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Decision Making under Conditions of Conflict

K. JIM RADFORD
KEITH W. HIPEL
Department of Systems Design Engineering, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1

LIPING FANG
Department of Mechanical Engineering, Ryerson Polytechnic University, 350 Victoria Street, Toronto, Ontario, Canada, M5B 2K3, and Department of Systems Design Engineering, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1

Abstract

A real-world application is employed to explain three general types of decision situations that can arise under conditions of conflict. In addition, meaningful connections and relationships among these areas of decision making are clearly pointed out. To permit useful decision technologies to be employed by practitioners for better understanding and for resolving a variety of actual decision problems, a range of flexible decision support systems is discussed. Subsequently, interesting research developments contained in the upcoming sequence of 12 articles on decision making under conflict are summarized and compared. The research articles not only present unique approaches to decision making involving multiple participants, each of whom may have multiple objectives, but suggest a variety of challenging research problems to be investigated in the future.

Key words: conflict analysis, decision support systems, decision technologies, game theory, multiple-participant–multiple-criteria decision making, multiple-objective decision making

1. The pervasiveness of conflict

Whenever people interact with one another, conflict seems to take place. For instance, in most industrial enterprises, such as car manufacturing and the production of television sets, competition is taking place among multinational corporations both within and among nations. During the past few years, bargaining and negotiation have been occurring among representatives for the United States of America, Mexico, and Canada, resulting in the North American Free Trade Agreement (NAFTA) that was officially implemented on January 1, 1994. Fraser and Garcia (1994) carried out a conflict analysis of the 1991–92 NAFTA negotiations from a Mexican perspective. As explained by De et al. (1994), the conflict problems associated with negotiations in professional bureaucracies, such as universities and the armed forces, are essential to the effective functioning of many organizations. Over the years, agreements between countries over the trading of items such as wheat and other commodities have been reached due to long and drawn-out negotiation sessions (Benjamin, 1994). Finally, an illustration of an environmental controversy arising over the pollution of an underground aquifer by a chemical company is provided by Hipel et al. (1993b).

The different kinds of conflicts that can occur range from a family squabble over the fair assignment of household tasks, in which the family members try to be as cooperative as possible since they live under the same roof, to outright aggression among cultural groups, such as the fighting among religious and ethnic groups in various regions of the former Republic of Yugoslavia. In addition to the level of hostility taking place in a dispute, other complicating factors include the relative power of each decision maker, hierarchical relationships among stakeholders, how the conflict evolves dynamically over time, deceit and deception, and difficulties in ascertaining the preferences of the participants. Because of the aforesaid and other reasons, there is great demand in the real world for the extension and development of flexible decision technologies for handling a wide variety of conflict situations that can occur in the context of multiple-participant decision making problems, in which each participant or decision maker may have multiple objectives. Accordingly, from August 31 to September 2, 1992, the International Conference on Decision Making under Conditions of Conflict was held in the Department of Systems Design Engineering, University of Waterloo, Waterloo, Ontario, Canada, in order to present, discuss, and debate recent and important developments in decision technologies for use in conflict situations. After undergoing a thorough reviewing process, the accepted papers from the conference were published as articles in issues 3 and 4 of *Group Decision and Negotiation.*

The main objectives of this article are to put decision making under conflict into proper perspective and to point out, assess, and compare the main contributions of the published articles from the Waterloo conference. Readers who would like a summary of the major findings of the subsequent 12 papers can refer to table 7 in section 4. As can be seen, a rich variety of exciting ideas is contained in the articles. Acknowledgments to the people who contributed to the planning and execution of the Waterloo conference as well as to this special issue on decision making under conflict are given in the Foreword at the front of issue 3.

