# Negotiations Support System with Third Party Intervention

by

Rami Abdulraheem A. Kinsara

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Systems Design Engineering

Waterloo, Ontario, Canada, 2013

**Abstract**

Systems methodologies to model third party mediation in international conflicts are developed within the framework of the Graph Model for Conflict Resolution (GMCR). The methodologies proposed give a better understanding of the conflict and how decision makers (DMs) can be motivated to undertake certain actions. The inverse approach to GMCR tackles the problem of specifying which preferences for DMs lead to a particular resolution, making it easier for a mediator or other third party to influence the course of the conflict. The methodologies will be applied to real world conflicts, including a complex water conflict in the Middle East.

# Table of Contents

# Chapter 1

# Introduction

## 1.1 Research Objectives

The main objective of this research is to model and understand third party intervention in conflicts. There are two perspectives on mediation modeling. The first is to predict the most likely outcomes of third party intervention in a conflict; in other words, the likelihood of success or failure. The second perspective is to provide the mediators with information to aid them in successfully bringing about a desired resolution using formal modeling and analysis.

About 70 percent of all international conflicts since 1945 have involved mediation (Bercovitch and Gartner, 2006). Although mediation can be defined in many ways, the definition used here is that mediation is a "process of conflict management, related to but distinct from the parties' own efforts, whereby the disputing parties or their representa-

tives seek the assistance, or accept an offer of help from an individual, group, state or organization to change, affect or influence their perceptions or behavior, without resorting to physical force, or invoking the authority of the law" (Bercovitch and Rubin, 1992). This definition captures aspects related to third party intervention. A related concept is arbitration where a third party could arbitrate a disputant to accept a resolution due to third party power of influence.

Of the many approaches to the study of third party intervention, three are prominent in the literature (Bercovitch and Gartner, 2009) :

1. Individual case studies: these lines of research, such as will be mentioned in the literature review in Chapter 2, analyze and explore specific conflicts in detail. Although this kind of analysis provides significant insights about a particular conflict, it may lack the ability to be generalized and accommodate other conflicts.

2. Experimental approaches: these approaches are laboratory experiments where variables are controlled by researchers in an artificial setting (Rubin, 1980; Carnevale and De Dreu, 2005)

3. Large scale systematic studies: these studies analyze data representing many conflicts and use criteria to identify factors and relationships affecting the conflicts and their outcomes. It gives a more generalized understanding of conflict management.

The methodology presented in this proposal borrows features from the last two approaches. It has controlled variables, yet it is applicable to real conflicts. This method-

ology is a generalized approach on its basic level, but applies to specific conflicts yielding profound insights.

## 1.2 Motivation

Conflicts are the most costly and insidious of all social processes (Bercovitch and Gartner, 2009). The development of an approach to model third party intervention in conflicts will bring together the most important element of international relations, which are conflicts, and the most influential element of conflicts, which is mediation. Surveying the literature, as will be outlined in depth in Chapter 2, reveals the need for a comprehensive approach to model and analyze the intervention of a third party in a conflict. Most studies on mediation address specific conflicts or a set of conflicts and wrap up with a regression model, which is not reliable and difficult to apply in reality.

The reason behind choosing the Graph Model for Conflict Resolution (GMCR) as a framework is the simplicity and flexibility of its approach while maintaining robustness and practicality in predicting outcomes (Kilgour et al., 1987; Fang et al., 1989, 1993; Inohara, 2011). Moreover, many developments have been introduced to the original GMCR framework (Kilgour and Hipel, 2005). For example: coalition analysis (Inohara and Hipel, 2008b,a), preference uncertainty (Li et al., 2004a) , fuzzy preferences (Bashar et al., 2012; Hipel et al., 2011) , and attitudes (Walker et al., 2008). GMCR possesses a realistic design for investigating conflicts such that on a basic level the only information needed to calibrate a conflict model before performing an analysis is:

1. the list of decision makers (DMs) in the conflict,

2. the options for each DM,

3. and the relative preferences for each DM.

It is simple to determine the DMs involved in a conflict and their respective options. However, it is not as easy to determine the preference ranking for each DM (Kilgour et al., 1996). In order to overcome this difficulty in GMCR, a methodology presented in this proposal helps negotiators identify possible preference rankings leading to a desired resolution. A number of water conflicts involving a third party in the Middle East were studied recently. The studies emphasize the effects of third party intervention in bringing about a resolution (Hipel et al., 2013). The regular GMCR was used to model and analyze the conflicts before and after third party intervention. The yielded outcomes were significantly different. The applications provided the motivation to seek a more generalized approach to formally model Third Party intervention within the framework of GMCR.

## 1.3 Thesis Organization

The following diagram in Figure 1.1 illustrates the organization of this proposal.

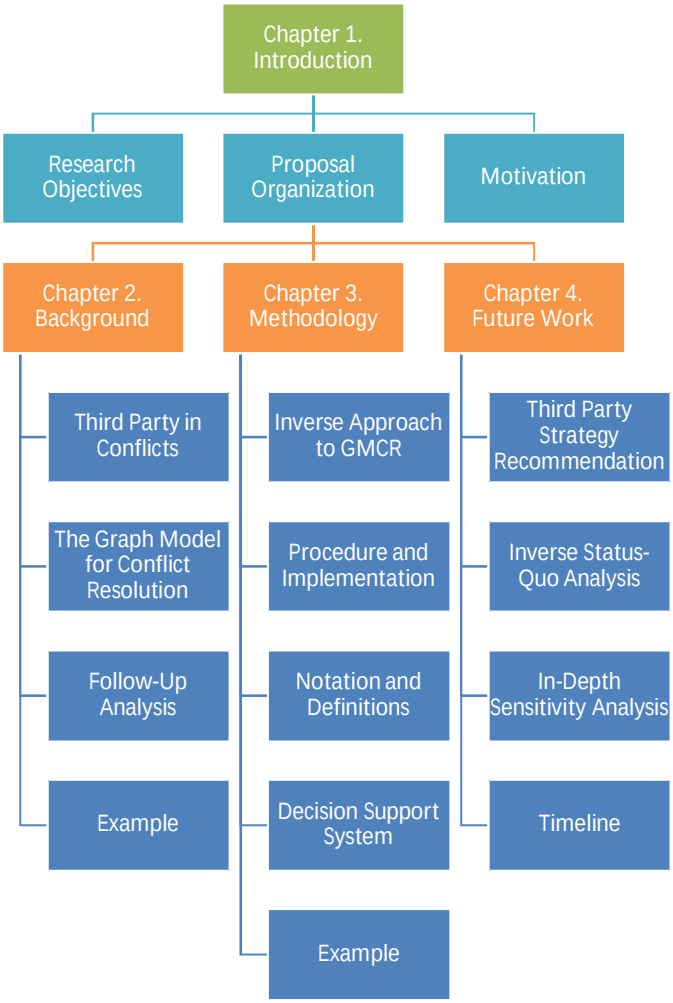


Figure 1.1: Proposal Organization

# Chapter 2

# Background and Literature Review

## 2.1 Third Party in Conflicts

Research into the impact of a third party in conflict resolution is reviewed in this section. The first subsection discusses the different types of conflict and the impact of third party intervention on them. Subsections 2.1.2 and 2.1.3 discuss the possible roles of a third party, in addition to other issues. Finally, subsection 2.1.4 reviews the existing modeling approaches for third party intervention.

### 2.1.1 Overview and Conflict Types

Third party intervention in conflicts has been widely investigated from different perspectives. Most of the research lies within the areas of international relations and political

sciences. These studies address issues regarding mediation including methods of intervention (Fisher, 2001), strategies for intervention (Prein, 1987), and conditions for successful intervention (Regan, 1996). Conflicts can be classified in a wide variety of ways. In the world of mediation, the differentiation between intrastate and interstate conflicts is usually clear. A study by Regan (1996) focuses on success conditions for third party interventions in intrastate conflicts. Another classification by Bercovitch and Gartner (2006) differentiates between high intensity conflicts and low intensity conflicts. Another categorization for conflicts is based on cause, including ethnic, religious, or ideological (Regan, 1996). The size of the conflict, or the number of parties involved provides one more means for classification (Jehn, 1997)

### 2.1.2 Third Party Roles

A third party can assume different roles in a conflict. Sakamoto et al. (2005) suggested three roles a third party can undertake in a conflict. These roles are commonly assumed when the mediator is not an actual party in the conflict, but is motivated to bring about a more preferred resolution. The suggested three roles are arbitrator, coordinator, and donor. The authors explain each role within a conflict. A third party is an arbitrator if it has the power to restrict or force a stakeholder to accept a certain resolution. If a third party can alter stakeholders' preferences, then it is either a coordinator or a donor. The difference between the last two roles depends on the time of influence of the third party. A coordinator influences the stakeholder to change preferences immediately, while a donor works on the long term (Sakamoto et al., 2005). On the other hand, Raiffa (1982)

classifies third parties as facilitators, mediators, arbitrators, or rule manipulators. Another study suggests mediators can be individuals, regional organizations, states, or international institutions (Bercovitch and Schneider, 2000; Bercovitch and Gartner, 2006). The latter study surveyed 2,354 international conflicts involving mediation since 1945 in order to analyze them and assess various general hypotheses. Table 2.1 summarizes their dataset. Some of their hypotheses will be outlined in subsection 2.1.4 of this proposal.

| Category | Frequency | Percent (within category) |
|---|---|---|
| **Mediators** | | |
| Individual | 106 | 4.50 |
| Regional | 362 | 15.38 |
| International | 792 | 33.64 |
| State | 1,094 | 46.47 |
| **Strategies** | | |
| Communications | 1,235 | 52.46 |
| Procedural | 434 | 18.44 |
| Directive | 685 | 29.10 |
| **Mediation History** | | |
| None | 137 | 5.82 |
| Offered Only | 129 | 5.48 |
| Fail | 1,182 | 50.21 |
| Ceasefire | 228 | 9.69 |
| Partial Settlement | 579 | 24.60 |
| Full Settlement | 99 | 4.21 |
| **Outcome** | | |
| Failure | 1,310 | 55.65 |
| Ceasefire | 234 | 9.94 |
| Partial Settlement | 657 | 27.91 |
| Full Settlement | 153 | 6.50 |
| **Total** | 2,354 | |

Table 2.1: Dataset Summary (Adopted from Bercovitch and Gartner (2006)

### 2.1.3 Miscellaneous issues

The literature is full of issues and factors affecting third party intervention. For example, factors affecting the process of intervention is that a mediator can act formally or informally, be invited to the conflict or not, intervene independently or on behalf of an organization, have interest in the outcome or in the process of intervention, be inclined toward one party or the other, and be consultative or directive in the intervention (Lewicki et al., 1992). Furthermore, mediation history can also have an effect on a new intervention attempt (Bercovitch and Gartner, 2006). A study by Carnevale and De Dreu (2005) addresses the element of time. They found that time pressure affects the mediator to be aggressive in intervening and to use pressuring tactics. Other studies on the effectiveness of third party intervention suggest factors that influence the success of specific situations. For instance, if an uninvited third party intervenes, Murray (1983) specifies three important factors for mediation efficiency: dispute maturity, disputants' relationship, and intervention timing. Other issues raised by different researchers include culture, power asymmetries, conflict ripeness, number of third parties, third party authority, bias, and consistency (Fisher, 2001).

