

THE COUNTERPLANNING PROCESS: REASONING UNDER ADVERSITY

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A heuristic model of planning in conflict situations is presented. This strategy-based model accounts for dynamic plan adaptation and replanning in obstructive and constructive counterplanning situations. The former situation is characterized by an actor striving to thwart the goals and plans of a second actor. The latter, is the dual situation; it provides general means for an actor to pursue his goal in spite of attempts by others to block his plans. The model has been implemented as part of the POLITICS system, a computer program that understands simple natural language accounts of international political conflicts.

1. Introduction

Planning and problem solving have been active research topics in Artificial Intelligence (e.g., GPS [1], STRIPS [2],¹ and NOAH [3]). However, most research efforts only considered one-actor situations, with no adversaries and with a static world model. Plan-understanding systems [4, 5, 6] have also been largely confined to planning scenarios where actors do not scheme to thwart each other's plans while planning to achieve their own goals in light of possible external interference.

We focused our research on situations where the decision maker has to contend with other parties that may be continuously trying to thwart his efforts. In such circumstances, plan formulation and decisions of how and when to implement the plans become much more complex than in simple one-actor planning situations. The primary problems that must be addressed in such situations include the non-deterministic nature of planning under uncertain outcomes and changing circumstances, predicting the most likely actions on the part of potential adversaries, formulating alliances with other parties that have common goals, and compromising with one's adversaries when necessary. We discuss part of our theory of counterplanning and its implementation in POLITICS, a computer program that models ideologically-oriented decision-making tasks in the domain of international diplomacy and political confrontations.

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2. The POLITICS System

The POLITICS system [7, 8]) understands a natural language description of a conflict situation by abstracting its meaning in terms of contextual knowledge of similar conflict situations (encoded as scripts [4, 9]), determining how the situation affects the goals of each political actor, and later applying counterplanning strategies to model the decisions open to the political actors under the circumstances defined by the input conflict situation. POLITICS evaluates possible decisions in terms of their effects upon the goals of the political actor, their likelihood for success (e.g., whether the planned decision can be implemented, or whether it is likely to be blocked by an opposing political actor.)

In the following example the POLITICS program analyzes a political event first from the point of view of a conservative American policy maker, and later from a liberal viewpoint, to answer some questions illustrating the goal-oriented counterplanning process.

•(INTERPRET US-CONSERVATIVE)

INPUT TEXT: The United States Congress voted to fund the Trident submarine project.

Q: What did the US Congress do this for?

A: THE UNITED STATES CONGRESS WANTS THE UNITED STATES ARMED FORCES TO BE STRONGER.

Q: Why should the US be stronger?

A: THE UNITED STATES ARMED FORCES SHOULD BE STRONG TO STOP COMMUNIST EXPANSION.

Q: What should the US do if Russia builds nuclear submarines?

A: THE UNITED STATES SHOULD BUILD MORE SUBMARINES.

•(INTERPRET US-LIBERAL)

INPUT TEXT: The United States Congress voted to fund the Trident submarine project.

Q: What did the US Congress do this for?

A: THE UNITED STATES CONGRESS FEARED FALLING BEHIND IN THE ARMS RACE.

Q: What should the US do if Russia builds Submarines?

A: THE UNITED STATES SHOULD NEGOTIATE WITH RUSSIA TO STOP THE ARMS RACE.

In processing the above example, POLITICS inferred that the US will build the new weapon system, and that this is an important event whose consequences should be further examined. At this point the liberal and conservative interpretations diverged. The liberal analyzed the negative implications towards peace, whereas the conservative focused on the beneficial effects of trident submarines to the US-Soviet strategic balance. Counterplanning is illustrated in the answer to the last question in each interpretation. In the conservative interpretation, POLITICS focused its counterplanning on how to keep the Soviet Union from becoming stronger than the United States. It applied a mutual-exclusion strategy: only one country can be the strongest military power. Therefore, if the US cannot stop the Soviets from building submarines, it should at least build a larger number of submarines and thereby remain stronger. The liberal interpretation focused counterplanning on how to end the arms race, as it considers this to be the most serious consequence of the arms race. Liberal POLITICS believes that both the United States and the Soviet Union want world peace more than military superiority. Liberal POLITICS applied a strategy that states that if a continued bilateral conflict violates more important goals of the conflicting parties, then they should jointly work to terminate that conflict.

