

SCENARIOS AS AN AID TO PLANNING

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ABSTRACT

In many complex domains full scale detailed solutions to problems -- plans and ways to implement them -- are not possible or practical. Rather than attempt to produce such detailed solutions, we propose an alternative of using scenarios: a set of "snapshots" of the future that outline possible courses of action, actions of foreign processes, and their consequences. In this paper, we present the scenario idea and discuss its use as an aid to tactical planning. We discuss an implementation of these ideas in a Tactical Assistant to aid planning in the errand running and conflict simulation game domains and present an example illustrative of its capabilities.

I INTRODUCTION

In many complex domains full scale detailed solutions to problems, i.e., plans and ways to implement them, are not possible or practical. This could be due to the inherent complexity of the domain as in oil well analysis or medical diagnosis; elements of uncertainty and chance as in errand running or weather prediction; actions of agents uncontrolled by or unfriendly to the protagonist process as in chess or GO; or a combination of all of these factors. Sacerdoti [7] has suggested that in complex domains complete plans are not feasible.

Rather than attempt to produce such detailed solutions we propose an alternative of creating a scenario: a set of "snapshots" of the future that outline possible courses of action, actions of foreign processes, and their consequences. This scenario can then be used to decide courses of action, outline contingency plans or force reexamination of goals set in the problem statement.

The issue of how to plan and act in uncertain environments was investigated by Siklossy & Dreussi [9] and Chien & Weissman [1]. Both suggest not planning too far into the future or in too much detail because the world state may not be what you expect when you get there. The use of scenarios allows meaningful and helpful statements to be made about such uncertain future states.

An alternative form of planning was the multi-level knowledge-source/blackboard model proposed by Hayes-Roth [3] to plan the running of errands. The model has as its base a cognitive study showing that when humans plan errand running they rarely do so in a methodical straightforward manner. Rather they seem to seize key events and decisions and fix them in the plan, building the rest of the intermediate plan around them in an "opportunistic" manner. Work has also been done by Schank [8] with various forms of memory organization to aid in completing tasks. His MOP structure is a way of relating various sequences of actions that can be used to handle differing circumstances that may confront a processor.

The POLITICS system of Carbonell deals with foreign processes in the form of adversaries. He has developed a series of domain independent heuristics for performing counterplanning - planning to disrupt or impede an opponent's goals [2]. These heuristics are such things as "to protect your goals, threaten the enemy's high valued goals".

Analysis has been done of actual military planning in a controlled situation by Hayes-Roth [4]. The study categorized the cognitive strategies used by planners and the effectiveness of those strategies in terms of the correctness of the plans produced. The three strategies discovered turned out to be very similar to those used by people who play conflict simulation games. The strategies are: analysis of problem specific information, mental simulation, and retrieval of past experience. In our work we employ the third: scenarios are generated by retrieval and modification of past experience.

II THE SCENARIO IDEA

A scenario is collection of projections of future events, each of which is based on a set of assumptions about the behaviors, intentions and effects of the various processes involved. Each projection depicts the course of events in this interpretation of the future - the important events or actions taken by the various processes involved.

Stated another way, the total set of possible future world states is in effect divided up into classes or categories on the basis of these assumptions about the processes involved. From each class one or more examples are chosen to illustrate the kinds of events that could occur in that class of worlds.

Projections of the future are focused on the goals of the process requesting the scenario. In domains like errand running or conflict simulation games there are numerous tactics available with which to secure goals. Each tactic describes an action or set of actions designed to aid in achieving a particular goal or subgoal given a particular situation. Any goal may have numerous applicable tactics. The set of applicable tactics may change depending on the situation. Any particular tactic may affect more than the designated goal favorably or adversely. Additionally, in complex domains the tactics are not guaranteed to produce a solution.

Thus for each goal a tactic or set of tactics can be chosen. A set of tactics to achieve all of the goals and the order to apply them is called a course of action. For any given set of goals there may be different courses of action available, each with advantages and disadvantages.

A listing of a way the future could "actually occur" with actions by all interested processes included is called the course of events. This listing may be thought of as a "series of snapshots" showing the state of the world as it undergoes changes. The activity resulting in the creation of a hypothetical course of events is called a projection.

