Conceptual Models for Planning

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Abstract. The classical paradigm in planning consists of making a precise plan taking into account the whole set of variables that may intervene in the planning system and under the supposition that none of the variables will change during the execution of the plan. This paper presents multiagent based models that permits the development of two prototypes in different contexts: the tactical and strategic contexts. We use four different stimulus/response agents in order to solve specific functions, such as classifying, quantifying, assigning and finally analysing the response of the computer. The possibility of rearranging the plan during its execution is an important advantage of planning with computer aided control.

1. Introduction

The conceptual model to use in planning is built on the base of the Agents theory. To implement the different agents we have used Artificial Intelligence techniques such as neural networks (namely the multilayer perceptron), fuzzy logic to understand human linguistic tags and intelligent searches assisted by heuristics algorithms. Nowadays there is an extensive collection of publications about these techniques and procedures, written by well-known authors like Lippman [1], Nilsson [2], Haykin [3], Russell [4], etc.

In a very high percentage of cases, human personnel carry out the procedures used in decision support for tactical or strategic planning.

Today, the current planning is made to be maintained in a medium-long term. It's supposed that there will be no changes. In case of any unexpected event, the human element will determine the modifications to be introduced in the plan. This is a risky factor due to the lack of time normally available in this kind of projects.

Nowadays, the necessity to make plans by analyzing possibilities it's a fact. However it should always be supported by the capability of reorganization in real time if an unexpected factor modifies our previous plan. This new point of view concerning planning is what we are going to call 'Planning with computer aided control.'

2. Planning Concepts

If we look up the meaning of Planning in a dictionary we can find simple concepts such as ‘act of arrangement for doing tasks by using some resources’, ‘make preparations’, or ‘to consider how to conduct actions in detail and arrange it in advance.’

Taking into account the purpose of our plan we can distinguish two different concepts. On one hand, we call tactical or short time planning when our scope is within a short term. We will work with tasks to be developed and the available resources for the plan. On the other hand, we talk about strategic planning when we think in a longer period of time. We focus our attention in the future and we try to make a long term plan by analysing facts or events.

Tactical Planning

Tactical planning is normally related to our daily activity and we look for a concrete purpose usually in terms of cost, time, effectiveness, etc. Projects management, whatever the fields we deal with, is a good example of tactical planning.

From a general point of view, the success of a project depends on four different factors:

- Obtaining, elaborating and transmitting information
- Tactical planning, for a short period
- Logistics preparation by accumulating the necessary resources
- Accurate execution of the plan

From a general point of view the planning process is a combination of tasks, resources and objectives in order to achieve a goal. In the planning phase a project team must define the different tasks and how long each task will take; the resources that can be used in order to do the tasks and the goal or goals of the project.

In case there is an unexpected change the project manager will decide which action to carry out. He will base his decision on his own experience, since he will have less time to study the complete area of new possibilities. For these reasons it is vital to make a project plan as accurate as possible.

This paper focuses its attention on the planning factor with the goal of reducing the time used in making it. We suppose that we have obtained the available information.

It’s vital that we don’t forget that even though we improve our way of making plans by following the planning models presented in this paper, we won’t succeed if any of the other factors fail. A lack of coordination in logistic or an inaccurate execution would prevent carrying out the plan successfully.

Within the general planning system, we can observe some limitations that avoid assuring the project's complete success, due to the following factors:

- A long time is spent to make a plan, specially if the process is manual.
- The methods used in planning are complex, and they are sometimes applied under subjective criteria.
- The available time to make a plan is often short. This circumstance can imply a non debugged elaboration of the plan.

– The optimization of the plan is light or simply doesn't exist. Due to the scarce available time, it is considered that the plan is well done if it follows the rules that have been pre-defined.

Strategic Planning

The concept of Strategic planning evokes a higher concept. Strategic planning is normally related to a far future and consists of studying past and present events in order to extrapolate the future. Statistical studies of Tendencies and Prospective (Godet [5]) are techniques used in economics, industry, sociology or politics in order to obtain a strategic plan.

During our every day live there are plenty of events, from domestic economy, standard of living, incidence of criminality, social integration, to radical terrorist attacks. All these events belong to a specific scenario in which we live.