2. Decision-making situations

The three circles in figure 1, contain the names of the three important types of decision situations that are compared and connected in a unique fashion by Hipel et al. (1993c). In this figure, the arrows indicate the directions in which conversions can take place from one decision-making area to another. Notice, for example, that conversion is shown going from MPMC (multiple-participant–multiple-criteria) problems to MPSC (multiple-participant–single-criterion) situations but not vice versa. This is because there is no practical meaning in converting an MPSC problem to an MPMC problem. Likewise, as indicated in figure 1,

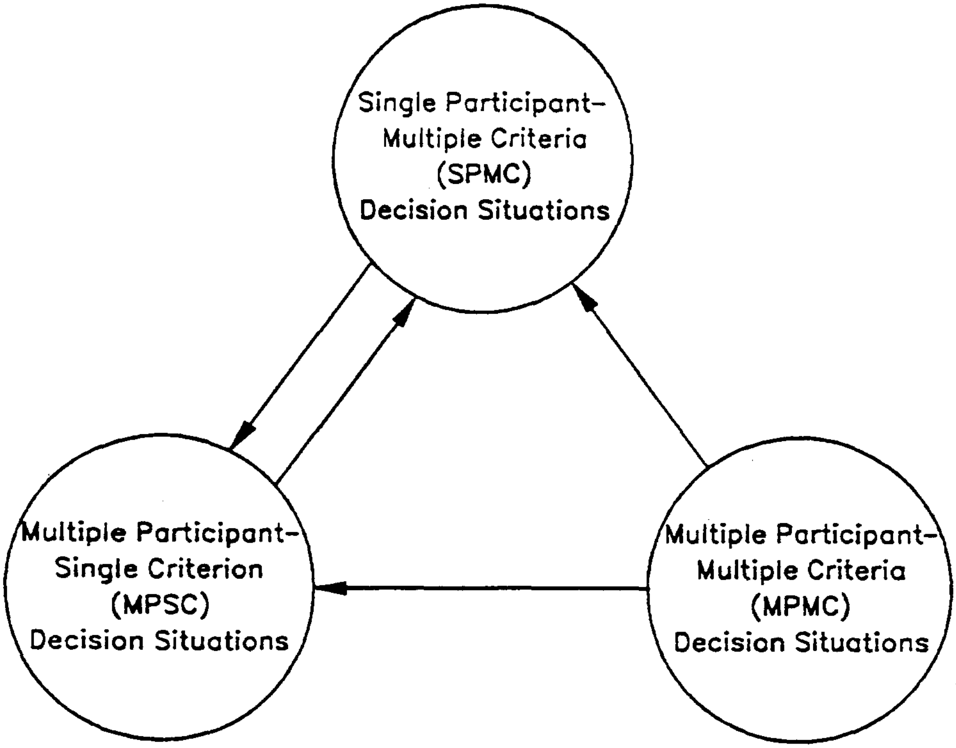

Figure 1. Relationships among decision-making situations.

one would not try to convert an SPMC (single-participant–multiple-criteria) situation to an MPMC problem.

To illustrate the three decision-making areas in figure 1 and the relationships among them, a simple and practical real-world example is employed. Because this practical application is based upon consulting work carried out for a client, the name of the organization involved, as well as other identifying information, has been changed. Nonetheless, the actual modeling of the problem is identical to that completed for the client.

2.1 North-Western Electronics as an SPMC situation

North-Western Electronics is a company engaged in the manufacture of electronics components. It wishes to prepare a strategic plan that will guide its activities over the next five to ten years. The company has stated a number of criteria against which possible future activities must be evaluated. These criteria can be stated briefly as follows:

C_1: The company's return on investment in each of its activities over a three-year period must be at least 11 percent;
C_2: The firm's activities must be diversified by engaging in new ventures that can be related or unrelated to its present activities;
C_3: The company can accept a high level of risk in any of its ventures only if the return from such ventures is correspondingly high;
C_4: The organization requires ease of entry into a new activity;
C_5: The firm wishes ease of exit from an undertaking if it does not prove to be profitable.

The company has also identified three possible activities that might contribute to its future development. These alternative activities are described briefly as follows:

A_1: To acquire an electronics company that is at a similar stage of development as its own and which manufactures products compatible with its own;
A_2: To invest in a company that undertakes research related to its present business;
A_3: To invest further in parts of the existing company that are considered likely to produce good returns in the years to come.

The company would like to evaluate these possible new activities with respect to its multiple criteria. In this respect, it can be regarded as being in an SPMC decision situation.