Another aspect of mediation is strategy. The range of strategies a mediator can undertake is immense. Regan (1996) suggests three basic strategies of intervention within intrastate conflicts: military, economic, or mixed. Young (1972) discusses four intermediary functions: informational, tactical, supervisory, and re-conceptualization. In another study on successful mediation, Bercovitch et al. (1991) outline different strategies that can be adopted by a third party: conciliation-facilitation, procedural, directive, substantive,

and supervisory. The authors explain each of these strategies and assess their impact based on a range of historical conflicts. While these studies emphasize specific strategies, other approaches provide a more generic context, referred to as intervention styles. For instance, Bartunek et al. (1975) organize intervention techniques into two broad styles: content form and process form. Another wide classification is that of Touval and Zartman, who categorize all intervention approaches as communication, formulation, or manipulation strategies (Bercovitch and Wells, 1993). Bercovitch and Gartner (2006) suggest that all strategies can be grouped into communication, procedural, or directive strategies.

### 2.1.4 Third Party Modeling

Many studies in the literature tackle third party intervention in the context of a specific historical conflict or set of conflicts such as the work by Regan (1996); Bercovitch et al. (1991); Dixon (1996). For instance, the research by Regan (1996) on success conditions for third party interventions focuses only on intrastate conflicts and analyzes the conflicts occurred during the period between 1944 to 1994 (Table 2.2). The author suggests a regression model based on the dataset he gathered as illustrated in Fig 2.1. The author emphasizes three intrastate conflict types: ethnic, religious, and ideological. Moreover, the regression model took into account other factors affecting the intervention such as the type of conflict, number of causalities, intervention type, and intervention target. Other attempts to formally model third party intervention based on particular conflicts include the research by Carment and James (1996); Hipel et al. (2013). Although most third party modeling based on historical conflicts use regression analysis (Regan, 1996; Dixon,

1996), the latter two studies use game theory based models. In addition, Fisher (2001); Lewicki et al. (1992) discuss different conceptual and descriptive models for third party intervention. Lastly, a standard conflict model of third party intervention is suggested by Siqueira (2003).

Results of Logit Regression on the Success or Failure of Intervention

| *Variable* | *Estimated Coefficient* | SE | T-*Ratio* |
|---|---|---|---|
| Conflict type | –.40 | .34 | –1.17 |
| Casualties | $-.70 \times 10^{-6}$ | $.13 \times 10^{-5}$ | –.54 |
| Type of intervention | 1.26 | .59 | 2.13 |
| Target of intervention | –.12 | .03 | –3.36 |
| Major Power × Type | –.07 | .02 | –2.91 |
| Major Power × Target | .12 | .03 | 3.25 |
| Constant | .89 | .54 | 1.63 |

Log likelihood (0) = –117.71
Log likelihood function = –107.95
Likelihood ratio test = 19.50 with 6 *df*

| | *Predicted Outcomes* | |
|---|---|---|
| *Actual Outcomes* | *Success* | *Failure* |
| Success | 11 | 7 |
| Failure | 48 | 124 |

NOTE: Number of correct predictions = 135; percentage of correct predictions = 71%.

Figure 2.1: A snapshot of the regression model by Regan (1996) with the results applied to the study dataset

| *Conflict* | *Type* | *Dates* | *Casualties* | *Interventions* | *Type of Intervention* | *Target of Intervention* | *Success* |
|---|---|---|---|---|---|---|---|
| Republic of Vietnam | Ideological | 1960-1965 | 300,000 | U.S. | Mixed | Government | No |
| | | | | DRV Vietnam | Military | Opposition | No |
| Zairian Civil War | Ethnic | 1960-1965 | 300,000 | Belgium | Military | Opposition | No |
| | | | | United Nations | Mixed | Government | Yes |
| | | | | Algeria | Military | Opposition | No |
| | | | | Egypt | Military | Opposition | No |
| | | | | Belgium | Mixed | Government | Yes |
| Ogaden Conflict I | Ethnic | 1960-1964 | 300 | Somalia | Military | Government | No |
| Laos I | Ideological | 1960-1962 | 30,000 | U.S. | Mixed | Opposition | Yes |
| | | | | U.S.S.R. | Military | Opposition | Yes |
| | | | | RVN Vietnam | Military | Opposition | Yes |
| Iraq (Kurdish Rebellion) | Ethnic | 1961-1966 | 5,000 | Syria | Military | Government | No |
| Eritrean War | Ethnic | 1962-1991 | 45,000 | Cuba | Military | Opposition | No |
| | | | | U.S.S.R. | Military | Opposition | No |
| | | | | U.S. | Mixed | Government | No |
| | | | | Cuba | Military | Government | No |
| | | | | U.S.S.R. | Mixed | Government | No |
| | | | | Sudan | Military | Opposition | No |
| Arab Republic of Yemen | Ideological | 1962-1964 | 100,000 | Egypt | Military | Government | Yes |
| | | | | Saudi Arabia | Mixed | Opposition | No |
| | | | | Jordan | Mixed | Opposition | No |
| Laos II | Ideological | 1963-1973 | 18,000 | U.S. | Mixed | Government | No |
| | | | | DRV Vietnam | Economic | Opposition | No |
| | | | | France | Military | Government | No |
| Sudanese Civil War | Religious | 1963-1972 | 200,000 | Belgium | Military | Government | No |
| Cyprus | Ethnic | 1963-1964 | 3,000 | U.K. | Military | Neutral | No |
| | | | | Greece | Military | Government | No |
| | | | | Turkey | Military | Opposition | No |
| | | | | United Nations | Military | Neutral | Yes |
| Chad Civil War I | Ethnic | 1965-1972 | 1,500 | France | Military | Government | No |
| | | | | Libya | Military | Opposition | No |
| Dominican Revolt | Ideological | 1965 | 1,000 | U.S. | Military | Government | Yes |
| | | | | Honduras | Military | Government | Yes |
| Thai Communist Insurgency | Ideological | 1965-1985 | 10,000 | U.S. | Mixed | Government | No |
| | | | | China | Military | Opposition | No |
| | | | | Malaysia | Military | Government | No |
| Guatemalan Communist Insurgency I | Ideological | 1966-1972 | 45,500 | U.S. | Mixed | Government | No |
| Congo, Kisanguni Mutiny | Ideological | 1967 | 20,000 | U.S. | Military | Government | Yes |
| | | | | Belgium | Mixed | Opposition | No |
| Burmese Communist Insurgency I | Ideological | 1968-1980 | 1,500 | China | Military | Opposition | No |
| Oman, Dhofar Rebellion | Ethnic | 1970-1975 | 2,000 | U.K. | Military | Government | Yes |
| | | | | Iran | Military | Government | Yes |
| | | | | Jordan | Military | Government | Yes |
| | | | | YPR Yemen | Military | Opposition | No |
| Cambodia | Ideological | 1970-1975 | 150,000 | RVN Vietnam | Military | Government | No |
| | | | | U.S. | Military | Government | No |
| | | | | DRV Vietnam | Military | Opposition | Yes |
| Northern Ireland | Religious | 1968-1994 | 3,000 | Libya | Military | Opposition | No |

Table 2.2: A dataset segment of the Intrastate Conflicts used in Regan's study (Table adopted from Regan (1996)

A study by Sakamoto et al. (2005) illustrates an approach to incorporate third party intervention in conflict modeling using GMCR. The research suggests three roles a third party can play (explained in subsection 2.1.2 of this report) and developed a conflict management procedure for them. Fig 2.2 below illustrates the authors' conflict management approach with the intervention of a third party.

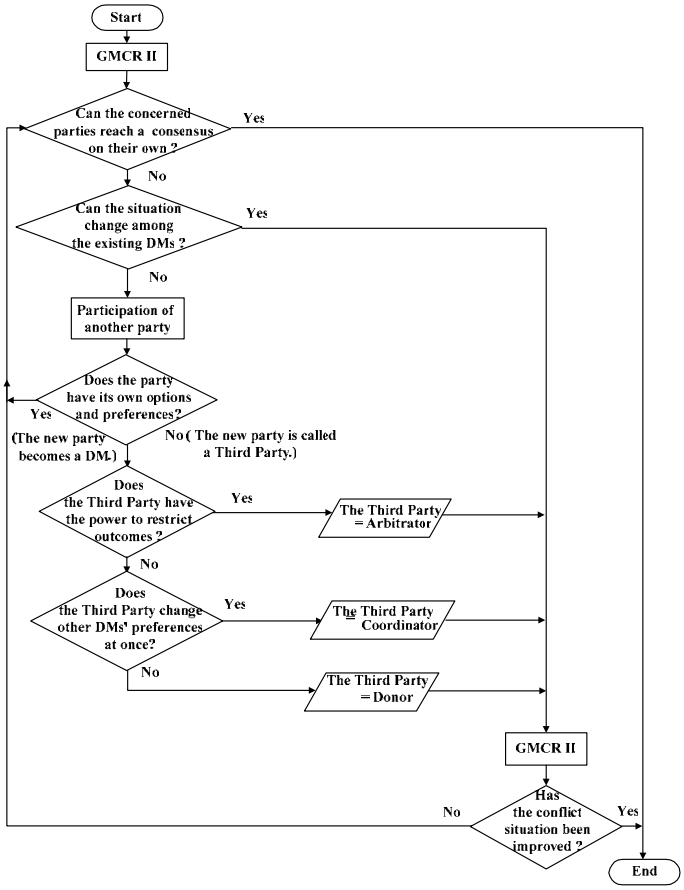


Figure 2.2: Chart developed by Sakamoto et al. (2005) to illustrate conflict management with a third party

A comprehensive study by Bercovitch and Gartner (2006) investigates in depth the success factors of third party intervention. The authors focus on mediators' identities, strategies, and mediation history to predict the outcome of mediation. According to the authors, mediators can be classified according to four categories: individuals, states, regional organizations, and international institutions. After discussing each category, the authors claim that in low intensity conflicts, state and regional mediators are more likely to be successful. However, they are less likely to be successful in high intensity conflicts. International mediators are likely to be effective in high intensity conflicts and individuals are unlikely to be successful in all conflict types. On the other hand, the authors suggest that mediation strategies include communication-facilitation, procedural, and directive strategies. Similarly, the authors make some hypotheses after explaining each of the strategies. They claim that directive strategies are most likely to be successful in high intensity conflicts but not in low intensity conflicts. Procedural strategies are mostly successful in low intensity conflicts. Tables 2.3 and 2.4 are summaries derived from the research hypotheses in the study.

| **Conflict Type** | **Identity** | | | |
|---|---|---|---|---|
| | ***Individuals*** | ***States*** | ***Regional Organizations*** | ***International Institutions*** |
| High Intesity | Unlikely | Less likely | Less likely | Likely |
| Low Intensity | Unlikely | Likely | Likely | Likely |

Table 2.3: Mediator type and likelihood to be successful

| **Conflict Type** | **Strategy** | | |
|---|---|---|---|
| | ***Directive*** | ***Procedural*** | ***Communication-Facilitation*** |
| High Intesity | Likely | Unlikely | Passive |
| Low Intensity | Unlikely | Likely | Passive |

Table 2.4: Mediator strategy and likelihood to be successful

# Chapter 3

# The Graph Model for Conflict Resolution (GMCR)

The Graph Model for Conflict Resolution (GMCR) has been developed and expanded since the mid-1980s (Kilgour and Hipel, 2005). GMCR is a tool to strategically analyze moves and counter moves in a conflict in order to predict the most likely outcome.