The object of the strategic planning consists of analysing the events that have a direct incidence over the complete scenario. For example, the scenario lived on Sept. 11th was the result of a determined number of events.

After studying the events that are linked to the scenario, a human expert group has to investigate the influence each event has over other events. This will enable a more in-depth study in terms of probabilities. The Delphi method (Dalkey [6]) is used to take the group to a common response. Since, we are talking about conditional probabilities the Bayes theorem has to be taken into account and the isolated probabilities for each event have to be adjusted. After fitting probabilities the analysts have to yield a set of scenarios with their consequent probability. This, taking into account that adding the probability of all possible scenarios is equal to 100%. Those scenarios with higher probability will be chosen for a sensitive analysis in detail.

We can follow a similar process to analyse different contexts, such as banking, commerce, etc.

3. Tools: Stimulus/Response Agents

An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors. An agent's behavior depends only on its percept sequence to date, then we can describe any particular agent by making a table of the action it takes in response to each possible percept sequence.

Before we design an agent program, we must have a pretty good idea of the possible percepts actions, what goals our performance measure that the agent is supposed to achieve, and what sort of environment it will operate in.

From a conceptual point of view, the tactical and strategic planning models can be built on the base of two agents: one in charge of the quantification or classification process and the other responsible for the assigning or sensitive analysis process. Each of these two agents is based on a specific AI technique; in our case the quantifier /classifier agent is built on neuro-fuzzy techniques (Zadeh [7]) and the assigner/analyzer agent has been built by means of intelligent search algorithms.

4. Conceptual Model for Tactical Planning

Looking at Figure 1; we can observe the function of the two agents. The first one, we call 'the quantifier agent" is in charge of the quantification of some resources' characteristics; after this action the computer obtains a factor that will modify the tasks duration. The second agent, that we call 'the assigner agent' is in charge of assigning the resources to the tasks, looking for the solution that fits the goal previously defined.

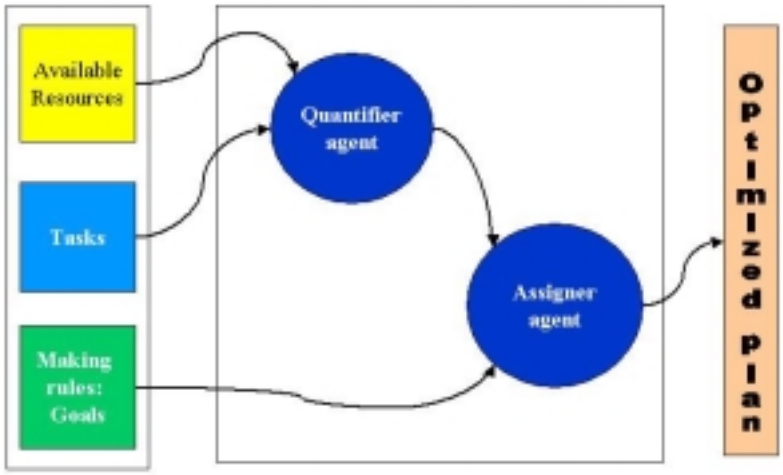

Fig. 1. Tactical planning model

The basic elements of each agent are shown in the following table:

Agent Type	Perceptions	Actions	Goals	Environment
Quantifier	A list of resources	detecting resources characteristics	Reckoning a factor to modify task duration	A file stored in a hard disk, or a table in memory
Assigner	A list of task and possible resources to be applied	detecting plan's goals, applying search operators	An optimised plan	Files stored in a hard disk, or tables in memory

From a user's point of view the computerized planning system works as a black box, to which it's necessary to give input and it will yield a possible solution to the problem.

In our case, the input will contain information about three different aspects:

- Tasks to carry out in the project
- Available resources for the project and their profile to perform a task
- Making rules to build the plan: Goals

On the other hand, the system will give us an output, which will consist of a depurated plan.

Linguistic Tags and Membership Functions

With the analysis of resources' attributes, we try to simplify the subjectivity of the human reasoning process. We define three distinctive characteristics when describing a specific resource:

- general experience in developing projects,
- capability to be applied on a specific task and
- ability to carry out the task.