A first step in this evaluation can be to assess the performance of possible future activities against the above criteria. The results of this assessment are as summarized in table 1, where Return on Investment is the only factor that can be evaluated on a numerical scale. The evaluation of the remaining factors must be done in ordinal form by use of letter grades such as: A, very good; B, good; C, average; D, fair; and E, poor. Extensions of this letter grade scale are made possible by adding a plus or a minus to the letter, as in C+ or A−. The task for the

Table 1. Evaluation of alternative activities in the strategic plan of North-Western Electronics

	Alternative activities		
Criteria	A_1 Acquire firm	A_2 Invest in research	A_3 Invest in existing business
C_1 Return on Investment (%)	11.7	15.6	10.5
C_2 Degree of diversification	A	B−	C+
C_3 Degree of risk	B−	B	A−
C_4 Ease of entry	B	C−	A
C_5 Ease of exit	C+	A−	B+

company is to place the possible alternatives in an order of preference, taking into account the data shown in table 1.

One such means of achieving this task is called the *elimination method* (MacCrimmon 1973; Radford 1989). This method entails the establishment of minimum or maximum performance levels for each of the criteria shown to the left in table 1.

Suppose that the performance levels that have been established by the company are as shown on the left-hand side of table 2. The first of these levels, for example, specifies that the return on investment must be greater than 11 percent. A "Yes" in this table denotes that the minimum performance is met by the alternative against the factor indicated, while a "No" denotes that the performance is not met.

The most preferred alternative can now be determined in the following way. Start with the highest priority evaluation factor (Return on Investment) and eliminate A_3. Move down to the second performance level and note that A_1 and A_2 would not be eliminated at this stage. Move to the third performance and note that again A_1 and A_2 would not be eliminated at this point. At the fourth level A_2 (Invest in Research) is removed and A_1 survives. Consequently, the result of the analysis is that the activities can be placed in order from most to least preferred as A_1, A_2, A_3.

Note that the elimination procedure does not necessarily result in an ordering of the activities that is uniquely correct. Nevertheless, it produces a ranking that reflects the performance estimates of the decision maker and that can be useful in practice. Using the preference tree approach developed by Fraser and Hipel (1988) for determining ordinal preferences among states in a conflict, Fraser (1993) presents a technique that is similar to the elimination method for use in ranking alternative solutions in an SPMC problem. Other techniques for ordering alternatives in an SPMC decision problem include contributions by Cook and Kress

Table 2. Performance of alternative activities against criteria for North-Western Electronics (*Yes* indicates that the criteria *is* met and *No* that it is *not*)

	Alternative activities		
Performance levels (in order of decreasing importance)	A_1 Acquire firm	A_2 Invest in research	A_3 Invest in existing business
C_1 Return on Investment must be greater than 11%	Yes	Yes	No
C_2 Degree of Diversification must be C+ or better	Yes	Yes	Yes
C_3 Degree of Risk must be C+ or better	Yes	Yes	Yes
C_4 Ease of Entry must be B or better	Yes	No	Yes
C_5 Ease of Exit must be B or better	No	Yes	Yes

(1991), Goicoechea et al. (1982), Hipel (1992), Roy (1985), Saaty (1980), Szidarovszky et al. (1986), and Vincke (1992).

2.2 North-Western Electronics as an MPSC situation

In the previous section, the decision problem confronting North-Western Electronics has been treated as an SPMC decision situation. Suppose now that rather than using the elimination method discussed in that section, the president decided that the situation should be studied by a panel consisting of his or her five vice presidents, who are called VPA, VPB, VPC, VPD, and VPE. At this stage, each vice president has the same single overall objective of ensuring that the company continues to be successful. However, each vice president has his or her own criterion for evaluating the alternatives. These differences of opinion can be represented as in table 3, which shows the initial preferences of the five vice presidents for the three alternative activities. In particular, for each vice president, the three alternatives consisting of A_1, A_2, and A_3 are ranked from most preferred on the left to the least preferred on the right.

The situation at North-Western Electronics is now modeled as an MPSC decision problem. In such a situation, it is not possible for each of the vice presidents to ensure that his or her most preferred activity be the one recommended to the president as being the best. In most such cases, the final recommendation can be made only after some discussion and interaction among those concerned. Since all the participants must eventually agree upon a final outcome (some possibly grudgingly), some changes in preferences (or in the nature of activities) must occur before an outcome acceptable by the five vice presidents can be reached. These changes are usually the result of negotiation among the participants (Radford 1989, 1990).

