Chapter 11
Multiple Criteria Approaches to Group Decision and Negotiation

D. Marc Kilgour, Ye Chen, and Keith W. Hipel

Abstract Collective decision making, the processes of group decision and negotiation, and the differences between them are explained and illustrated. Then the applicability of techniques of multiple criteria decision analysis (MCDA) to problems of group decision and negotiation (GDN) is discussed. A review of systems for Group Decision Support and Negotiation Support then highlights the contributions of MCDA techniques. The roles of decision makers and others in GDN are discussed, and overall progress in GDN is reviewed. Finally, some suggestions for worthwhile future contributions from MCDA are put forward.

Keywords Collective decisions · Group decision · Negotiation · Multiple criteria decision analysis · Multiple-party multiple-objective decisions · Multilateral · Bilateral

11.1 Introduction: Group Decision and Negotiation

The ability to reach informed and appropriate collective decisions is probably a prerequisite for civilization, and is certainly crucial for individuals and organizations today. Formal procedures for reaching a decision are often recommended, reflecting the belief that collective decision making can be "improved" by a systematic

---

D.M. Kilgour (✉)
Department of Mathematics, Wilfrid Laurier University, Waterloo, Ontario, N2L 3C5, Canada
e-mail: mkilgour@wlu.ca

Y. Chen
College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, 210016, China
e-mail: chenye@nuaa.edu.cn

K.W. Hipel
Department of Systems Design Engineering, University of Waterloo, Waterloo, Ontario, N2L 3G1, Canada
e-mail: kwhipel@uwaterloo.ca

M. Ehrgott et al. (eds.), *Trends in Multiple Criteria Decision Analysis*,
International Series in Operations Research and Management Science 142,
DOI 10.1007/978-1-4419-5904-1_11,

approach. Group Decision and Negotiation (GDN) is an academic and professional field that aims to assist groups, or individuals within groups, in interacting and collaborating to reach a collective decision. The broad aims of the field are to provide procedures to ensure that collective decisions are as good as possible, and to study the nature of the structural, strategic, tactical, social, and psychological issues faced by individuals as they narrow in on a collective choice. GDN combines approaches from operations research, computer science, psychology, political economy, systems engineering, social choice theory, game theory, system dynamics, and many other fields, including Multiple Criteria Decision Analysis (MCDA). In fact, the recently published *Handbook of Group Decision and Negotiation* [51] contains a full chapter on the contributions of MCDA [84].

The field of GDN boasts a large and growing research literature. Within the Web of Science database, for instance, a search on the keywords "group decision" and "group negotiation" identifies about 20,000 papers, scattered over more than 100 research areas including management science, engineering, psychology, neuroscience, political science, and many others [81].

The amount of research is not surprising, given that collective decision making is among the most important processes carried out by corporations, governmental and nongovernmental organizations (NGOs), and individuals around the world. For example, negotiations conducted by the United Nations among national governments, regional organizations, NGOs, and other groups, cover a broad range of issues including international law, international security, economic and social development, and human rights [78]. Meetings aimed at making a group decision are ubiquitous in corporate and governmental organizations; they often follow explicit procedures in order to obtain information that is as accurate and complete as practicable, thereby reaching appropriate decisions judiciously and quickly.

What is group decision and what is negotiation? Is it useful to distinguish between them? A **Group Decision** is a decision problem shared by two or more concerned parties who must make a choice for which all parties will bear some responsibility. A **Negotiation** is a process in which two or more independent, concerned parties may make a collective choice, or may make no choice at all. Generally speaking, group decision is a generic process and negotiation is a specific one and, as discussed by Walton and MacKersie [91], negotiation often has a distributive dimension that group decision lacks. The points of difference between group decisions and negotiations are reflected in the possible outcomes, the process, the numbers of participants, the existence of common ground, and the types of participation. The details are given next.

Difference in outcome: The possibility of disagreement is the major distinction between group decision and negotiation. In a group decision process a decision must be made, whereas in negotiation each party has the option of "walking away." Because of this fundamental fact, negotiating parties are advised to take into account what Fisher et al. [38] and Raiffa [76] call their BATNA, or Best Alternative To Negotiated Agreement. A party that prefers not to have responsibility for a particular choice need not agree to it.

It may seem that group decision could be made similar to negotiation by allowing the group the option of deferring a decision, or doing nothing. But this similarity is superficial as a group may decide to do nothing because of the numbers and influence of those members who prefer that option; other members may disagree, but remain in the group. The fundamental property of negotiation is that all parties *agree* with the collective choice. In group decision, by contrast, it is common for the parties to disagree on what is the best choice, but to select an alternative that achieves a minimum level of support within the group.

Difference in process: One well-known group decision procedure is voting. In a properly conducted election, all options are known at the time of voting, and the members of the group indicate preferences, which are combined according to some standard systems to obtain a group choice [21]. Voting has some special properties that make it very useful for some decisions but not for others. For instance, most voting systems give all voters equal weight in the final decision; tinkering with the "one person, one vote" property usually causes a voting system to lose many of its other appealing properties [37]. Moreover, provided there are three or more voters and three or more alternatives, every voting system is vulnerable to strategy, and therefore voting results do not provide a reliable reading of "group preference" [4]. Voting is widely used for surveying opinion (a "straw vote") but rarely considered sufficient for a group decision in a corporate context, in part because the act of voting provides no forum for information search or exchange, for the development of preferences, or for the modification of the information or preferences of others. In negotiation, of course, the opportunity for persuasion is central, and indeed is often the point of the process.

Difference in numbers of participants: Among the less important differences between group decisions and negotiations is the tendency for group decisions to involve larger numbers of parties. A group decision or negotiation that involves two parties is called *bilateral*; if it involves more than two parties, it is called *multilateral*. Almost all group decisions are multilateral, at least in the formal sense of the number of parties at the table. By contrast, bilateral negotiations are at least as common as multilateral.

Difference in common ground: Group decisions are usually made by a group, i.e., by parties who have something in common; typically, they are all employees of the same corporation, and can therefore be assumed to have an interest in the quality of the decision, insofar as it contributes to the success of their common enterprise. The group decision ideal is that a "meeting" of individuals with a common interest in a good decision, but different information and perspectives, can be an informative and even creative process that identifies the choice most consistent with the common interest. Good decisions are certainly the key to success for a business, and it is widely held that even an expert individual is rarely as successful in decision making as a process that canvasses multiple points of view [88]. Negotiations, on the other hand, often involve parties whose relationship is partially or even entirely adversarial, and who begin with evaluations of options that differ substantially and even (in the bilateral case) diametrically.

Difference in types of participation: Another small but significant difference is that parties in negotiations are often represented by negotiators, who may be compensated for their efforts. One reason is that many negotiations, especially those involving large organizations–labor and management, for example – are rarely limited in the time and resources they use up. Another reason may be the view that tactics and style are important determinants of success in negotiation, causing each party to want professionalism on its side.

Despite their differences, group decision and negotiation are often studied together, or in parallel, mainly because of the collective decision aspect that they share. For example, group decision and negotiation can and should include searches for new alternatives, efforts to repackage existing options to form new alternatives, and detailed assessments and evaluations of alternatives. Many procedures studied in the field of Group Decision and Negotiation are designed to assist in these endeavors. Of course, GDN has its own distinctive problems and issues. For instance, the decision environment in GDN is usually ill-structured and dynamic. Moreover, the vague or conflicting perceptions of decision makers often make it difficult to pin down exactly which problem each one understands the group to be facing. For example, [68] discussed problem structuring in the GDN context; the ability to find a shared vision of a group problem can be crucial in a context of uncertainty, inconsistent perceptions, and diverging interests. For these and other reasons, it can be extremely difficult to apply standard tools to understand and analyze practical GDN problems [47].