The questions answered by the POLITICS system require an inference process that relates the input event to factual information contained in memory, as well as a decision-making process whose focus is to further the goals of the United States as perceived by a conservative (or liberal) American policy maker. Although the POLITICS system is essentially an integrated understanding system, it can be divided conceptually into several modules, including: 1) Natural Language understanding and generation in a semantically-rich domain. 2) A process to focus attention and thereby constrain inferences based in the goal hierarchy representation of political ideologies. 3) A script and situational inference rule applier. 4) A reasoning system based on our heuristic model of counterplanning. This paper focuses only on the counterplanning process, a significant aspect of human reasoning that has not been heretofore directly addressed in Artificial Intelligence.

Planning and Counterplanning require self-knowledge of the goals that one strives for, and at least partial knowledge of the goals of other actors with whom one interacts. In POLITICS, the goals of all relevant actors form the bulk of the Ideological-belief model. For

instance, a model of a conservative American asserts that the primary Soviet goal is world domination, and that the primary US goals are communist containment and a strong national defense. The POLITICS model of a US liberal, however, states that the primary US and Soviet goals are the maintenance of world peace, and that humanitarian goals are more important than a strong defense. Because of the varying sets of goals and the different priorities among the goals, POLITICS is able to model different political ideologies using the same reasoning process. This reasoning process consists primarily of the counterplanning heuristics focused on fulfilling the ideological goals.

3. The Counterplanning Control Process

The counterplanning process is encoded as a set of heuristic strategies applicable to general conflict situations, and a control-flow algorithm that determines when to apply the various classes of counterplanning strategies. We first discuss the control-flow algorithm; later we analyze the structure and content of the heuristic strategies.

There are two general types of conflict situations where an actor may apply the counterplanning process. The first situation is characterized by an actor (X) trying to thwart another actor (Y) from achieving his goal G(Y). X may prevent Y from achieving G(Y) by directly making the goal state impossible to achieve, or by repeatedly blocking Y's plans to fulfill G(Y). We call this process obstructive counterplanning. The second type of counterplanning scenario is essentially the dual of the first type: An actor X is trying to achieve his goal G(X) in spite of attempts by Y to prevent G(X) and to block X's plans for pursuing G(X). This process, called constructive counterplanning, differs from obstructive counterplanning only in terms of the subjective perspective of the counterplanner. The perspective shift causes the counterplanner to apply different strategies at different times, as the application of strategies is goal driven. Figure 1 is a control-flow diagram for the obstructive counterplanning process.

To illustrate the obstructive counterplanning mechanism, consider a simple example. Prison guard X wants to prevent prisoner Y from escaping. Hence, G(Y) is Y being free outside the prison. We enter figure 1 at the top. Does the guard know the prisoner's escape plan? Let us assume that he does not. His next step is to determine what, if any, plan the prisoner formulated. This plan determination may itself involve some planning: Should the guard ask the prisoner?, Should he threaten him? (Schank and Abelson [4] discuss the social planning units). Let us again assume that the guard fails. At this point we enter the third box in figure 1. The guard can ask himself "what would I do if I was trying to escape?" If he finds a reasonable plan, he should assume that this may be the prisoner's plan and he should apply the obstructive counterplanning strategies to block the plan. For instance,