Table 4 shows the similarity of structure between the SPMC and MPSC models of the decision situations. On the left-hand part of the table, activities available to a decision maker are rated with respect to the five evaluation criteria used in table 1. Specifically, each number refers to an ordinal ranking where a higher number means more preferred. Hence, according to criterion C_1 on the left, alter-

Table 3. Initial preferences of participants for alternative activities in the North-Western Electronics conflict

Participants	Initial preferences of participants (most preferred to least preferred)		
VPA	A_2	A_1	A_3
VPB	A_1	A_2	A_3
VPC	A_3	A_2	A_1
VPD	A_3	A_1	A_2
VPE	A_2	A_3	A_1

Table 4. Comparison of SPMC and MPSC situations for North-Western Electronics

	SPMC				MPSC		
	Activities				Preferences for outcomes (most preferred to least preferred)		
Criteria	A_1	A_2	A_3	Participants			
C_1	2	3	1	VPA	A_2	A_1	A_3
C_2	3	2	1	VPB	A_1	A_2	A_3
C_3	1	2	3	VPC	A_3	A_2	A_1
C_4	2	1	3	VPD	A_3	A_1	A_2
C_5	1	3	2	VPE	A_2	A_3	A_1

native A_2 is most preferred and A_3 is least preferred. On the right-hand side of table 4, the preferences of five participants for the three outcomes or alternatives from table 3 are shown. The similarity of structure between the SPMC situation and the MPSC situations suggests that methods that have been developed to deal with one type of situation can be used in the other sort of situation. Consequently, an SPMC decision problem such as that shown in table 1 can be analyzed using methods that have been developed for studying an MPSC situation. For example, suitable solution concepts from conflict analysis could be employed for carrying out stability analyses of a conflict modeled as an MPSC problem, in order to determine the compromise resolutions or equilibria (Fang et al. 1989; Fang et al. 1993; Fraser and Hipel 1979, 1984). Likewise, the MPSC example in table 3 can be studied using techniques developed for SPMC situations, which are referenced in section 2.1. The interchangeability of participants and criteria permits greater flexibility in the treatment of both multiple-participant and multiple-criteria decision situations. In fact, Hipel et al. (1993c) put forward the assertion that SPMC and MPSC problems are essentially the same and that these two types of decision situations can be modeled in an identical fashion.

2.3 North-Western Electronics as an MPMC situation

When this case study was actually carried out in practice, the decision problem was first modeled as an SPMC situation (section 2.1), followed by an MPSC problem (section 2.2). In reality, it may be that the five vice presidents of North-Western Electronics would wish to evaluate the possible new activities in terms of multiple (rather than single) criteria. Moreover, it may also be true that each of the vice presidents would like to evaluate these activities using criteria different from those adopted by his or her colleagues. The results of these evaluation requirements might be a situation that can be illustrated as on the right-hand side of table 5.

The resolution of the MPMC situation confronting North-Western Electronics can now be achieved in the following steps:

Table 5. Comparison of MPSC and MPMC situations North-Western Electronics

Participants	MPSC Ordering of alternatives (most preferred on the left)	Participants	Criteria	MPMC Ordering of alternatives (most preferred on the left)
VPA	A_2 A_1 A_3		C_{A1}	A_2 A_1 A_3
		VPA	C_{A2}	A_2 A_3 A_1
			C_{A3}	A_1 A_2 A_3
VPB	A_1 A_2 A_3	VPB	C_{B1}	A_1 A_2 A_3
			C_{B2}	A_1 A_3 A_2
VPC	A_3 A_2 A_1	VPC	C_{C1}	A_3 A_1 A_2
			C_{C2}	A_3 A_2 A_1
VPD	A_3 A_1 A_2		$C_{D1}C_{D2}$	A_3 A_2 A_1
		VPD	C_{D3}	A_1 A_3 A_2
				A_3 A_1 A_2
VPE	A_2 A_3 A_1	VPE	C_{E1}	A_2 A_3 A_1
			C_{E2}	A_2 A_3 A_1

1. Refer to the top of the right-hand side box in table 5. Consider VPA in that box to be involved in an SPMC situation, in which he or she must decide on the ordering of alternatives on the basis of criteria C_{A1}, C_{A2}, and C_{A3}. The results of this SPMC situation are then transferred to the left-hand part of table 5 as VPA's contribution to the MPSC evaluation at the left of that table.
2. Repeat the process for VPB, VPC, VPD, and VPE;
3. Conduct an MPSC analysis using the information on the left of table 5 and the methodology referred to in section 2.2. Equivalently, one could analyze the MPSC problem shown on the left in table 5 as the SPMC situation given on the left in table 4.