## 3.1 Procedure

The basic procedure of GMCR involves two main stages: modeling and analysis. In the modeling stage, the user identifies the conflict parameters which include:

- Decision makers (DMs)
- Options for each DM

- Infeasible states (such as mutually exclusive situations)
- Allowable transitions
- Relative preferences

After identifying the conflict parameters, the user will analyze the conflict from each DM's perspective to determine the likely final resolution. This stage include:

- Determining individual stability (i.e. for each DM)
- Overall equilibria
- Sensitivity analysis

The following diagram in Figure 3.1 illustrates the basic GMCR procedure (The diagram is adapted from Fang et al. (1993)).

## 3.2 Notation and Definitions

The graph model representing a real world conflict includes DMs, options, and preferences. These parameters are formally defined as follows:

**Definition 3.2.1.** Let $N = \{1, 2, \ldots, n\}$ represent the set of DMs, for each DM $i \in N$, the set $O_i$ is $i$'s options or strategy set and $S = \{s_1, s_2, ..., s_m\}$ represent the set of feasible states.

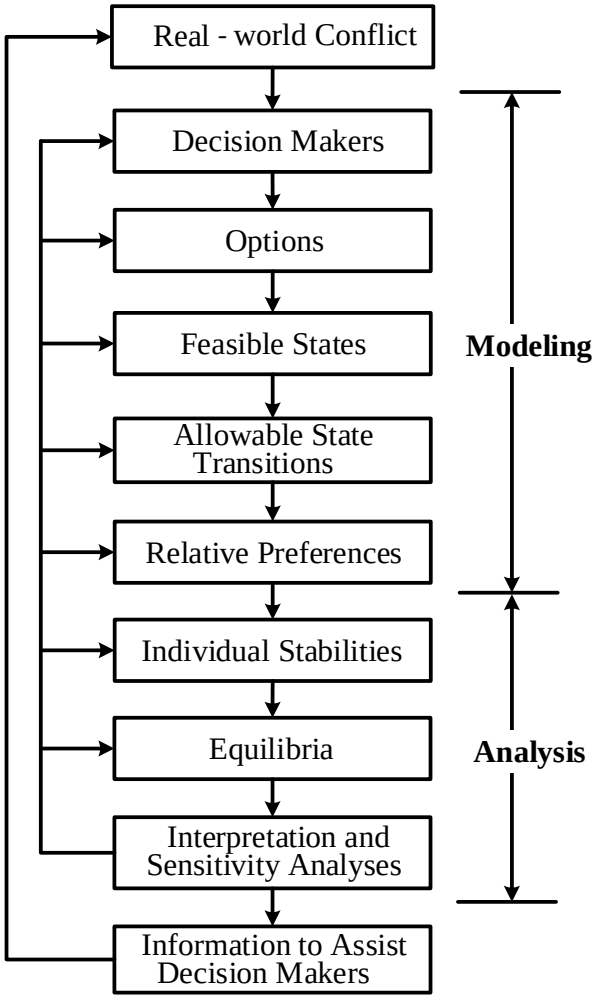


Figure 3.1: The basic procedure of GMCR in a real world conflict (adapted from Fang et al. (1993))

The set of possible states in a conflict is represented by the expression $2^o$ where $o$ is the total number of options in a conflict. Some of the possible states may be infeasible such as mutually exclusive options, at least one type of options, or dependent options. In a conflict model, a set of feasible states is defined.

**Definition 3.2.2.** Let $S = \{s_1, s_2, ..., s_m\}$ represent the set of feasible states in a conflict.

For each DM $i \in N$, a set of directed graphs $D_i = (S, A_i)$ can be used to model the conflict.

The feasible states of a conflict are represented by vertices in the graph model. In each graph, an arc $A_i$ exists between states $s_a$ and $s_b \in S$ if DM $i$ can move unilaterally in one step between the two states. It is called a *directed* graph because the arc has an orientation which can be one way (irreversible move) or two ways (reversible move).

**Definition 3.2.3.** Let $i \in N$ and $s \in S$. The reachable list of DM $i$ from state $s \in S$ is defined as:

$$R_i(s) = \{s_a \in S \quad : \quad (s, s_a) \in A_i\}$$

The move in one step by DM $i$ from a state $s_a$ to a state in the reachable list $\{s_b \in S\}$ is called a unilateral move (UM).

The preference information of DM $i$ is a binary relation $\{\succ_i, \sim_i\}$ over $S$, where $s_a \succ_i s_b$ means that DM $i$ prefers $s_a$ to $s_b$ and $s_a \sim_i s_b$ means that DM $i$ is indifferent between states $s_a$ and $s_b$. The binary relation $\{\succ_i, \sim_i\}$ is considered complete.

**Definition 3.2.4.** Let $i \in N$ and $s \in S$. The unilateral improvement list for DM $i$ from state $s \in S$ is defined as:

$$R_i^+(s) = \{s_a \in R_i(s) \quad : \quad s_a \succ_i s\}.$$

The move in one step by DM $i$ from a state $s_a$ to a state in the unilateral improvement list $\{s_b \in S\}$ is called a unilateral improvement (UI).

## 3.3 Stability Definitions and Solution Concepts

The main goal of the graph model for conflict resolution is to predict the stability of each state for each DM. There are four basic solution concepts according to which a state can be assessed for stability: Nash stability (sometimes called rationality), sequential stability (SEQ), general metarationality (GMR), and symmetric metarationality (SMR).

The solution concepts describe how a DM is motivated to make moves and counter moves. These concepts (or behavior patterns) determine whether a specific state will be terminal or a DM will be motivated to deviate to another state. Different DMs may have different behavior patterns based on different factors. These factors include risk, foresight, and available information. Behavioral characteristics according to the different solution concepts are given in Table 3.1 below.

**Definition 3.3.1. (Nash Stability)** Let $i \in N$ and $s \in S$. State $s$ is *Nash stable* for DM $i$ *iff* $R_i^+(s) = \phi$.

**Definition 3.3.2. (Sequential Stability)** Let $i \in N$ and $s \in S$. State $s \in S$ is *sequentially stable* (*SEQ*) for DM $i$ *iff* for every $s_1 \in R_i^+(s)$ there exists at least one $s_2 \in R_{N-i}^+(s_1)$ such that $s_2 \precsim_i s$.

**Definition 3.3.3. (General Metarationality)** Let $i \in N$ and $s \in S$. State $s \in S$ is *general metarational* (*GMR*) for DM $i$ *iff* for every $s_1 \in R_i^+(s)$ there exists an $s_2 \in R_{N-i}(s_1)$ such that $s_2 \precsim_i s$.

**Definition 3.3.4. (Symmetric Metarationality)** Let $i \in N$ and $s \in S$. State $s \in S$ is *symmetric metarational* (*SMR*) for DM $i$ *iff* for every $s_1 \in R_i^+(s)$ there exists an $s_2 \in$

$R_{N-i}(s_1)$ such that $s_2 \precsim_i s$ and $s_3 \precsim_i s$ for all $s_3 \in R_k(s_2)$.

| **Solution Concepts** | **Stability Descriptions** | **Foresight** | **Knowledge of Preferences** | **Disimprovement** | **Strategic Risk** |
|---|---|---|---|---|---|
| Nash stability (**R**) | Focal DM (decision maker) cannot move unilaterally to a more preferred state. | Low | Own | Never | Ignores risk |
| General Metarational (**GMR**) | All focal DM's unilateral improvements are sanctioned by subsequent unilateral moves by others | Medium | Own | By opponents | Avoids risk; conservative |
| Symmetric Metarational (**SMR**) | All focal DM's unilateral improvements are sanctioned, even after response by the focal DM. | Medium | Own | By opponents | |
| Sequential Stability (**SEQ**) | All focal DM's unilateral improvements are sanctioned by subsequent unilateral improvements by others. | Medium | All | Never | Takes some risks; satisfices |

Table 3.1: Behavioral characteristics describing different solution concepts

**Definition 3.3.5. (Equilibrium)** Let $i \in N$ and $s \in S$. State $s \in S$ is called *equilibrium* $(E)$ *iff* it is stable for every DM.

Sometimes the graph model for conflict resolution is referred to as a 3-tuple or triplet $G = \langle N, S, (\succ_i, \sim_i)_{i \in N} \rangle$ where $N$ is the list of DMs $N = \{1, \ldots, n\}$, $S$ is the set of feasible states $S = \{1, \ldots, m\}$, and $(\succ_i, \sim_i)$ is the binary relation DM $i$ has on $S$. Consequently, $Nash(G) = \{\ s \in S\ :\ s\ $ is a Nash Equilibrium of $G\}$. More explicitly,

$$Nash(N, S, (\succ_i, \sim_i)_{i \in N}) = \{\ s \in S\ :\ s\ \text{ is Nash stable for all } i \in N \text{ in } \langle N, S, (\succ_i, \sim_i)_{i \in N} \rangle\}$$

and similarly for SEQ, GMR, and SMR.

## 3.4 Follow-Up Analysis

To take the basic analysis further, a number of follow-up analyses may be undertaken to test the reliability of the predicted outcomes and whether they are achievable from the status quo or not.

### 3.4.1 Sensitivity Analysis

Since many conflict parameters are subjective, it may be essential to test different scenarios in order to determine the robustness of the conflict model. Sensitivity analysis also points out how different parameters can influence the stability results. The most common type of sensitivity analysis is the change of preference since it is the most difficult parameter to obtain and determine. Other sensitivity analysis types include:

- Adding or combining DMs
- Change of options (adding, removing, or modifying)
- Changing moves reversibility
- Coalition analysis
- Modeling misunderstandings (hypergames)
- Examining other patterns of human behavior

### 3.4.2 Status Quo analysis

Every real world conflict has a starting point from which the conflict evolves. This point or state is called *status quo* (Fang et al., 1993). Depending on the status quo, a potential equilibrium may or may not be reached. Li et al. (2004b, 2005) developed algorithms and formal definitions to inspect the attainability of a potential resolution (*equilibrium*) from a certain state (*status quo*).

## 3.5 Decision Support System for GMCR

### 3.5.1 Review of Existing Decision Support Systems

# Chapter 4

# Strategic Investigations of Water Conflicts in the Middle East

It was noted earlier in the introduction that a recent study on water conflicts emphasized the effect of third party intervention in bringing about a resolution. This study will be summarized in this section. An in-depth analysis and background can be found in Hipel et al. (2013).