We have used three linguistic tags to define the human resource experience: *Novel*, *Junior* and *Senior*. The capability is defined by declaring the task or tasks on which the resource might be applied. Concerning the ability, which is related to the specific knowledge to solve a task in particular, we define four different degrees by means of four linguistic tags: *Scarce*, *Acceptable*, *Good* and *Excellent*. This information has to be provided by an expert human team.

We have to map the characteristics of experience and knowledge with the output which describes the efficiency in developing the task. We have given three degrees of efficiency: *High*, *Medium* and *Low*. We have applied a membership function to define every tag. The logical AND operator is used when applying the conditional rules. As a result we obtain an output pattern based on the Sugeno model (Sugeno [8]).

Figure 2 shows the twelve logic rules used to describe the possible conditional statements made by degrees of *experience*, *knowledge* and *efficiency*.

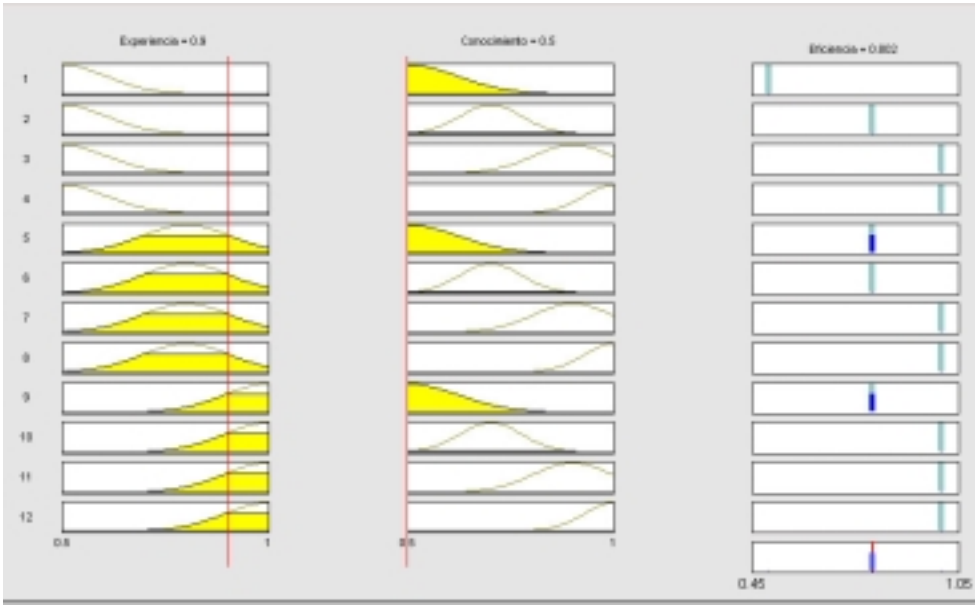

Fig. 2. Conditional rules

Defuzzyfying Phase

In order to obtain a final factor in an easier computational way, we have implemented a neural network that has been trained with the input and output pattern. After the training phase we have validated the neural-fuzzy system with different patterns from the original training set.

The output of the neural-fuzzy system is a factor that describes the efficiency to carry out a specific task. This factor will affect directly the initial estimated duration of a task when applying the resource.

Goals to Achieve in Planning

One important input in the project planning model gives the rules on which the Assigner agent will base its search. The project manager will define which goal he wants to achieve, this goal has a direct influence when applying operators on behalf of the Assigner agent.

Initially we have preset three different goals that can be selected:

- Minimum use of resources and minimum cost of the project
- To carry out all tasks in a minimum time
- To finish the project in a limited time and with minimum cost

The Resources Assigner Agent

Once we have obtained a list of task and resources, our second goal is to solve the distribution problem. This problem consists of the correct selection of an available resource to be applied to a task. However, not all possible assignments fit the defined goal for the plan. This problem is solved by the Assigner agent, which is based on an Artificial Intelligence procedure, such as the intelligent search.

Due to the need of getting an optimized plan that matches a predefined goal, and the need of obtaining the plan in real time, we have implemented a heuristic algorithm that shortens the intelligent search process.