The development of GDN as a field has been motivated by the need for better approaches to collective decision problems. Tools from other fields have often been successful in GDN, even though they may fit only a few GDN problems, and often not exactly. However, as will be illustrated later, there remain aspects of collective decision making that are not accounted for in GDN. For many of these, adaptation is essential to comprehend the nature of the difficulties, which is often to only way to achieve a good solution.

11.2 Multiple Criteria Decision Analysis in Group Decision and Negotiation

Multiple criteria decision analysis (MCDA) is a set of techniques and principles designed to help a decision maker (DM) compare and evaluate alternatives according to two or more criteria (objectives), which are usually conflicting [10]. Most MCDA procedures are designed to elicit a DM's preferences, both over the level of performance of alternatives according to a particular criterion and over the relative importance of criteria, or to combine these preferences according to a procedure that helps the DM choose the best alternative, rank the alternatives, or sort the full set of alternatives into a few (ordered) groups of approximately equally preferred alternatives [80].

Traditionally, MCDA takes the set of alternatives and the set of criteria as given, and focuses on preference elicitation and aggregation. Recently, though, there has been more attention to problem construction, and greater effort is now recommended to search out new alternatives, identify objectives more appropriately, and select criteria that reflect the DM's real interests and objectives. This trend began with Keeney's ideas on value-focused thinking [49], which suggest a systematic method that provides an excellent approach to this aspect of MCDA.

MCDA procedures are designed to be applied to data measuring the performance of each alternative according to each criterion, the so-called *performance matrix*, plus input from the DM that describes the DM's preferences. Procedures for choosing, ranking, or sorting are different, but clearly they have much in common.

There have been many applications of MCDA to collective decision problems. For example, many participative decision-aiding frameworks implemented in environmental contexts, including Marchi et al. [65], Norese [71], Strager and Rosenberg [87], Mustajoki et al. [69], and Adrianto et al. [1], use MCDA methodologies. But applying an MCDA technique to a collective decision problem poses an unavoidable theoretical problem: Collective preferences may not exist. In other words, the "DM's" preferences are an essential input to any MCDA method, and each individual in the group may have well-defined preferences, but the notion that collective preferences are determined by individual preferences is naive.

The existence of individual preferences does not imply the existence of a collective preference with properties similar to those of the individual preferences, as is illustrated by the well-known Condorcet Paradox [4]. In this example, three individuals, 1, 2, and 3, are asked to consider three alternatives, A, B, and C. As shown in Table 11.1, Person 1 prefers A to B to C; Person 2 prefers B to C to A; and Person 3 prefers C to A to B. It is obvious that two people prefer A to B, two people prefer B to C, and two people prefer C to A.

The existence of a collective preference therefore presents a dilemma: We must either accept that group preference can be intransitive, or we must make one person a dictator. The first option is to accept that even though A is preferred to B and B to C, it does not follow that A is preferred to C, as transitivity would require–in this case, in fact, the opposite preference holds. The second option is to accept that a collective preference is transitive only because one person is more important than the other two combined. If the collective ordering in the Condorcet example A to B to C, for instance, then person 1 is more important than 2 and 3 combined, in that 1's preference of A to C outweighs 2's and 3's preferences of C to A. Simply put, person 1 a dictator, so the group preference is the same as 1's preference, and 2 and 3 simply don't matter. In any case, we must accept that even when individual preferences are well-behaved, a well-behaved group preference that reflects all individual preferences may not exist.

Table 11.1 Condorcet paradox: Preference orderings of 1, 2, and 3 over A, B, and C

Individual	Preference order
Person 1	A > B > C
Person 2	B > C > A
Person 3	C > A > B

The lesson of the Condorcet Paradox is relevant to the application of MCDA procedures to a "DM" who is really a group, because MCDA procedures require the DM to have a preference with respect to performance on criteria, and with respect to criteria. A useful group preference may exist in some cases, but in others a transitive non-dictatorial group preference may simply not be available. Of course there are situations in which group preference is well-defined and has the expected properties, or in which, even absent a sensible group preference, MCDA procedures give sensible results. Moreover, from a practical point of view, the fact that a decision has a shaky theoretical basis does not imply that it is necessarily bad. Nonetheless, the Condorcet Paradox shows that, when the DM is replaced by a group, MCDA procedures may be inapplicable in principle.

This concern applies whenever MCDA procedures are applied to GDN as if a group of individuals with an interest in a decision were an individual DM. In some instances, the group–say, the planning committee for a new building or a retail expansion–has the collective power to make a decision. The group is asked to answer, collectively, the same questions that would be used to elicit the preferences of a DM in accordance with the MCDA procedure selected. The inferred "collective preference" is then used to make a decision, or as input to a decision. But, as noted above, such an application of an MCDA procedure may be difficult to justify–even though it often works well in practice.

A variant of this idea for applying MCDA procedures is based on a consultation meeting or process involving the "stakeholders" affected by a decision to be made, for example, by a government agency or a corporation. In some instances, the stakeholders have some control over certain aspects of the decision [7, 41]. But the process may have other goals, such as making the stakeholders aware of the full range of issues entering into the decision, or even making a decision that is politically acceptable. Inasmuch as the stakeholders have the power to make a decision, the techniques of GDN are certainly applicable. The possibility of other roles in a group decision process is discussed in detail below.

Another "pitfall" for applications of MCDA techniques to GDN problems is the identification of individuals with criteria. This strategy is simple, and quickly solves the problem of identifying the criteria, but it is generally not helpful. One major objective of MCDA techniques is to trade criteria off against each other in a controlled way and, in extreme cases, to drop or combine criteria. Procedures advising that some group members be dropped and that others be combined, or that explain how to trade one person off against another, are rarely credible or persuasive in a group setting. MCDA procedures are designed for multiple criteria; they succeed by helping the DM break the problem down into comparisons of performance on each criterion, and then into weighing the relative importance of the criteria. If the "DM" is a group, it will be more difficult to elicit the DM's attitude and judgment, but to ignore actual criteria on which alternatives can be measured and compared is to throw away the proven features of MCDA methods [7].

In the end, of course, a group decision process may take on many "political" features, and it may be inevitable that the interests of some are sacrificed in favor of the interests of others [44]. And, while not recommended, the identification of individuals with criteria can produce some useful insights into the process–for instance, Nurmi [72] provides an assessment of the vulnerability of MCDA to many well-known voting paradoxes. But in general we recommend that criteria and individuals be treated as separate entities.

We now turn to a general description of the application of MCDA methods to group decision and negotiation. While we classify this work into the categories *MCDA and group decision support* and *MCDA and negotiation*, we will make note of ideas, techniques, and systems that fit into both categories.

11.3 MCDA and Group Decision Support (GDS)

To understand Group Decision and Group Decision Support, it is useful to distinguish among the possible roles of an individual (or a group of individuals with a common viewpoint) in a group decision process. In addition, there are a few studies of actor typologies within decision-aiding processes, including [5, 57].