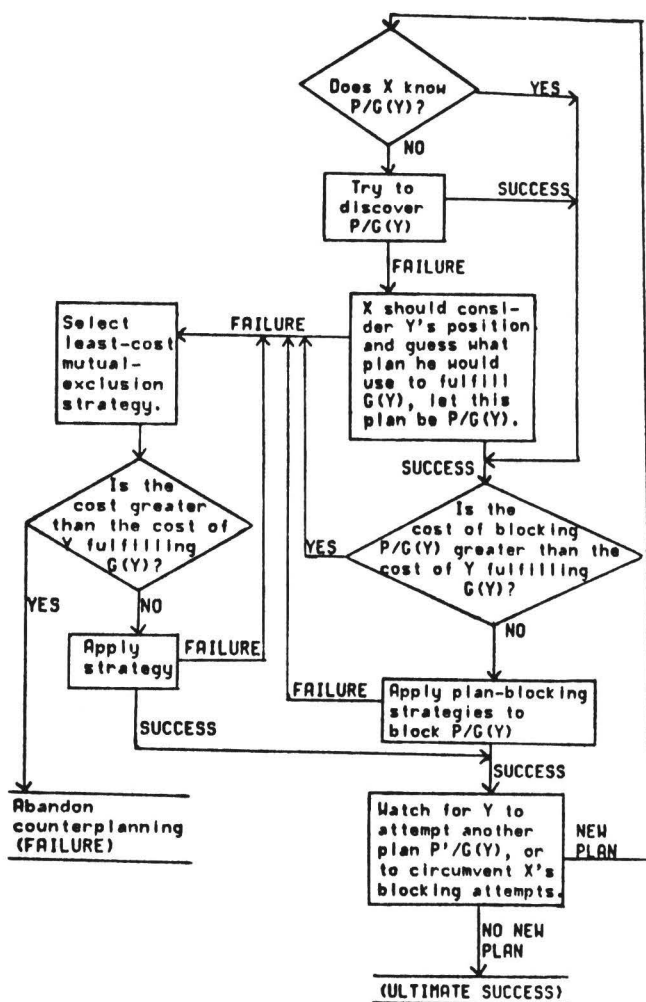


Figure 1: Control structure of the Counterplanning process (obstructive phase). Actor X attempts to block actor Y from achieving his goal G(Y). P/G(Y) is Y's plan for fulfilling G(Y).

the guard may find that stealing the key is a reasonable plan, in which case he may apply the violate-necessary-precondition strategies (discussed later) to conclude that he should keep the keys away from the prisoner.

If no plan presents itself, the only option open to the guard is to take general precautions (i.e., apply mutual exclusion strategies) such as pointing a gun at the prisoner and informing him that either he remains put, or he will be dead. Thus escaping and staying alive become mutually-exclusive states in the prisoner's mind.

There are exit conditions in the counterplanning algorithm. For instance, if the prisoner's plan is to blow up the prison (and he has the means to do so), the guard

may decide that the risk of being blown up is more costly than his goal of thwarting the prisoner. Similarly, if he has to keep a gun trained on the prisoner for the length of the prison sentence, the guard may decide that this is more costly than letting the prisoner escape.

