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Perceptual Graph Model Systems

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Abstract Theoretical structures are developed to account for the impact of emotion and perception in strategic conflict. In particular, the possibility principle facilitates modeling the effects of emotions on future scenarios contemplated by decision makers, while perceptual graph models and the associated graph model system permit the decision makers to experience and view the conflict independently. These new theoretical advances expand current modeling capabilities, thereby furnishing realistic, descriptive models without exacting too great a cost in modeling complexity. Specifically, these developments enhance the applicability of the modeling algorithms within the Graph Model for Conflict Resolution to real-world disputes by integrating emotion and perception, common ingredients in almost all conflicts. To demonstrate that the new developments are practical, an illustrative application to a real-world conflict is presented.

Keywords Graph Model for Conflict Resolution · Graph model system · Perceptual graph models · Possibility principle · Strategic conflict · Emotion

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1 Introduction

Conflicts, ranging from benign differences of opinion to deadly confrontations, inevitably arise whenever human beings interact with one another in the course of managing their daily affairs. Disagreements among individuals over minor issues can easily change into hostile reactions as a result of the way situations are perceived, and the emotional values that are attached. It is no wonder that conflict is often described as omnipresent and emotional.

As an ubiquitous phenomenon, conflict embodies the relational dynamics of adversaries, who perceive the attainability of goals to be undermined by the individual goal-seeking capabilities of others (Obeidi et al. 2005b). Specifically, conflict is driven by the perceived incompatibility of something of relevance, and the interference of others on the achievement of one's goals. As an emotional phenomenon, conflict is a process that commences with the establishment of an issue, and then evolves through stages involving both emotion and strategic choice (Obeidi et al. 2005a,b). It is not surprising that features that characterize conflict also engender negative emotion, which tends to prevail during confrontations in ways that further exacerbate decision makers' perceptions of behavioral possibilities and available outcomes. Hence, conflict is often accompanied with negative emotions such as anger, fear, and frustration (Jones and Bodtker 2001).

Many techniques have been developed to model and analyze conflict: Metagame Theory (Howard 1971), Conflict Analysis (Fraser and Hipel 1984), Hypergame Analysis (Bennett 1977, 1980; Wang et al. 1988), and the Graph Model for Conflict Resolution (Fang et al. 1993). All of these formal conflict analysis methods treat conflict as an interactive decision problem between two or more decision makers (DMs); each DM has preferences over outcomes, which may not be in accord with others' preferences; and each DM has to choose among courses of action to achieve his or her goals. The interdependence of DMs' actions conceives the setting as a multi-party-multi-objective decision making situation, or conflict.

Although it is intuitive that emotion shape and affect the ways DMs conceptualize conflict and the possible resolutions the DMs may adopt, not until recently have emotions been considered in conflict analysis and resolution techniques. In particular, Howard et al. (1992) proposed drama theory as a new approach that recognizes the importance of emotions in conflict. However, in drama theory emotions are the result of dilemmas facing the DMs at the moment of declaring their positions. Hence, in drama theory emotions in a conflict model may not be treated realistically (Inohara 2000). The stance taken in this research is that emotions are inherent in conflict and must, therefore, be included in a conflict model (Obeidi et al. 2005b).

Accordingly, the development of formal methodologies to address complex decision problems and disputes in a way that takes into account how DMs conceptualize events in relation to their environment and how they emotionally react and respond to these events is crucial in building realistic models of conflict, thereby providing better predictions and resolutions. To account for the effects of emotion in strategic conflict, the possibility principle was introduced for incorporation into the Graph Model for Conflict Resolution (Obeidi et al. 2003, 2005b, 2006). However, the approach assumes that all DMs have identical viewpoints, which reflect the implicit assumption that all DMs are sympathetic to each others' emotions and thereby have unequivocally identical views of the possible states of the interaction. Hence, this idealization may simplify a graph model embedded with the possibility principle to the extent that its application to real-word conflict is hindered. Generally, emotion engendered in conflict may impair a DM's tendency to identify with opponents and his or her ability to assess strategy combinations objectively. Hence, it is natural to assume that each DM develops a viewpoint that reflects his or her personal rendition of the conflict. Accordingly, a perceptual graph model was proposed to accommodate this inconsistency in DMs' perceptions (Obeidi et al. 2005a), whereby each DM is assumed to have a private graph which for him or her represents the only graph model for the conflict.

The main objective of this research is to formally define such a perceptual graph model. Another goal is to expand the research of Obeidi et al. (2003, 2005b) by defining a graph model system as a conceptual framework for realistically representing a conflict. In the next sections, the Graph Model for Conflict Resolution and the possibility principle are described. Then, perceptual graph models and the associated graph model systems are formally defined. Finally, the Burnt Church confrontation in the Miramichi Bay, New Brunswick, Canada, is employed to illustrate how the new approach to modeling emotions and perceptions in conflict situations works in practice.

2 The Graph Model for Conflict Resolution

Among the aforementioned methodologies to model and analyze interactive decision problems, the Graph Model for Conflict Resolution (Fang et al. 1993) is probably the simplest and most flexible and therefore most capable of carrying out realistic strategic studies of actual conflict. Within the structure of a Graph Model, the basic ingredients include the DMs, states, and each DM's relative preferences among states. Each DM's possible moves from state to state are modeled using a directed graph in which nodes represent states and arcs indicate state transitions controlled by the DM. A state represents a temporary scenario, and it enables the representation of a DM's available actions as the state-to-state transitions it controls. DMs' interactions are depicted by the evolution of the conflict from a status quo state via DMs' state transitions until some stable state is reached, representing a resolution of the conflict.