In addition to the friendly processes, there may be foreign processes operating in the domain. These may include potentially disruptive processes whose actions may prevent accomplishing the goals of the friendly processes. Foreign processes are grouped into three categories according to their intentions. A random process is one that occurs without any discernable reason. Usually these are environmental processes unrelated to any goal or purpose. A competitive process is one that may have goals that conflict with the friendly processes' goals. Usually conflicts arise from mutual desires for domain resources. It is possible for competing processes to cooperate to accomplish common goals. Finally there are unfriendly or inimical processes. These are processes whose goals are always in conflict with friendly goals and whose actions can always be interpreted as hostile; this is the case in most gaming domains.

In order to make a projection of the future, assumptions must be made about the behaviors and intentions of the foreign processes. The assumptions place the behaviors and intentions into categories. For example, the behavior of an unfriendly process in a given situation might be assumed to be aggressive in one projection and neutral in another. Or, the effects of a random process in a given situation might be assumed to be helpful in one projection and detrimental in

another. With a given set of assumptions, foreign process actions can then be postulated. These actions are then interpreted in light of their effects on the proposed course of action under consideration.

This then is the basis of scenarios: In response to a set of goals, a set of courses of action to achieve the goals is proposed. Consideration is then given to the effects of foreign processes. This consideration is along parameters whose values will represent assumptions about the effects, behaviors and intentions of the foreign processes involved. At least one projection of the future course of events that could be expected given these assumptions is the generated as an example of that possible world category.

A complete scenario consists of examples, each of which is an analysis of each course of action under a representative sample of reasonable assumptions about foreign processes. A course of events example consists of a "sequence of snapshots" that make up a projection of future activity. A scenario is thus a set of analyses of courses of action within assumptions about foreign processes.

A. The Structure of a Scenario

The basic outline of the structure of a scenario is as follows:

- I. Course of Action 1. Set of tactics chosen to accomplish the goals within the limitations of the given situation.
 - A. Segment 1.1. Possible World Classification Parameters and their values: Classification of effects of, or thresholds for, random processes; Behaviors and intentions of competitive or unfriendly processes.
 - i. Projection 1.1.1. Example of Course of Events given these assumptions: Tactics and their expected consequences; Foreign process effects.
 - ii. Projection 1.1.2. Example of Alternative Course of Events given these assumptions.
 - iii. . . .
 - B. Segment 1.2. Analysis of first course of action based on the next set of reasonable assumptions. Projections of the future similar to Segment 1.1.
 - C. . . .
- II. Course of Action 2. A different way of achieving the goals. Segments and Projections analogous to I.
- III. . . .

III CREATING A SCENARIO

As mentioned above, there are three basic methods of creating scenarios: Static Analysis, Simulation, and Retrieval and Modification of Experience. The last method is perhaps the most interesting. This involves having a large body of experience in the domain. When a new situation is encountered, the data base of experiences is examined and a situation similar to the current one is recalled. Along with the remembered situation is knowledge about what happened when certain things were tried - what worked, what didn't, etc. The experience is then an example used to illustrate the current situation and possible futures. This is similar to the Constrained Example Generation method of Rissland on which it is based [5]. Differences between the remembered situation and the exact current situation indicate modifications or interpretations that must be made in order to comprehend the full implications of the experience. These modifications produce the projections that make up the scenario.

IV A COMPUTATIONAL SOLUTION

In this section we introduce a means of incorporating the theory of scenarios into a problem solving aid.

A. The Tactical Assistant

A Tactical Assistant is a form of expert system designed to help a user, who has high level strategic goals but is not immediately concerned with the low level details of a domain, choose a specific course of action. The user proposes a set of goals to be achieved within the current situation. The Tactical Assistant takes this set and generates a scenario set analysis of the courses of action that may achieve the goals, and presents it to the user. In response the user may change the goal set, redefine the situation (e.g., allocating different resources to different goals) or perhaps make suggestions about possible courses of action. The Tactical Assistant then generates a revised scenario. This iteration continues until the user is satisfied with the outline of the future presented (or gives up).

In the errand running domain, this process can be thought of as the user first making a list: "These are the things I would like to do today". The Tactical Assistant, with its knowledge of the town, traffic patterns, etc, generates a scenario laying out the ways to accomplish the goals given different tactical choices, noting any conflicts or problems that may arise. This scenario is reviewed by the user, who then may reschedule, postpone or cancel proposed actions, in turn causing the Tactical Assistant to revamp the scenario. The system through its analysis can alert the user to possible problems. This analysis is the equivalent of asking a series of "What if?" questions, for example, "What if I run out of money?" or "What if I get stuck in traffic?"