This analysis suggests that MPMC problems can be treated by initially considering each of the participants as being in an SPMC decision situation, as in the right-hand side of table 5. This first step can be followed by an analysis of the resulting MPSC situation, as illustrated on the left-hand side of table 5. As a matter of fact, Hipel et al. (1993c) put forward the assertion that MPMC decision situations can be converted into MPSC situations and that appropriate methods that have been developed to model and analyze MPSC and SPMC situations can be used in studying MPMC problems.

3. Decision support systems

A rich variety of formal decision making models has been developed in fields such as operational research, systems engineering, statistics, and management science. Some of these techniques have been designed for employment in the three areas of decision making discussed in section 2 and depicted in figure 1. However, as noted earlier, there are still many opportunities for future research in these areas. Whatever the case, besides having a sound theoretical basis, decision techniques usually require implementation algorithms to facilitate their use in practical applications. Moreover, to permit convenient and expeditious usage by practitioners, a given technique and its associated algorithms should be computerized as a decision support system (DSS) (Sage 1991). In this way, the decision technique is transformed into a realizable decision technology.

When designed for use in negotiations, a DSS is commonly referred to as a negotiation support system. Thiessen and Loucks (1992) and Jelassi and Foroughi (1989) provide overviews and comparisons of existing negotiation support systems. Articles describing the theory and application of negotiation support systems include contributions by Angus (1990), Anson and Jelassi (1990), Gauvin et al. (1990), Jarke et al. (1987), Nagel and Mills (1989), Nunamaker (1989), Singh et al. (1985), and Winter (1985).

Table 6 provides a list of DSSs that can be employed for studying various aspects of decision making under conditions of conflict. Some of these DSSs are applied to applications or at least referred to in the upcoming set of articles that are summarized and compared in the next section.

4. Developments in multiple-participant decision making

Table 7 provides a summary of the major contributions and models used in the upcoming sequence of twelve articles. The first seven articles deal mainly with the development and application of various types of decision models that fall within the MPSC category in figure 1. The last five articles are concerned with describing, applying, or comparing one or more of the DSSs that are listed in table 6 of the previous section. As can be seen, each article makes a unique contribution to the theory and practice of decision making under conditions of conflict.

In his two articles, Howard cleverly employs the metaphor of drama theory to model, analyze, and interpret how a conflict may dynamically evolve over time from its inception in act one, through the build-up, climax, and resolution to the finale at the end of the performance. Other important contributions from Howard include his pioneering research in metagame analysis (Howard 1971) and soft game theory (Howard 1990). In fact, Howard's work in metagame analysis stimulated extensive research to be carried out in conflict analysis, such as the work by Fraser and Hipel (1979, 1984) and Radford (1989). For articles regarding recent developments in conflict analysis, the reader may wish to refer to a special issue on conflict analysis appearing in *Information and Decision Technologies* (Vol. 16, Nos. 3 and 4, 1990, pp. 183–371). At the start of this special issue consisting of twelve articles, Hipel (1990) puts conflict analysis into perspective by explaining its past and present; he also suggests promising research directions for the future. Further contributions to conflict analysis are contained in articles published in

