Influencing Global Situations:

A Collaborative Approach

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Abstract

The authors present an approach to investigating the human decision cycle. Of particular interest for this paper is the decision cycle employed by individuals and organizations during crisis and potential conflict. The collaborative approach described here is especially beneficial in today's world of rapidly evolving, global situations within which U.S. security policies and operational plans are generated. The need for collaborative investigation processes such as the authors' innovative approach, called *Influence Net* modeling, are discussed. To illustrate the concepts and "mechanics" of the collaborative process, examples are taken from an automated system, called **SIAM**, which was developed to assist *Influence Net* modeling.

1. Motivation for this Investigation

With the end of the bi-polar political world, decision makers in the U.S. national security arena are faced with an ever-increasing number of situations that have the potential to become crises. In this paper, the term crisis includes situations of economic instability, ideological or cultural contrasts, as well as the more traditional (and oftentimes military-based) political and diplomatic security concerns. These crisis situations may occur while the involved parties are at peace; however, crises left untended or inaccurately estimated tend towards armed conflict situations that affect U.S. national and global stability interests.

U.S. security decision makers, including military planners, no longer face a single national government opponent whose power derives primarily from its military's capabilities. Today, world "actors" capable of generating crisis and instability, perhaps unintended, also include individuals representing multi-national organizations and multi-national states; examples of the former include economic consortia and terrorist cartels; examples of the latter include pan-Islamic countries and the ASEAN nations. The behavior of this set of actors, and their attendant actions, expand the more traditional list of state-sponsored conflict situations. In addition, as technological advances make the "global economy" a reality, conflicts formerly considered "internal disputes" possess the ability to disrupt, even destroy, the processes governing everyday lives of the citizens of many nations. In recognition of these events, the U.S. security arena has expanded the military's roles and missions to include the following:

- Urban conflictthe insertion and extraction of forces, such as employed in Somalia,
- Distributed forcesinsertion of forces, possibly deep insertion, such as currently deployed throughout the Bosnian theater, and
- Major regional conflict (MRC)force-on-force deployment to a single theater or multiple, concurrent campaigns.

In addition to the increasing number of crisis situations, the characteristics of today's "actors" differ from the traditional single power studied in great detail during the previous 50 years. Significant effort and cost has been invested examining the doctrine, policies, and capabilities possessed by the national government of the former Soviet Union. Although well documented, the results of this extensive investigation do not apply to many situations that will arise in the future. Tomorrow's adversaries may not possess satisfaction with the traditional bi-polar political status-quo. In greater contrast, the alignment of multi-national states and non-political organizations will reduce (or eliminate) the significance of politically-based motivations underlying the behavior and actions that can result in crisis or conflict. Such motivations include personal advancement, economic superiority, and expansion of cultural or religious ideology.

This diversity of characteristics among (potential) opponents continues to generate situations inconsistent with previous national policy making and planning strategies. In response to this evolving global scene, today's security missions must address situations that precede armed conflict. Examples of operations other than war (OOTW) situations for which national security policy and military planning are required today include:

- Supporting the non-proliferation of massively destructive weapons (WMD) by multiple state-sponsored organizations;
- Pre-empting disruptive/destructive actions of terrorist organizations;
- Mitigating the adverse effects of multi-national "black market" economic organizations' activities;
- Supporting humanitarian efforts conducted throughout the globe; and
- Maintaining peacekeeping missions in regions around the world that, left untended, may move towards conflict.

In short, today's troublesome actors and situations possess a diversity and complexity unparalleled in our nation's history. The impact of this changing world scene is recognized in part by the U.S. defense community, as evidenced in a recent publication on defense strategy: "Future joint warfighting capabilities [include] near real-time knowledge of the enemy and [we must] communicate that to all forces in near-real time..."

Based on the above discussion, one goal for today's decision makers must be to

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Establish a process to identify and evaluate a continuum of options tailored to the behavior of states, groups, and individuals.

However, the characteristics of potential situations are not the only parameters that define U.S. security concerns. Budget realities that headline today's news also must be considered. As the 21st century approaches, the national security community increasingly is mandated to reduce the size of its infrastructure. Combat forces of the next decade will be significantly diminishedthe size of U.S. forces as well as the numbers available from our traditional allies. Not only are the warfighting forces "taking the hit;" the planning and intelligence communities similarly are undergoing a reduction in force. In addition to the human factor, national security facilities are reducing their focus with attendant consolidation mandating the closure of basesboth CONUS and OCONUS. Similar financial constraints upon our allies are reducing the likelihood that "host-country basing" will be available when regional crises arise.

The resulting reduction in national security infrastructure is occurring at the same time that the world is seeing an increase in the potential (and diversity) of situations that require those very resources. Unless addressed properly, applying the remaining forces can result in significant risk to U.S. citizenry, in general, and military personnel, specifically. Therefore, the decision maker's goal, identified above, must be expanded to include:

Establish a process to identify and evaluate a continuum of options that reduces cost and risk for a spectrum of crises.>

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2. Statement of the Problem

As scenarios for crisis and conflict arise, members of the U.S. national security community are tasked to examine the behavior and capabilities possessed by both our allies and opponents. Traditionally, two categories of investigation and analysis have been employed to identify influence strategies and their operational implementations:

1. Seminars, workshops, and informal communications that extract knowledge from experts in the field of study. Sometimes this information is captured in a paper report that presents the results of the study to the decision maker; typically, this capture is performed by a single member of the study group. However, whether or not the results of the knowledge elicitation are documented, the experts' underlying source material, assumptions, justifications, and reasoning are maintained very rarely. Such information is crucial not only for the current decision maker, but also for future decision makers and their analysts who require historical, empirical evidence as the situation evolves.

1. Mathematical and computer-based models/simulations that attempt to estimate current and future states of "physics-based" phenomena. As with the first category, the results of this type of investigation usually are "watered down" for presentation to the consumer or other analysts. The input parameters and internal "rules" of such models are glossed over in the presentation of these results. Many times only the results of such simulations are sufficient to estimate the status of a situation. However, as with the seminar technique, reducing the documentation and presentation of the model's underlying reasoning may lead to confusion and misinterpretation by the decision maker. The problem is exacerbated when such models are revisited by future decision makers and their analysts.

Too often in the past, the traditional techniques for examining a situation have produced assessments that are not borne out in time. For example, workshop-like analysis indicates that a leader is not believed to possess aggressive intentions, but an unstable situation initiates because that leader is not in control of events. Sometimes, both techniques are employed concurrently, producing conflicting results. For example, observable evidence and "physics-based" models/simulations prove that an adversary possesses the technical capability to conduct aggression, but the adversary "backs off" when an outside influence is applied. In this case, the motivation, perception, and intentions of the adversary underscoring the resulting behavior may not have been accounted for correctly, if at all.

