A Multiagent Based Model for Tactical 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 project and under the supposition that none of the variables will change during the project development. 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. Many times this objective is not easy to achieve, due to the different variables that intervene in the planning process.

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.

This paper presents a multiagent based model that permits to develop two prototypes in different contexts. One of these prototypes was introduced in the NMSG symposium held in Breda (The Netherlands) in 2001. The conceptual model has been improved in order to be applied in another different context. A second prototype has been developed under the same conceptual model and using similar Artificial Intelligence Tools.

We use four different stimulus/response agents in order to solve specific functions, such as classifying, quantifying, assigning and finally optimising the response of the computer.

The first prototype is able to solve an artillery preparation or counter-preparation plan by using as few artillery units as possible. The second prototype solves the planning process in project management.

Usually, the way in which the project manager assigns the resources to the tasks determines the cost or the total duration of the plan. In simple projects, a person with specific experiences can build a plan but when there are many available possibilities to perform this assigning process, the combinatorial explosion exceeds the human capacity. On the other hand, when applying resources to tasks it is necessary to take into account the experience and knowledge of each human resource. These characteristics are normally defined with linguistic tags instead of using quantified values.

In this paper we present a solution that opens the door of a new paradigm that we call 'planning with control in real time'. A computer aided plan would support the project manager by proposing a faster and probably better solution than the human calculated option.

***Keywords**: Planning, Task, Resources, Goals, Agents, Neural networks, Intelligent searches, Fuzzy logic, Heuristic algorithms.*

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OVERVIEW

In projects management it is vital to make a project plan as accurate as possible. Many times this objective is not easy to achieve due to the different variables that intervene in the planning process. The classical paradigm in planning consists of making a precise plan taking into account the whole set of variables that may intervene in the project and under the supposition that none of the variables will change during the project development. 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 whole area of new possibilities.

In a very high percentage of cases, human personnel carry out manually the procedures used for tactical or strategic planning. These two different point of view have a different perspective of the planning process. 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.

From a general point of view the planning process in tactical environment is a combinations 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.

Nowadays, the necessity to make plans by analysing 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.'

Usually, the way in which the project manager assigns the resources to the tasks determines the cost or the total duration of the plan. In simple projects, a person with specific experiences can build a plan but when there are many available possibilities to do this assigning process, the combinatorial explosion exceeds the human capacity.

In this paper we present a solution that opens the door of a new paradigm such as 'planning with control in real time'. The model that we have developed is based on stimulus/response agents. Two prototypes have been built in order to be solved in different planning contexts by using the conceptual model. A computer aided plan would support the project or operation manager by proposing a faster and probably better solution than the human calculated option.

The aim of this paper is to present the result of the research about the mechanization of the reasoning process in the tactical planning process. The conceptual model is built on base of the Agents theory. To implement the different agents we have used Artificial Intelligence techniques such as neural networks, fuzzy logic, and intelligent searches assisted by heuristics algorithms.

As a future project, and within the same investigation line, we are creating a new conceptual model which will serve the base for the construction of new prototypes to resolve planning problems but this time within the strategic environment.

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 field 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

The tactical 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. To solve the planning problem we suppose that we have initially 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, especially 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 dramatic scenario lived on Sept. 11th 2.001 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 areas, such as banking, commerce, etc.

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 planning model can be built on the base of four agents: one in charge of the quantification, other for the classification process, other responsible for the assigning, and finally an agent in charge of making the Assigner Agent more efficient. Each of these four 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/optimiser agent has been built by means of intelligent search algorithms.

CONCEPTUAL MODEL FOR TACTICAL PLANNING

Figure 1 describes the data transmission among agents. 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. Depending on the context we are planning on, it is possible the necessity of a classification, so we have arranged an Agent in charge of this process. The Assigner Agent is in charge of assigning the resources to the tasks, looking for the solution that fits the goal previously defined. The Optimiser Agent will shorten the searching time in case we need to make the Assigner Agent more efficient.