A *DM* is a member of the decision-making group; together, the DMs have control of the decision process, including data collection, data aggregation and assessment, and final implementation. A *stakeholder* is an individual (often a representative of a group) who is significantly affected by the final decision, but does not necessarily have any control over it. The main difference between DMs and stakeholders is that although stakeholders have preferences over the resolution of a decision problem, their primary concern is not with the full scope of the resolution, and they may have no significant influence on the decision process. Another role is that of *expert*, an individual with special knowledge of the decision problem, but no interest (in the sense of being disinterested–of having nothing to gain or lose) in its resolution.

MCDA provides useful terminology to describe these roles. A stakeholder, typically, is concerned about only a few of the criteria. The expert, because of both special knowledge and disinterest, is often called upon to provide an "unbiased" assessment of the performance of alternatives according to one or several criteria, or of the relative weights of the criteria themselves.

Group Decision Support aims to provide formal assistance to a group as it moves toward a decision by encouraging focused communication about the possible alternatives, the choice of criteria, the measurement of performance, the weights to be given to criteria, and the overall evaluation of alternatives. Basic techniques for group decision support have been available for many years. They include

- *Brainstorming*, originally suggested by Osborn [75], is a group creativity technique designed to generate a large number of ideas for the solution to a problem.
- *Nominal group technique* [48], an approach for use among groups of many sizes, aiming to make a decision quickly, as by a vote, but taking everyone's opinions taken into account (as opposed to traditional plurality voting, where the largest group prevails).
- *Delphi method* [79], a systematic interactive method to obtain and integrate knowledge from a panel of independent experts.

- *Voting* [23], which can be carried out according to various voting procedures and aggregation rules.

Note, for example, that Delphi is designed exclusively to enable a group of experts to produce a consistent judgment, whereas voting on alternatives or criteria makes sense for DMs only.

It is clear that GDS has a role for MCDA, as group decision making must involve assessments of the relevance of performance levels on criteria, and of the relative importance of criteria. One of the first applications of MCDA methodologies to group decision support was Bui's [12] discussion of the analysis, design, and implementation of group decision support systems from an MCDA viewpoint. Bui's system utilized several MCDA methods for individual preference elicitation and preference aggregation to support a group decision process.

As Bui and Jarke [13] suggested, MCDA can provide a systematic framework for tackling three important tasks in GDS: organization of the whole decision process, preference representation for different DMs, and preference aggregation. The combination of MCDA and GDS has generated many important research products. These methods can be divided, roughly, into two categories.

- *GDS based on procedures:* These MCDA-based methods focus on the design of effective procedures through which the DMs can interact in a way that brings out important information, generates new ideas, minimizes disagreement, and leads to a final choice. Procedure-based MCDA-GDS methods are very close to negotiation in some sense and have been extensively applied to both GDS and multilateral negotiation problems. Clearly, the aforementioned "soft-thinking" approaches, such as brainstorming, the nominal group technique, and the Delphi method already incorporate some multiple-criteria or multiple-objective ideas for GDS. Other procedure-based MCDA-GDS methods that have been developed, refined, and applied to group decision problems are summarized next.

  - MEDIATOR is a negotiation support system based on evolutionary systems design and database-centered implementation [46], but it can be used usefully as a group decision support system.
  - Outranking Methods, a family of popular MCDA methodologies that originated in Europe in the mid-1960s [80]. Both ELECTRE and PROMETHEE have been applied to support group decisions, for example, in [24, 28] and [64].
  - Preference disaggregation approaches, which analyze a DM's global assessment in order to identify the criterion aggregation model that underlies the preferences, have been extended to a group decision context, for example, in [66].
  - SCDAS (Selection Committee Decision Analysis and Support) is a system designed to support a group of decision makers working together on selecting the best alternative from a given finite set of alternatives. The framework utilizes aspiration-led and quasi-satisficing paradigms for eliciting user preference, and an achievement function for ranking alternatives [58].
  - A topologically based approach to measuring the distance between DMs that was used by [14] to formalize the problem of reaching consensus.

- Several techniques based on AHP (Analytic Hierarchy Process) [83] have been applied to GDS problems in various contexts. These include [2, 29, 56], and [77].
- JUDGES, a descriptive GDS for the cooperative ranking of alternatives [14].
- An integrated framework of Drama Theory and MCDA, developed in [61], exploit their potential for synergy, with a view to providing more effective unilateral or multilateral decision support.
- The idea of jointly improving directions is at the basis of a series of research initiatives aimed at reaching Pareto optimality in group decisions over multiple continuous issues, for example, in [30, 31], and [32].

An early book on MCDA-GDS that summarizes many GDS approaches is [43]. The impacts of three procedural factors on information sharing and quality of group decision are examined in [42].

- *GDS based on optimization and aggregation:* These approaches aim to generate the optimal group decision by designing and employing optimization models. Representative methods include

  - Various techniques based on fuzzy logic, such as [18, 73] and [99], have been developed to incorporate multiple experts' ratings into GDS.
  - The Dempster-Shafer evidential reasoning approach [85] has been applied to GDS, for example, by [8, 9, 27] and [97], to effectively aggregate different DMs' knowledge.
  - Ordered Weighted Average (OWA) operators, initially proposed by Yager [96], constitute convenient ways to average information from multiple sources or different DMs for GDS [3, 60] and [94].
  - A few optimization aggregation procedures have been designed to integrate preference data in multiple formats, such as fuzzy logic, interval relations, and probability, from different DMs, by [39, 62] and [95].

  Many other optimization aggregation approaches, including [45, 55], and [92], to name a few, are applicable to GDS problems.

Group Decision Support Systems (GDSS) are computer systems specifically designed to guide and assist a group of DMs. Many GDSSs require a special computer installation, a special room, or specialized expertise to operate the system, especially if facilitation of the decision process is going on at the same time. The Co-oP system [12], one of the earliest GDSSs, incorporated MCDA methods such as AHP and outranking techniques to encourage cooperative multiple criteria group decision making. Another example is Web-HIPRE [70], a Java applet-based MCDA system that provides a common platform for individual and GDSS. Virtually all GDSSs encourage communication and contribution by each member of the group; many of them aim at the creative generation of additional alternatives and the creation or confirmation of a group identity and role, and some also include substantial recording and surveying capabilities, and may be designed for meetings that are distributed in space and even in time ("non-synchronous"). One well-known GDSS for electronic meetings is Meetingworks [67].

Even broader than GDSS are Group Collaboration Systems (GCS), which support collaborative processes of strategy-making, process engineering, or product design and development [26]. The most ambitious of the GCS can support collaboration across several organizations. GCS are a natural extension of GDSS, and are often classed as Group Decision Support, as they may be used to develop a decision on a specific problem, or a set of linked decisions. Well-known group support systems, often called groupware, include Decision Explorer [6] and ThinkLets [11].

Of course, it is difficult to choose among systems using only their specifications. Davey and Olson [25] compared GDSS using laboratory methods. Other comparative research includes [20, 22, 40], and [74].

11.4 MCDA and Negotiations

As an area of study, negotiation is much more diffuse than Group Decision. The reason is that negotiations can be conducted under fixed rules only if all parties agree, since any party has the option of "walking away" from the process–and can be expected to do so, if it perceives a strategic advantage. Advice on negotiation can be found by following up on advertisements in popular magazines or in popular trade books such as *Getting to Yes* [38]. Among the more serious general academic studies of negotiation is Raiffa et al.'s *The Art and Science of Negotiation* [76]. These two works are generally credited with popularizing the concept of a negotiator's BATNA, or Best Alternative To Negotiated Agreement. To a rational, informed negotiator, the BATNA is a "hard" floor, to which any agreement must be superior.