Moreover, in today's world, technological advances that "speed up" the time line towards crisis, and the proliferation of this technology to more and more actors, means that (potential) crisis situations will rapidly evolve. In addition, understanding these situations depends on a greater number of parameters that are not "physics-based." The diversity of human motivation and perception must be addressed by today's analysts responsible for identifying influence strategies and plans. Such diversity means that experts from an increasing number of domains must be included in the analysis process; for example, psychologists, historians, economists, international industrialists, diplomats, and philosophers.

However, as the community of analysts diversifies, problems of communication among these experts also increases. Differences in terminology, knowledge, assumptions, and inference/reasoning practices may lead to confusion and irreconcilable disagreement about the anticipated behavior and actions of a troublesome actor. Therefore, not only are a greater number of experts required to identify alternate influence strategies, but the decision maker must understand the interaction of parameters across domains of expertise in order to evaluate the alternate strategies. This requirement expands the original goals (above) to include the following:

Establish a process to identify and evaluate a continuum of minimal cost/risk options for a spectrum of crises and allows experts to collaborate and document their facts, assumptions, and inferences.

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3. Influence Net ModelingA Collaborative Approach

In an attempt to address these goals of collaborative analysis, the authors have developed a technique for analyzing the causal relations of complex situations. This techniques, known as *Influence Net* modeling, is a combination of two established methods of decision analysis: Bayesian inference net analysis originally employed by the mathematical community; and influence diagramming techniques originally employed by operations researchers. As illustrated in the following sections, *Influence Net* modeling incorporates both an intuitive, graphical method for model construction, and a foundation in Bayesian mathematics for the rigorous analysis of such models.

The domain experts, themselves, create "influence nodes," which depict events that are part of (possibly complicated) cause-effect relations within the situation under investigation. These experts also create "influence links" between cause and effect that graphically illustrate the causal relation between the connected pair of events; this cause-effect relation can be either promoting or inhibiting, as identified by the link "terminator" (an arrowhead or a filled circle). The resulting graphical illustration is called the "*Influence Net* topology;" a sample topology is pictured in Figure 1.

Notice that this technique allows one influence event to have multiple, possibly conflicting, effects. Similarly, an event may have multiple influences acting upon it. That is, the opinions of experts from diverse fields can be synthesized to account for the combination of influences from distinct domains. Additionally, the *Influence Net* model incorporates the multi-generation effect of complicated influences. An event may have both a direct and an indirect influence on another event identified in the model. In this way, the accumulated impact of a single, initiating event is accounted for in the expert-constructed model. (Initiating events for the sample topology are located around the perimeter of the net.) At the other end of the *Influence Net* model, there may be multiple, and possibly conflicting, conclusions of the situation. These *Influence Net* "roots" may describe ultimate objectives of the influence strategy, or they may depict different "final states" for the situation, including states not addressed by the influence strategy. (The single "root" event for the sample topology is located in the center of the net.)

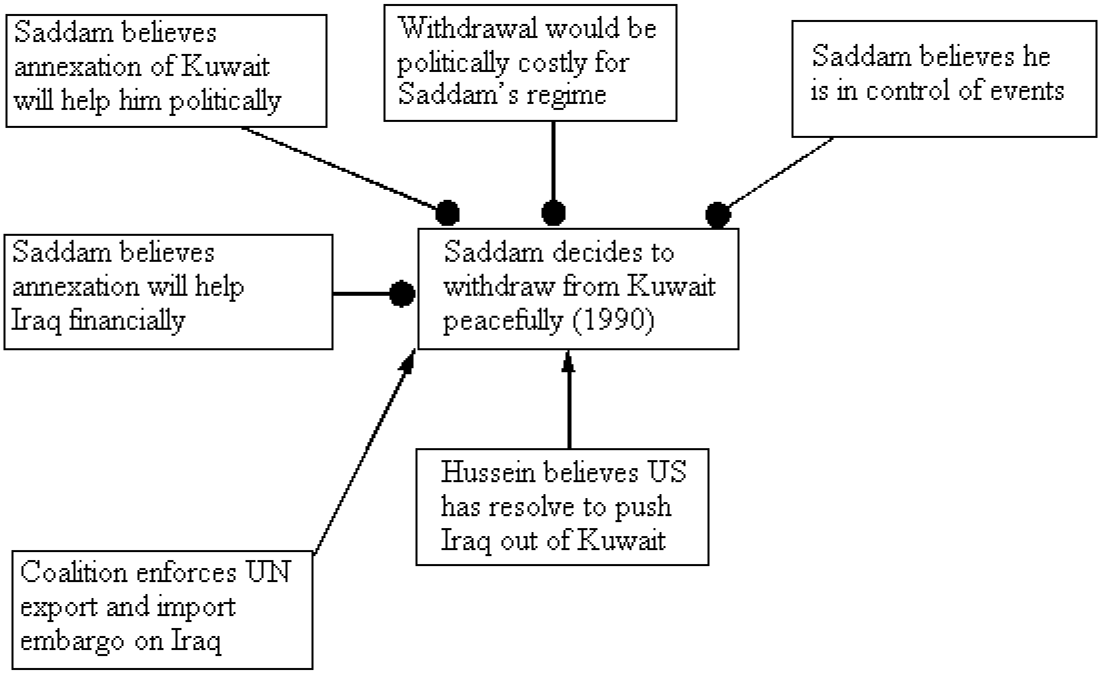
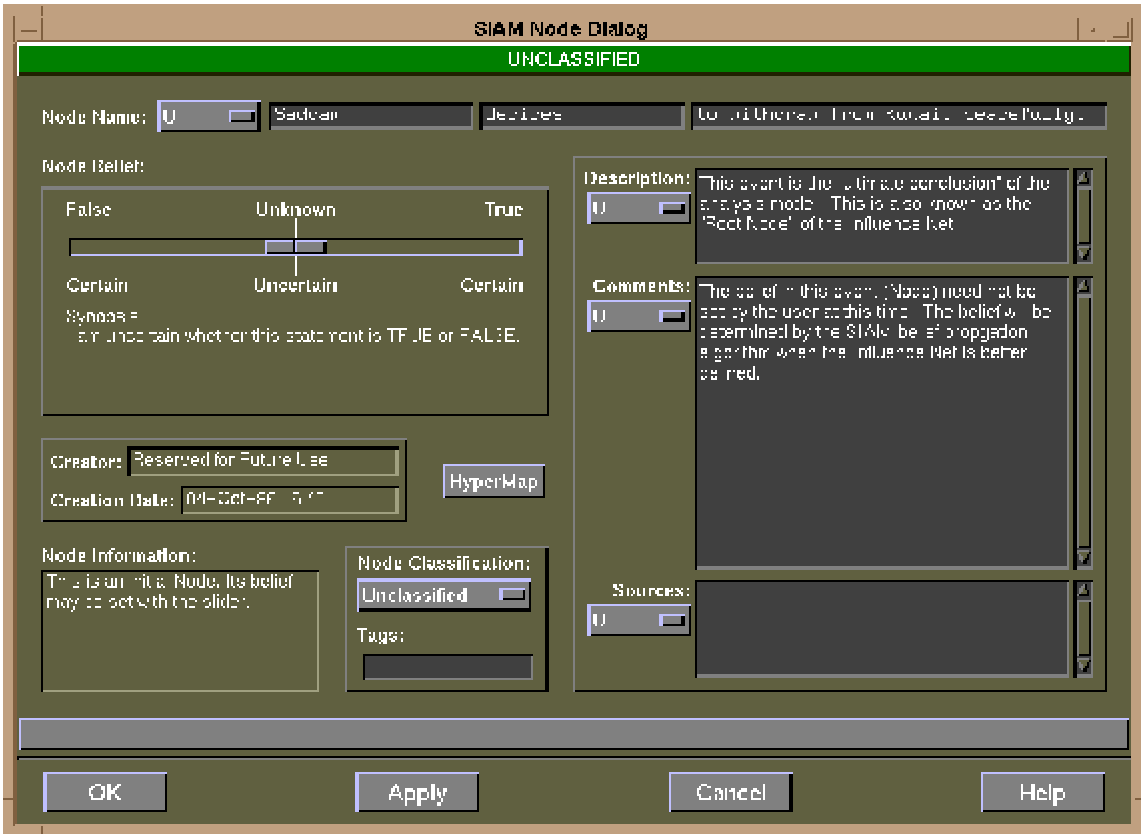