## 4.1 Background

The arid nature of the Middle East environment causes continuously escalating conflicts among the countries of the region. Conflicts arise as water resources dwindle due to increased industrial and agricultural projects and population growth. The main renewable

sources of freshwater in the region are rivers. Like all water resources, they are replenished by their hydrological cycle, with renewal rates varying from days to centuries. The rate of renewal for Middle Eastern rivers is decreasing due to population growth and the increasingly arid conditions of the region. At 2,700 km, the Euphrates is the longest and arguably most important river in the Middle East (Southwest Asia) (Kolars and Mitchell, 1991). The Euphrates originates in eastern Anatolia in Turkey and flows through Syria and finally Iraq, where it joins the Tigris River. Conflicts regarding the river became serious during the 1960s, when Turkey began building dams on the Euphrates to generate electricity and increase the availability of irrigation water in Southeast Turkey (Akanda et al., 2007). As a result of external mediation, war was narrowly avoided twice, in 1975 and 1998 (Akanda et al., 2007).

The original study investigated three interconnected conflicts along the Euphrates River occurring in 1975, 1990, and 1998. This example will only focus on the conflicts that took place in 1975 and 1998 as both of them involved mediation.

### 4.1.1 The conflict in 1975

In 1966, Turkey started the construction of the Keban Dam, which is a hydroelectric dam on the Euphrates River (Fig 4.1). After the construction was finished in 1974, Turkey started the filling of the Keban Reservoir. During the flooding, Turkey maintained a 450 $m^3/s$ discharge of the Euphrates to the two downstream countries consisting of Syria and Iraq. This rate was agreed upon by both countries through the United States Agency for International Development (USAID), which was financing the project (Inan, 2000).

However, Syria also started filling the lake behind its newly constructed Thawra Dam. Simultaneously, the area was hit by a significant drought (Kalpakian, 2004). As a result, the flow of the Euphrates River entering Iraq was reduced to a trickle. Iraq accused Syria of this reduction and of endangering the lives of three million Iraqi farmers dependent on river irrigation water (Morris, 1997). Iraq complained that the flow had dropped from the normal 920 $m^3/sec$ to an unacceptable 197 $m^3/sec$ (Priscoli and Wolf, 2009). Iraq requested an intervention by the Arab League; however, Syria argued that it was receiving less water from Turkey as well and refused to cooperate. As the tension increased, Syria closed its airspace to all Iraqi aircraft, suspended Syrian flights to Baghdad, and transferred troops from the Israeli border to the Iraqi frontier by May 1975 (Morris, 1997). Iraq also sent its troops to the shared border and threatened to bomb Syria's dam.

Before the conflict could escalate any further, Saudi Arabia and the Soviet Union intervened - only mediation on the part of Saudi Arabia was able to alleviate the situation (Priscoli and Wolf, 2009). On June 3, 1975, an agreement between Iraq and Syria, with the mediation of Saudi Arabia, averted the impending war. The agreement stipulated that Syria is to release extra amounts of water to Iraq (Akanda et al., 2007): specifically, 58% of what Syria receives from the Euphrates is to be released to Iraq (Priscoli and Wolf, 2009). In addition to resolving the conflict, Saudi Arabia contributed to a basin fund that would finance irrigation reform and other methods to reduce unmet demands (Akanda et al., 2007).


Figure 4.1: The Euphrates River along with the dams constructed on it (The New York Times, 2009)

### 4.1.2 The Conflict in 1998

Many events took place between the conflict in 1975 and prior to 1998. Mainly, an ironic coalition between Syria and Iraq against Turkey because of the latter's announcement of the largest water resources project in South-Eastern Anatolia known as the "GAP Project", which includes 22 dams and 19 hydropower installations on the Euphrates-Tigris (Frenken et al., 2009). In addition, tension increased between Turkey and Syria due to the latter support of the rebellion movement of the Kurdish Workers Party (PKK), which is struggling to create a Kurdish state in South Eastern Turkey (Güner, 1998). Syria's continuous support for the PKK was affecting Turkey's stability and depleting its resources. Despite bilateral security agreements between Syria and Turkey in 1992 and 1993, Turkey continued

to accuse Syria of supporting the PKK, while Syria insisted that it forced the PKK to move its bases from Syrian territory in conformity with the bilateral agreements between itself and Turkey (Güner, 1998). In 1993, the Turkish Prime Minister declared that if Syria did not ban PKK from its country, there could be no solution to the water problem. The issue was raised again in the trilateral summit of 1994 between the Foreign Ministers of Turkey, Syria, and Iraq with no improvements. Moreover, in 1995, Turkey organized military operations in northern Iraq against PKK members who fled to Syria, thus confirming Turkish suspicions. Finally, in 1998, Turkey charged Syria with support of the PKK and harboring its leader, perhaps providing refuge to the leader in Damascus. Turkey escalated the situation and threatened to invade Syria. Egypt intervened and the Egyptian President, Hosni Mubarak, secured Syria's pledge to stop supporting the PKK (Akanda et al., 2007). On account of the intervention of Egypt and in order to avert an invasion by Turkey, the Syrian government agreed to ban PKK from Syria by signing the Adana Agreement on October 20, 1998 (Priscoli and Wolf, 2009). Finally, Table 4.1 outlines the historical evolution of the most notable events related to the Euphrates conflicts.

| Dates | Events |
|---|---|
| Early 1970s | Rebellious Kurdish Workers Party (PKK) was formed. Syria supported this party. |
| Late 1974 | The filling of Keban and Thawra dams started. |
| Early 1975 | Iraq complained about the flows in the Euphrates dropping from the normal 920 $m^3$/sec to an "intolerable" 197 $m^3$/sec. Iraq requested that the Arab League intervene. However, Syria said it was receiving less than average flow and dropped out of the Arab League. Both countries amassed their troops on the shared borders and the situation escalated. |
| June 3, 1975 | Intervention and mediation efforts by Saudi Arabia are at last successful and war was averted. Agreement details were not announced. |
| 1977 | Turkey announced plans for the "GAP Project", which includes 22 dams and 19 hydropower installations on the Euphrates-Tigris Rivers. |
| 1987 | Turkey guaranteed a minimum water flow of 500 $m^3$/s and Syria, in return, promised to cooperate in security matters. A few months later, Turkey complained about terrorist activities and accused Syria of supporting them. |
| January, 1990 | The filling of the Ataturk Dam by Turkey started, shutting off completely the flow to the Euphrates River. Even though the interruption was intended to be for only one month, Syria and Iraq boycotted companies involved in the GAP project. Moreover, military leaders from both nations drew up plans for armed retaliation against Turkey. After three weeks, Turkey released water to the Euphrates River. |
| 1992 – 1994 | Bilateral security agreements between Syria and Turkey were discussed, with little success. Turkey continued to accuse Syria of supporting the PKK. In 1993, the Turkish Prime Minister declared that if Syria did not ban PKK from its country, there could be no solution to the water problem. |
| 1995 | Turkey organized military operations in northern Iraq against PKK members who fled to Syria, thus confirming Turkish suspicions. |
| August, 1998 | Turkey threatened full military action and invasion against Syria for continuing to support PKK rebels. |
| October, 1998 | With the mediation of Egypt, the Adana Agreement, obligating the Syrian government to ban PKK, was signed by Turkey and Syria. |

Table 4.1: Notable events related to conflicts along the Euphrates River

## 4.2 Conflict Analysis of the 1975 Dispute

The DMs and options for the 1975 conflict are given in Table 4.2. Notice that Syria has an option regarding the release of the water plus an option of escalating the situation. Iraq has the single option of attacking Syria. Since both Saudi Arabia and the Soviet Union have similar preferences and reasons for getting involved, they are considered as a single DM labeled as "Third Party". The Third Party has a single option of acting or not. Table 4.2 describes the options for each DM. Each option is labeled with a number and can be either taken (Y for yes) or not (N for no). For example, option 3, which is entitled Attack, is the situation in which Iraq can use military action to force Syria to release water into the Euphrates. Undertaking this option, as indicated by Y for yes, means using force, while not taking this option, N for no, indicates accepting the situation and allowing Syria to fill the Thawra Dam without escalation.

| DM | Option | Choice | Description |
|---|---|---|---|
| **Syria** | 1.Release Water | **Y** | Syria agrees to halt the filling of Thawra Dam and let the Euphrates flow into Iraq |
| | | **N** | Syria continues to fill its dam |
| | 2.Escalate | **Y** | This could be done by cutting relations with Iraq, sending troops to the shared border, closing the air space to Iraqi aircraft, or any combination of these actions |
| | | **N** | Syria does not undertake any of the escalating options |
| **Iraq** | 3.Attack | **Y** | This includes bombing of the dam and going to war with Syria |
| | | **N** | Iraq does not act and accepts the situation |
| **Third Party** | 4.Act | **Y** | This includes mediation and reconciliation between the two countries and monetary support |
| | | **N** | Do not intervene |

Table 4.2: DMs, options and descriptions for the 1975 conflict

To emphasize the effect of the third party, this conflict will be analyzed without and

with the intervention of the third party. The sets of possible states are given in Tables 4.3 and 4.4, respectively. Notice that there is one infeasible situation in which Syria both releases the water and escalates the situation at the same time (mutually exclusive options). Taking this into account resulted in the removal of two states in the model without the intervention of the third party and the removal of four states in the model with the participation of the third party.

| **DM** | **Option** | **States** | | | | | |
|---|---|---|---|---|---|---|---|
| **Syria** | 1.Release Water | **N** | **Y** | **N** | **N** | **Y** | **N** |
| | 2.Escalate | **N** | **N** | **Y** | **N** | **N** | **Y** |
| **Iraq** | 3.Attack | **N** | **N** | **N** | **Y** | **Y** | **Y** |
| Label | | 1 | 2 | 3 | 4 | 5 | 6 |

Table 4.3: DMs, options and states for the 1975 conflict without the third party

| **DM** | **Option** | **States** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Syria** | 1.Release Water | N | Y | N | N | Y | N | N | Y | N | N | Y | N |
| | 2.Escalate | N | N | Y | N | N | Y | N | N | Y | N | N | Y |
| **Iraq** | 3.Attack | N | N | N | Y | Y | Y | N | N | N | Y | Y | Y |
| **Third Party** | 4.Act | N | N | N | N | N | N | Y | Y | Y | Y | Y | Y |
| Label | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

Table 4.4: DMs, options and states for the 1975 conflict with the third party

Figures 4.2 and 4.3 show the integrated Graph Model of the conflict both without and with the participation of the third party, respectively. The numbers in the nodes refer to the state numbers as indicated in Tables 4.3 and 4.4. The lines with arrows between the nodes are moves that can be carried out by the indicated DM in one step.