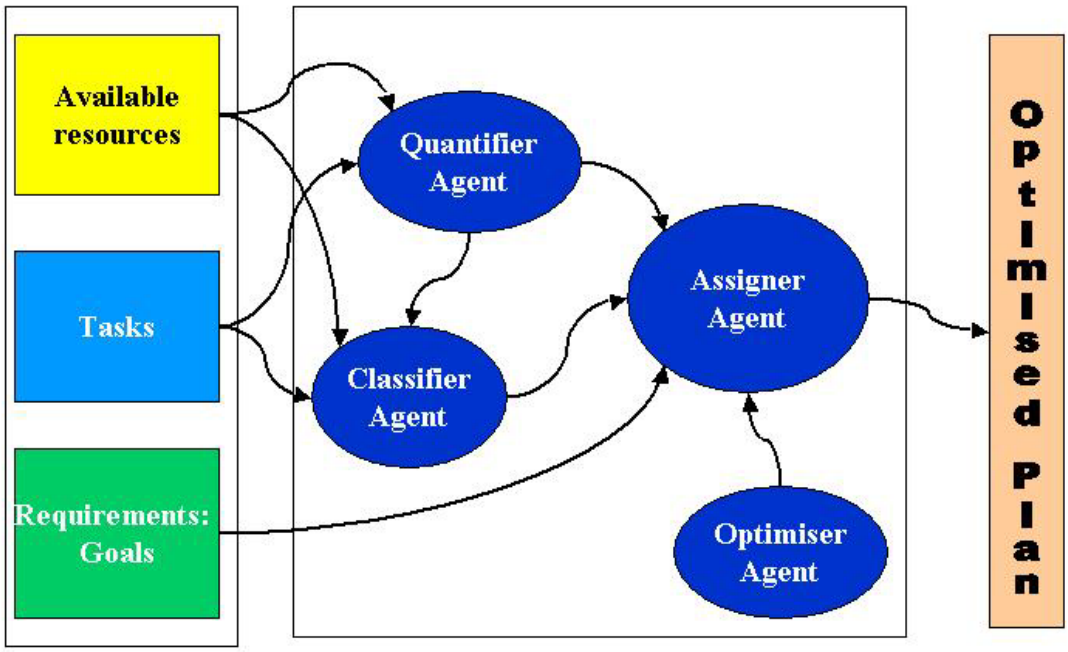


Figure 1: Tactical Planning Model.

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
Classifier	A list of resources	Detecting resources characteristics	A classified task or resource list	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
Optimiser	Variables within the assigning process	Use of an efficient search algorithm	An efficient and optimised plan	Code stored in a file 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 specific task
- Requirements to build the plan: Goals

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

In order to check the suitability of the conceptual model we have developed two prototypes that are involved in different environments. The first one deals with the Field Artillery planning and the second one tries to give a more accurate solution to the planning process in Project Management.

PROTOTYPE 1: FIELD ARTILLERY PLANNING

The aim of this prototype is to demonstrate the suitability of the mechanization of the reasoning process in field Artillery planning by using Artificial Intelligence (AI) procedures.

The research is focused in particular on the preparation and counterpreparation artillery plans, due to their special complexity. The rest of the different artillery plans could be solved by using similar tools, perhaps in an easier way.

In this kind of problems the combinatorial explosion is the factor that prevents man to prospect the whole possibilities set in real time. He only can obtain a possible solution without being certain that it is the best. For that reason, the Artificial Intelligent procedures and their implementation in high-performance computers are suitable to serve as a powerful tool in the planning process.

To serve as an example, we can imagine an artillery preparation plan for neutralizing twenty targets with five field artillery units in a ten-minute plan. The officer in charge of the planning process will take about thirty minutes to find a viable solution, which will not be optimised by respecting a minimum use of resources, and will not be free of possible human error. By using the computer aided planning tool, the computer explores nearly a hundred and thirty five thousand possible assignation states, and it yields the solution that best fits the porpoise of the plan by saving as many artillery units as possible and taking only a few seconds.

The analysis and results of this prototype are treated in deep in the paper entitled “A tactical planning approach by using AI. procedures” presented in the NMSG Symposium held in Breda (Nov. 2.001), J.M. Castillo, F. Arriaga [8].

PROTOTYPE 2: PROJECT MANAGEMENT

The goal of this prototype consists of the mechanization of the reasoning process in the planning phase of the project management by using AI procedures.