One important subdivision of negotiation is bilateral (two parties) or multilateral (many parties). Negotiations are interest-based or positional – or often both. In interest-based negotiations, which may be bilateral or multilateral, the possible alternatives are not specified in advance, and the parties typically have some common preferences. A win–win solution is possible; efforts to generate new alternatives or creatively recombine old ones are often repaid with a solution that is better for both sides. On the other hand, positional (or zero-sum, or fixed-pie) negotiations are generally bilateral; if so, the two sides' evaluations of the alternatives are diametrically opposite. There is little room for creativity or even new information, and bargaining proceeds mostly by threatening and holding out. Positional negotiations are widely understood to be the most intractable of negotiations, because there is no possible win–win outcome. Of course, most practical negotiations are partly positional; for example, if there is a fixed list of alternatives, and the parties' rankings of their desirability are the same, then the bargaining must be positional.

Many useful approaches to the study of negotiation, especially at a theoretical level, have come from traditional social sciences like economics and political science, and from the study of mathematical models of negotiation. The examination of many game-theory models of negotiation, such as the Stahl [86]–Rubinstein [82] alternating-offer bargaining model, reveals that in interest-based negotiations, negotiators are most likely to achieve a win–win outcome if they work to learn about the values of others, while slowly revealing their own values. In fact, this idea presumes multiple-criteria outcomes, where the relative values of criteria (and even the evaluations of performance on a criterion) may be different for different parties. In this context, there is scope to find outcomes that are preferred to the status quo for both parties, or *Pareto-superior* to it. Bargaining is efficient (in the economic sense) if it achieves a *Pareto-optimal* outcome, one to which no other outcome is Pareto-superior. Political science has contributed some practical studies, often at the diplomatic level, of multilateral negotiation procedures (like the "rolling text" now commonly used by the United Nations) and of negotiation ripeness [98].

We now proceed to a brief survey of MCDA-related work on negotiation. As already noted, both negotiation and group decision are problems of collective decision making, so many procedures have some applicability to both. For example, many of the procedure-based GDS approaches reviewed above can be applied to negotiation; in fact, some were originally developed to support negotiation. Hence, we do not repeat our discussion of these methods, and focus on procedures that are applicable mainly or exclusively to negotiation support.

One important and rapidly developing area is e-negotiation, which refers to negotiations using computers–usually the Internet–as the medium of communication. Negotiators may be humans, who may be distant in time and space, electronic negotiating agents, or robots. For a general account of the development of systems, see [50]. The development of the World Wide Web has given great impetus to e-negotiation and its role in e-marketplaces, especially in personalizing and customizing processes. Clearly, electronic negotiating agents can be used only in a context in which they can evaluate offers; these agents are now well developed, and e-negotiation systems often offer human negotiators a "wizard" to assist them in evaluating offers. Note that preferences must be input to a negotiating agent or wizard, either explicitly or based on inferences from choices on some test set of cases. Many ideas for these systems have been imported directly from MCDA. For example, Vetschera [90] examined whether DMs' preferences embedded in e-negotiation models are actually reflected in the behavior of negotiators, or in negotiation outcomes.

Other computer-related work involves multiagent modeling of negotiation, an area of study in which autonomous agents carry out a sequence of negotiations, based on some ideas from complexity theory and agent-based models. The parameters of the agents are set using ideas from MCDA. Some relevant work includes [19, 33, 59], and [93].

An MCDA approach to positional negotiation has been developed using a novel case-based distance method [15], in which a case set provided by each negotiator is input to a program to generate criterion weights for a weighted distance representation of the negotiator's preference. Then negotiation support using these distances helps the negotiators to identify and reach an efficient compromise.

Finally, negotiation involves many essentially strategic choices–negotiators must choose courses of action (what to offer, whether to accept an offer) that determine how well their goals and objectives are met. Strategic advice is important, particularly in negotiation preparation, and several systems that assist participants in strategic conflict are applicable. One is the Graph Model for Conflict Resolution, implementedin the Decision Support System GMCR II [34–36, 52], and [53]. Because preferences are its input, the Graph Model presumes the availability of an MCDA system to evaluate a DM's preferences for various possible outcomes, which can be interpreted as "packages" of features. Thus, the Graph Model goes one step further than MCDA, assisting a DM at planning negotiation strategy and at responding to unexpected developments during a negotiation.

11.5 Examples

We now use two practical examples to illustrate real-world processes that fall between negotiation and group decision, showing that strategic choice and negotiation preparation play an important part in the determining outcomes. The first example includes the application of MCDA concepts and methods for group decision; the second demonstrates analysis and support for a multilateral negotiation using the Graph Model for Conflict Resolution and the associated decision support system GMCR II [34, 53]). The intention here is to raise open issues and suggest directions for development.

Example 11.1. **Ralgreen Brownfield Redevelopment**

Brownfields are abandoned, idle, or underutilized commercial or industrial properties, with potential for redevelopment, where past activities caused, or may have caused, environmental contamination [89]. In many countries, interest in brownfield redevelopment (BR) increased rapidly in the 1990s as it became clear that revitalization of urban areas was the only way to relieve expansion pressure on the greenfields surrounding urban centers. BR often involves multiple DMs and stakeholders, as illustrated in the story of the Ralgreen BR project that follows.

The Ralgreen community is located in Kitchener, Ontario, Canada. It now contains 101 residential units, including semi-detached and row housing and low-rise apartments. Until the late 1940s, the Ralgreen area was part of a family farm just outside the city. Around 1948, the property owners and the City of Kitchener had agreed that a pond on the property could be infilled with organic materials that included cinders and ash from the City's incinerators. The land was used for agricultural purposes until 1965, when the property was sold to a developer who built the Ralgreen subdivision.

Beginning in 1996, Ralgreen residents complained to the City of Kitchener about geotechnical issues: settlement and displacement of structures; seepage of liquids into basements; methane; and mould. By 1997, investigations by consultants for the Ralgreen residents had linked the problems to the infilled pond. In 2000, a mediated settlement was reached by residents and the City of Kitchener. The subdivision would be cleaned up in accordance with the guidelines of the Ontario Ministry of Environment. Figure 11.1 shows the DMs and stakeholders involved in this issue just prior to the agreement in 2000.

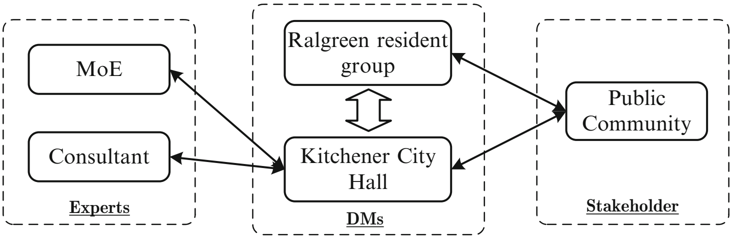

Fig. 11.1 DMs and stakeholders in Ralgreen BR

The two key DMs in the Ralgreen BR were the City of Kitchener (City Hall) and the Ralgreen residents' group. Some but not all of their interests were in direct conflict [17]. Other participants included in the negotiation were Ontario Ministry of Environment (MoE), a consultant employed by City Hall playing the role of expert, and environmental groups in the broader community, which can be considered stakeholders. The arrows in Fig. 11.1 show the interactions among the DMs and other participants. For instance, the consultants communicated with City Hall suggesting for possible clean-up plans and evaluating them according to several criteria.