A standard graph model can be expressed by a quartet of components:

$$G = [N, S, (A)_{i \in N}, (\succeq_i)_{i \in N}] \tag{1}$$

The set of all DMs is N, where $2 \leq |N| < \infty$. For convenience, assume $N = \{1, 2, \ldots, n\}$. S is the set of states, where $2 \leq |S| < \infty$. An important step in modeling a conflict is identifying actual states that may take place. Hence, the states represent feasible, distinguishable outcomes or scenarios of the conflict, and are thought of as the vertices of each DM's directed graph. One of the states, s_0, is designated as the status quo, or initial state, and the conflict evolves as individual DMs unilaterally cause transitions among states until some final state is reached, which represents a resolution of the conflict. Formally, for each DM $i \in N$, $A_i \subset S \times S = \{(s_1, s_2) : s_1, s_2 \in S, s_1 \neq s_2\}$

is the set of state transitions or arcs controlled by i. For $s_1, s_2 \in S$ and $s_1 \neq s_2$ (i.e., no loops are allowed), (s_1, s_2) is an arc in DM i's directed graph (S, A_i) if DM i can cause, in one step, a transition from state s_1 to state s_2. In this case, s_2 is reachable for i from s_1.

An additional component of a graph model is each DM's preferences among states. A DM's preferences can be expressed in a relative fashion by pairwise comparisons of states, whereby a DM prefers one state more than another or is indifferent between them. In general, for each DM $i \in N$, a complete and reflexive weak preference relation $\succeq_i$ expresses each DM's preferences over S. $\succeq_i$ can be decomposed into a pair of binary relations $\{\succ_i, \sim_i\}$. Conventionally, DM i strictly prefers s_2 to s_1, written $s_2 \succ_i s_1$, if and only if $s_2 \succ_i s_1$ but not $s_1 \succeq_i s_2$. Also, DM i is indifferent between s_2 and s_1, written $s_1 \sim_i s_2$, if and only if $s_2 \succeq_i s_1$ and $s_1 \succeq_i s_2$. These relationships possess the following properties: $\succ_i$ is asymmetric such that for any $s_1, s_2 \in S$, $s_1 \succ_i s_2$ and $s_2 \succ_i s_1$ cannot occur simultaneously; $\sim_i$ is reflexive and symmetric such that for any $s_1, s_2 \in S$, $s_1 \sim_i s_1$, and if $s_1 \sim_i s_2$ then $s_2 \sim_i s_1$; $\{\succ_i, \sim_i\}$ is complete such that for any $s_1, s_2 \in S$, then at least one of $s_1 \succ_i s_2$, $s_2 \succ_i s_1$, or $s_1 \sim_i s_2$ is true.

Preference information can be either transitive or intransitive. Whatever the case, the graph model can be conveniently employed for modeling and analysis. In fact, in real world conflicts relative preference relationships among states are often transitive, which allow expressing DMs' preferences by ranking (ordering) the states for each DM from most to least preferred, where ties are allowed.

In the graph model, G, DM i's graph is the directed graph (S, A_i), and S is common to all DMs. In this sense, the graph model is a directed graph with multiple arcs, in which each arc is labeled with the name of the DM who controls it.

3 The Possibility Principle

In social interactions, people evaluate information not only logically but also with respect to its ability to help achieve personal goals. Recent developments in neurobiology and psychology strongly reveal the inextricable association between brain structures that are responsible for cognitive processes, especially in the ventromedial prefrontal cortex, and structures that are tied to processing emotion in the limbic system (LeDoux 2000; Bechara and Damasio 2005). (The ventromedial prefrontal cortex is an area located in the prefrontal lobe of the brain that is closely associated with structures in the limbic system, such as the amygdala and the hippocampus, which are responsible for processing emotion.) Among others, Bechara and Damasio (2005) believe that reasoning is guided by the emotive evaluation of an action's consequences.

Damasio (1994, 2003) suggests the *somatic marker hypothesis* in which he conjectures that when facing an outcome subsequent to a given choice, the experienced feelings, whether they are pleasant or unpleasant, engender responses in the body proper and the brain. These bodily related responses can be in the internal milieu (fluids in the bloodstream and in the spaces between cells), in the function of the viscera and the central nervous system, and in the musculoskeletal system. Upon experiencing these somatic (from Greek *soma*, i.e., body) states at least once, neural patterns of the feelings are marked and become distinctively associated with the choice that induced these feelings. This alerts the decision maker of consequences linked to negative feelings, and biases him or her toward consequences associated with positive emotions. Accordingly, the somatic markers facilitate decision making by influencing an individual's choices based on their memorized affective values (Damasio 1994, 2003; Bechara and Damasio 2005).

A key postulate in Obeidi et al. (2005a,b) is that central to any conflict are the emotional reactions that occur when opponents endeavor to manage, control, and cope with the situation. As a result, conflict is a *process*, triggered by an event or stimulus and evolves through different stages. In this process, both emotion and reasoning are equally important: emotion influences the conceptualization of the conflict in early stages, while reasoning dominates in later stages. On the other hand, the significance of the somatic marker hypothesis in conflict modeling and analysis arises from the suggestion that emotion has a role in influencing how DMs discern their choices in social interactions. Therefore, to account for the effects of emotion on recognizing outcomes in conflict, the following *possibility principle* is suggested: "Emotions play a central role in determining whether a feasible state is perceived as potential or hidden, reflecting its visibility in the conflict model" (Obeidi et al. 2005b, p. 488).