Table 6. Decision support systems for application to conflict problems

Acronyms and references	Purposes	Contacts
Conan (Howard 1990)	The option form of metagame analysis is used to interactively model and analyze conflicts	Nigel Howard Systems 10 Bloomfield Road, Moseley Birmingham, England, B13 0BY Tel/Fax: 021-449-4480
DecisionMaker (Fraser and Hipel 1984, 1988, 1989)	Uses the option form and solution concept of sequential stability for modeling, analyzing and interpreting both small and large conflicts	Niall M. Fraser Dept. of Management Sciences University of Waterloo Waterloo, Ontario, Canada, N2L 3G Tel: (519) 885-1211, ext. 3291 Fax: (519) 746-7252 or Keith W. Hipel Department of Systems Design Eng. University of Waterloo Tel: (519) 888-4644 or (519) 885-1211 ext. 2830 Fax: (519) 746-4791
GMCR (Fang et al., 1993)	Uses the graph model for conflict resolution and a wide vareity of models of human behaviour to model and analyze disputes having two or more decision makers	Software is included on a diskette with the Wiley book by Fang et al. (1993). One can also contact Liping Fang Dept. of Mechanical Engineering Ryerson Polytechnic University 350 Victoria St., Toronto, Ontario, Canada, M5B 2K3 Tel: (416) 979-5000 ext. 7215 Fax: (416) 979-5265 or Keith W. Hipel and D. Marc Kilgour Department of Systems Design Eng. University of Waterloo Tel: (519) 888-4644 or (519) 885-1211 ext. 2830 Fax: (519) 746-4791
INTERACT (Bennett et al. 1994)	Uses option form and graphical displays to analyze situations under the control of several interested parties	Peter Bennett Dept. of Management Sciences Strathclyde University 26 Richmond Street, Glasgow United Kingdom G1 1XH Tel: 041-552-4400 Fax: 041-552-6686
NEGOPLAN (Kersten and Szpakowicz, 1990, 1994; Matwin et al. (1989)	Uses first-order logic to develop structural models of decisions situations	Gregory E. Kersten School of Business Carleton University Ottawa, Ontario, Canada, K1S 5B6 Tel: (613) 788-2388 Fax: (613) 788-4427
SPANNS (Meister and Fraser, 1994)	For use in a tactical negotiation support, SPANNS has a rule-based expert system for the tactical support component and a conflict analysis model for the strategic component	Niall M. Fraser whose address is given with DecisionMaker

Table 7. Major contributions of the decision making articles

Authors	Titles	Models	Contributions
N. Howard	"Drama Theory and its Relation to Game Theory. Part 1: Dramatic Resolution vs. Rational Solution"	Outline of drama-theory models	Unlike game theory, drama theory allows actors' preferences and perceived opportunities to be changed by themselves under the pressure of preplay negotiations. A many-person, multiphase theory of dramatic transformation is presented, showing how the *core* (in the sense of game theory) of a drama is transformed by the interaction among the characters into a strict, strong equilibrium to which they all aspire. Part 1 provides a general discussion of drama theory along with an application.
N. Howard	"Drama Theory and its Relation to Game Theory. Part 2: Formal Model of the Resolution Process"	Details of drama-theory models	In a drama, characters' preferences and options change in preplay negotiations. Part 2 presents a formal drama model and a detailed discussion of the dramatic resolution process.
G.E. Kersten S. Szpakowicz	"Decision Making and Decision Aiding: Defining the Process, Its Representations, and Support"	First-order logic	A general definition of the decision problem and decision-making process is presented, and the implications of this new definition in decision representation, analysis, and support are discussed.

Table 7. (Continued)

Authors	Titles	Models	Contributions
M. De K.W. Hipel D.M. Kilgour	"Hierarchical Power in Personnel Negotiations"	Hierarchical power for describing power asymmetry in which a player can choose in the knowledge of the opponent's choice	Hierarchical power is used in conjunction with other principles of personnel management to analyze the behavior of professionals during negotiations in an organization.
D.M. Kilgour	"Game-Theoretic Properties of Final-Offer Arbitration"	Game-theoretic models of final-offer arbitration in two-sided disputes	The inherent effectiveness and fairness of game-theoretic treatment of final-offer arbitration are assessed.
V.A. Olds N.M. Fraser D.M. Kilgour	"Modeling Sequential Responses in Interactive Decisions"	Sequential response models from noncooperative game theory, including a double departure game model	A general sequential response model is described for allowing players to respond sequentially to the actions of their opponents.
W. Engleman	"Conditions for Disarmament: A Game-Theoretical Model	Prisoners dilemma	Using the Prisoner's Dilemma model, it is explained how changes of preference relations can overcome the arms race problem.
D.B. Meister N.M. Fraser	"Conflict Analysis Technologies for Negotiation Support"	Negotiation support system based on conflict analysis techniques	Methods from conflict analysis are integrated into a negotiation support system called the Single Party Prescriptive Analysis Negotiation Support System (SPANSS) for use in both strategic and tactical negotiations.