The four clean-up plans finalized and presented to Kitchener City Council in 2001 are listed below.

- A^1: Demolition of 20 houses, structural renovation of nine houses, full-scale waste removal and building/lot resale to neighborhood density.
- A^2: Demolition of 14 houses, structural renovation of 15 houses, full-scale waste removal and building/lot resale to neighborhood density.
- A^3: Demolition of 18 houses, partial waste excavation, landfill encapsulation, site-specific risk assessment, and parkland construction.
- A^4: Demolition of 14 houses, structural renovation of 15 houses, stratified removal of waste to 1.5 m below surface, with clean soil fill.

A two-stage decision procedure was conducted including initial screening with selection of an option by the group of stakeholders. Options were evaluated according to several criteria [16]. The two stages are described next.

Initial Screening: A screening procedure was used to identify and remove inferior alternatives, so that further comparisons involved only feasible and promising options. Accordingly, each alternative was assessed for feasibility and evaluated, in accordance with MoE guidelines, based on the following criteria:

- Construction and field implementation (CFI)
- Consistency with the mediated settlement and legal acceptability (CML)
- Compatibility of land reuse with residential setting (CLR)

As shown in Table 11.2, A^4 failed the CML and CLR tests and was therefore rejected. The remaining three alternatives were carried forward for further investigation.

Table 11.2 Satisfaction of screening criteria

	Criteria		
Alternatives	CFI	CML	CLR
A^1	✓	✓	✓
A^2	✓	✓	✓
A^3	✓	✓	✓
A^4	✓	×	×

Further Investigation: In 2002, after several meetings and public consultations, Kitchener City Council adopted alternative A^1. In a study of this project [16], the authors reanalyzed the decision process by applying MCDA tools to A^1, A^2, and A^3, the three alternatives that survived the screening process. Criteria were selected for the evaluation of these alternatives, as follows: C_1: protection of human health and the environment; C_2: acceptability to the community; C_3: operational and maintenance costs; C_4: expected property tax returns; C_5: effect on property values; C_6: demolition time; C_7: amount of waste to be excavated.

The analysis was conducted using the Analytic Hierarchy Process (AHP) [83]. After the establishment of alternatives and criteria, analysis steps included comparisons of all possible pairs of alternatives on all criteria, followed by evaluations, which produced an overall score for each alternative. For details on the AHP analysis, refer [16]. Alternative A^1 had the highest score, confirming its choice in the actual event. In 2005, soil reports confirmed the success of the Ralgreen redevelopment, and the project was considered to be complete.

Example 11.2. **Elmira Aquifer Pollution**

The town of Elmira, with a population of about 7,500, is located within a rich agricultural region about 100 km west of Toronto in Ontario, Canada. Until 1989, Elmira's municipal water supply was drawn from the aquifer underlying the town. In late 1989, the Ontario Ministry of Environment (MoE) discovered that this underground aquifer had been contaminated by the carcinogen N-nitroso demethylamine (NDMA). Blame fell on the pesticide and rubber products plant of Uniroyal Chemical Ltd. (Uniroyal), which was located in Elmira, had a history of environmental problems, and was associated with NDMA-producing processes. MoE issued a Control Order under the Environmental Protection Act of Ontario, requiring that Uniroyal implement a long-term collection and treatment system, undertake studies to assess the need for a cleanup, and execute any necessary cleanup under MoE supervision. Uniroyal immediately exercised its right to appeal. At the same time various interest groups formed and attempted to influence the process through lobbying and other means. The Regional Municipality of Waterloo and the Township of Woolwich (Local Government) adopted common positions in the dispute and, encouraged by MoE, hired independent consultants and procured extensive legal advice at substantial cost. Negotiations among MoE, Uniroyal and Local Government commenced in mid-1991. MoE's objective was to carry out its mandate as effectively as possible; Uniroyal wanted the Control Order rescinded or at least modified; Local Government wanted to protect its citizens and its industrial base.

DMs	Options	Distinct States								
		7	3	4	8	5	1	2	6	9
MoE	1. Modify (Modify the control order for Uniroyal)	N	N	Y	Y	N	N	Y	Y	---
Uniroyal	2. Delay (Lengthen the appeal process)	N	N	N	N	Y	Y	Y	Y	---
	3. Accept (Accept current control order)	Y	Y	Y	Y	N	N	N	N	---
	4. Abandon (Abandon Elmira operation)	N	N	N	N	N	N	N	N	Y
Local Government	5. Insist (Insist that the original control should be applied)	Y	N	N	Y	Y	N	N	Y	---

Fig. 11.2 Feasible states in the Elmira conflict model

This rather typical environmental conflict was studied by Kilgour et al. [54], who assessed what negotiation support could have been provided by the Graph Model for Conflict Resolution and the DSS GMCR II [34, 53]). The application of GMCR II takes into account not only multilateral negotiation, but also the possible benefits of coalition formation. Essentially, one asks how well each DM can do on his or her own, and then whether some group of DMs would benefit by cooperating in a coalition.

The left column of Fig. 11.2 lists the three DMs in the basic Elmira graph model, followed by the options or courses of action each one controlled. The right portion of Fig. 11.2 shows the nine feasible states, listed in descending order of MoE's preference. Each column on the right represents a state: "Y" indicates that an option is selected by the DM controlling it, "N" means that it is not selected, and "-" means either Y or N. For example, state 8 is the scenario in which MoE modifies the control order, Uniroyal accepts this modification, and Local Government continues to insist on the original control order. In state 9, Uniroyal abandons its Elmira facility, so all other options are irrelevant–the resulting states are considered indistinguishable.

GMCR II contains a procedure called Option Prioritization to input state preferences for each DM. (For example, Fig. 11.3 shows MoE's ranking in descending order of preference, with ties allowed.) The hierarchal preference statements used by GMCR II to order the feasible states are provided in Fig. 11.3; statements are ordered from most to least important. (Numbers in the left column refer to options in Fig. 11.2.) Notice that MoE most by prefers that Uniroyal not abandon its Elmira plant, indicated by the initial statement "−4," which implies that states with N opposite option 4 precede those with Y beside option 4. Next in MoE's order of priority is that Uniroyal accept the current control order (indicated "3"), so among states with the same status relative to the highest priority statement (−4), states with Y beside option 3 are preferred to those with N. As illustrated in Fig. 11.3, Option Prioritization can handle an if and only if (iff) preference statement. In fact, this procedure accommodates any statement in "first-order logic," and ranks states according to the truth or falsity of these statements, using an algorithm that assumes transitivity of preferences. The algorithm for producing a preference ranking based on these priorities is similar to the discrimination method

	Preference Statements	Explanation
More Preferred	−4	MoE most prefers that Uniroyal not abandon its Elmira plant.
↑	3	Next, MoE would like Uniroyal to accept the current control order.
	−2	MoE then prefers that Uniroyal not delay the appeal process.
↓	−1	MoE would not like to modify the control order.
Less Preferred	5 IFF -1	MoE prefers that Local Government insists that the original control order be applied (5), if and only if (iff) it does not modify the control order (-1) itself.