The research is focused in particular on computer science projects. It would be applicable to such projects with similar characteristics, especially those which represent the same response in task duration when applying several resources.

As well as in the Field Artillery planning prototype, the combinatorial explosion is the factor that prevents man to prospect the entire set of possibilities in real time.

The conceptual model we have elaborated on is built on the base of the Agents theory. To implement the different agents we have used Artificial Intelligence techniques such as fuzzy logic, neural networks and intelligent searches assisted by heuristics. First we use the fuzzy logic to quantify some linguistic tags which determine characteristics of the project resources; then a multilayer perceptron is used as a defuzzyfier. Once tasks and resources have been treated adequately, we implement an intelligent search algorithm to make the assignation process by looking for the goal defined previously.

FUZZY LOGIC: 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 [9]).

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

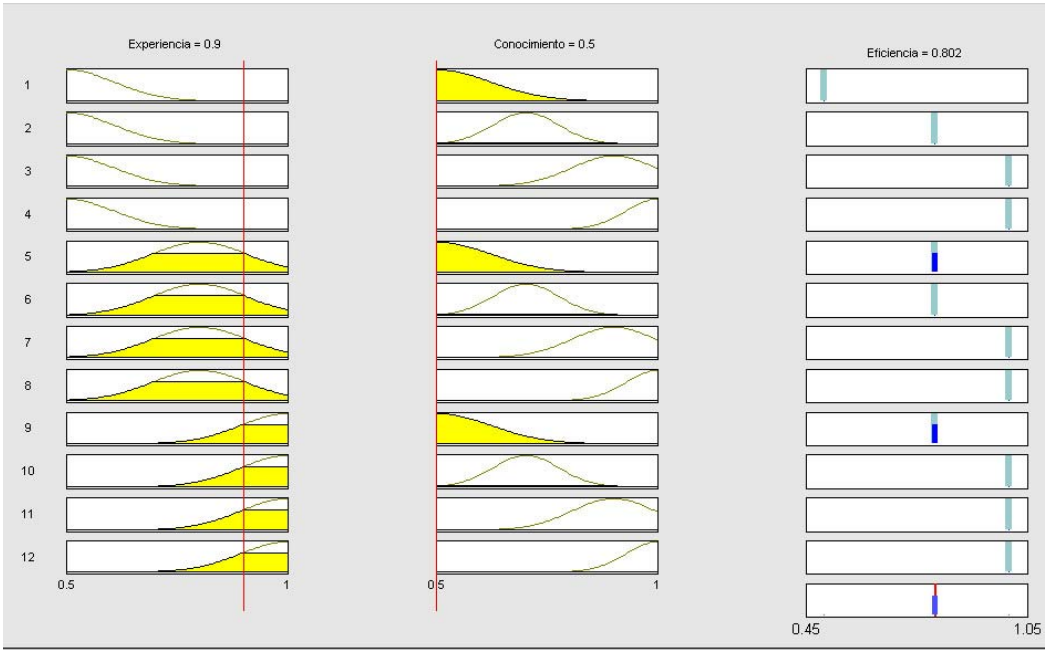


Figure 2: Conditional Rules.

DEFUZZY 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 PROJECT MANAGEMENT

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 operator's application on the set of states is shown.