Figure 1. Sample *Influence Net* topology.

4. *Influence Net* Collaborative ModelingImplemented In An Automated Decision Support System

The topology of the *Influence Net* model, constructed for a specified situation by the domain experts themselves, is only one result of this collaborative technique. The likelihood of the identified influence events, as well as the importance of their causal connections, must be quantified in order to perform analysis of the efficacy of alternate influence strategies. The *Influence Net* modeling technique allows domain experts to assign "beliefs" to the likelihood of initiating influences and "strengths" to each of the causal connections.

The *Influence Net* modeling technique has been implemented in an automated decision support system called Situational Influence Assessment Module (**SIAM)**; illustrations presented in the succeeding paragraphs are taken from this software application. The "node belief slider bar" of Figure 2 illustrates how experts assign beliefs with the **SIAM** system. In addition, source material, expert judgment, and inference reasoning underlying the assignment of this event can be documented by the domain experts themselves. This information is stored in the areas designated as "Description," "Comments," and "Source" in Figure 2. Using these areas, the domain experts/analysts are able to maintain a "reasoning trail" as the situation evolves.



Node Name: U Saddam Decides to withdraw from Kuwait peacefully.

Synopsis:
I am uncertain whether this statement is TRUE or FALSE.

Creator: Reserved for Future Use

Node Information: This is an Initial Node. Its belief may be set with the slider.

Node Classification: Unclassified

Description: U This event is the "ultimate conclusion" of the analysis model. This is also known as the "Root Node" of the Influence Net

Comments: U The belief in this event (Node) need not be set by the user at this time. The belief will be determined by the SIAM belief propagation algorithm when the Influence Net is better defined.

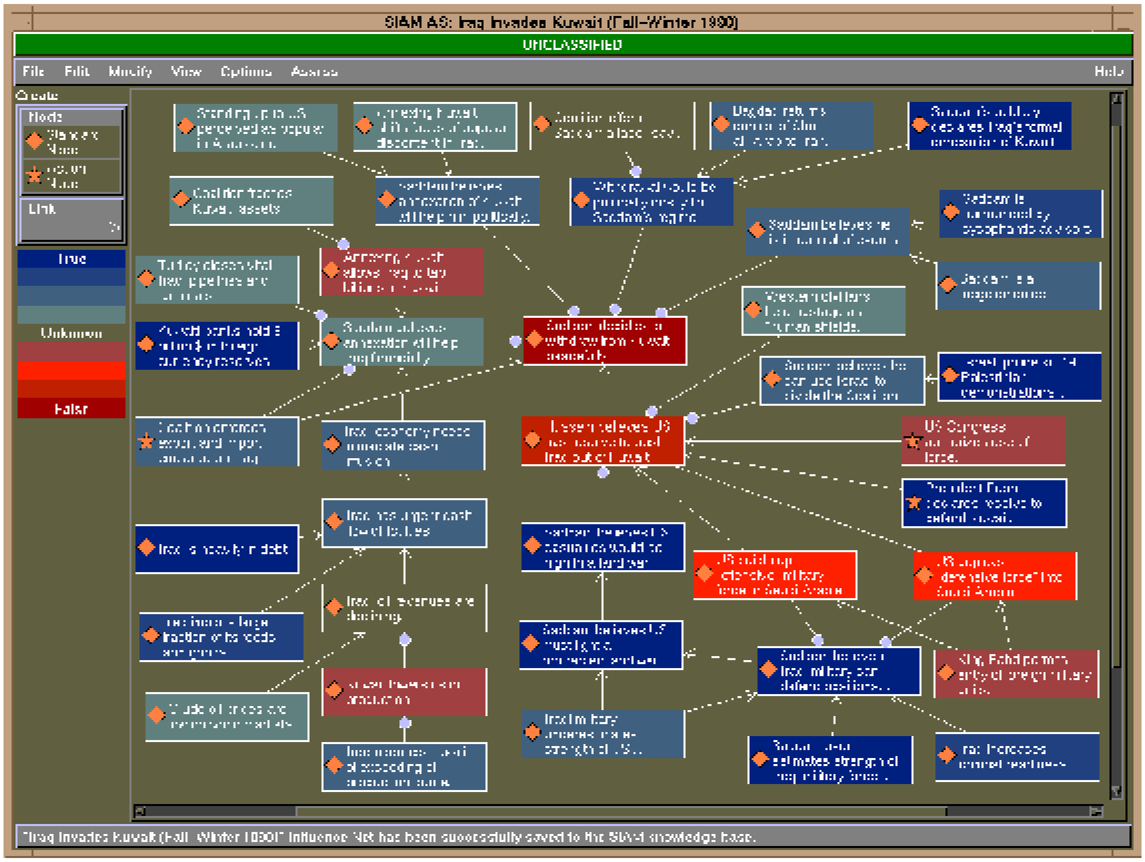
Sources: U

Figure 2. Node belief assignmenta sample.