The possibility principle can be easily incorporated into the modeling stage within the paradigm of Graph Model for Conflict Resolution. Conventionally, in building a standard graph model, identifying the feasible states, S, is based on a reasoning process by contemplating which states are believed to be valid, and hence could actually occur in the conflict. Thus, those states that are infeasible for logical reasons are eliminated from the model. However, building on the somatic marker hypothesis, attention must be focused on feasible states that are not perceived by a DM either due to the presence of negative emotions (these states are labeled as *hidden states*) or the lack of positive emotions (these states are labeled as *potential states*).

As Fig. 1 illustrates, the conventional set of feasible states, S, is partitioned, for each DM $i \in N$, into the three subsets: (1) Hidden states, H_i, which cannot occur due to the presence of negative emotion such as fear and anger. A hidden state is invisible for a DM and a rejected possibility. In other words, negative emotion blocks it; (2) Potential states, P_i, which cannot occur due to the lack of positive emotion necessary to allay concerns and disseminate trust between DMs (Dunn and Schweitzer 2005); (3) Recognized states, S_i, consisting of all states of S not included in H_i or P_i. These states may not be uniformly discernable to all DMs. For instance, as shown later in

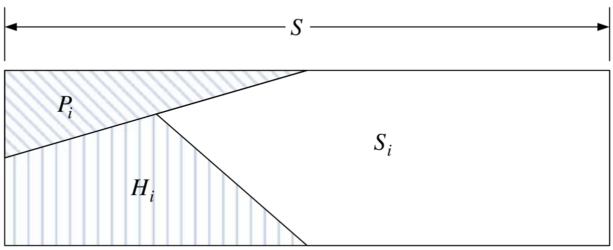

Fig. 1 The possibility principle and identification of the set of recognized states

Fig. 4 different recognized state sets may exist in a conflict model for each DM $i \in N$, depending on which sets are categorized as hidden states or potential states.

Awareness of the presence and causes of emotions in the conflict and an empathetic understanding of their effects on DMs' perceptions provide more realistic and expedient integration of the possibility principle into the Graph Model methodology. To identify states that are reasonable and emotionally harmonious from the point of view of each DM, usually least preferred states are candidates for elimination (Obeidi et al. 2006). This has the effect of restricting the set of feasible states with respect to each DM's perception of the conflict.

Although the suggested classification of the effect of negative and positive emotions on modifying the graph model by restricting the set of recognized states is common in most conflicts, in certain situations a fervid DM may recognize a self-destructive future if it engenders short-term relief with a sense of glorification (Obeidi et al. 2005b). Hence, the presence of intense negative emotion, such as anger, may, in some cases, expand the set of recognized states to include a self-destructive future.

4 Perceptual Graph Models

As mentioned in the previous section, incorporating emotion within the Graph Model methodology requires partitioning the set of states, S, into three subsets: hidden, potential, and recognized. When logically possible states are no longer achievable for one or more DMs due to emotions, the apprehension of a conflict becomes inconsistent, and resolutions may become difficult to predict. Hence, it is appropriate to model the conflict using a perceptual graph for each DM to allow for differences in the DMs' perceptions. In a standard graph model, DMs' graphs are integrated into a unified model. But with inconsistent perceptions, each DM's viewpoint defines an entire conflict model.

The underlying principle of the perceptual graph model system is that the DMs' perceptions must be the basis for analysis. Even when $n = 2$, in addition to the focal DM i and the opponent j, DM k is introduced to keep track of who owns the perceptual graph. Therefore, DM k's set of *recognized states* defines k's *perceptual graph model*, which is generally a private model.

Formally, for each DM $k \in N$, let $S_k \subseteq S$ be k's set of *recognized states*, where S_k is formed by eliminating from S_k's hidden and potential states. Note that S_k reflects k's *perception*—in particular, some states may not be discernible to all DMs in a model. Usually, it is assumed that $S_k \neq \emptyset$, for otherwise DM k would not apprehend that he or she has a stake in the conflict, and thereby $k \notin N$; in fact, it is assumed that $s_0 \in S_k$. Similarly, for DMs $i, k \in N$, define S_i^k as DM k's perception of i's state set, and note that $S_i^k \subseteq S_k$. As a special case, if the focal DM is the owner of the perceptual graph, then $k = i$, so $S_i^i \subseteq S_i$.

For $i, k \in N$, define A_i^k as DM k's perception of i's state transitions. A_i^k consists of the arcs of DM i's directed graph, A_i, which are wholly contained within DM k's set of recognized states. For $k = i$, $A_i^i = A_i$ which represents DM i's arcs contained in S_i. Generally, $A_i^k \subset S_i^k \times S_i^k$, and can be expressed as $A_i^k = \{(s, t) \in A_i : s, t \in S_i^k, s \neq t\}$.

Similarly, for $i, k \in N$, let $\succeq_i^k$ be DM k's perception of i's relative preferences among states. The perceived weak preference relation, $\succeq_i^k$, represents the restriction of $\succeq_i$ on S_k, and expresses i's preference over S_k, as perceived by DM k. $\succeq_i^k$ has the same properties as $\succeq_i$; it is reflexive and complete.