Note that "-" represents the option is not chosen.

Fig. 11.3 Option prioritizing for MoE

DMs	Options	Status Quo	Transitional Non-cooperative Equilibrium	Cooperative Equilibrium
MoE	1. Modify	N	N →	Y
Uniroyal	2. Delay	Y	Y →	N
	3. Accept	N	N →	Y
	4. Abandon	N	N	N
Local Government	5. Insist	N →	Y	Y
State Number		1	5	8

Fig. 11.4 Evolution of the Elmira conflict

of MacCrimmon [63]. The ranking of states (entered in a similar way) for Uniroyal is $1 \succ 4 \succ 8 \succ 5 \succ 9 \succ 3 \succ 7 \succ 2 \succ 6$, and for Local Government it is $7 \succ 3 \succ 5 \succ 1 \succ 8 \succ 6 \succ 4 \succ 2 \succ 9$.

Once a graph model has been constructed by defining DMs, options, allowable transitions, and relative preferences, GMCR II carries out a stability analysis to determine which states are stable for each DM according to a rich range of solution concepts describing potential human behavior under conflict. States that are stable for all DMs according to a particular mode of behavior constitute a possible equilibrium or compromise resolution. Figure 11.4 shows how choices in the Elmira model evolved from the status quo state, state 1, via a transitional noncooperative equilibrium to the final cooperative equilibrium. At the status quo state, MoE is refusing to modify its control order, Uniroyal is delaying the negotiation process and Local Government has not taken a position. As shown, Local Government caused the conflict to move from state 1 to 5 by insisting that MoE implements the original control order. Later, MoE and Uniroyal formed a coalition in which MoE modified the control order and Uniroyal accepted the revision, moving the state of the conflict from 5 to 8, as depicted in Fig. 11.4. Keep in mind that both MoE and Uniroyal prefer state 8 to state 5 and, hence, it was in their joint interest to form a coalition and thereby achieve a result they both preferred. Local Government did not benefit, however. These strategic and coalitional events model very well the actual historical evolution of the Elmira dispute.

11.6 Conclusions

The need for more and better collective decisions, to address problems such as global warming, probably guarantees that systems for the support of group decision and negotiation have a strong future. Formal procedures have proven successful in facilitating better collective decisions, and have become crucial to many individuals and organizations. As an academic and professional field, GDN has demonstrated its ability to assist groups, or individuals within groups, in interacting and collaborating to reach a collective decision. It seems very likely that in the future more collective decision making and collaboration will take place at a distance, probably using the internet. If so, the recently developed systems for e-meetings and e-negotiations have a particularly strong future.

GDN combines approaches from operations research, computer science, psychology, political economy, system engineering, social choice theory, game theory, system dynamics, and many other fields. Multiple Criteria Decision Analysis (MCDA) has played, and is playing, an important role. While ideas and techniques from MCDA are directly applicable to GDN only rarely (exceptions include systems for the support of two negotiators in a multi-issue positional negotiation, like the case-based distance approach of [15]), it is clear that many successful systems for the support of negotiators, or the support of group decisions, have borrowed and adapted ideas and techniques from MCDA. Since collective decisions are important, this flow can be expected to continue. To some degree, ideas from GDN will find application in broader areas of MCDA. One example is Nurmi's study [72] of whether MCDA is vulnerable to voting paradoxes.

Ideas that could improve collective decision making are likely to receive a good trial in GDN, simply because the problems are ubiquitous and the issues are often crucial. Some of the open issues that we have suggested above include different decision roles, strategy, and coalition formation. New methods for addressing these issues will be helpful, though we should not forget the successes that existing GDN methods have achieved. Any procedures that will help organizations and individuals search out useful information, exchange it efficiently, and use it to reach decisions judiciously and quickly, are sure to be in demand for a long time.

References

1. L. Adrianto, Y. Matsuda, and Y. Sakuma. Assessing local sustainability of fisheries system: A multi-criteria participatory approach with the case of Yoron Island, Kagoshima prefecture, Japan. *Marine Policy*, 29(1):9–23, 2005.

2. B.S. Ahn, B.S. Ahn, and S.H. Choi. Erp system selection using a simulation-based ahp approach: A case of Korean homeshopping company. *Journal of the Operational Research Society*, 69:322–330, 2008.
3. B.S. Ahn and H. Park. Least-squared ordered weighted averaging operator weights. *International Journal of Intelligent Systems*, 23:33–49, 2008.
4. K.J. Arrow. *Social Choice and Individual Values*. Wiley, New York, 2nd edition, 1963.
5. C. Banville, M. Landry, J.M. Martel, and C. Boulaire. A stakeholder approach to mcda. *Systems Research*, 15:15–32, 1993.
6. Banxia Software Ltd. Decision explorer. Available online at http://www.banxia.com/dexplore/index.html.
7. V. Belton and J. Pictet. A framework for group decision using a mcda model: Sharing, aggregating or comparing individual information. *Revue des Systèmes de Décision*, 6(3):283–303, 1997.
8. M. Beynon. A method of aggregation in DS/AHP for group decision-making with the non-equivalent importance of individuals in the group. *Computers and Operations Research*, 32:1881–1896, 2005.
9. M. Beynon. The role of the DS/AHP in identifying inter-group alliances and majority rule within group decision making. *Group Decision and Negotiation*, 15:21–42, 2006.
10. D. Bouyssou, T. Marchant, P. Pirlot, M. amd Perny, A. Tsoukias, and Ph. Vincke. *Evaluation and Decision Models: A Critical Perspective*. Kluwer, Dordrecht, 2000.
11. R.O. Briggs, G.J. de Vreede, and J.F. Nunamaker Jr. Collaboration engineering with ThinkLets to pursue sustained success with group support systems. *Journal of Management Information Systems*, 19:31–63, 2003.
12. T.X. Bui. *Co-oP: A Group Decision Support System for Cooperative Multiple Criteria Group Decision Making*. Springer-Verlag, Berlin, 1987.
13. T.X. Bui and M. Jarke. Communications design for Co-oP: A group decision support system. *ACM Transactions on Office Information Systems*, 4:81–103, 1986.
14. C. Carlsson, D. Ehrenberg, P. Eklund, M. Fedrizzi, P. Gustafsson, P. Lindholm, G. Merkuryeva, T. Riisanen, and A.G.S. Ventre. Consensus in distributed soft environments. *European Journal of Operational Research*, 61:165–185, 1992.
15. Y. Chen, D.M. Kilgour, and K.W. Hipel. Bilateral negotiation using case-based distance methods. International Conference on Group Decision and Negotiation GDN 2006, University of Karlsruhe, Germany, 28 June 2006.
16. Y. Chen, J.A. Witmer, K.W. Hipel, and D.M. Kilgour. Strategic decision support for brownfield redevelopment. In *Proceedings of the 2007 IEEE International Conference on Systems, Man and Cybernetics, Montreal, Quebec*, pages 1860–1865. IEEE Press, 2007.
17. Y. Chen, J.A. Witmer, K.W. Hipel, and D.M. Kilgour. Systems engineering approach to Brownfield redevelopment: Ralgreen community revitalization in Canada. In M. Lambert, T. Daniell, and M. Leonard, editors, *Proceedings of Water Down Under 2008, Adelaide, Australia*, pages 601–612. Engineers Australia, Mudbury, Australia, 2008.
18. F. Chiclana, F. Herrera, and E. Herrera-Viedma. Integrating three representation models in fuzzy multipurpose decision making based on fuzzy preference relations. *Fuzzy Sets and Systems*, 97:33–48, 1998.
19. A.K. Choudhury, R. Shankar, and M.K. Tiwari. Consensus-based intelligent group decision-making model for the selection of advanced technology. *Decision Support Systems*, 42: 1776–1799, 2006.
20. M.T. Chu, J. Shyu, and G.H. Tzeng. Comparison among three analytical methods for knowledge communities group-decision analysis. *Expert Systems with Applications: An International Journal*, 33:1011–1024, 2007.
21. J.M. Colomer, editor. *Handbook of Electoral System Choice*. Palgrave-Macmillan, London New York, 2004.
22. G. Colson. The OR's prize winner and the software ARGOS: How a multi-judge and a multi-criteria ranking GDSS helps a jury to attribute a scientific award. *Computers and Operations Research*, 27:741–755, 2000.