The experts' judgment concerning the truth or falsity of the event is graphically depicted with color in the **SIAM** system: Four shades of red are available to indicate the judged degree of falsity; four shades of blue to indicate the judged degree of truth; and gray indicates there is no expert opinion either way. The color-coded illustration of the complete version of our sample *Influence Net* model is depicted in Figure 3.

5. *Influence Net* Collaborative ModelingGraphical Construction for Quantitative Analysis

As previewed above, the *Influence Net* modeling technique can be used in quantitative analysis as well as in producing the model's graphical topology. Quantitative analysis supports the decision maker's need to examine "what if" scenarios for their crisis potential. Furthermore, when the decision maker can identify critical influence events that transform a stable situation into a crisis, then courses of action that effectively mitigate the crisis can be examined. Toward this end, the domain experts are asked to assign quantitative "strengths" of the cause-effect relations illustrated by the graphical "links."



"Iraq Invades Kuwait (Fall - Winter 1990)" Influence Net has been successfully saved to the SIAM knowledge base.

Figure 3. Likelihood of events are illustrated through color.

In the **SIAM** system, these "causal strengths" are assigned with slider bars similar to the slider bars used to assign event beliefs. Figure 4 illustrates the method through which the domain experts assign these two strengths for each causal connection. As with other elements of the *Influence Net* model, the source material and commentary justifying assignment of the causal connection is captured in the areas designated as "Comments" and "Source."

Notice that the cause and effect events of the relation are shown on the ends of the directional link. In addition to the graphical node illustrations of the influence events, their descriptions are included to remind the domain experts of the more complete definition of the events. Also note that, regardless of the estimated beliefs in these nodes, the nodes shown in this figure are gray filled. That is, when assigning the strength (or importance) of the causal relation, we are interested only in the causality itselfnot in their truth in today's situation. This causal strength will remain the same even if the situation were to change one's belief in the truth of influencing events. To assign these two causal strengths, the domain experts answer two questions:

1. If the likelihood of the influencing event (also called "parent") were absolutely **true**, what would be the impact on the occurrence of the effect (also called "child")? Would the effect event be more likely? Less likely? No impact at all?

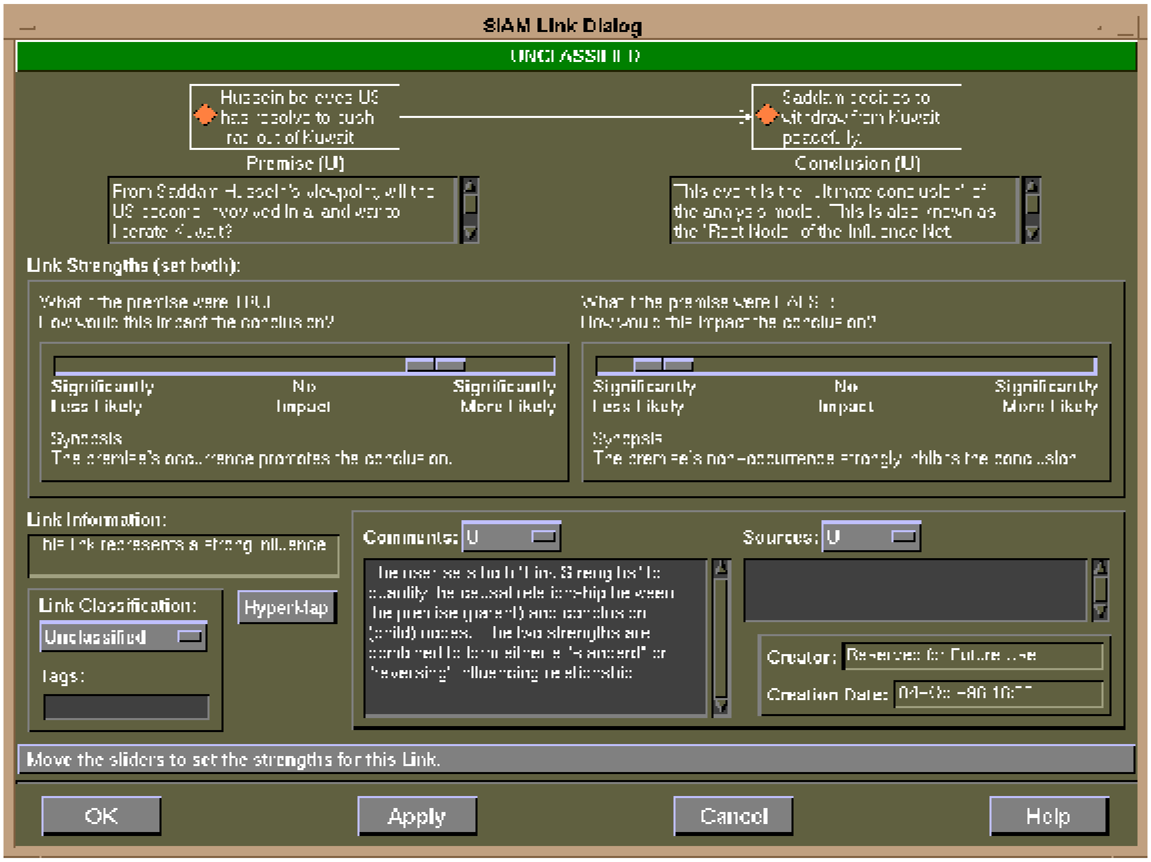
1. If the likelihood of the "parent" were absolutely **false**, what would be the impact on the occurrence of the "child"? Would it be more likely? Less likely? No impact at all?

Initially this task might seem confusing. After all, if the influencing event is known to be true, then why address the "false" strength, and vice versa? The reason both sides of this relation are examined is that *Influence Net* modeling is used to investigate the effects of changes in a situation. For example, if the current leader of a stable government is replaced by an aggressive personality, would a crisis result? Analogously, if today's conditions in an unstable nation were properly addressed through economic development and international aid, would a potential crisis be prevented?

If the expert-assigned causal strengths indicate that the relationship is a "reversing" influence, then the filled circle terminator is drawn. On the other hand, if the causal strengths imply that the influencing event produces an effect that "runs in the same direction," then an arrowhead terminator is used. This combined influence "direction" is indicated in the "Link Information" area of Figure 4. When the causal relationship information is completed, the graphical link is displayed in the *Influence Net* topology, as illustrated in Figure 3.

Once a consensus on the topology of the *Influence Net* model is achieved, the decision maker (and the gathered domain experts) must be able to perform "what if" analysis to identify effective influence strategies. The *Influence Net* modeling technique incorporates a mathematically robust algorithm to compute the cumulative effects of all influences on a specified event. This algorithm, called Belief Propagation, automatically "rolls-up" the complex, and possibly contradictory, influences to determine the likelihood of the event's occurrence. The resulting likelihoods are displayed in the **SIAM** system using the same color coding discussed above to illustrate the user-assigned beliefs in the initiating events; i.e., four shades of red to indicate the degree of falseness in the event; four shades of blue to indicate the degree of truth; and gray fill to indicate that the overall impact of influences on the event indicates neither true nor false.