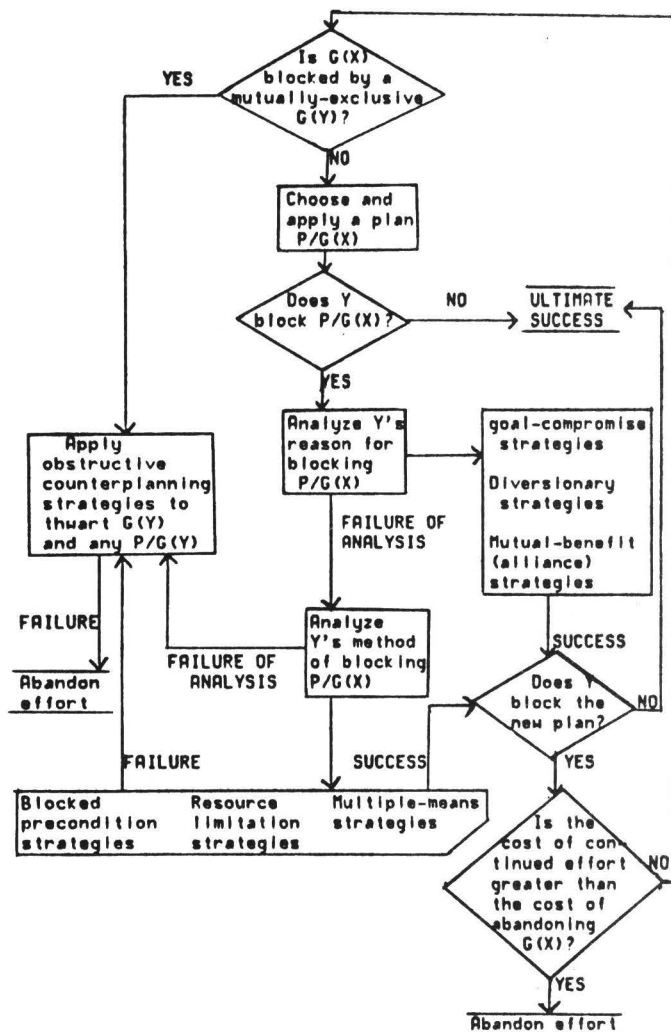


Figure 2: Control structure of the counterplanning process (constructive phase.) Actor X wants to achieve G(X) in spite of Y's attempts to thwart his plans or prevent his ultimate goal.

Figure 2 is the control-flow for constructive counterplanning. Using the constructive counterplanning algorithm one can trace the options available to the prisoner for formulating an escape plan taking into account the guard's possible thwarting efforts.