The variables that will intervene directly in the operator selection process within the search algorithm will be:

Available resources

- Number of resources per type
- Resource's experience in projects
- Resource's knowledge in solving a specific task
- Resource's cost per hour

Tasks to do

- Tasks to develop within the project
- Duration of the tasks in days
- Dependencies between tasks
- Specific starting day for a task

In order to get a plan that fits the pre-defined goal, we have to take into account the remaining factors as variables within the production rules in our software code. These variables are:

– Number of work hours per day
– Goals:

- Minimum use of resources and minimum cost of the project
- To carry out all tasks in a minimum time
- To finish the project in a limited time and with minimum cost

Search Operators

The resource operator is in charge of making all possible combinations, from a single resource to the whole set of possible assignments. On the other hand the task operator will yield a new state in the project plan by calculating all possibilities in starting a new task.

Depending on the goal, the search key consists of starting with a minimum of resources combining the tasks set; if no solution is reached we increase with a single new resource; and so on, until obtaining a plan that fits the pre-defined goal.

If the exhaustive search arrives to the last state by using all resources and the possible tasks combinations and no solution is found, the possibilities are either to increase the number of available resources or to reduce the task list.

The complexity of the exhaustive searches lies in the very high number of states produced in the seeking process.

In Figure 3 the operators application on the set of states is shown.

Only in case we have selected a project plan goal with the use of minimum time, we apply a heuristic algorithm, which will shorten the search process.

Our heuristic algorithm will establish what is the critical path of the project plan in every new state; and it will act by adding more resources in each task that belongs to the mentioned critical path in order to shorten the complete duration of the project.

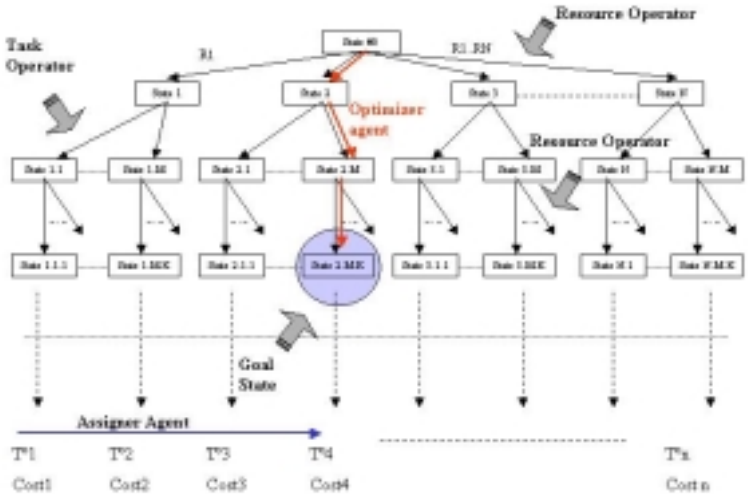

Fig. 3. Heuristic algorithm application

Tactical Planning Prototype

A software prototype has been developed to demonstrate the usability and suitability of the model. It has been built with very simple interfaces, that allows user introducing data and obtaining results in a pretty easy way.

We can summarize the use of the prototype in four steps: Introduction of tasks, definitions of resources' characteristics, definition of the project's goal and activation of the agents.

The results obtained from the use of the prototype permits assurance for the suitability of the model compared to other classical paradigms such as CPM (Critical Path Method).

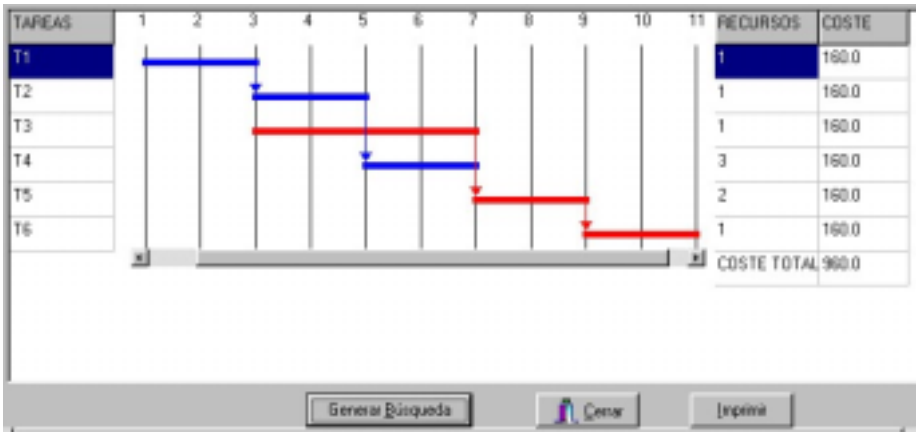

Fig. 4. Project plan

4. Conceptual Model for Strategic Planning

We have built two agents in the Strategic planning model. The first one will obtain the scenario after analysing the proposed events. We have used a neuro-fuzzy network in charge of reproducing the human knowledge and experience in making up a scenario by studying the influence among events. Thus, we talk about possibilities instead of probabilities and we avoid using complex probabilistic techniques unclear for the human expert group in most cases.