Using this algorithm (and its automated implementation in **SIAM**), the impact of modifying the model's topology can be investigated as the situation evolves. For example, as more information is obtained, the likelihood of an initial event may change from unknown to true. The combined impact of this added knowledge can be identified in real-time using the *Belief Evaluation* option of the **SIAM** system. Similarly, as additional cause-effect relationships are identified through the collaborative process, these causal connections can be added to the model through the graphical construction already discussed; their quantitative impact then can be determined through the Belief Propagation algorithm. Therefore, not only can a group of experts from diverse fields of study graphically construct a model of complex causality, but the underlying algorithm facilitates the quantitative examination required to perform sensitivity analyses.



Hussein believes US has resolve to push Iraq out of Kuwait

Saddam decides to withdraw from Kuwait peacefully.

Premise (U)

From Saddam Hussein's viewpoint, will the US become involved in a land war to liberate Kuwait?

Conclusion (U)

This event is the ultimate conclusion of the analysis model. This is also known as the 'Root Node' of the Influence Net.

Link Strengths (set both):

What if the premise were TRUE
How would this impact the conclusion?

Synopsis
The premise's occurrence promotes the conclusion.

What if the premise were FALSE
How would this impact the conclusion?

Synopsis
The premise's non-occurrence strongly inhibits the conclusion

Link Information:
This Link represents a strong influence

Link Classification: Unclassified

Tags:

Comments: U

The user sets both 'Link Strengths' to quantify the causal relationship between the premise (parent) and conclusion (child) nodes. The two strengths are combined to form either a 'standard' or 'reversing' influencing relationship.

Sources: U

Creator: Reserved for Future Use

Creation Date: [illegible]

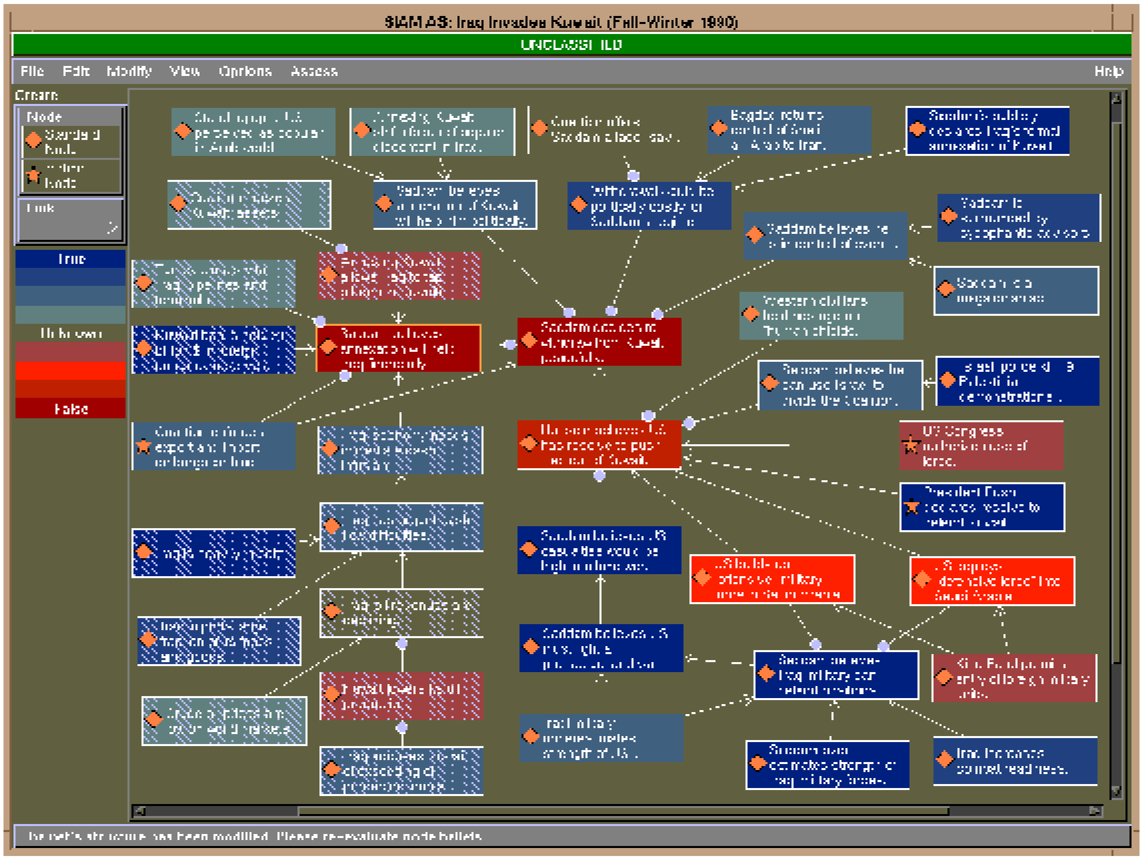
Move the sliders to set the strengths for this Link.

Figure 4. Link "strength" assignmenta sample.

In addition to the algorithm's automated "roll-up" of expert-provided beliefs and strengths, Belief Propagation accommodates manual overrides at any point in the network model. For example, suppose the computed likelihood of an influencing event does not "agree with expert intuition." One explanation for this apparent disparity is that the *Influence Net* model may be incomplete; that is, *Influence Net* modeling can be employed to identify gaps in knowledge about the situation's influencing relations. Another explanation is that the human mind (even the mind of a domain expert) cannot "juggle" the complex combination of possibly conflicting causal relations. An automated *Influence Net* system such as **SIAM** can "keep track" of all combinations of cause-effect relationships.

Using the Belief Propagation algorithm's override capability (as implemented in the **SIAM** application), the decision maker and supporting domain experts can manually constrain the belief of an influence event. In this fashion, the constrained belief might represent a confidence that is more in agreement with "expert intuition." A second use for the override capability is to identify intermediate events that have significant influence impact on the modeled situation. That is, ***if*** the decision maker ***could*** alter events to agree with the manual override belief, then ***would*** the constrained event produce a sufficient influence?

In addition to the quantitative manipulation supported with an override capability, *Influence Net* modeling as implemented in the **SIAM** system provides graphical feedback to the modelers. As illustrated in Figure 5, the overridden event is shadowed with a yellow border. Note that the color fill of this node differs from the belief/color fill obtained when using the default Belief Propagation algorithm; compare the color depicting the constrained belief with that filling the same node pictured in Figure 3. Also note that any influencing events "blocked" by the overridden node are "shaded;" i.e., any event that must "go through" the constrained node in order to influence the ultimate objective ("root") event is "grayed out." This shading is employed to inform the modeler that, although the event is included in the graphical topology of the model, its influence impact is "ignored" during quantitative analysis.