4. The Structure of the Counterplanning Strategies

Our model of counterplanning is essentially a goal-directed rule-based system. Each strategy is a rule that tests the goal conflict state between the two actors, the goal trees of each actor, and the plan that each actor is pursuing. If the test of a rule is true, the action part of the rule suggests a counterplanning method that is likely to succeed. The action part of the rule may have additional conditions or refinements. The structure of a counterplanning strategy is illustrated below.

```
STRATEGY <rule#k>   <title>
  TRIGGER  Conjunction of <test1, test2, ..., testn>
  IF       Conjunction of <testn+1, testn+2, ...>
  THEN     Sequence of <action1, action2, ...>
  REFINEMENT <subrule#k1, subrule#k2, ...>
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Figure 3: The structure of a counterplanning strategy.

The test part of each rule is divided into the "TRIGGER" clause and an additional "IF" clause. In order for a rule to apply, both clauses must be true in the counterplanning situation. The reason for our division of the test clause in such a manner is to reduce the time that the process model spends searching for an applicable strategy. All the trigger conditions are "inexpensive" tests: these tests can be applied directly to the situation without requiring further inference or complicated matching. These trigger conditions are compiled into a discrimination network. This organization allows the addition of new strategies without a corresponding linear increase in the search time required to test all the applicable counterplanning strategies.

Once the trigger conditions for a rule have been met, the additional "IF" tests are performed. These tests may be arbitrarily complex, perhaps requiring further inference and the invocation of other counterplanning strategies. However, the trigger conditions usually restrict the set of applicable counterplanning strategies to a small number in any given situation (typically three or four). Furthermore, counterplanning strategies reflect common-sense reasoning about how to deal with adverse situations. As such, each strategy is sufficiently general to apply across many reasonable types of human conflict. This means that the total number of counterplanning strategies is relatively small compared to the total number of rules and information contained in the situation-specific scripts. We have found that approximately forty counterplanning strategies suffice to model the counterplanning actions in the situations and goal conflicts we have considered.

The action part of each strategy (preceded by "THEN") is a sequence of counterplanning methods to be applied in the current context by one of the actors. If a strategy is applied, the "refinement" field is checked after the

sequence of actions is performed. The refinement contains one or more additional rules that usually provide further detail to the counterplanning situation. These rules are truly subrules to the counterplanning strategies because they are invoked only in the case that all the tests of the strategy are true, and, in addition, the test clause of each subrule is also true. In structure, our strategies are much closer to the rules in expert systems (such as PECOS, [10]) than to more traditional production systems (e.g., the PSG system [11]).

The following sections analyze some of the more significant types of counterplanning strategies. More complete sets of strategies are discussed in [7, 8]. We also discuss the way in which counterplanning strategies are used in text-understanding and question-answering tasks.

5. Diversionary Counterplanning Strategies

We turn to some of the more specific counterplanning strategies applicable to a mutual-exclusion goal conflict. A frequently-encountered set of strategies operates on the principle of diverting the efforts of an actor in the goal conflict away from direct pursuit of his goal. There are essentially three classes of diversionary strategies, all relying on the fact that if an actor has to divert his efforts to other matters, he is less likely to succeed at his original task. We group the diversionary strategies into the three categories listed below:

DIVERSIONARY STRATEGIES.

- 1) Threaten higher-level goals of one's opponent.
- 2) Dissipation of effort: Threaten opponent's other goals.
- 3) Deception: Misleadingly convince one's opponent that other goals are threatened.

Let us look at one important diversionary strategy and its deceptive option. The process of convincing one's opponent that the actions of a counterplanning strategy have been carried out, without this being the case, is called the deceptive option of that strategy.

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STRATEGY 1:    THREATEN HIGHER-LEVEL GOAL

  TRIGGER  Mutual-exclusion goal-conflict situation
            between G(Y) and G(X).

  IF       X can find a goal G'(Y) to block, where
            G'(Y) is a goal of higher importance to
            Y than G(Y),

  THEN     X should try to block G'(Y). X can expect
            Y to pursue G'(Y) and abandon G(Y).

  REFINEMENT X should choose G'(Y) such that:
            1) Y cannot pursue both G'(Y) and G(Y)
               simultaneously, or
            2) Y can accomplish G'(Y) only if the
               blocking action is abandoned.
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Strategy 1 means that in a mutual-exclusion goal-conflict situation, one actor (X) may threaten a higher-level goal of the second actor (Y), in order to make Y divert his efforts to preserve that higher-level goal. Since an actor's attention, time, and material resources are limited, Y may not be able to protect his higher-level goal and pursue the goal that conflicts with X's goal simultaneously. Thus, X will be in a better position to win the conflict situation and achieve his own goal. The "refinement" part of the rule gives some advice to help X make his choice on which one of Y's higher-importance goals to threaten. X knows which goals Y may consider more important by examining Y's goal tree. Our model assumes that the various actors know about each other's primary motivations. X should threaten a goal that requires Y's full attention, time or material resources to protect. Alternatively, X can threaten an important goal that Y cannot protect. This gives X a bargaining position to tell Y that he will stop his threat only if Y abandons the (presumably less important) goal that conflicts with X's goal.