Furthermore, a perceptual graph model has to keep track of what each DM knows. Conclusions drawn from analyzing a perceptual graph model are conditional upon a DM's awareness of opponents' perceptions of his or her set of recognized states. A DM who is aware of others' lack of perception of some states may have an upper hand in the conflict. On the other hand, a DM who is *unaware* of others' lack of perception will be under the impression that his or her model is a standard graph model. An indicator of a DM's awareness will be used to distinguish between these two cases. Specifically, for DM k let α_k be an index that represents DM k's awareness of whether other DMs' inconspicuous states are included in his or her perceptual graph model, as follows:

$$\alpha_k = \begin{cases} 0 & \text{DM } k \text{ is unaware that other DMs} \\ & \quad \text{perceive different graph models.} \\ 1 & \text{DM } k \text{ is aware of others'} \\ & \quad \text{inconspicuous states in } S_k. \end{cases} \tag{2}$$

Consequently, for $i, k \in N$ define DM k's *perceptual graph model* as:

$$G_k = \left[N, \left(S_i^k\right)_{i \in N}, \left(A_i^k\right)_{i \in N}, \left(\succeq_i^k\right)_{i \in N}, \alpha_k\right] \tag{3}$$

where N is a finite set of DMs; $2 \leq |N| < \infty$. S_i^k is DM k's perception of i's states; $S_i^k \subseteq S_k$. A_i^k is DM k's perception of i's transitions among states; $\succeq_i^k$ is DM k's perception of i's preferences, and α_k is DM k's index of awareness.

All DMs' perceptions are accounted for by defining, for every DM in N, a private, perceptual graph. A *graph model system* consists of a list of all DMs' perceptual graph models:

$$\widehat{G} = (G_1, G_2, \ldots, G_k, \ldots, G_n) \tag{4}$$

Each DM may or may not be aware of the presence of inconsistent perceptions. A graph model system, therefore, includes a viewpoint for every DM. A *viewpoint* is the perspective used by a DM in viewing and analyzing the conflict and it reflects the DM's awareness of other DMs' perceptions. DM k's viewpoint marks those states in G_k which are shared with other DMs, and it partitions k's set of recognized states S_k according to recognition by the opponents. Hence, if $\alpha_k = 0$, DM k's viewpoint is S_k such that $S_k = S_i^k$ for all $i \in N$; whereas if $\alpha_k = 1$, DM k's viewpoint is $S^C \cup S_k^P$ such that $S_k \supseteq S_i^k$ for all $i \in N$. Note that S^C is the set of states *commonly perceived* by all DMs, such that $s_0 \in S^C$, and S_k^P is the set of states *private* to DM k. In other words, each DM's viewpoint reflects its personal rendition of the conflict. Hence, in G_k, DM k's viewpoint reflects his or her strategic and behavioral dispositions.

A graph model system compiles all DMs' perceptual graph models, and expresses the perspective used by every DM in viewing and analyzing the conflict. But since a DM may or may not be aware that other graph models differ from his or her own, different variants of graph model systems are required to describe conflicts. Each variant of a graph model system corresponds to a configuration of awareness, which is a set of ordered combinations of DMs' viewpoints. Therefore, a perceptual graph system must be defined for each variant of awareness.

The standard model, G, represents a "realistic," emotionless view, which would apply if perceptions were consistent. It records states, state transitions, and preference information, which are then inherited by the graph model system. Hence, each perceptual graph model in the system is a sub-model that shares some features of the standard graph model. Commonalities among perceptual graph models may be the result of either compassionate or emotionless DMs. In the former case, all DMs share the same view, i.e., $G_1 = G_2 = \cdots = G_n = \widehat{G}$, while in the latter case there is only one underlying standard model.

In general, the way each DM views the conflict may be explained by a mapping process that depends on the DM's temperament. This mapping process may elicit an equally perceived, under-perceived, or over-perceived graph. An emotionless DM has a perceptual graph that is a replica of the standard graph model, whereas an emotional DM's mapping may transpose a standard graph into an under-perceived perceptual graph model. The mapping process in this case is represented by an *emotive mapping function*, ξ. For DM $k \in N$ define ξ_k as the process that maps all information in the standard graph model into DM k's perceptual graph, written as: $G_k = \zeta_k(G)$. Similarly, the emotive mapping function is applied to states ($S_k = \zeta_k(S)$), state transitions $\left(A_i^k = \zeta_k(A_i)\right)$, and preferences $\left(\succeq_i^k = \zeta_k(\succeq_i)\right)$. On the other hand, an attentive DM's mapping process may produce an over-perceived graph that contains more states than the standard graph model. Such a DM may be motivated by an urge for vengeance or altruism. For instance, hatred or ignorance might motivate a terrorist to perpetrate an atrocity even though its outcome might reasonably be deemed infeasible, while a propitiator will attempt to find innovative states in an effort to bring about rapprochement. Next, the Burnt Church confrontation in the Miramichi Bay, New Brunswick, Canada, among the government of Canada, the Mi'kmaq First Nation, and non-native-commercial fishermen over the sharing of a natural resource and fishing rights is used to illustrate the practical application of perceptual graph models and the associated graph model system. Obeidi et al. (2006) delineate a comprehensive outline for this confrontation.