Influence net's structure has been modified. Please re-evaluate node beliefs.

Figure 5. Graphical feedback of manual overrides.

After the modeler has identified the source of the model's apparent disparity with expert intuition, the manual override constraining the selected influence event's belief can be removed. Once overrides are removed from the model, the influence events' color coding again reflects the results of the automated Belief Propagation algorithm. This technique allows the decision maker and domain experts to vary the number and strengths of influencing events until a consensus is reached regarding the most effective course of action.

6. *Influence Net* Collaborative ModelingComparative Assessment Techniques

The construction and modification of *Influence Net* models have been the central points of discussion up to this point in this paper. However, the creation and manipulation of influencing events and their causal relationships are only one aspect of this collaborative modeling process. Clearly, the identification of influencing events and documentation of related source material is required to construct an *Influence Net* model. But once consensus has been reached concerning the model's topology, there are several comparative analysis techniques that can be employed to quantify the impact of influencing events. The Belief Propagation algorithm, just discussed, is one of these techniques. The results generated by this algorithm indicate the overall impact of the model's events on individual events. In this section, we examine the relative contribution of individual events to influence the situation considered as a whole.

The two techniques discussed in this section"Driving Parents" and "Pressure Points"can corroborate "gut" feelings and apparently disparate information that imply a particular conclusion. However, it should be cautioned that *Influence Net* modeling does not provide "fail safe" proof that an event's occurrence can be "predicted." This modeling technique, including the automated assessment techniques to be presented below, produce analysis results that indicate a relative ranking of influence impact. That is, no single, "right" answer should be derived from the use of *Influence Net* modeling. Its primary benefit is in the capture of data and inferential knowledge through supporting the collaboration of human experts.

By their nature, automated analysis techniques require implementation as part of an automated system, such as **SIAM**. Using an automated support utility, these techniques allow decision makers and domain experts to select any event in the *Influence Net* topology for an in-depth look into its most influential relationships. Specifically, the comparative assessment techniques are employed to examine:

- The relative impact of contributing influencing events (**Driving Parents**),
- The sensitivity of end-state events to contributing initial events (**Pressure Points**), and
- Side effectspossibly unintendedof combinations of influencing events.

Clearly modelers could modify individual influence event beliefs and causal relation strengths to perform sensitivity analysis to identify events with greatest impact. However, this method would quickly prove time consuming and requires in-depth understanding of the cumulative impact of complex influencing interactions.

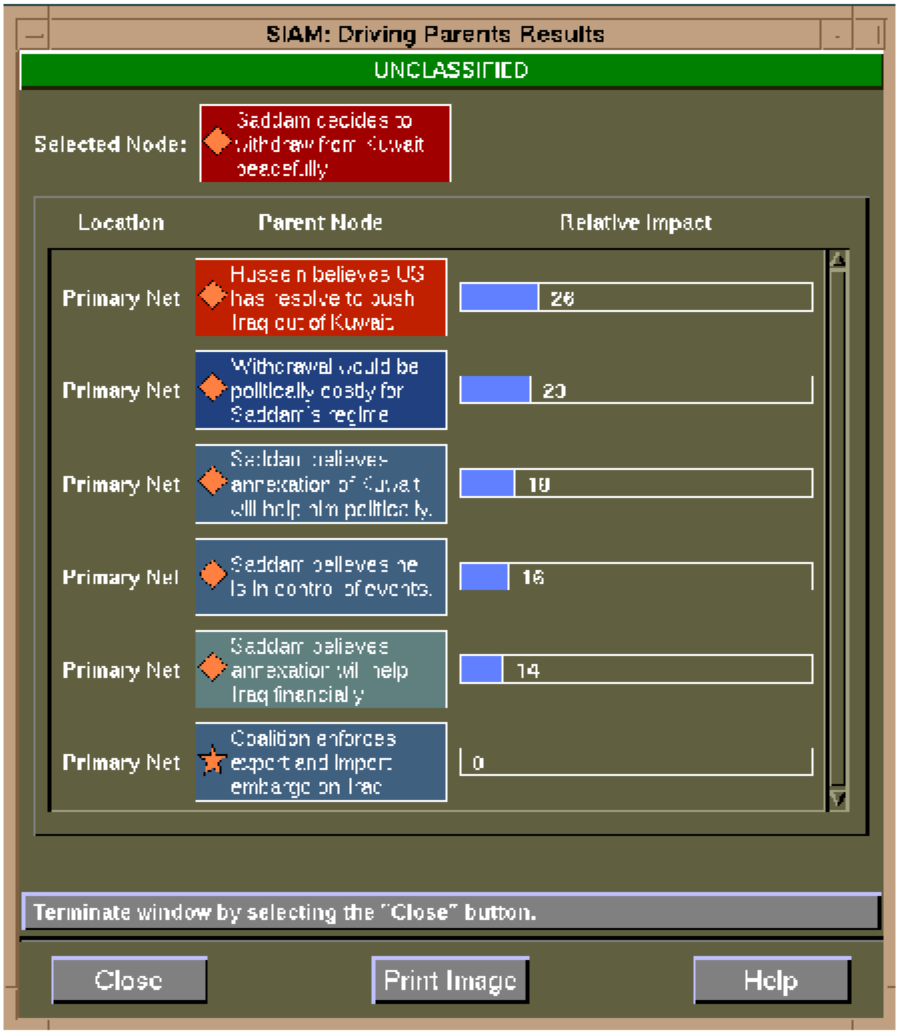
7. ***Influence Net*** **Assessment TechniquesDriving Parents**

The Driving Parents technique identifies the relative **impact** of events immediately influencing a specified event in the *Influence Net* topology. The directly influencing events, that is the "parents," of a selected event are examined to determine their individual impact on a selected "child" event. This examination employs the beliefs and causal connection strengths currently active in the model. That is, for the "child" event of interest, the expert-provided parent-child connecting link strengths and the parent event's current belief are employed to evaluate a quantitative impact for the parent-child relation. This evaluation is conducted for each parent event of the selected child. Then the individual impact values are normalized over all parent-child pairs. Note that this technique is not in the category of assessments called "sensitivity analyses." Rather, Driving Parents provides the modelers with a way to partition the complicated *Influence Net* model into rank-ordered areas of influence, based on the current estimate of the situation.