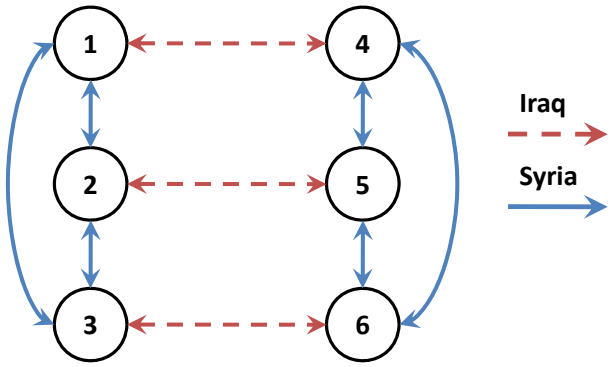


Figure 4.2: Integrated Graph Model of the 1975 conflict without the third party

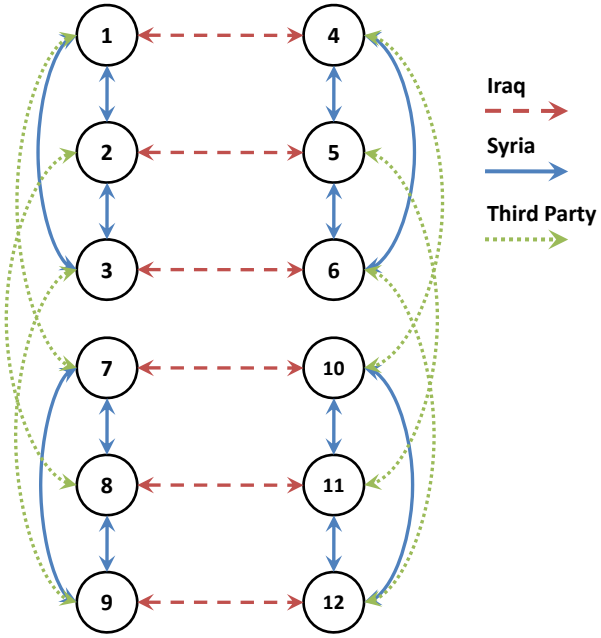


Figure 4.3: Integrated Graph Model of the 1975 conflict with the third party

Table 4.5 presents the preference prioritization information for each DM in the 1975 conflict without the participation of the third party, from most important at the top to least important at the bottom for each DM. The statements presented herein are a sample of how the ranking of states is constructed. This information is used to order the states from most to least preferred by the DM. Assuming transitivity for the preferences, Table 4.6 presents the ranking of states from most to least preferred for both Syria and Iraq using option prioritization (Hipel et al., 1997; Fang et al., 2003a,b). For example, State 1, which is the status quo, is the best state to be in for Syria. State 5, in which Syria releases the Euphrates and Iraq attacks at the same time, is considered the worst possible state for Syria.

| DM | P# | Preference Information (From most to least important) | Further Explanation |
|---|---|---|---|
| **Syria** | **1** | Remain at the status quo | Syria continues filling its dam and Iraq accepts the situation without any escalation or intervention |
| | **2** | Escalate the situation if Iraq decides to attack | Syria next prefers going to war with Iraq if it is attacked, which is more preferred than releasing water |
| **Iraq** | **1** | Syria releases more flow of the Euphrates River | Iraq most prefers the situation in which Syria stops filling its dam without any escalation |
| | **2** | Execute an attack if Syria does not release more water | Iraq's interest in water far outweighs the consequence of going to war |

Table 4.5: Preference prioritization information for the 1975 conflict without the third party

| DM | States | | | | | |
|---|---|---|---|---|---|---|
| **Syria** | **1** | **3** | **6** | **2** | **4** | **5** |
| **Iraq** | **2** | **4** | **6** | **1** | **5** | **3** |
| | *Most Preferred* | | | | *Least Preferred* | |

Table 4.6: Ranking of states for the DMs in the 1975 conflict without the third party

The third party could be viewed as an actual DM if it has its own options and preferences. However, if the party is not an actual stakeholder in the conflict but is motivated to bring about a more preferred equilibrium, then it can be categorized as Arbitrator, Coordinator or Donor (Sakamoto et al., 2005). If the party has the influence to change other DMs' preferences or options, then the party is called a Donor. On the other hand, if the party has the power to exclude some states, then it is considered to be an Arbitrator. In this conflict, the third party, Saudi Arabia, is clearly a Donor as it contributed to financing the basin development and both DMs, Syria and Iraq, want to please Saudi Arabia. Therefore, DMs' preferences, especially on the part of Syria, are changed. Table 4.7 presents the preference prioritization information for each DM in the 1975 conflict with the participation of the third party from most to least preferred. Table 4.8 gives the preferences for Syria, Iraq, and the third party from most to least preferred.

| DM | P# | Preference Information (From most to least important) | Explanation |
|---|---|---|---|
| **Syria** | **1** | Remain at the status quo | Syria continues filling its dam and Iraq accepts the situation without any escalation or intervention |
| | **2** | Release the flow of the Euphrates if and only if Iraq does not attack and with the mediation of a third party | This is the new preference information after the intervention of the Third Party |
| | **3** | Escalate the situation if Iraq decides to attack | Syria's least preferred situation is to go to war with Iraq |
| **Iraq** | **1** | Syria releases the flow of the Euphrates | Iraq's most preferred situation is that Syria stops the filling of its dam without any escalation and with or without an intervention |
| | **2** | Strike an attack if Syria does not release more water | Iraq's interest in water far outweighs the consequence of going to war |
| **Third Party** | **1** | Acts and influences Syria to release the flow of the Euphrates | The mediator's interest is to promote peace in the region and reduce harm for everyone |

Table 4.7: Preference prioritization information for the 1975 conflict with the third party

| DM | States | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Syria** | 1 | 3 | 8 | 9 | 2 | 7 | 12 | 6 | 10 | 4 | 11 | 5 |
| **Iraq** | 8 | 2 | 6 | 12 | 4 | 10 | 7 | 5 | 11 | 1 | 9 | 3 |
| **Third Party** | 8 | 2 | 1 | 7 | 9 | 3 | 4 | 10 | 6 | 12 | 5 | 11 |
| | *Most Preferred* | | | | | | | | | | | *Least Preferred* |

Table 4.8: Ranking of states for the DMs in the 1975 conflict with the third party

The objective of the analysis is to determine the equilibrium states, which are the states from which no DM is motivated to move and, therefore, the conflict will probably end at that particular state. To determine the equilibrium states we use stability definitions (or solution concepts), which describe human behavior and patterns based on moves

and counter moves. Equilibria are states that are stable for all DMs. After inputting the foregoing information into the decision support system GMCR II, equilibrium results are obtained for both Syria and Iraq without the third party (Table 4.9) and with the third party (Table 4.10). Restricting Iraq's alternative of attacking does not affect the equilibria for both cases. In Tables 4.9 and 4.10, the left column gives the different stability definitions while the remaining columns present the stability calculation results for each solution concept corresponding to the state. Nash and Sequential Stability (SEQ) are considered the strongest stability definitions. General Metarationality (GMR) and Symmetric Metarationality (SMR) are not considered as strong stability definitions since DMs are permitted to harm themselves during the process of sanctioning. Fang et al. (1989) discuss the relationships among the different solution concepts.

| Solution Concepts | **States** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|---|
| R (Nash) | | | | | | | ✓ |
| GMR | | ✓ | | | | | ✓ |
| SMR | | ✓ | | | | | ✓ |
| SEQ | | | | | | | ✓ |

Table 4.9: Equilibrium results for the 1975 conflict without the third party

| Solution Concepts | **States** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R (Nash) | | | | | | | ✓ | | ✓ | | | | |
| GMR | | | ✓ | | | | ✓ | ✓ | ✓ | | | | ✓ |
| SMR | | | ✓ | | | | ✓ | ✓ | ✓ | | | | ✓ |
| SEQ | | | | | | | ✓ | | ✓ | | | | |

Table 4.10: Equilibrium results for the 1975 conflict with the third party

It is clear from the aforementioned analysis that when the third party does not participate (Table 4.9), the strongest equilibrium is state 6 which means that both Syria and Iraq

go to war. And that is what nearly happened as both countries amassed their troops on their shared border. The status quo, State 1, is a very weak equilibrium and the unilateral improvement by Iraq will most likely be taken; that is, Iraq will move to state 4 in which it will attack. In contrast, with the intervention of the third party, a new equilibrium is introduced: State 8 in which Syria releases water and no escalation or attack from Iraq occurs. Referring to the ranking of states in Tables 4.6 and 4.8 as well as the integrated graphs in Figures 4.2 and 4.3, one can easily view the unilateral moves and improvements for each DM. A unilateral move is any possible move controlled by that particular DM, whereas a unilateral improvement necessitates that this move is also a movement to a more preferred state. The analysis of the conflict demonstrates how each DM's preferences may have an impact on the overall conflict. Table 4.11 provides the actual historical evolution of the conflict when moving from the status quo on the left via several intermediate states to the final equilibrium on the right. One can clearly see how both Syria and Iraq almost went to war until the third party intervened. It is clear that the actual historical evolution of the conflict is consistent with the earlier analysis.

| **DM** | **Option** | **Status Quo** | | Intermediary states | | **Equilibrium** |
|---|---|---|---|---|---|---|
| **Syria** | Release Water | N | N | N | N | → Y |
| | Escalate | N | N → | Y | Y | → N |
| **Iraq** | Attack | N → | Y | Y | Y | → N |
| **Third Party** | Act | N | N | N → | Y | Y |
| Label | | 1 | 4 | 6 | 12 | 8 |

Table 4.11: Historical evolution of the 1975 conflict

## 4.3 Strategic Investigation of the 1998 Controversy

The DMs and options for the 1998 conflict are given in Table 4.12. Turkey has two options: escalate the situation against Syria or carry out a full invasion. Syria has two options of stopping its support for the PKK or escalating the situation. The third party, Egypt, has a single option of acting or not.

| DM | Option | Choice | Description |
|---|---|---|---|
| **Turkey** | Escalate | **Y** | This includes threatening Syria, and massing the troops on the shared border with Syria |
| | | **N** | Do not escalate |
| | Invade | **Y** | This includes an invasion of Syria and the declaration of war |
| | | **N** | Do not attack |
| **Syria** | Stop PKK Support | **Y** | This includes banning of the PKK in Syria and the extradition of PKK leader to Turkey |
| | | **N** | Syria continues to support PKK rebels |
| | Escalate | **Y** | This includes attacks on Turkey and its development projects |
| | | **N** | Do not escalate |
| **Third Party** | Act | **Y** | This includes mediation and reconciliation between the two countries of Turkey and Syria. |
| | | **N** | Do not intervene |

Table 4.12: DMs, options and descriptions for the 1998 conflict

The set of feasible states is provided in Table 4.13. Note that there is one infeasible situation in which Syria can both ban PKK and escalate at the same time (mutually exclusive options). Also notice that state 9 is an indistinguishable state if Turkey decides to invade Syria, since a full scale war will occur and the game will end. Because the third party played an Arbitrator role in this conflict, the situation in which it acts and Syria does not ban the PKK, is removed. The remaining possible states or scenarios are provided in Table 4.13. Figure 4.4 shows the Integrated Graph Model of the conflict.