Let us see the deceptive version of strategy 1. This strategy is based on the same principle of diverting the attention and efforts of the opposing counterplanner away from goal conflict. However, the method used need not correlate with reality. As such, one should expect that a deceptive strategy is more likely to fail (e.g., if the opposing actor discovers the truth.).

STRATEGY 2: DECEPTION: FALSE THREAT

- Same as strategy 1 but either
- 1) X only appears to threaten the higher level goal G'(Y), or
 - 2) X threatens to block G'(Y) but has falsely convinced Y that G'(Y) should be one of Y's high-level goals.

There are other diversionary strategies (listed in [7]); however they all share a common principle: An actor cannot overtax his attention and resources by simultaneously pursuing multiple courses of action. Awareness of this simple principle applied to other actors (as well as the counterplanner) guides our formulation of the diversionary counterplanning strategies. Each strategy is based on a different method of causing an actor to worry about more than one goal at a given time. There are various kinds of limitations on the different items that an actor can focus his attention on at one time. We classify the limitations on the simultaneous pursuit of multiple courses of action into the following categories:

- 1) Limitations on available time.
- 2) Mental and physical limitations on the number of actions that can be performed simultaneously.
- 3) Limitations of material resources.
- 4) Limitations of ability.
- 5) Goal of avoiding certain consequences of one's actions.
- 6) Interactions between different courses of actions.

6. Counterplanning Strategies Based on Goal Compromise

Bargaining strategies are characterized by the opponents' willingness to compromise. Willingness to compromise is mediated by many factors such as the two opponents' perceptions of whether compromise is possible, necessary, or desirable. There are two basic classes of bargaining strategies: The first class is based on partial goal fulfillment and the second is based on goal compromise. In order to discuss these strategies, we need to define the notion of partial goal fulfillment. For goals comprising of a conjunction of (possibly recurring) subgoals, partial fulfillment is defined in the obvious manner: The goal is partially fulfilled if some of the subsumed goals are fulfilled. For instance consider the following case:

EVENT 1: John wanted to marry Susan. They decided to live together instead.

Did John achieve his goal? Strictly speaking the answer is "no". But, if we understand that marriage is a complex goal, we realize that for all intents and purposes John fulfilled most of the goals subsumed by marriage, such as achieving companionship, periodic satisfaction of the sex drive, etc. Since marriage also involves a change in social and legal status not necessarily associated with living together, we say that John partially fulfilled his goal. Therefore, by this measure, partial fulfillment of a goal is the case where the specific goal sought is not fulfilled, but a significant fraction of the underlying reasons for pursuing the goal are fulfilled.

The second way in which partial goal fulfillment is measured applies to goal states that can take a continuum of values. Acquisition of money and achievement of social stature are examples of continuous-valued goals; there are virtually infinite degrees of social stature and of the amount of money that a person can acquire. We define success differently for preservation goals than for achievement goals (called "P-goals" and "A-goals" respectively in the Schank and Abelson [4] goal taxonomy). Let us call the initial value of the goal state "I", the desired value of the goal state "D", and its resultant value at the time when we must decide whether the goal succeeded "R". For P-goals it is usually the case that $I = D$, and for A-goals $I < D$. The success and failure conditions of continuous-valued goals are given by the following table:

	FAILURE	PARTIAL SUCCESS	SUCCESS
A-GOAL	$I = R < D$	$I < R < D$	$I < R = D$
P-GOAL	$R < I = D$	$R \text{ slightly } < I = D$	$R = I = D$

Table 1: Partial fulfillment of goal states.

Here are the partial-goal-fulfillment and goal-substitution bargaining strategies:

STRATEGY 3: GOAL COMPROMISE

TRIGGER G(X) and G(Y) are mutually exclusive and may be fulfilled partially.

IF X cannot achieve G(X) by other counterplanning strategies,

THEN X should try to partially fulfill G(X) by bargaining with Y to compromise mutually on partially fulfilling their respective goals.

Metaphorically, strategy 3 states that if one cannot have the entire pie then one should try to bargain for at least a slice of the pie. Strategy 4 is more cooperative in nature than strategy 3, but involves the same principle of compromise on partially attainable goals:

STRATEGY 4: COOPERATION BY MUTUAL NEED

TRIGGER G(X) and G(Y) are mutually exclusive and may be partially fulfilled.

IF neither X nor Y can independently achieve their respective goals, but can succeed only by pooling their efforts,

THEN X and Y should compromise on partially fulfilling G(X) and G(Y) and plan jointly for their fulfillment.

Strategy 4 states that cooperation may be a necessary course of action in spite of conflicting goals. Event 2 illustrates this point:

EVENT 2: Jesse James and Bill Morgan joined forces to heist the payroll train.

We infer that both actors had the A-goal of acquiring the money in the payroll train. These goals are mutually exclusive but may be partially fulfilled. Suppose we had to answer the question: "Why did Jesse James and Bill Morgan join forces?" The most reasonable answer is: "Probably because neither could heist the train by himself." This answer cannot be inferred from the goal conflict itself; the existence of a goal conflict suggests competitive rather than cooperative actions. Therefore, the understander has to be aware of strategy 4 - cooperation between actors with conflicting goals is reasonable if neither actor can otherwise fulfill his goal.