Figure 6 illustrates the results of the Driving Parents ranking for the indicated selected child node; this screen illustration was generated by the **SIAM** system, as executed from the *Assess* menu option. Each of the immediate (parent) influences on the selected child node are illustrated in the "Parent Node" column. These direct influences are listed in descending order sorted by their relative normalized impacts. The "percentage of the influence pie" is illustrated in the column headed by "Relative Impact." In this fashion, the modelers can focus on one particular section of the *Influence Net* topology. However, since the impact of a parent depends, in turn, on the strengths and beliefs of possibly distant influences, this technique should not be considered the final step in the assessment process.

8. ***Influence Net*** **Assessment TechniquesPressure Points**

As indicated above, Driving Parents evaluations employ the current settings of the modeled situation. One of the greater benefits of automated decision support utilities is the ability to "let the machine do the crunching." In particular, automated sensitivity analyses can be performed by relatively low-end computer processors in near-real time. Unlike Driving Parents, the Pressure Point assessment technique is in the category of evaluation methods called **sensitivity analysis**. Although Driving Parents helps the modelers focus on the more likely areas of influence, individual initial events with the greatest potential to influence an event must be identified in order to determine effective courses of action.



Selected Node: Saddam decides to withdraw from Kuwait peacefully

Location	Parent Node	Relative Impact
Primary Net	Hussein believes US has resolve to push Iraq out of Kuwait	26
Primary Net	Withdrawal would be politically costly for Saddam's regime	20
Primary Net	Saddam believes annexation of Kuwait will help him politically.	18
Primary Net	Saddam believes he is in control of events.	16
Primary Net	Saddam believes annexation will help Iraq financially	14
Primary Net	Coalition enforces export and import embargo on Iraq	0

Terminate window by selecting the "Close" button.

Figure 6. Driving Parents assessment results.

Pressure Points analysis is employed to identify the critical initial events with the greatest potential to increase or decrease the likelihood of occurrence of a specified event. For example, which one or two initiating influences are more likely to cause the "root" objective to occur? If a manageable number of such influences can be identified, then the decision maker has the beginnings of a course of action, without spreading available resources beyond their effectiveness. In this sense, *Influence Net* modeling supports the "what if" analysis necessary to identify potential actions.

In addition to supporting the decision maker's allocation of resources, the sensitivity analysis results generated through Pressure Points assessment can be employed by analysts responsible for information gathering. Specifically, these results help identify where gaps in currently available knowledge have the greatest potential to invalidate forecasting efforts. With such results, today's decreasing data gathering resources can be assigned to best "cover" the unknowns.

Rather than examining only the current estimate of the "state of the world," Pressure Points assessment considers the range of possibilities allowed if the situation were to be modified in defined ways. The sensitivity of a selected event to an initial influence event is determined from the complete set of influence paths connecting the initial influence and the selected event. Using all possible paths connecting the two events, the quantitative effect of the selected event on the initial influence is evaluated. This evaluation is performed for the complete range of beliefs in the initial influence. That is, as the belief in the initial influence is varied through the scale from absolutely false to absolutely true, the resulting effect on the selected event is monitored.

If the selected event's likelihood changes significantly as the initial influence's belief traverses this dramatic span, then the initial influence is said to have great **potential** for influencing the selected event. This strong potential can result when the initial influence has multiple, reinforcing paths through which the selected event is affected. On the other hand, if some of these multiple influencing paths "cancel out" the remaining paths, then the overall effect of the initial influence will be slight. (It is noted that a lack of sensitivity of a selected event to an initial influence also results if the initial influence is "buried" in the *Influence Net*'s topology, confirming human intuition.)

The variability of the selected event on each of its initial influences is illustrated in Figure 7 under the column "Sensitivity." As shown in this illustration, this parameter can be used to rank the initial influences by their potential to affect the selected event. Note here that the term "sensitivity" is intended to imply a potential to change the likelihood of the selected event; this term does not indicate whether the selected event's likelihood will increase or decrease as the initial influence changes. In the **SIAM** implementation, this ***direction*** of the initial influence's effect is indicated by the contents of the column "Influence."

Since there may be several paths of influence between the initial and selected events, the simple terms "promote" and "inhibit," used to describe individual causal connection strengths, are not sufficient for this purpose. The overall effect of the initial influence on the selected event is said to be "reversing" if an ***increase*** in the belief of the initial influence produces a ***decrease*** in the selected event's belief. That is, the initial influence's combined effects reverse the outcome, when considering all possible connections with the selected event. If the initial influence's effect "runs in the same direction" as the selected event's likelihood, then no entry is shown in this column.

In addition to the overall sensitivity of a selected event to its initial influences, decision makers need to be informed of the degree to which a situation may be improved or degraded, when compared with the current state. Towards this end, the **SIAM** system displays these indicators under the columns labeled "Promoting Potential" and "Inhibiting Potential." Summed together, these two potentials for change equal the total sensitivity of the selected event to the initial influence. In essence, an initial influence's sensitivity potentials are defined as:

Promoting Potential - the overall capacity to **increase** the likelihood of the selected event over the current state

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Inhibiting Potential - the overall capacity to **decrease** the likelihood of the selected event over the current state

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SIAM: Pressure Point Results

UNCLASSIFIED

Selected Node: Hussein believes US has resolve to push Iraq out of Kuwait.

Sort By: ● Sensitivity ○ Promoting ○ Inhibiting

Location	Initial Node	Influence	Sensitivity	Promoting Potential	Inhibiting Potential
Primary Net	King Fahd permits entry of foreign military units.		78	88	13
Primary Net	US Congress authorizes use of force		14	10	5
Primary Net	President Bush declares resolve to defend Kuwait.		11	0	11
Primary Net	Western civilians held hostage as "human shields"	Reversing	4	3	1
Primary Net	Saddam overestimates strength of Iraqi military forces	Reversing	1	1	0

Terminate window by selecting the "Close" button.

Figure 7. Pressure Points assessment results.

These additional assessment results identify initial influences that pose a significant risk of degrading the overall issue, while providing minimal chances of improving the situation. On the other hand, initial influences with relatively high potential for promoting a desired selected event and relatively low potential for inhibiting it are prime focus for applying influencing courses of action.

As a side commentthe decision maker may desire that a selected event be false. In the sample scenario illustrated in Figure 3 a U.S. decision maker would desire that the ultimate conclusion "Saddam decides to withdraw from Kuwait peacefully" be true. Suppose a second "root" conclusion were to be added to this topology: "Saddam decides to invade Saudi Arabia." Again from the U.S. decision maker's perspective, it is desired that this conclusion be inhibited, not promoted. Therefore, Pressure Point analysis would been performed in search of influencing actions that have significant inhibiting potential.