The second agent is very useful to determine which events we can influence in order to obtain a desired scenario. We have implemented an intelligent search to make the sensitive analysis of variables (in this case events) that can help us to get an ideal scenario.

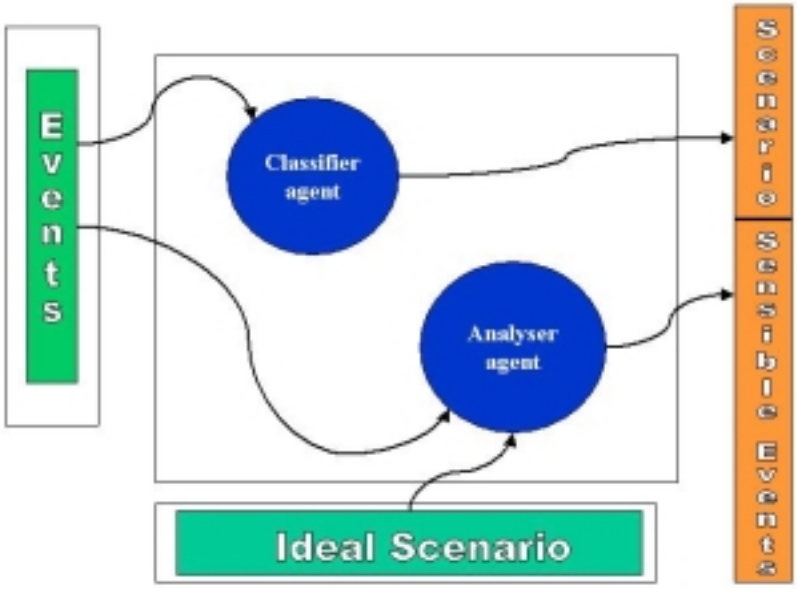

Fig. 5. Strategic planning model

The basic elements of each agent are shown in the following table:

Agent Type	Perceptions	Actions	Goals	Environment
Classifier	A list of events	Applying expert group knowledge	Creating a scenario	A file stored in a hard disk, or a table in memory
Analyzer	A list of events and the ideal scenario	Making a sensitive analysis	List of events to influence on	Files stored in a hard disk, or tables in memory

We have used techniques similar to those exposed for the tactical planning model, to define linguistic tags and defuzzifying process for the Classifier agent. Equally, we have used the same procedures to arrange operators for an intelligent search as a result of the Analyser agent application.

Strategic Planning Prototype

In a similar way that for the tactical planning model, we have developed a software prototype to demonstrate the suitability of the model and agents designed to perform a strategic plan.

We can summarize the use of the prototype in three steps: definitions of the events and their intensity, obtaining the scenario, definition of the ideal scenario and activation of the analyser agent. This agent will select the events in which we can influence to approach our scenario to the ideal one.

The results obtained from the use of the strategic planning prototype permits assurance for the suitability of the model compared to other paradigms such as the Prospective method.

5. Conclusions

This paper present two conceptual models for planning in different contexts: tactical and strategic. The models have been built on the base of Artificial Intelligence techniques.

The tactical planning model presents some advantages compared to the CPM and classical planning methods. It is also a complement of the approach of Castillo [9]. These advantages are summarized as follows:

- Capacity to manage the suitability of resources in terms of experience and knowledge and their influence in making a specific task.
- Declaration of the aim of the project in terms of time, resources or cost.
- Exhaustive search to get the best solution that fit the aim of the project.

The strategic planning model presents some advantages compared to the Prospective method, that we can summarize as follows:

- Better understanding and use of the model for the human expert group, since we don't use probabilistic calculation.
- An adaptive learning module is in charge of the scenarios generation
- Automatic sensitive analysis to determine which events have more influence over the scenario.

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