| DM | Option | States | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Turkey** | Escalate | N | Y | N | Y | N | Y | N | Y | -- |
| | Invasion | N | N | N | N | N | N | N | N | **Y** |
| **Syria** | Ban PKK | N | N | Y | Y | N | N | Y | Y | -- |
| | Escalate | N | N | N | N | Y | Y | N | N | -- |
| **Third Party** | Act | N | N | N | N | N | N | Y | Y | -- |
| Label | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

Table 4.13: DMs, options and states for the 1998 conflict with the third party

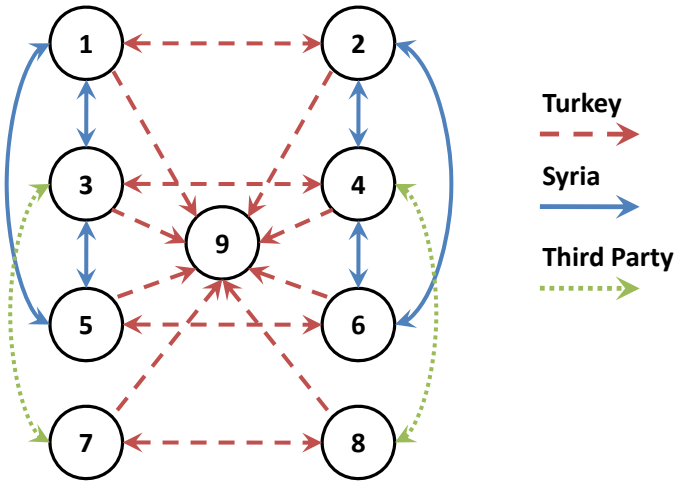


Figure 4.4: Integrated Graph Model of the 1998 conflict with the third party

In this situation, the third party acts as an Arbitrator, since the party has the power to exclude some states (Sakamoto et al., 2005). In this conflict, the third party, Egypt, restricted Syria's move of not banning the PKK if it intervened. Egypt brings to the table legitimacy and extensive experience gained through experience with the conflicts along the Nile basin (Akanda et al., 2007). Syria was united with Egypt under the United Arab Republic (UAR) before Syria declared independence from the UAR in the 1970s. UAR was mostly led by the Egyptian President, Gamal Abdel Nasser. These factors combined to give

Egypt a say in Syria's politics. Table 4.14 presents the preference prioritization information for each DM in the 1998 conflict from most to least preferred. Table 4.15 presents the hierarchical preference statements for Turkey, Syria, and the third party from most to least important. Table 4.16 outlines the analysis results after inputting the foregoing information into GMCR II.

| DM | P# | Preference Information (From most to least preferred) | Further Explanation or Comments |
|---|---|---|---|
| **Turkey** | **1** | Syria stops its support for PKK | |
| | **2** | Escalate the situation if Syria does not ban PKK | |
| | **3** | Invade Syria if and only if Syria does not ban PKK | Turkey's least preferred situation is remaining at the status quo |
| **Syria** | **1** | Remain at the status quo | Syria continues to support the PKK and Turkey does not escalate (However, this move is restricted by the Third Party's intervention) |
| | **2** | Turkey does not invade | Syria's least preferred situation is an invasion by Turkey |
| | **3** | Escalate if Turkey escalates | |
| **Third Party** | **1** | Syria stops its support of PKK and Turkey does not invade Syria | Third Party is against the support of the rebellious PKK and wants to bring peace to the area |

Table 4.14: Preference prioritization information for the 1998 conflict with the third party

| DM | States | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Turkey** | 3 | 7 | 8 | 4 | 6 | 9 | 2 | 1 | 5 |
| **Syria** | 1 | 5 | 7 | 6 | 2 | 3 | 8 | 4 | 9 |
| **Third Party** | 7 | 3 | 8 | 4 | 1 | 2 | 5 | 6 | 9 |
| | *Most Preferred* | | | | | | | | *Least Preferred* |

Table 4.15: Ranking of states for DMs in the 1998 conflict with the third party

| Solution Concepts | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
|---|---|---|---|---|---|---|---|---|---|
| R (Nash) | | | | | | ✓ | ✓ | | ✓ |
| GMR | | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| SMR | | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| SEQ | | | | | | ✓ | ✓ | | ✓ |

Table 4.16: Equilibrium results for the 1998 conflict with the third party

This conflict study shows that Turkey played a more important role than Syria and did not have to use water as a weapon. Moreover, Turkey's superior military power puts it at an advantage, which allowed it to threaten Syria with an invasion, thereby bringing the game to an end. The strongest equilibrium states are 6 and 9 (Table 4.16) in which both Syria and Turkey escalate the situation and Turkey invades eventually if the third party does not act. However, with the mediation of the third party, a new equilibrium came about: state 7 in which the third party acts and Syria bans the PKK. As will be explained in the final section, Syria has been put in a Pareto-inferior situation as it had to give up other things in addition to banning the PKK. The notion of classifying the role of the third party into Arbitrator, Coordinator, and Donor can determine, in advance, how a third party can influence and bring about a potential resolution to the conflict. Table 4.17 shows the actual historical evolution of the 1998 conflict.

| **DM** | **Option** | Status Quo | | | Final Equilibrium |
|---|---|---|---|---|---|
| **Turkey** | Escalate | N → | Y | Y → | N |
| | Invasion | N | N | N | N |
| **Syria** | Ban PKK | N | N | N → | Y |
| | Escalate | N | N → | Y → | N |
| **Third Party** | Act | N | N | N → | Y |
| Label | | 1 | 2 | 6 | 7 |

Table 4.17: Historical evolution of the 1998 conflict

## 4.4 Fundamental Insights

The analyses confirm similar conclusions drawn by Priscoli and Wolf (2009) in their studies of Middle East water conflicts. Firstly, unilateral development of water resources without the coordination and cooperation of other countries sharing the same water recourse may

create conflict. Secondly, if one riparian country holds the geographical and military power, unbiased agreements are difficult to achieve. For example, Turkey is upstream and most of the water originates in its territory. Moreover, it has the most advanced military power (Priscoli and Wolf, 2009), giving it the upper hand in negotiations. As a consequence, Syria ended up in a Pareto-inferior situation because it did not ban the PKK earlier in the conflict which led to the signing of the Adana Agreement. The terms of the agreement include more things Syria has to give up in addition to banning PKK. For instance, Syria accepted Turkish rule over Hatay province, a long disputed land between the two countries. Syria publicly recognized Hatay as a Turkish territory after the Adana agreement, thereby losing two of its playing cards. The third lesson that can be garnered from the case in this paper is the vital role of third party intervention in resolving conflicts.

For the analysis part, the presented conflicts, especially the conflicts in both 1990 and 1998, can be seen as a single evolving conflict. This can serve as a base for methodology development. In addition, a more in-depth analysis could be carried out by mixing various approaches to conflict analysis. For instance, one can carry out hypergame analysis and coalition analysis at the same time for the 1990 conflict.

It is clear that the conflict along the Euphrates River is indeed a complex one. Bilateral and tripartite negotiations continue with mixed success. However, no solid agreement to date has been reached. This paper forms a strong base for carrying out an in-depth analysis of the present situation and determining how the conflict could evolve and what resolution could result in the future.

# Chapter 5

# Modeling Third Party Intervention in Conflict Resolution

## 5.1 Models and Approaches

In order to formally model third party intervention in conflicts, three areas will be investigated, as follows:

1. Inverse approach to conflict resolution: A modeling technique that will allow mediators to choose a desired outcome as equilibrium, and work backwards to achieve it.

2. Inverse status quo analysis: An extension to the previous area that determines whether the desired equilibrium is reachable from the original state.

3. Third party prediction: A tool to analyze conflicts inviting mediation and give insight as to which role a mediator should play to resolve the conflict.

## 5.2 Prediction vs. Negotiation

# Chapter 6

# Inverse GMCR

## 6.1 Overview and Objective

The Graph Model for Conflict Resolution (GMCR) forms an ideal framework to model and analyze conflicts; however, there are challenges to its application, especially in estimating the relative preferences of DMs involved in the conflict. In order to address this problem, the inverse approach to GMCR allows the mediator to determine how a desired resolution to the conflict can arise by generating all possible preferences that achieve it.

The premise of the inverse approach is that the mediator needs a negotiation tool to influence the DMs. To be valuable, this tool should contain information about what motivates each party to undertake the options leading to the resolution desired by the mediator. Therefore, mediators can focus their resources and strategies to guide the parties toward preferences that lead to the desired resolution. This tool is not just useful to third

parties; actual stakeholders can take advantage of it to influence their opponent(s).

The current GMCR framework, which forms the basis for the inverse approach, requires preference ranking information that may not be easy to obtain. The inverse approach introduces a modeling approach that requires minimal preference ranking information up front. A desired resolution, or equilibrium, is decided and a list of preference ranking information leading to the resolution is generated. Thus the inverse approach utilizes GMCR as a negotiation tool rather than a prediction tool.

The main objectives of the inverse approach to GMCR are the following:

- Allow a third party to determine a desired resolution and understand how to achieve it
- Produce strategic information that will help mediators to influence the DMs involved in the conflict
- Give a range of preference rankings that measures the robustness of the conflict resolution

In contrast, the current GMCR methodology informs the user only about the possible resolution of a conflict based on the input preferences. This approach explains how this resolution can be reached. Although this approach is motivated by the need to facilitate third party intervention, other DMs involved in the conflict can also make use of it. This approach will allow for strategic negotiation based on tactical information to achieve a desired outcome.

## 6.2 Basic Implementation

The main difference between the inverse approach and the standard GMCR procedure is in the order of steps. The diagram in Figure 3.1 illustrates the current procedure for applying GMCR in the real world. A modified version of the graph, shown in Figure 6.1, illustrates how to apply the inverse approach to GMCR. The original procedure requires the following inputs for the conflict to be analyzed: (1) decision makers (DMs), (2) options for each DM, and (3) preference rankings of the states for each DM (Fang et al., 1989, 1993). On the other hand, the inverse approach will not require the ranking of states for all DMs. Its requirements are: (1) DMs, (2) options for each DM, (3) desired equilibrium, and (4) stability definition. The result will be a list of possible state rankings that will make the desired resolution stable under the selected stability definition.