23. L.F. Cranor. *Declared-Strategy Voting: An Instrument for Group Decision-Making*. Ph.D. thesis, Washington University, December 1996.
24. S. Damart, L.C. Dias, and V. Mousseau. Supporting groups in sorting decisions: Methodology and use of a multi-criteria aggregation-disaggregation DSS. *Decision Support Systems*, 43:1464–1475, 2007.
25. A. Davey and D.L. Olson. Multiple criteria decision making models in group decision support. *Group Decision and Negotiation*, 7:55–75, 1998.
26. G.J. De Vreede and D.R. Vogel. Group support systems for the collaborative design of organizational systems: Introduction to the special issue. *Group Decision and Negotiation*, 9:93–96, 2000.
27. A. DeKorvin and M.F. Shipley. A Dempster-Shafer-based approach to compromise decision making with multiattributes applied to product selection. *IEEE Transactions on Engineering Management*, 40:60–67, 1993.
28. L.C. Dias and J. Climaco. ELECTRE TRI and group decision aiding: An analytic study on the robustness of the conclusions. *Group Decision and Negotiation*, 9:355–377, 2000.
29. R.F. Dyer and E.H. Forman. Group decision support with the analytic hierarchy process. *Decision Support Systems*, 8:99–124, 1992.
30. H. Ehtamo and R.P. Hamalainen. Interactive multiple-criteria methods fo reaching Pareto optimal agreements in negoatiations. *Group Decision and Negotiation*, 10:475–491, 2001.
31. H. Ehtamo, E. Kettunen, and R.P. Hamalainen. Searching for joint gains in multi-party negotiations. *European Journal of Operational Research*, 130:54–69, 2001.
32. H. Ehtamo, M. Verkama, and R.P. Hamalainen. How to select fair improving directions in a negotiation model over continuous issues. *IEEE Transactions on Systems, Man and Cybernetics, Part C*, 29:26–33, 1999.
33. B. Espinasse, G. Picolet, and E. Chouraqui. Negotiation support systems: A multicriteria and multi-agent approach. *European Journal of Operational Research*, 103:389–409, 1997.
34. L. Fang, K.W. Hipel, and D.M. Kilgour. *Interactive Decision Making: The Graph Model for Conflict Resolution*. Wiley, New York, 1993.
35. L. Fang, K.W. Hipel, D.M. Kilgour, and X. Peng. A decision support system for interactive decision making, part 1: Model formulation. *IEEE Transactions on Systems, Man and Cybernetics, Part C*, 33:42–55, 2003.
36. L. Fang, K.W. Hipel, D.M. Kilgour, and X. Peng. A decision support system for interactive decision making, part 2: Analysis and output interpretation. *IEEE Transactions on Systems, Man and Cybernetics, Part C*, 33:56–66, 2003.
37. D.M. Farrell. *Electoral Systems: A Comparative Introduction*. St. Martin's Press, New York, 2001.
38. R. Fisher, W.L. Ury, and B.M. Patton. *Getting to Yes: Negotiating Agreement Without Giving In*. Penguin, New York, 2nd edition, 1991.
39. E. Herrera-Viedma, F. Herrera, and F. Chiclana. A consensus model for multiperson decision making with different preference structures. *IEEE Transactions on Systems, Man and Cybernetics: Part A*, 32:394–402, 2002.
40. B.F. Hobbs and P. Meierm. Multicriteria methods for resource planning: An experimental comparison. *IEEE Transactions on Power Systems*, 9:1811–1817, 1994.
41. B.F. Hobbs and P. Meierm. *Energy Decision and the Environment: A Guide to the Use of Multicriteria Methods*. Kluwer, Boston, MA, 2000.
42. A.B. Hollingshead. The rank-order effect in group decision making. *Organizational Behavior and Human Decision Processes*, 68:181–193, 1996.
43. C.L. Hwang and M.J. Ling. *Group Decision Making Under Multiple Criteria*. Springer-Verlag, Berlin, 1987.
44. P. Iz and P. Korhonen. Introduction. *Group Decision and Negotiation*, 7:1–2, 1998.
45. K. Jabeur and J.M. Martel. A collective choice method based on individual preference relational systems (p.r.s.). *European Journal of Operational Research*, 177:1549–1565, 2007.
46. M.T. Jelassi and R.A. Beauclair. MEDIATOR: Towards a negotiation support system. *European Journal of Operational Research*, 31:314–333, 1987.