The general goal substitution strategy, illustrated in the following event, is presented below.

EVENT 3: Johnny and Billy were arguing over a candy bar. Johnny offered to let Billy ride his new bicycle if he would let Johnny eat the candy. Billy agreed.

STRATEGY 5: GOAL SUBSTITUTION

TRIGGER G(X) and G(Y) are competing goals and X knows about Y's other goals.

IF X can bring about G'(Y), one of Y's goals that is at least as important as G(Y),

THEN X should bargain with Y to substitute G'(Y) for G(Y) as Y's actively pursued goal. (This leaves X free to pursue G(X).)

REFINEMENT Apply this strategy only if G(Y) is not a P-goal.

7. Predictive vs Interpretive Reasoning

For the task of generating hypothetical scenarios, one can only use counterplanning strategies in a predictive manner. However, in story understanding tasks, the counterplanning strategies are used to interpret the actions of the actors. In such situations, it is better to apply the strategies in an interpretive manner. To see what we mean, consider event 4:

EVENT 4: The United States supported Israel in the 1973 Middle-East war. Subsequently the Arabs imposed an oil embargo on the United States and its allies.

QUESTION: Why did the Arabs impose the oil embargo?

Strategy 1 can be used in a predictive framework or in an interpretive manner. In understanding event 4 we need to pose and answer the question "Why did the Arabs impose an oil embargo?" Using knowledge about the goals of the Arabs and the goal of the United States to help Israel, the understander can establish the goal conflict between the Arabs and the United States. The mutual-exclusion goal conflict is between the US goal of aiding Israel and the Arab goal of preventing US aid to Israel.

Having interpreted the situation thus far, an understander can proceed in two different manners. The first manner is to predict all the possible Arab counterplanning actions to make the US stop aiding Israel. If, in interpreting the rest of the event, the understander matches an action with one of the previously predicted counterplanning actions, the understander can conclude that indeed the Arabs were counterplanning against the US and their counterplan was the predicted course of action. Such a process would require the understander to generate vast numbers of hypotheses and subsequently test each hypothesis as a possible explanation of the situation. There is no evidence to suggest that people generate all possible inference paths in a given interpretation in order to discard all but one path that matches reality. It appears more plausible that people only pursue a small number of relevant inference paths. Therefore, generating all possible plans of action is not a reasonable

psychological model of human thinking, nor does it lend itself to reasonable constraints on the computational time that the system may require in order to generate and test all alternative actions on the part of the Arabs.

A more reasonable alternative to the generate and test process is the following: Given the existence of the mutual-exclusion goal conflict, we can predict that the two actors may counterplan against each other. No further predictive inferences are generated at this point. The rest of the event should be interpreted in light of the expectation that the two actors may counterplan to resolve their goal conflict.

When the understander learns of the Arab oil embargo, he tries to see if this is a reasonable course of action to take as a counterplan against the US goal of aiding Israel. Counterplanning strategy 1 (refinement 2) matches the type of interaction between the Arab plan and the US goal. The Arabs are threatening a higher-level US preservation goal by cutting off oil supplies, and the US cannot do anything to directly remedy the situation. Now the Arabs can bargain to end the embargo in return for the end of US aid to Israel. Therefore, the understander can establish the Arab counterplanning actions by applying strategy 1 in an interpretive manner. The result of the Arab actions is matched to the action part of the strategy. This match, suggested by our previous expectation that a counterplanning action was likely, allows the understander to infer that the Arabs were invoking counterplanning strategy 1. Therefore, we can say that the reason for the Arab action is the test clause of the strategy. Thus, we have a mechanism for using counterplanning strategies in an abductive manner to interpret actions in conflict situations, as well as a deductive manner to propose counterplans. The general interpretive technique of predicting an overall framework and subsequently instantiating its component parts has been successfully applied in other AI systems such as SAM [9] and HEARSAY-II [12].

The interpretive mode of reasoning is superior to the purely predictive mode because it does not require the generation and subsequent testing of an arbitrarily large set of possible courses of action. It is also a more reasonable model of human thought. Before and during the 1973 Arab-Israeli war, few people foresaw an Arab oil embargo. When the embargo came, however, the reasons for the Arab action became clear.

8. Concluding Remark

We have seen how counterplanning is a necessary process for both decision making in the face of adversity and for understanding natural language descriptions of such conflict situations. The counterplanning strategies discussed in this paper are illustrative rather than exhaustive. More complete sets of strategies are discussed in [7, 8]. Counterplanning is a general

inference mechanism for understanding human conflict situations. Since most interesting stories and events involve some type of goal conflict, we need to include counterplanning as a necessary tool in the Artificial Intelligence repertoire.

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