5 Case Study: Burnt Church Conflict

5.1 Background of the Burnt Church Conflict in the Miramichi Bay

In August 1993, the Department of Fisheries and Oceans (DFO) in Canada arrested Donald Marshall, a Mi'kmaq native fisherman from the Burnt Church community of eastern New Brunswick, while he was fishing for eels, and indicted him with three federal offences for violating fisheries regulations. (The Mi'kmaq is a large Algonquian tribe, whose homelands stretch along the East Coast of Canada in Nova Scotia, Cape Breton Island, Prince Edward Island, and New Brunswick.) In a controversial ruling in

September 1999, the Supreme Court of Canada acquitted Mr. Marshall and concluded that according to the Peace and Friendship Treaties of 1760–1761, which was signed between the British Crown and the Mi'kmaq–Maliseet communities, First Nations are entitled to the communal right to pursue a moderate livelihood by hunting, fishing, and trading for food, and for social and ceremonial purposes. Thus, as a Mi'kmaq, Mr. Marshall is supposedly exempted from fisheries regulations.

DFO's Fisheries Act restricts lobster fishing to the spring season when lobsters are of better quality and more profitable (Caddy 2001). But, the Supreme Court of Canada ruling, known as the Marshall Decision, was perceived by the 34 Mi'kmaq bands, and other First Nation bands in Canada, as an assertion to their entitlement to fish and hunt at any time during the year. DFO, for that reason, asked the Supreme Court of Canada to clarify its Marshall Decision ruling, particularly with regards to First Nations entitlement. The Supreme Court of Canada elaborated by stating that First Nations right to fish is not natural but a regulated right, which is sanctioned by DFO in consultation with the First Nations (Supreme Court of Canada 1999a,b).

To control and regulate fisheries in the Miramichi Bay, DFO issued a limited number of fishing licenses in the fall 1999 to native fishers for food, social, and ceremonial purposes, and began bilateral negotiations with different Mi'kmaq bands to control native fisheries according to a new fishing strategy. In addition, DFO offered to sign a one-year agreement with the Mi'kmaq bands that would control and regulate all commercial fisheries in exchange for new fishing boats wharves. Twenty-nine Mi'kmaq bands signed agreements to adhere to DFO's proposed fishing strategy. The Mi'kmaq fishermen of Burnt Church, however, challenged DFO's directives and decided to fish for lobsters in the Miramichi Bay of Brunswick despite a fierce opposition by Canadian non-native fishermen. The Mi'kmaq fishermen issued their own permits and treaty tags to local community members; establishing a full-scale Fall fishery season in defiance of DFO's directives and non-native fishermen's desperate petitions. The Mi'kmaq bands also refused to negotiate an agreement with DFO fearing that would circumvent their perceived inherent right, which is intensified by the Marshall Decision, and they insisted on implementing their own autonomous fishing management plan. Permits and treaty tags issued by the Mi'kmaq were considered unlawful by DFO and local non-native fishermen. However, non-native fishermen whose livelihoods depend on the Miramichi lobster fishery violently confronted the Mi'kmaq fishermen and destroyed many of their traps and fishing equipment. Vandalism on both sides ensued and the Mi'kmaq fishermen clashed with DFO's enforcing officers.

In the spring of 2000, DFO officers led several raids against Mi'kmaq native fishermen's boats in the Miramichi Bay. Active fishing boats that did not carry legal DOF's fishing permits and tags were seized and hundreds of lobster traps were destroyed. Concurrently, for the violent protests in the Miramichi Bay during the fall of 1999, officers from the Royal Canadian Mounted Police (RCMP) arrested several Mi'kmaq from the Burnt Church community and charged them with vandalism and the destruction of public property. No non-natives were arrested in the course of these raids; igniting anger among the Mi'kmaq. A new wave of violence erupted again when DFO terminated the 2000 fall lobster fishery in Miramichi Bay after native fishers had exceeded their quotas of lobsters, which were issued to them exclusively for food, social, and ceremonial purposes. The Burnt Church community was on the brink of large scale violence. Fortunately, a rapid fall in temperatures led to an early offshore lobster migration, ending the fall fishing season prematurely, and diffusing the tension between DFO, the Mi'kmaq, and the non-native fishermen.

As the fishing season in spring 2001 was about to begin, everyone braced for renewed violent confrontations in Miramichi Bay not only between DFO officers, who wanted native fishermen to comply with DFO's regulations, and the Mi'kmaq, who felt they were fighting for their rights; but also between the Mi'kmaq and non-native fishermen, who were economically threatened by the native fishermen's uncontrolled fishing in the Miramichi Bay. Most Mi'kmaq fishermen were angered by the way they were indiscriminately treated and strongly demanded that any new fishery management plan must address their concerns, needs, and historical rights.

5.2 The Standard Graph Model of the Burnt Church Conflict in the Miramichi Bay

It is often convenient to develop a graph model for a conflict by specifying the options (or courses of action) available to each DM. In general, a DM may exercise a strategy by selecting any combination of options it controls, and when every DM selects a strategy, a state (i.e., a distinguishable outcome or scenario) is defined. An option tableau (Howard 1971) is used to record any finite number of DMs, each of whom can have any finite number of options. The model is considered to be in some state, which is expressed in the option tableau as a column of Ys and Ns; where "Y" indicates an option that is selected by the controlling DM, and "N" an option that is not taken. When a DM unilaterally changes its option selection, a state-to-state transition happens, which causes the conflict to evolve. Thus, changes of state are controlled by the DMs. A directed graph is defined for each DM that contains all feasible states (depicted as nodes) and state transitions (depicted as arcs) it controls. Since each DM's graph has the same set of states, it is often convenient to integrate all DMs' directed graphs as one standard graph model and label each arc to indicate the DM who controls it.