9. *Influence Net* Modeling - Identifying Unintended Side Effects

Once critical initial events are identified, then the decision maker has the option to apply influencing "actions" to the pressure points. (In the **SIAM** system, such "action" influences are designated with a star-shaped icon, rather than the standard diamond-shaped icon used to depict situation conditions. These action influences and their causal connections are constructed in the same manner as described in Sections 4 and 5.) In this manner, the addition of action influences to the *Influence Net* topology supports the collaborative analysis required to determine the efficacy of implementing the identified course of action. Moreover, the addition of such influencing events provides the decision maker with a view into unexpected side effects resulting from these actions.

Consider the most significant pressure point identified in Figure 7: "King Fahd permits entry of foreign military units." By applying appropriate influence on King Fahd's decision cycle, there is considerable potential to promote Saddam Hussein's belief in the resolve of the U.S. government "to push Iraq out of Kuwait." However, this same action might adversely affect another event in the situation. For example, suppose our sample *Influence Net* model had included the influence of King Fahd's decision cycle on the OPEC trading partners. It is conceivable that actions to promote King Fahd's decision to allow foreign military units into his realm would adversely affect oil prices, anger the OPEC trading partners, and possibly increase Saddam Hussein's stature among Arab world nations. These events, in turn, adversely affect influences on Saddam Hussein's decision to withdraw from Kuwait peacefully.

10. *Influence Net* ModelingIn Conclusion

Since "real world" causality crucially depends on complex, and sometimes conflicting events, collaboration of a group of domain experts is essential to identify effective, low risk, and cost efficient courses of action. Providing an environmentvirtual or realto discuss current situations and "what if" analysis of these situations is critically valuable to the ultimate consumer's decision making cycle. In addition to the documentation of factual source data, this environment must encourage and capture the essential human inference reasoning process.

Advances in computer processing, software development practices, and availability of relatively inexpensive modeling software tools have the potential to dramatically improve the collaboration process. Rather than previously employed procedures that summarized information gathered from domain experts, today's workshop environments offer real-time access to knowledge of diverse and complementary fields of study. This interactive collaboration, conducted in one room or through electronic communications across the globe, assists decision makers and their supporting experts in sorting and evaluating information required to understand complex "real-world" situations.

Influence Net modeling encourages this interactive collaboration through the use of graphical model construction and assessment. Construction of the graphical *Influence Net* topology by the experts themselves encourages "face-to-face" discussion, which can lead to consensus and, eventually, credibility in the experts' model. A reasonably complete and accurate model is critical if the decision maker is to select actions that will have maximum effectiveness when applied to the situation as a whole.

Automating *Influence Net* modeling facilitates the collaboration process by documenting the data, expert reasoning, and assessment results. When the experts no longer are available, or the situation evolves, the captured (electronic) model forms the basis for additional study. Finally, automated systems, such as **SIAM**, can be employed to produce graphical results that, when incorporated into a publication or presentation, offer the consumer the "picture that's worth one thousand words." Any decision maker or supporting expert in today's fast-paced world is well aware of time pressures to "sell" a plan of action. Graphical modeling and presentation techniques more closely match the human brain's ability to communicate effectively. Rather than automation and science replacing human knowledge, *Influence Net* collaboration brings the benefits of human interaction back into the spotlight.

Biography

Dr. Julie A. Rosen

Dr. Rosen is a senior scientist for Science Applications International Corporation (SAIC). She serves as the Principal Investigator for several U.S. government projects involving the Situational Influence Assessment Module (**SIAM**) software application, in particular, and *Influence Net* modeling technology, in general. Her duties on these projects include: contract management, scenario development, software system requirements definition, and software design and implementation of the algorithms used to perform mathematical and statistical reasoning under uncertainty in input data.

Prior to her recent efforts in *Influence Net* modeling, Dr. Rosen served as Principal Investigator for a project with the US Navy (N871) Strategic Deterrence JMA Assessment Program. In this role, her responsibilities included the initial development of an automated decision support utility that allows policy makers and planners to evaluate the effectiveness and cost efficiency of US Navy systems.

Earlier in her career, Dr. Rosen served as Senior Scientist on several projects for which a proprietary data fusion algorithm was implemented in software systems. This probabilistic algorithm, and accompanying implementation software applications, were developed to automatically fuse contact reports from various single source sensors into an integrated picture of the battlefield for use by field commanders.

As a Senior Consultant at Booz, Allen & Hamilton, Dr. Rosen was responsible for the analysis of the impact of several communications protocols on the performance of an Air Force-fielded network system. The parameters of interest in this work included the communication protocols employed, as well as the degree of error correction coding and diversity. As a staff member of other studies conducted for various DoD agencies, she examined the performance of an optical communications system as it depended on proposed synchronization and coding schemes.

Dr. Rosen holds M.A. and Ph.D. degrees in Mathematics from the University of Maryland. She currently is a staff member with Science Applications International Corporation (SAIC).

Mr. Wayne L. Smith

Mr. Smith is an engineer for Science Applications International Corporation (SAIC). He is the lead engineer for several efforts related to the Situational Influence Assessment Module (**SIAM**) software application, in particular, and *Influence Net* modeling technologies, in general. In this role, Mr. Smith has been responsible for the full range of systems and software engineering efforts, including: requirements elicitation and definition, architecture definition, object-oriented design and implementation, software testing, and installation.

Prior to the initiation of the **SIAM** project, Mr. Smith worked in the area of simulation and analytic modeling of underwater warfare. His work in this area has been in support of the SSN-21 program, the Centurion New Design SSN program, and Low Frequency Active Acoustic (LFAA) programs.

Earlier in his career, Mr. Smith served as Principal Investigator and technical leader of the team that developed and maintained the Interpretive Simulation Program (ISP). The ISP is used by the Navy to perform its Independent Verification and Validation (IV&V) of the Tomahawk Land Attack Missile (TLAM) Operational Flight Software (OFS) and to validate planned TLAM missions. He also supported modeling and Validation Testing for the Tomahawk Land Attack Missile (TLAM) Operational Flight Software (OFS). This modeling and analysis included OFS performance evaluation of digital terrain data, terrain correlation, Kalman filtering, and inertial navigation.

While a graduate student at the Rensselaer Polytechnic Institute, Mr. Smith served as Course Coordinator and Research Assistant. In this capacity he supported the NASA/USRA University Advanced Design Program, which included an internship at the NASA Lewis Research Center to augment aerospace design education at RPI. Mr. Smith researched and published results on advanced propulsion concepts, trajectory simulation techniques for transatmospheric flight, and multi-cycle engine requirements for single-stage-to-orbit vehicles. Mr. Smith also taught propulsion theory, orbital dynamics, and trajectory simulation.

Mr. Smith holds B.S. and M.S. degrees in Mechanical Engineering from the Rensselaer Polytechnic Institute. He currently is a staff member with Science Applications International Corporation (SAIC).

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