P. Bennett A. Tait K. Macdonagh	"INTERACT: Developing Software for Interactive Decisions"	Decision support system called INTERACT	A computer program called INTERACT is developed for analyzing decision situations controlled by several stakeholders.
N.M. Fraser F. Garcia	"Conflict Analysis of the NAFTA Negotiations"	Conflict analysis techniques	Conflict analysis is used to model the 1991–92 negotiations for the North American Free Trade Agreement (NAFTA) at two points in time from a Mexican perspective.
C.M. Benjamin	"Metagame/CONAN Analysis of US/ USSR Negotiations for Long-Term Grain Agreement"	Metagame analysis along with the decision support system called CONAN	The bargaining and negotiations that took place between the United States and the former Soviet Union toward long-term grain purchase agreements are modeled and analyzed using CONAN, based on the information collected from interviews with U.S. and U.S.S.R. officials involved in the events.
C.A. Powell	"Cognitive Hurdles in the Use of Decision Support Systems to Enhance Problem Understanding"	Decision support systems based on metagame and conflict analysis	Cognitive problems are identified when sofware for interactive decisions is applied in practice.

proceedings for special sessions on conflict analysis held at conferences in France (Singh and Travé-Massuyès 1991; IEEE 1993), the United States (IEEE 1991), and Canada (Eden and Radford 1990). Fang et al. (1993) improved the theory and practice of conflict analysis by developing the graph model for conflict resolution. Finally, Hipel et al. (1993a) provided an overview of game-theoretic and conflict-analysis models in engineering decision making.

Kersten and Szpakowicz furnished a general account of decision making as a multistep process. The three decision situations referred to in section 3 and figure 1 are contained within their general framework. As a matter of fact, all of the other articles in table 7 specifically address various aspects of the decision-making structure of Kersten and Szpakowicz. A general systems approach to decision making is provided by Shakun (1988).

Each of the next four articles in table 7 are concerned with mathematically modeling various interesting characteristics of conflicts. In particular, De et al. present a model for describing hierarchical power and explain how it can analyze behavior of professionals during negotiations in an organization. Kilgour investigates the game-theoretic properties of final-offer arbitration, while Olds et al. provide a model of sequential responses in interactive decision making. Finally, Engleman employs Prisoner's Dilemma along with preference changes to explain how the arms race can be controlled.

Kersten and Szpakowicz suggest ideal properties and capabilities of DSSs. Although it may be extremely difficult, if not impossible, to reach their DSS utopia, significant progress is made in the last five articles in table 7. The DSSs used in these articles are also listed in table 6 along with a list of people who can be contacted for obtaining the computer packages.

To explain how their DSS, which is called SPANNS, works in practice, Meister and Fraser apply SPANNS to a labor-management negotiation problem. After describing the main features of INTERACT, Bennett et al. employ their DSS to structure the conflict over the control of the Black Sea fleet that was owned by the Soviet Union before its recent demise. Fraser and Garcia use DecisionMaker to model the North American Free Trade Agreement from a Mexican perspective, while Benjamin utilizes CONAN for studying the negotiations over long-term trade agreements between the U.S. and the former Soviet Union. Powell discusses cognitive hurdles that must be overcome when DSSs such as CONAN and DecisionMaker are used by practitioners. Finally, for applications of GMCR to environmental and trade disputes, the reader can refer to the book by Fang et al. (1993).

5. Conclusion

As exemplified by the fine research contributions offered by the authors of articles appearing in this special issue, significant strides have been made in the development and application of decision-making techniques involving multiple participants, each of whom may have multiple objectives. The information in the third and fourth columns of table 7 indicates that a rich array of decision tools are being developed and employed for addressing challenging decision problems. In fact, the last five articles given in table 7 deal with the construction and implementation of flexible DSSs listed in table 6.

Although good progress has been made in the design, development, and implementation of useful decision technologies, much work remains to be accomplished. As pointed out in section 2, further research is required for expanding the box of decision tools available for use in the three decision areas depicted in figure 1. By understanding and strengthening the useful connections among these decision areas, it may be possible to transfer appropriately modified decision technologies from one area to another as well as to develop new and more comprehensive techniques. Certainly, a promising future awaits those who can produce operational decision technologies for satisfying the research demands mentioned in section 2, as well as by the authors in the upcoming set of twelve articles and other researchers.

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Kindly refer to table 7 for the references appearing in this issue.

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