In the Graph Model, a particular DM can represent an individual person, a group of people, or an organization. Hence, as of May 1, 2001, there are three major DMs in the Burnt Church conflict as shown in Table 1: the Mi'kmaq fishermen, DFO, and the non-native fishermen. The Mi'kmaq controls two main options: continue fishing without obtaining government-issued fishing licenses in defiance of both DFO and non-native

Table 1 Decision makers and options in the Burnt Church conflict

Decision Makers	Options	Status Quo as of May 1, 2001	
Mi'kmaq			
	1. Continue Fishing	Y	Mi'kmaq's Strategy
	2. Negotiate with DFO	N	
DFO			
	3. Allow Mi'kmaq to Fish	N	DFO's Strategy
	4. Negotiate with Mi'kmaq	Y	
Non-natives			
	5. Confront the Mi'kmaq	N	Non-natives' Strategy

fishermen; and negotiate a favorable agreement that guarantees their inherent right within the spirit of the Peace and Friendship treaties and compensates them with money and fishing equipment in return for accepting DFO's directives with respect to fishery management. On the other hand, DFO has two options: allow the Mi'kmaq fishermen to fish for lobster in the Miramichi Bay with no control according to their own autonomous fishing management plan; and negotiate with the Mi'kmaq. Moreover, the non-natives are also a major stakeholder in this conflict since they are vulnerable to uncontrolled fishing in the Miramichi Bay. They have an option to violently confront the Mi'kmaq fishermen. Table 1 lists the DMs, their options, and the status quo state. The status quo state indicates that at the time the conflict is modeled the Mi'kmaq refuse to negotiate with DFO an agreement for regulating fisheries in the Miramichi Bay and continue fishing for lobster; DFO is not allowing the Mi'kmaq to illegally fish while attempt to convince the Mi'kmaq to negotiate a binding agreement for the control of fishing practices in the Bay. Non-natives, meanwhile, are not confronting the Mi'kmaq.

Since an option can be taken or not by each DM, there might be $32(2^5)$ mathematically defined states in the Burnt Church conflict; but substantive logical reasons may restrict some option combinations, which means that they are unlikely to happen or infeasible. When these option combinations are specified, the remaining feasible states represent the actual set of states that may take place in the conflict. In the Burnt Church conflict model, 17 option combinations are removed from the model because they are either mutually exclusive or dependent. If the Mi'kmaq decide not to fish, non-natives will not select their option of confronting the Mi'kmaq. Also, DFO will select the negotiation option if Mi'kmaq are willing to negotiate. Finally, DFO will not allow the Mi'kmaq to fish or offer to negotiate if the Mi'kmaq voluntarily decide to follow DFO's directives. Table 2 shows the remaining 15 feasible states, $S = \{1, 2, 3, \ldots, 15\}$; as noted, state 4 is the status quo state at the time of modeling the conflict.

Figure 2 is the standard graph model in the Burnt Church conflict. The arcs represent the unilateral moves by each DM from one state to another. The notation on the arcs indicates the DM who controls the state-to-state transitions by changing its option selections. For instance, DFO controls state transitions from the status quo, state 4, to states 2, 3, and 7. Mi'kmaq control state transition from state 4 to states 5 and 6; while non-native control state transition from state 4 to state 12.

Table 2 Feasible states in the Burnt Church conflict

Decision makers	States														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mi'kmaq															
1. Continue fishing	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
2. Negotiate with DFO	N	N	N	N	Y	Y	N	Y	Y	N	N	N	Y	N	Y
DFO															
3. Allow Mi'kmaq to fish	N	N	Y	N	N	N	Y	Y	Y	N	Y	N	N	Y	Y
4. Negotiate with Mi'kmaq	N	N	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y
Nonnatives															
5. Confront the Mi'kmaq	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y