In the conflict simulation gaming domain, the user posts a series of objectives for the friendly forces to achieve. In addition, suggestions or specifications about force disposition and dispersion, times of goal completion, and tactics can be made. The Tactical Assistant examines the knowledge base of experience for appropriate past experiences. These are modified to fit the current situation and are then presented to the user for review. Again, this review may prompt the user to modify their objectives, suggestions or specifications, in turn generating new scenarios, etc.

The Tactical Assistant could also aid the user during execution of the suggested plan. If something went wrong it would still have all the alternative courses of action available to recover and continue towards the goal.

B. How Does the Tactical Assistant Work?

The Tactical Assistant has detailed knowledge about the domain that it uses in making projections. This knowledge includes the tactics available in the domain, a detailed model of the domain, and detailed models of foreign processes operating in the domain. The knowledge may be in the form of rules for simulation, frames of experience, or both.

From the goal set and the current situation the Tactical Assistant develops the plausible courses of action. Since any particular tactic may affect more than its designated goal the Tactical Assistant must understand and be able to handle such side effects. The Tactical Assistant examines the available courses of action, weighs the costs and benefits, notes any possible problems with foreign processes, and summarizes the courses of action as a scenario for the user.

C. Functional Specifications

Figure 1 shows a functional diagram of the scenario generation by retrieval and modification of experience mechanism.

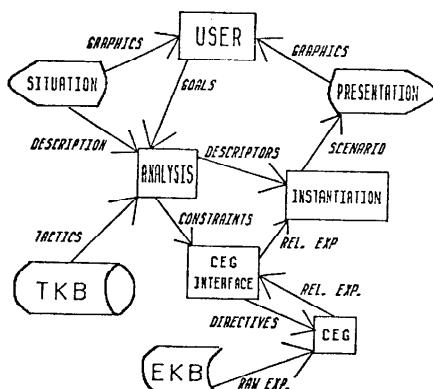


Fig. 1: Scenario Generation Mechanism

Briefly, the major subsystems and their functions are:

The Situation Analysis Subsystem examines the arrangement of friendly and enemy forces in relation to the goals of the friendly process. It then generates descriptors for each force. These descriptors are of a high level semantic nature which are used as constraints to locate experiences of similar situations. Once the relevant experiences have been recovered these descriptors are used to modify, or instantiate, the experience to fit the current situation exactly.

The Constrained Example Generation Interface Subsystem directs the Constrained Example Generation (CEG) system [6] to search the knowledge base. It also includes the judgement routines needed by the CEG system to evaluate the closeness of each potentially relevant experience to the current situation.

The User Presentation Subsystem consists of a series of graphic display routines that draw for the user each course of action from the instantiated experiences.

V. SCENARIOS - AN EXAMPLE

Figure 2 shows a sample situation from the conflict simulation game Chickamauga. The goal of the Confederate forces (light color) is to remove from play the Union forces (dark color). Figures 3 through 5 show the course of action of one of the relevant experiences. Figure 6 shows the same course of action after instantiation. Figures 7, 8, and 9 show some of the other courses of action that the system has selected as being of interest. The complete scenario consists of all these projections plus some 47 others that show other tactics, assumptions about uncontrolled processes and outcomes.

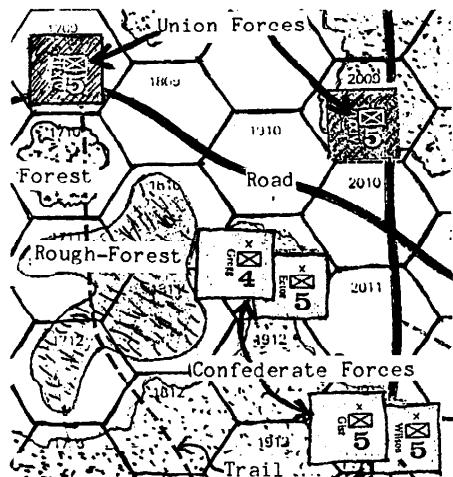


Fig. 2: Noted are the roads, trails and terrain present.

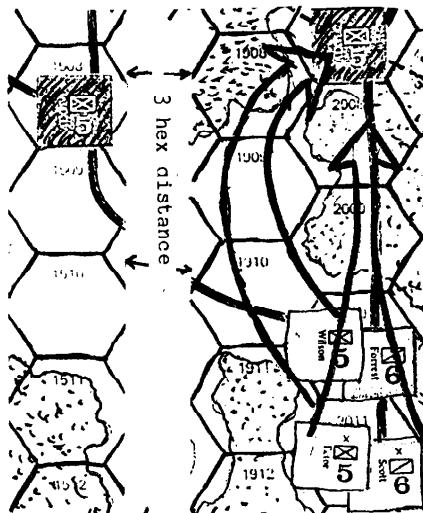


Fig. 3: The first move of the relevant experience shows the Confederates moving and destroying the first Union force.