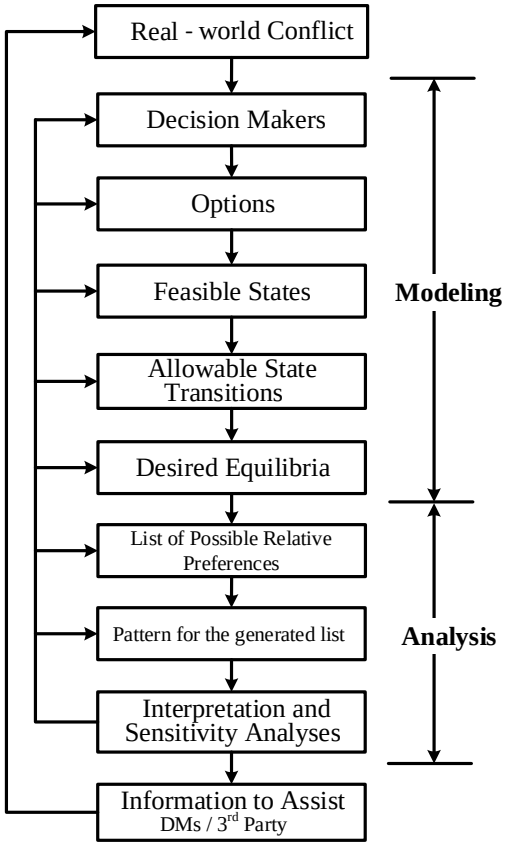


Figure 6.1: The inverse approach to GMCR procedure in a real world conflict (modified from Fang et al. (1993))

In order to formally define the *inverse approach to GMCR*, we need to furnish some definitions and notation.

**Definition 6.2.1.** Let $N = \{1, 2, \ldots, n\}$ represent the set of DMs and $S = \{s_1, s_2, ..., s_m\}$ represent the set of feasible states in a graph model. The ordinal payoff vector of DM $i$, denoted by $P_i$, is

$$p^i = P_i = (p_1^i, p_2^i, \ldots, p_m^i), \quad P_i \in \mathbb{R}^m$$

If $s_a, s_b \in S$, then DM $i$ prefers $s_a$ to $s_b$ or is indifferent ($s_a \succsim_i s_b$) *iff* $p_a^i \geq p_b^i$. An equivalent notation is

$$P_i(s_j) = p_j^i$$

so that $s_a \succsim_i s_b$ *iff* $P_i(s_a) \geq P_i(s_b)$

For example, if $P_i = (5, 0, 6, 2, 6)$ then the ordinal payoff value for DM $i$ for state 1 is equal to 5. Thus, $P_i(s_1) = 5, P_i(s_2) = 0, P_i(s_3) = 6, P_i(s_4) = 2$, and $P_i(s_5) = 6$. Because preferences are assumed to be transitive, the payoff vector can be translated into a preference profile. A preference ranking for DM $i$ is a list of feasible states ordered from most to least preferred for DM $i$. In the previous example, the preference ranking for DM $i$ would be $PR_i = s_3 \sim s_5 \succ s_1 \succ s_4 \succ s_2$.

Note that the same preference ranking can be represented by many different ordinal payoff vectors. Two such ordinal payoff vectors are called equivalent.

**Definition 6.2.2.** If $p^i \in \mathbb{R}^m$ is a preference vector for DM $i \in N$, then $(p^1, p^2, \ldots, p^n) \in \mathbb{R}^{mn}$ is a preference profile.

The inverse approach will be defined using both preference vectors and preference profiles. In the graph model, analysis means finding all equilibria given a preference profile. In the inverse approach, the problem is to find all preference profiles under which a given state is an equilibrium under a selected stability definition. After the introduction of preference profiles, a graph model can be denoted $G = \langle N, S, P \rangle$ where $N$ is the list of DMs $N = \{1, \ldots, n\}$, $S$ is the set of feasible states $S = \{1, \ldots, m\}$, and $P$ is the preference profile $P \in \mathbb{R}^{mn}$.

The *inverse problem* for a desired equilibrium state $s_E \in S$ is to find all $p \in \mathbb{R}^{mn}$ such that state $s_E$ is stable for all DMs if the preference profile is $p$.

**Inverse Nash problem for $s_E$:** Find $p \in \mathbb{R}^{mn}$ such that $s_E \in Nash(G)$ where $G = \langle N, S, P \rangle$

**Inverse SEQ problem for $s_E$:** Find $p \in \mathbb{R}^{mn}$ such that $s_E \in SEQ(G)$ where $G = \langle N, S, P \rangle$

**Inverse GMR problem for $s_E$:** Find $p \in \mathbb{R}^{mn}$ such that $s_E \in GMR(G)$ where $G = \langle N, S, P \rangle$

**Inverse SMR problem for $s_E$:** Find $p \in \mathbb{R}^{mn}$ such that $s_E \in SMR(G)$ where $G = \langle N, S, P \rangle$

A more formal definition according to each solution concept will follow.

### 6.2.1 Algorithm for extensive enumerations

In order to implement the inverse approach, two approaches were investigated. The first one was the brute-force method. As the name suggests, this method tests each possible preference profile for each DM against the desired equilibrium. Since the number of possible preference rankings is fairly large, a decision support system was designed to test the concept. The number of iterations required for a model, assuming strict ordinal preferences, is given by $(m!)^n$ where $m$ is the number of feasible states and $n$ is the number of DMs. If the combination of preference vectors for all DMs (i.e. preference profile) achieves the desired equilibrium, it will be saved into a list. The second algorithm was designed after observing

the pattern produced by the brute-force method. It was clear that results followed certain rules which can be defined more formally, as outlined in the following subsections.

## 6.3 Advanced Implementation

### 6.3.1 Patterns

### 6.3.2 Inverse Nash Equilibrium

**Definition 6.3.1.** State $s_E$ is a Nash equilibrium $iff$ $p_i(s) \leq p_i(s_E)$ for all $i \in N$ and all $s \in R_i(s_E)$

Thus, the inverse approach should produce all preference profiles that make the desired state $s_E$ a Nash equilibrium. For illustration, the inverse approach list according to preference profiles (or payoff vectors), denoted by $IPV(s_E)$, is shown in fig 6.2. Note that each of the $T$ rows is a preference profile which is a combination of preference vectors that will make state $s_E$ stable for all DMs. The possible number of profiles is denoted by $T$.

Note that ${}^h p_j^i$ is player $i$'s ordinal payoff for state $j$ in profile $h$.

$$IPV(s_E) = \begin{Bmatrix} [{}^1p_1^1, {}^1p_2^1, \ldots, {}^1p_m^1] & [{}^1p_1^2, {}^1p_2^2, \ldots, {}^1p_m^2] & \cdots & [{}^1p_1^n, {}^1p_2^n, \ldots, {}^1p_m^n] \\ [{}^2p_1^1, {}^2p_2^1, \ldots, {}^2p_m^1] & [{}^2p_1^2, {}^2p_2^2, \ldots, {}^2p_m^2] & \cdots & [{}^2p_1^n, {}^2p_2^n, \ldots, {}^2p_m^n] \\ \vdots & \vdots & \ddots & \vdots \\ [{}^Tp_1^1, {}^Tp_2^1, \ldots, {}^Tp_m^1] & [{}^Tp_1^2, {}^Tp_2^2, \ldots, {}^Tp_m^2] & \cdots & [{}^Tp_1^n, {}^Tp_2^n, \ldots, {}^Tp_m^n] \end{Bmatrix}$$

Figure 6.2: Representation of the inverse preference profiles list for state $s_E$

**Definition 6.3.2.** A *Nash* $IPV(s_E)$ is a list of preference profiles, $p \in \mathbb{R}^{mn}$, where in each profile, for all $i \in N$, all $q \in R_i^+(s_E)$ satisfies $P_i(q) \leq P_i(s_E)$.

### 6.3.3 Inverse SEQ Equilibrium

**Definition 6.3.3.** An *SEQ* $IPV(s_E)$ is a list of preference profiles, $p \in \mathbb{R}^{mn}$, such that for each state $q \in R_i^+(s_E)$ in the preference profile, there exists at least one state $k \in R_{N-i}^+(q)$ satisfying $P_i(k) \leq P_i(s_E)$ for all $i \in N$

In other words, the combination of payoff vectors must ensure that for each UI a DM can take, there exists at least one sanction that will put the original player in a less preferred state. Please note that the notation $N - i$ means all DMs other than $i$.

### 6.3.4 Inverse GMR Equilibrium

**Definition 6.3.4.** A *GMR* $IPV(s_E)$ is a list of preference profiles, $p \in \mathbb{R}^{mn}$, such that for each state $q \in R_i^+(s_E)$ in the preference profile, there exists at least one state $k \in R_{N-i}(q)$ satisfying $P_i(k) \leq P_i(s_E)$ for all $i \in N$

### 6.3.5 Inverse SMR Equilibrium

**Definition 6.3.5.** An *SMR* $IPV(s_E)$ is a list of preference profiles, $p \in \mathbb{R}^{mn}$, such that for each state $q \in R_i^+(s_E)$ in the preference profile, there exists at least one state $k \in R_{N-i}(q)$ satisfying $P_i(k) \leq P_i(s_E)$ and all $h \in R_i(k)$ satisfy $P_i(h) \leq P_i(s_E)$ for all $i \in N$

## 6.4 Inverse GMCR Coalitions

## 6.5 Inverse GMCR Goals Technique

## 6.6 Example

In order to illustrate the inverse approach, the example in section 4 will now be analyzed using the inverse approach. A desired state is chosen to be the resolution of the conflict. The desired state is state 2, in which both Syria and Iraq stop escalating and water is released to Iraq (Table 4.3). Because the mediator is aiming to influence Syria, the preference ranking for Iraq will be considered fixed (Table 4.6). The objective is to assist the third party at influencing Syria and choosing the best strategy to achieve the desired resolution. For this example, the decision support system was used to execute the inverse approach. The findings indicate that 240 possible preference profiles can achieve the desired resolution. After analyzing these results, two meaningful patterns were identified that lead the conflict to the desired equilibrium:

- If Syria has state 2 as the most preferred state (Nash Stability)
- If and only if Syria prefers states 4, 5, or 6 to state 2 (Sequential Stability)

In other words, state 2 will be the resolution to the conflict if and only if (1) Syria prefers not to escalate or (2) being attacked by Iraq is less preferred for Syria. Having this strategic information could be vital to the mediators as they focus their efforts on

influencing Syria to change its preference rankings. Consequently, the final outcome of the conflict will change.

# Chapter 7

# Comprehensive Decision Support System

The introduction of the inverse approach makes the need for a decision support system obvious. Solving problems by hand is possible but tiresome, time consuming, and error-prone. First, a code to test each preference profile was developed. This is called the Brute-Force method The matrix approach to GMCR allows for faster processing (Xu et al., 2007; Xu, 2009). The last decision support system, GMCR II, was developed by Xiaoyoung (John) Peng back in 1999 (Peng, 1999). Until recently, no significant update was made to the decision support system, even though, the program had issues that sometimes caused it to crash or display error messages. A project to combine both the logical and matrix approaches into a more robust and flexible decision support system was initiated by Oskar Petersons and Rami Kinsara under the supervision of Prof. Keith Hipel and Prof. D. Marc

Kilgour. The objective of this system is to overcome the limitations in the previous version and also add new extensions and capabilities that it did not support. A main objective of the new system is to include the inverse approach methodology. An important feature of the software is the ability to narrate the output results. More extensions and features are planned.