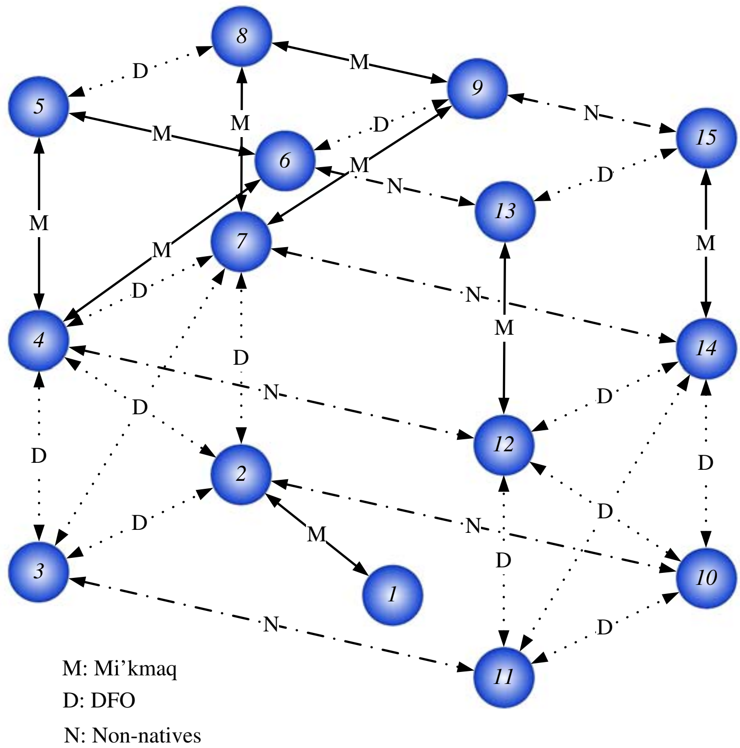

Fig. 2 The standard graph model for the Burnt Church conflict

5.3 Perceptual Graph Models for the Burnt Church Conflict

The Mi'kmaq fishermen's strong feelings of entitlement to harvest, at will, natural resources for food, social and ceremonial purposes along with non-native fishermen's deep-seated feelings of unfairness as a result of the apparent federal government's appeasement of First Nations' demands, make the stakes very high and imbue this conflict with fervent negative emotions. The Mi'kmaq native band, for instance, viewed the Marshall Decision as an assertion to their historical and inherited rights to gather products to sustain a moderate livelihood. They perceived the government's interpretation of the Supreme Court of Canada's ruling as a transgression of their rights. They also viewed DFO's directives to terminate their fishery in fall 2000 both discriminatory and insulting; and thus they were very angry (Caddy 2001). On the other hand, although non-native fishermen's livelihoods were equally affected by the ruling, the government did not offer them compensations at all comparable to those that were offered to the Mi'kmaq fishermen. They felt disenfranshised from DFO–Mi'kmaq discussions, and were very angered by the Mi'kmaq's uncontrolled lobster fishery without obtaining the proper fishing licenses.

For this emotion-laden conflict, the possibility principle (Obeidi et al. 2005b) is used to account for the effects of emotion on DMs' perceptions of particular outcomes

Table 3 Emotion-based option tableau for the Burnt Church conflict

Decision makers	Feasible States														
	Hidden and potential														
	Mi'kmaq		Non-natives				Recognized								
	1[a]	5[b]	3[a]	7[a]	8[a]	9[a]	2	4	6	10	11	12	13	14	15
Mi'kmaq															
1. Continue fishing	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Negotiate with DFO	N	Y	N	N	Y	Y	N	N	Y	N	N	N	Y	N	Y
DFO															
3. Allow Mi'kmaq to fish	N	N	Y	Y	Y	Y	N	N	N	N	Y	N	N	Y	Y
4. Negotiate with Mi'kmaq	N	Y	N	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y
Non-natives															
5. Confront the Mi'kmaq	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y

[a] Hidden states
[b] Potential states

by eliminating hidden or potential states that are not readily noticeable. Least preferred states for a particular DM, though logically valid, are often candidate states to be removed. Accordingly, the set of feasible states in Table 2 is further reduced, as shown in Table 3, by identifying the set of potential and hidden states for both the Mi'kmaq and non-native fishermen. For the Mi'kmaq, the Marshall Decision was a tipping point that emphasized their treaty right to fish and which they can use in negotiation with DFO as a leverage. Thus, state 1, although logically feasible, is hidden from the Mi'kmaq. Moreover, state 5 is a potential state that could become visible if DFO addressed their treaty-right concerns and non-native fishermen stopped harassing them. On the other hand, states 3, 7, 8, and 9 are hidden states from the point of view of non-native fishermen since they believe that uncontrolled fishing in the Miramichi Bay is going to directly affect their ability to sustain their livelihood. Emotion, therefore, causes the Mi'kmaq and non-native fishermen to have different emotive mapping functions, which causes inconsistency in their perception of the conflict.

As shown in Fig. 3, the Mi'kmaq's emotive mapping function, ζ_M, maps the feasible set of states into Mi'kmaq's set of recognized states, $S_M = \{2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15\}$. Non-natives' emotive mapping function, ζ_N, excludes states 3, 7, 8, and 9, which creates the non-natives' perceived set of recognized states, $S_N = \{1, 2, 4, 5, 6, 10, 11, 12, 13, 14, 15\}$. Finally, DFO's emotive mapping function, ζ_D, results in the same set of feasible states. Figure 4 shows a perceptual graph model system, which consists of a graph model for each DM. Dimmed nodes and arcs indicate inconspicuous states and their associated state transitions, to the owner of the graph model.

A realistic description of a conflict must take into account the different combinations of DMs' viewpoints. In the Burnt Church conflict, there are three DMs, and each DM is either not aware that other DMs perceive different graph models or aware of others' inconspicuous states in its own set of perceived states. Hence, eight different perceptual graph model systems must be used to describe this conflict. For instance, one of the graph model systems corresponds to a variant of awareness in