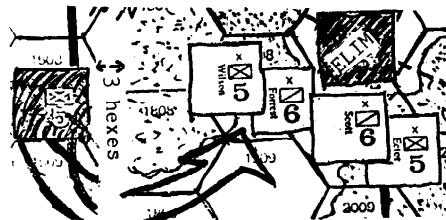


Fig. 4: The second move shows the Union's aggressive response: to attack the rear Confederate force.

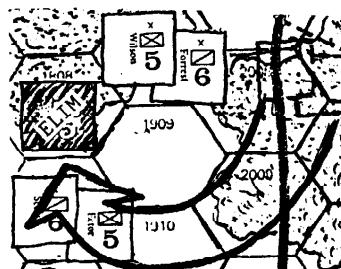


Fig. 5: The third move shows the Confederates turning, encircling and destroying the last Union force.

VI. Summary and Conclusions

Scenarios are useful tool for examining uncertain futures in many domains. In particular, our research has shown good results in two widely differing domains, errand running and conflict simulation games. The same generation mechanism was used for both these domains, leading to the conclusion that with the inclusion of the proper domain specific knowledge, many other problem areas could be handled similarly.

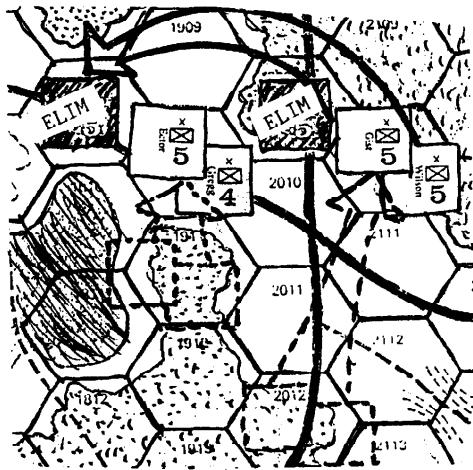


Fig. 6: The same course of action (all in one diagram) modified to fit the actual current situation.

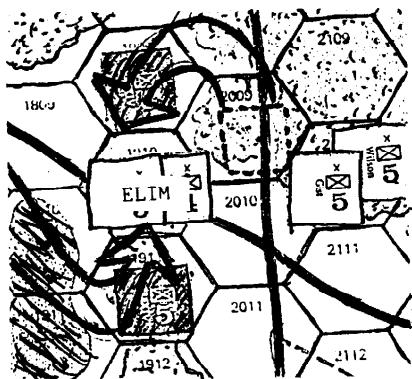


Fig. 7: An alternative outcome: the first Union force is not destroyed and together the Union forces damage the Confederates.

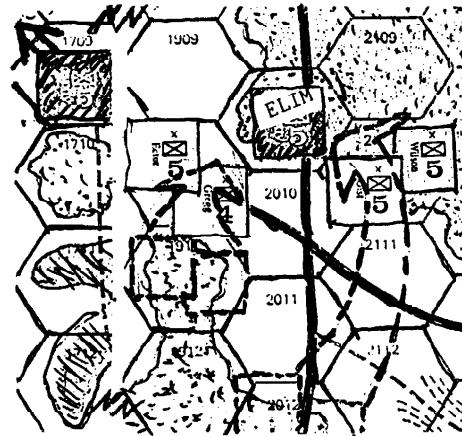


Fig. 8: An alternative outcome: the first Union force is destroyed but the second, unattacked, escapes.

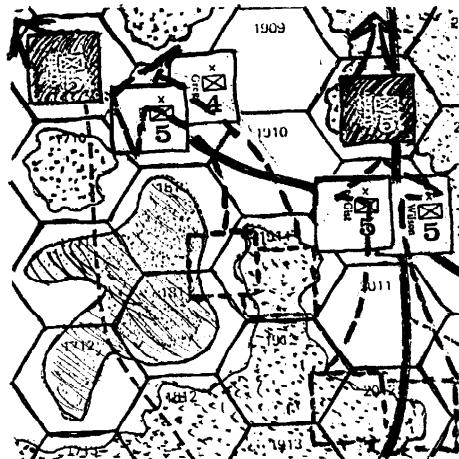


Fig. 9: An alternative course of action shows the Confederates dividing their forces, unable to destroy either Union force which then escape.

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