## 7.1 Conflict Specification

### 7.1.1 Option Objects

**Option Name**

**Reversibility**

### 7.1.2 Condition Objects

### 7.1.3 Infeasible Conditions

### 7.1.4 DM Objects

**DM Name**

**Options Controlled**

**Preference**

## 7.2 Conflict Data Processing

### 7.2.1 Removing Infeasible States

### 7.2.2 Preference Prioritization

### 7.2.3 Direct Ranking Handling

### 7.2.4 Reachability Matrix



## 7.3 Analysis Engines and Output

**Logical Solution**

# Chapter 8

# Conclusions

In addition to the methodologies presented in this proposal, several important topics are outlined in the following sections and will be investigated. These topics fall within third party modeling in conflict resolution. Various third party roles and strategies are investigated and presented in Chapter 2 of this proposal. A methodology is needed to determine the best role and strategy that a mediator should undertake in any particular conflict situation. The motivation to introduce such a methodology is to operationalize the notion of third party intervention.

Although basic features of the inverse approach are outlined in this proposal, further enhancements are planned to extend the capability and usefulness of the methodology. One area being studied is the development of a cost and payoff extension to the inverse approach to GMCR. This feature will allow for narrowing down the list of possible profiles and will allow for more relevant and meaningful results.

An inverse approach to determine the required starting points in order to attain desired equilibria will be investigated. This will be achieved by tracking the evolution of the conflict backward from a desired equilibrium to the status quo states.

As mentioned earlier, with the introduction of the inverse approach, a more in-depth model for sensitivity analysis that determines the robustness of any equilibrium by outlining the range of preference profiles in a conflict will be put forward.

Work has already started on a new decision support system using both the logical and matrix approaches for GMCR calculations. The new decision support system has the capability to perform basic inverse approach calculations using the definitions presented herein. In addition, the software will have the capability to perform regular and inverse status quo analysis. It should be noted that extensions made to the graph model for conflict resolution can be easily embedded into the new decision support system.

In order to better understand and appreciate the insights of the proposed methodologies, real world examples will be analyzed and investigated. The intention is to apply the methodologies to different conflict types, including political, environmental, and business conflicts. The research goals and approximate completion dates are summarized and outlined in Table 8.1 below.

| Research Milestone | Scheduled Completion |
|---|---|
| The presentation of the comprehensive report. This include the research objectives and a detailed clarification of the work that should be completed during my PhD degree | May, 2013 |
| Fine-tune the methodology for the inverse approach to GMCR and apply it to different examples. This also include submitting a journal paper about the subject | September, 2013 |
| Develop a cost and payoff extension to the inverse approach to GMCR and submit a paper about the subject | December, 2013 |
| Develop a tool to operationalize and determine the best role and strategy for mediators to undertake in different conflict situations | February, 2014 |
| Develop an inverse approach status quo analysis methodology | April, 2014 |
| Establish a framework for in-depth sensitivity analysis allowing for preference profile ranges using the inverse approach | May, 2014 |
| Submitting papers about each methodology after applying them to different real world conflicts | Ongoing |
| Seminar presentation | October, 2013 |
| Thesis writing and completion | September, 2014 |

Table 8.1: Research Milestones and Schedule

# References

Akanda, A., Freeman, S., and Placht, M. (2007). The tigris-euphrates river basin: Mediating a path towards regional water stability. *The Fletcher School Journal for issues related to Southwest Asia and Islamic Civilization, Spring 2007*.

Bartunek, J. M., Benton, A. A., and Keys, C. B. (1975). Third party intervention and the bargaining behavior of group representatives. *Journal of Conflict Resolution*, 19(3):532–557.

Bashar, M. A., Kilgour, D. M., and Hipel, K. W. (2012). Fuzzy preferences in the graph model for conflict resolution. *Fuzzy Systems, IEEE Transactions on*, 20(4):760–770.

Bercovitch, J., Anagnoson, J. T., and Wille, D. L. (1991). Some conceptual issues and empirical trends in the study of successful mediation in international relations. *Journal of Peace Research*, pages 7–17.

Bercovitch, J. and Gartner, S. (2006). Is there method in the madness of mediation? some lessons for mediators from quantitative studies of mediation. *International Interactions*, 32(4):329–354.

Bercovitch, J. and Gartner, S. S. (2009). New approaches, methods, and findings in the study of mediation. *International Conflict Mediation: New Approaches and Findings*, pages 1–15.

Bercovitch, J. and Rubin, J. (1992). *Mediation in international relations: Multiple approaches to conflict management.* St. Martin'S Press, Inc.

Bercovitch, J. and Schneider, G. (2000). Who mediates? the political economy of international conflict management. *Journal of Peace Research*, 37(2):145–165.

Bercovitch, J. and Wells, R. (1993). Evaluating mediation strategies. *Peace & Change*, 18(1):3–25.

Carment, D. and James, P. (1996). Two-level games and third-party intervention: Evidence from ethnic conflict in the balkans and south asia. *Canadian Journal of Political Science*, 29(03):521–554.

Carnevale, P. J. and De Dreu, C. K. (2005). Laboratory experiments on negotiation and social conflict. *International Negotiation*, 10(1):51–66.

Dixon, W. J. (1996). Third-party techniques for preventing conflict escalation and promoting peaceful settlement. *International Organization*, 50(04):653–681.

Fang, L., Hipel, K. W., and Kilgour, D. (1989). Conflict models in graph form: Solution concepts and their interrelationships. *European Journal of Operational Research*, 41(1):86 – 100.

Fang, L., Hipel, K. W., and Kilgour, D. M. (1993). *Interactive decision making: The graph model for conflict resolution*. Wiley New York.

Fang, L., Hipel, K. W., Kilgour, D. M., and Peng, X. (2003a). A decision support system for interactive decision making-part i: model formulation. *Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on*, 33(1):42–55.

Fang, L., Hipel, K. W., Kilgour, D. M., and Peng, X. (2003b). A decision support system for interactive decision making-part ii: analysis and output interpretation. *Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on*, 33(1):56–66.

Fisher, R. (2001). Methods of third-party intervention.

Frenken, K. et al. (2009). Irrigation in the middle east region in figures aquastat survey-2008. *Water Reports*, (34).

Güner, S. (1998). Signalling in the turkish-syrian water conflict. *Conflict Management and Peace Science*, 16(2):185–206.

Hipel, K., Kilgour, D., and Abul Bashar, M. (2011). Fuzzy preferences in multiple participant decision making. *Scientia Iranica*, 18(3):627–638.

Hipel, K., Kilgour, D., and Kinsara, R. (2013). Strategic investigations of water conflicts in the middle east. *Group Decision and Negotiation*, pages 1–22.

Hipel, K. W., Marc Kilgour, D., Fang, L., and Peng, X. J. (1997). The decision support system gmcr in environmental conflict management. *Applied Mathematics and Computation*, 83(2):117–152.

Inan, Y. (2000). The law of international water courses and the middle east. *J. Intl. Aff.*, 5:2.

Inohara, T. (2011). Majority decision making and the graph model for conflict resolution. *Systems Man and Cybernetics (SMC), 2011 IEEE International Conference on*, pages 2702–2070.

Inohara, T. and Hipel, K. W. (2008a). Coalition analysis in the graph model for conflict resolution. *Systems Engineering*, 11(4):343–359.

Inohara, T. and Hipel, K. W. (2008b). Interrelationships among noncooperative and coalition stability concepts. *Journal of Systems Science and Systems Engineering*, 17(1):1–29.

Jehn, K. A. (1997). A qualitative analysis of conflict types and dimensions in organizational groups. *Administrative science quarterly*, pages 530–557.

Kalpakian, J. (2004). *Identity, conflict and cooperation in international river systems*. Ashgate Pub Limited.

Kilgour, D., Hipel, K. W., and Fang, L. (1987). The graph model for conflicts. *Automatica*, 23(1):41 – 55.

Kilgour, D. M., Fang, L., and Hipel, K. W. (1996). Negotiation support using the decision support system gmcr. *Group decision and negotiation*, 5(4):371–383.

Kilgour, D. M. and Hipel, K. W. (2005). The graph model for conflict resolution: past, present, and future. *Group Decision and Negotiation*, 14(6):441–460.

Kolars, J. F. and Mitchell, W. A. (1991). *The Euphrates River and the Southeast Anatolia Development Project: Water: the Middle East Imperative*. Southern Illinois University Press.

Lewicki, R. J., Weiss, S. E., and Lewin, D. (1992). Models of conflict, negotiation and third party intervention: A review and synthesis. *Journal of Organizational Behavior*, 13(3):209–252.

Li, K. W., Hipel, K. W., Kilgour, D. M., and Fang, L. (2004a). Preference uncertainty in the graph model for conflict resolution. *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on*, 34(4):507–520.

Li, K. W., Hipel, K. W., Kilgour, D. M., and Noakes, D. (2005). Integrating uncertain preferences into status quo analysis with applications to an environmental conflict. *Group Decision and Negotiation*, 14(6):461–479.

Li, K. W., Kilgour, D. M., and Hipel, K. W. (2004b). Status quo analysis in the graph model for conflict resolution. *Journal of the Operational Research Society*, 56(6):699–707.

Morris, M. E. (1997). Water and conflict in the middle east: Threats and opportunities. *Studies in conflict & terrorism*, 20(1):1–13.

Murray, J. S. (1983). Third-party intervention: Successful entry for the uninvited. *Alb. L. Rev.*, 48:573.

Peng, J. (1999). A decision support system for conflict resolution.

Prein, H. (1987). Strategies for third party intervention. *Human Relations*, 40(11):699–719.

Priscoli, J. D. and Wolf, A. T. (2009). *Managing and transforming water conflicts*. Cambridge University Press.

Raiffa, H. (1982). *The art and science of negotiation*. Belknap Press.

Regan, P. M. (1996). Conditions of successful third-party intervention in intrastate conflicts. *The Journal of Conflict Resolution*, 40(2):pp. 336–359.

Rubin, J. Z. (1980). Experimental research on third-party intervention in conflict: Toward some generalizations. *Psychological Bulletin*, 87(2):379.

Sakamoto, M., Hagihara, Y., and Hipel, K. W. (2005). Coordination process by a third party in the conflict between bangladesh and india over regulation of the ganges river. In *Systems, Man and Cybernetics, 2005 IEEE International Conference on*, volume 2, pages 1119–1125. IEEE.

Siqueira, K. (2003). Conflict and third-party intervention. *Defence and Peace Economics*, 14(6):389–400.

Walker, S., Hipel, K. W., and Inohara, T. (2008). Attitudes and coalitions within brownfield redevelopment projects. In *Systems, Man and Cybernetics, 2008. SMC 2008. IEEE International Conference on*, pages 2901–2906. IEEE.

Xu, H. (2009). Matrix representations and extension of the graph model for conflict resolution. *PhD Thesis*.

Xu, H., Hipel, K. W., and Kilgour, D. M. (2007). Matrix representation of conflicts with

two decision-makers. In *Systems, Man and Cybernetics, 2007. ISIC. IEEE International Conference on*, pages 1764–1769. IEEE.

Young, O. R. (1972). Discussions and reviews: Intermediaries: additional thoughts on third parties. *Journal of Conflict Resolution*, 16(1):51–65.