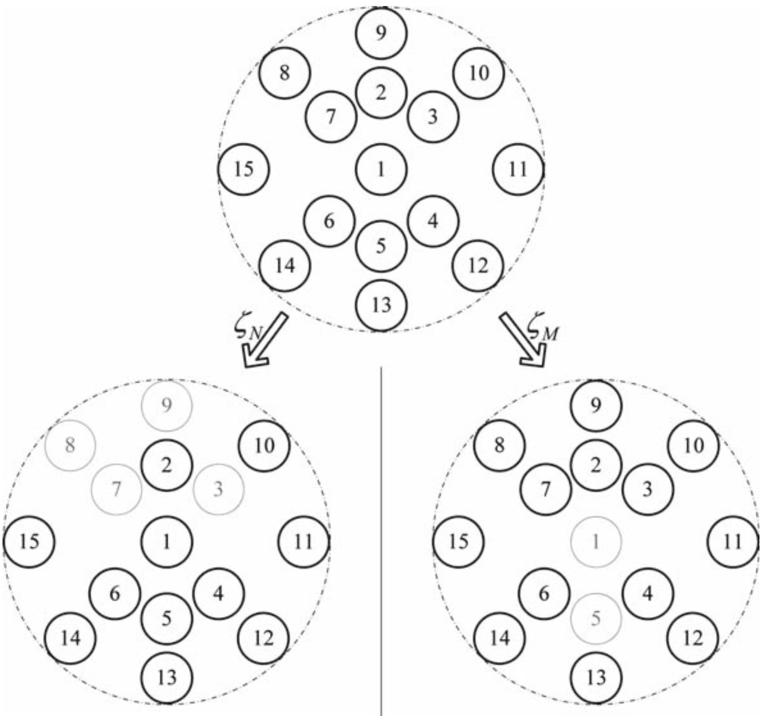

Fig. 3 DMs' emotive mapping functions of states in the Burnt Church conflict

which the three DMs are not aware that they perceive different graph models, i.e., $(\alpha_M, \alpha_D, \alpha_N) = (0, 0, 0)$. At the other extreme, another graph model system corresponds to a variant of awareness in which the Mi'kmaq are aware of states in S_M that are not perceived by DFO and non-natives, DFO is aware of states in S_D that are not perceived by Mi'kmaq and non-natives, and non-natives are aware of states in S_N that are not perceived by Mi'kmaq and DFO, i.e., $(\alpha_M, \alpha_D, \alpha_N) = (1, 1, 1)$.

6 Conclusions

Emotion is unquestionably an essential ingredient in conflict (Obeidi et al. 2005a,b). When DMs have strikingly different value systems, beliefs, or cultures, it is more likely that conflict will be laden with negative emotions, and inconsistencies in perception will prevail among the DMs. The role of emotion and DMs' subjective apprehensions of the underlying problem, therefore, must be incorporated with strategic analysis of the underlying decision problem. Consider, for instance, the military confrontation, which ensued in July 2006, between Hezbollah fighters based in southern Lebanon and Israel. Apparently, fear and anger drive the struggle between the parties.

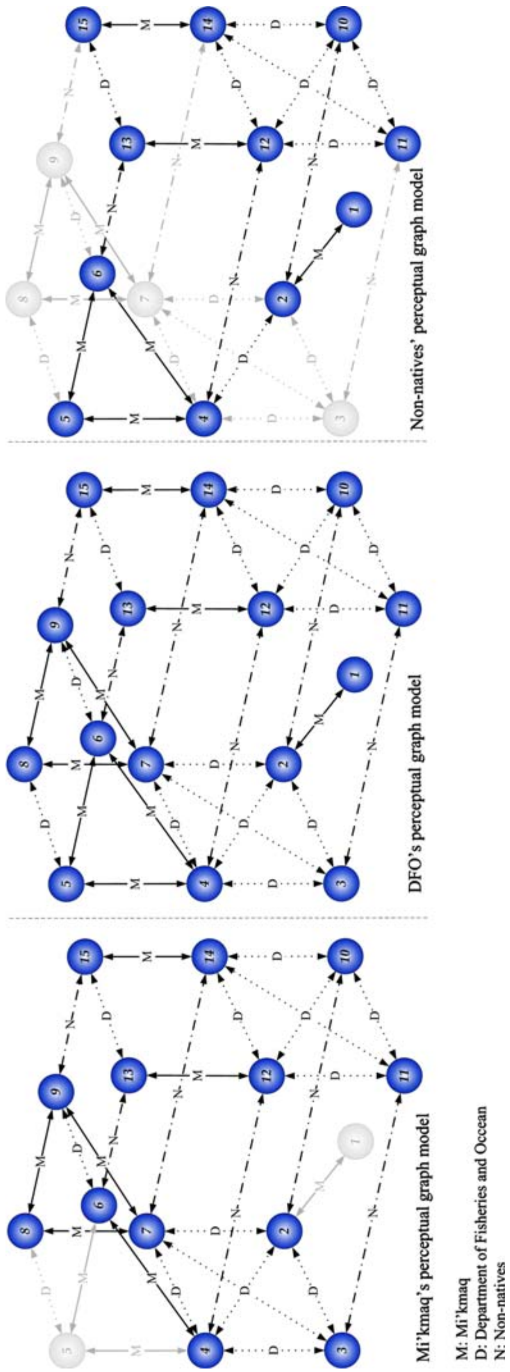

Fig. 4 DMs' perceptual graph model in the Burnt Church conflict

Reconciling emotion and perception into strategic conflict modeling and resolution requires descriptive theoretical modeling of conflict. The possibility principle focus on state identification by determining those states that are actually perceived by DMs. In applying the possibility principle, the set of feasible states are partitioned into hidden and potential states. The hidden states are those logically valid states that may be invisible to a controlling DM because he or she has strong negative emotion, such as fear or anger; and the potential states are those states that may be invisible to a controlling DM because he or she lacks positive emotion, such as love and joy, which promotes a sense of trust and rapport among DMs.

In the Graph Model technique, it is assumed that all DMs have consistent perceptions of outcomes, which allows integrating all DM's directed graph into one standard graph model. But in reality, inconsistencies in DMs' perceptions are often common, which makes a standard graph model of conflict impractical. A subjective graph model for each DM and a graph model system of all DMs' perceptual graph models are described to facilitate integrating subjective perceptions within the framework of the Graph Model. A graph model and graph model systems include specifications of each DM's awareness of whether or not it is aware that others perceive the conflict differently. To demonstrate how the possibility principle and perceptual graph models can be applied in practice, the Burnt Church First Nations confrontation in the Miramichi, New Brunswick, Canada is used.

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