed in the field, in conjunction with the development of more effective NSS and GDSS technologies. A necessary subsequent step in such a research agenda should be the real-world, "live" testing of these computer-based systems in order to evaluate their actual benefits as well as their shortcomings.

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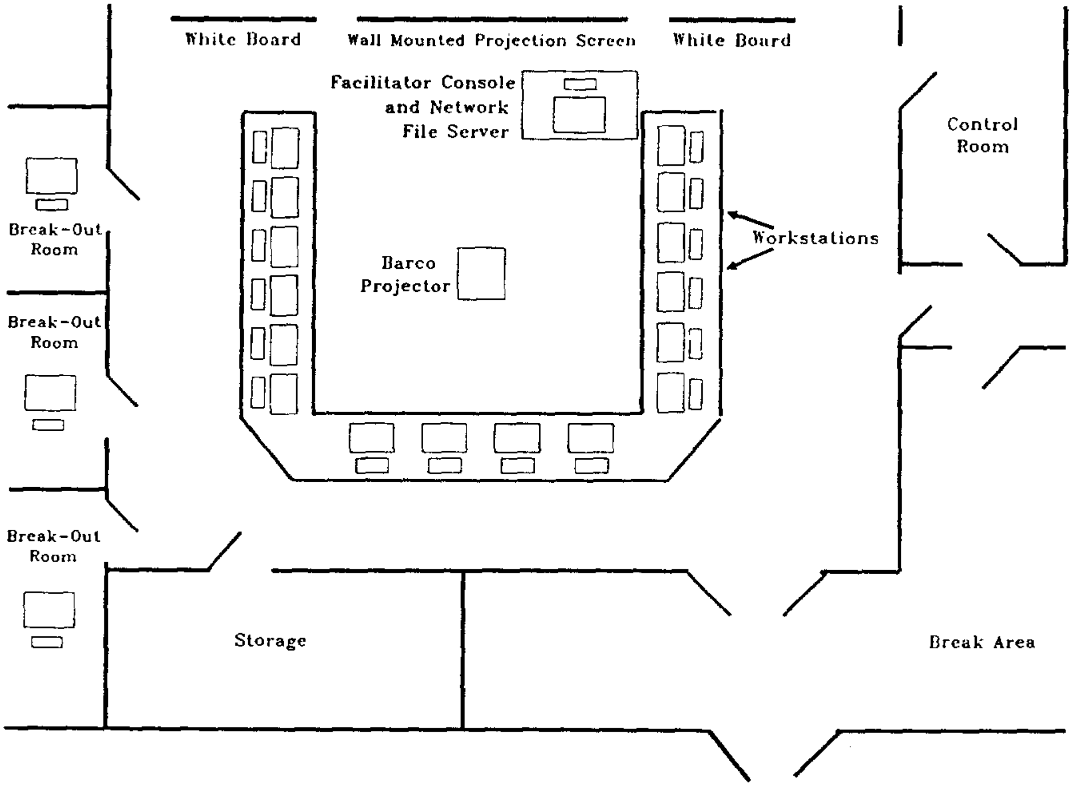

Fig. 1 The University of Arizona Small GDSS Facility.

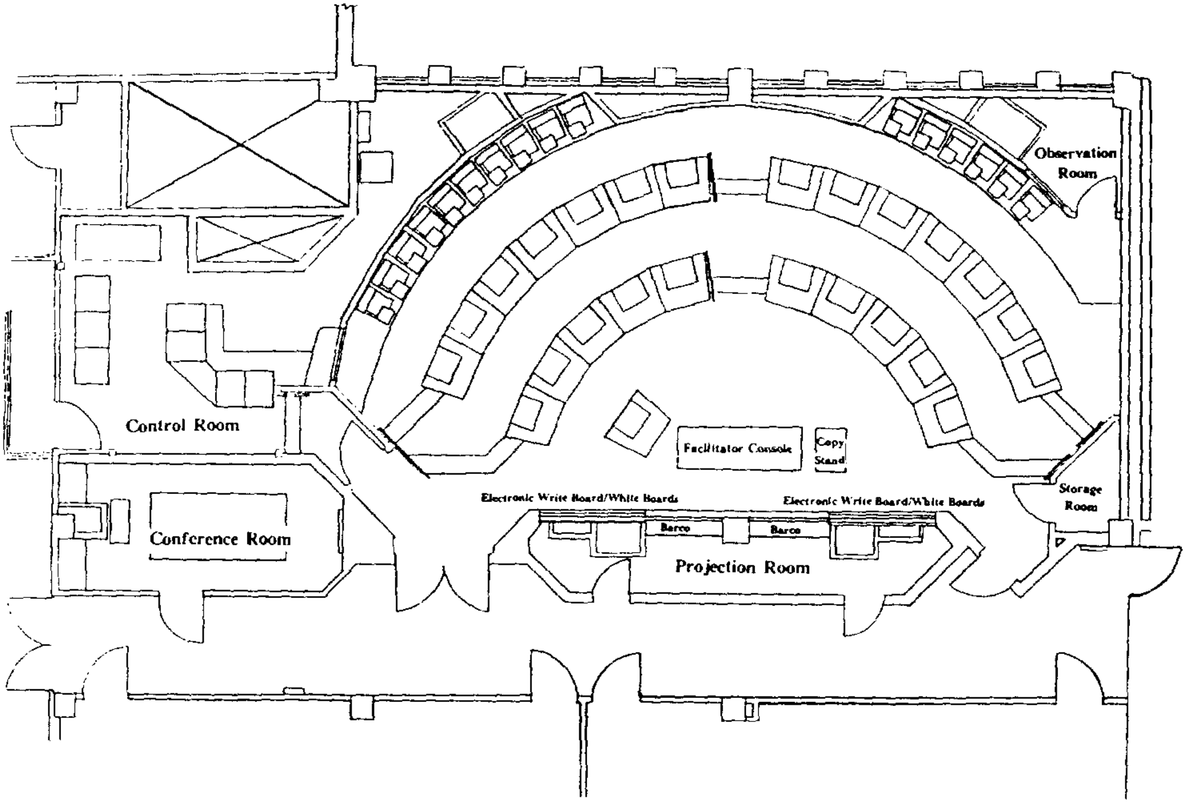

Fig. 2 The University of Arizona Large GDSS Facility.

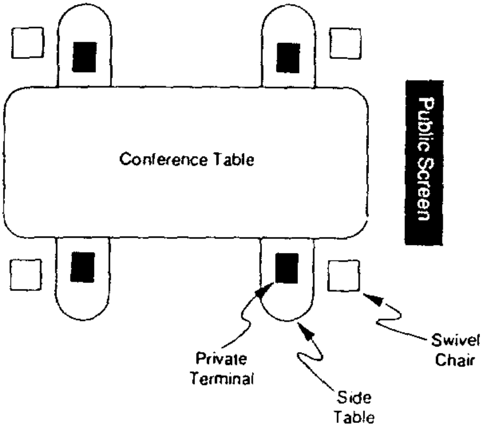

Fig. 3 The University of Minnesota GDSS Facility.

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