47. M.T. Jelassi, G. Kersten, and S. Zionts. An introduction to group decision and negotiation support. In C.A. Bana e Costa, editor, *Readings in Multiple Criteria Decision Aid*, pages 50–58. Springer-Verlag, Berlin, 1990.
48. J. Jones and D. Hunter. Consensus methods for medical and health services research. *British Medical Journal*, 311:376–80, 1995.
49. R.L. Keeney. *Value Focused Thinking: A Path to Creative Decision Making*. Harvard University Press, Cambridge, MA, 1992.
50. G.E. Kersten. E-negotiation systems: Interaction of people and technologies to resolve conflicts. Interneg working papers, John Molson School of Business, Concordia University, 2004. Available online at http://interneg.concordia.ca/interneg/research/papers/2004/08.pdf
51. D.M. Kilgour and C. Eden, *Handbook of Group Decision and Negotiation*, Springer, Dordrecht, 2010.
52. D.M. Kilgour and K.W. Hipel. The graph model for conflict resolution: Past, present, and future. *Group Decision and Negotiation*, 14:441–460, 2005.
53. D.M. Kilgour, K.W. Hipel, and L. Fang. The graph model for conflicts. *Automatica*, 23:41–55, 1987.
54. D.M. Kilgour, K.W. Hipel, L. Fang, and X. Peng. Coalition analysis in group decision support. *Group Decision and Negotiation*, 10:159–175, 2001.
55. S.H. Kim, S.H. Choi, and J.K. Kim. An interactive procedure for multiple attribute group decision making with incomplete information: Range-based approach. *European Journal of Operational Research*, 118:139–152, 1999.
56. V.S. Lai, B.K. Wong, and W.M. Cheung. Group decision making in a multiple criteria environment: A case using the AHP in software selection. *European Journal of Operational Research*, 137:134–144, 2002.
57. M. Landry, C. Banville, and M. Oral. Model legitimisation in operational research. *European Journal of Operational Research*, 92:443–457, 1996.
58. A. Lewandowski. SCDAS-decision support system for group decision making: Decision theoretic framework. *Decision Support Systems*, 5:403–423, 1989.
59. C. Li, J.A. Giampapa, and K. Sycara. Bilateral negotiation decisions with uncertain dynamic outside options. *IEEE Transactions on Systems, Man, and Cybernetics: Part C*, 36:31–44, 2006.
60. B. Llamazares. Choosing OWA operator weights in the field of Social Choice. *Information Sciences*, 177:4745–4756, 2007.
61. F.B. Losa and V. Belton. Combining MCDA and conflict analysis: An exploratory application of an integrated approach. *Journal of the Operational Research Society*, 57:510–525, 2006.
62. J. Ma, Z.P. Fan, Y.P. Jiang, and J.Y. Mao. An optimization approach to multiperson decision making based on different formats of preference information. *IEEE Transactions on Systems, Man, and Cybernetics: Part A*, 36:876–889, 2006.
63. K.R. MacCrimmon. An overview of multiple objective decision making. In J. Cochrane and M. Zeleny, editors, *Multiple Criteria Decision Making*, pages 18–44. University of South Carolina Press, Columbia, USA, 1973.
64. T. Marchant. PROMETHEE and GAIA in a multi-decision maker environment. *Ricerca Operativa*, 26(79):19–43, 1997.
65. B.D. Marchi, S.O. Funtowicz, S.L. Cascio, and G. Munda. Combining participative and institutional approaches with multicriteria evaluation. an empirical study for water issues in Troina, Sicily. *Ecological Economies*, 34:267–282, 2000.
66. N.F. Matsatsinis and A. Samaras. MCDA and preference disaggregation in group decision support systems. *European Journal of Operational Research*, 130:414–429, 2001.
67. Meetingworks, Inc. Available online at http://www.meetingworks.com/
68. J. Mingers and J. Rosenhead. Problem structuring methods in action. *European Journal of Operational Research*, 152:530–554, 2004.
69. J. Mustajoki, R.P. Hamalaien, and M. Marttunen. Participatory multicriteria decision analysis with Web-HIPRE: A case of lake regulation policy. *Environmental Modelling & Software*, 19(6):537–547, 2004.

70. J. Mustajoki and R.P. Hamalainen. Web-HIPRE: Global decision support by value tree and AHP analysis. *INFOR*, 38:208–220, 2000.
71. M.F. Norese. ELECTRE III as a support for participatory decision-making on the localisation of waste-treatment plants. *Land Use Policy*, 23(1):76–85, 2006.
72. H. Nurmi and T. Meskanen. Voting paradoxes and MCDM. *Group Decision and Negotiation*, 9:297–313, 2000.
73. H. Nurmi. Approaches to collective decision-making with fuzzy preference relations. *Fuzzy Sets and Systems*, 1:249–259, 1981.
74. D.L. Olson, G. Fliedner, and K. Currie. Comparison of the Rembrandt System with Analytic Hierarchy Process. *European Journal of Operational Research*, 82:522–539, 1995.
75. A.F. Osborn. *Applied Imagination: Principles and Procedures of Creative Problem Solving*. Charles Scribner's Sons, New York, 3rd edition, 1963.
76. H. Raiffa, J. Richardson, and D. Metcalfe. *Negotiation Analysis: The Science and Art of Collaborative Decision Making*. Harvard University Press, Cambridge, MA, 2nd edition, 2002.
77. T. Retchless, B. Golden, and E. Wasil. Ranking US army generals of the 20th century: A group decision-making application of the Analytic Hierarchy Process. *Interfaces*, 37:163–175, 2007.
78. H. Rey-Valette, S. Damart, and S. Roussel. A multicriteria participation based methodology for selecting sustainable development inidcators: An incentive tool for concerted decision making beyond the diagnosis framework. *International Journal of Sustainable Development*, 10(1/2):122–138, 2007.
79. G. Rowe and G. Wright. The Delphi technique as a forecasting tool: Isues and analysis. *International Journal of Forecasting*, 15:353–375, 1999.
80. B. Roy. *Multicriteria Methodology for Decision Aiding*. Kluwer, Dordrecht, 1996.
81. B. Roy. Decision-aiding today, What should we expect? In T. Gal, Th. Stewart, and Th. Hanne, editors, *Multicriteria Decision Making Advances in MCDM Models, Algorithms, Theory, and Applications*, pages 1–35. Kluwer, Boston, MA, 1999.
82. A. Rubinstein. Perfect equilibrium in a bargaining model. *Econometrica*, 50:97–110, 1982.
83. T. Saaty. *The Analytic Hierarchy Process*. McGraw-Hill, New York, 1980.
84. A. Salo and R.P. Hämäläinen, Multicriteria Decision Analysis in Group Decision Processes. In D.M. Kilgour and C. Eden, editors, *Handbook of Group Decision and Negotiation*, Springer, Dordrecht, 2010.
85. G. Shafer. *A Mathematical Theory of Evidence*. Princeton University Press, Princeton, NJ, 1976.
86. I. Stahl. *Bargaining Theory*. Economic Research Institute, Stockholm, 1972.
87. M.P. Strager and R.S. Rosenberger. Incorporating stakeholder preferences for land conservation: Weights and measures in spatial MCA. *Ecological Economics*, 58(1):79–92, 2006.
88. J. Surowiecki. *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations*. Random House, New York, 2004.
89. US Environmental Protection Agency (USEPA). Road map to understanding innovative technology options for brownfields investigation and cleanup, 2005. EPA-542-B-05-001.
90. R. Vetschera. Preference structures and negotiator behavior in electronic negotiations. *Decision Support Systems*, 44:135–146, 2007.
91. R.E. Walton and R.B. MacKersie. *A Behavioral Theory of Labor Negotiations: An Analysis of a Social Interaction System*. MacGraw Hill, New York, 1965.
92. Y.M. Wang, J.B. Yang, and D.L. Xu. A preference aggregation method through the estimation of utility intervals. *Computers and Operations Research*, 32:2027–2049, 2005.
93. T. Wanyama and B. Far. A protocol for multi-agent negotiation in a group-choice decision making process. *Journal of Network and Computer Applications*, 30:1173–1195, 2007.
94. Z.S. Xu. Uncertain linguistic aggregation operators based approach to multiple attribute group decision making under uncertain linguistic environment. *Information Sciences*, 168:171–184, 2004.
95. Z.S. Xu. Multiple-attribute group decision making with different formats of preference information on attributes. *IEEE Transactions on Systems, Man, and Cybernetics, Part B*, 37:1500–1511, 2007.

96. R.R. Yager. On ordered weighted averaging aggregation operators in multicriteria decision making. *IEEE Transactions on Systems, Man and Cybernetics*, 18:183–190, 1988.
97. J.B. Yang and M.G. Singh. An evidential reasoning approach for multiple-attribute decision making with uncertainty. *IEEE Transactions on Systems, Man, and Cybernetics*, pages 1–18, 1994.
98. I.W. Zartman. *Ripe for Resolution: Conflict and Intervention in Africa*. Oxford University Press, New York, 1989.
99. G.Q. Zhang and J. Lu. An integrated group decision-making method dealing with fuzzy preferences for alternatives and individual judgments for selection criteria. *Group Decision and Negotiation*, 12:501–515, 2003.