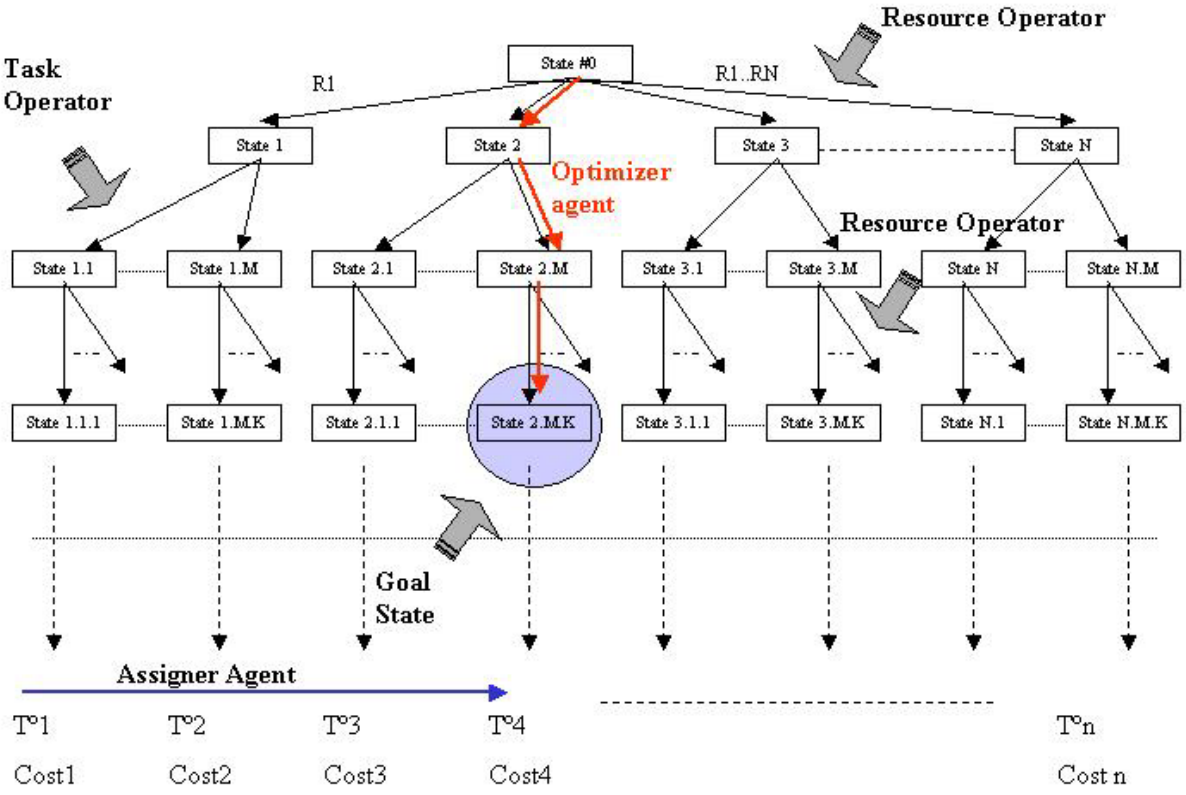


Figure 3: Heuristic Algorithm Application.

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.

PROJECT MANAGEMENT SOFTWARE

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).

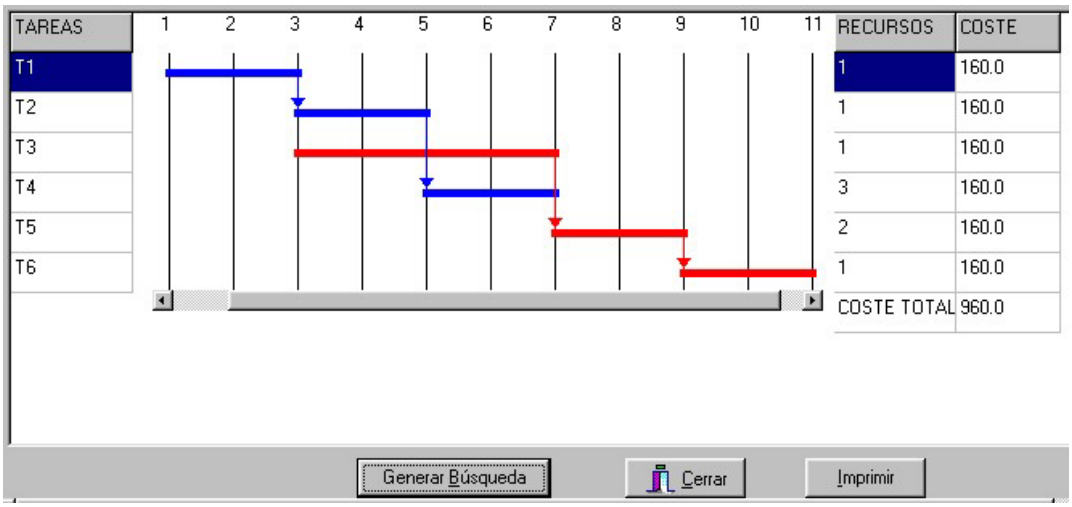
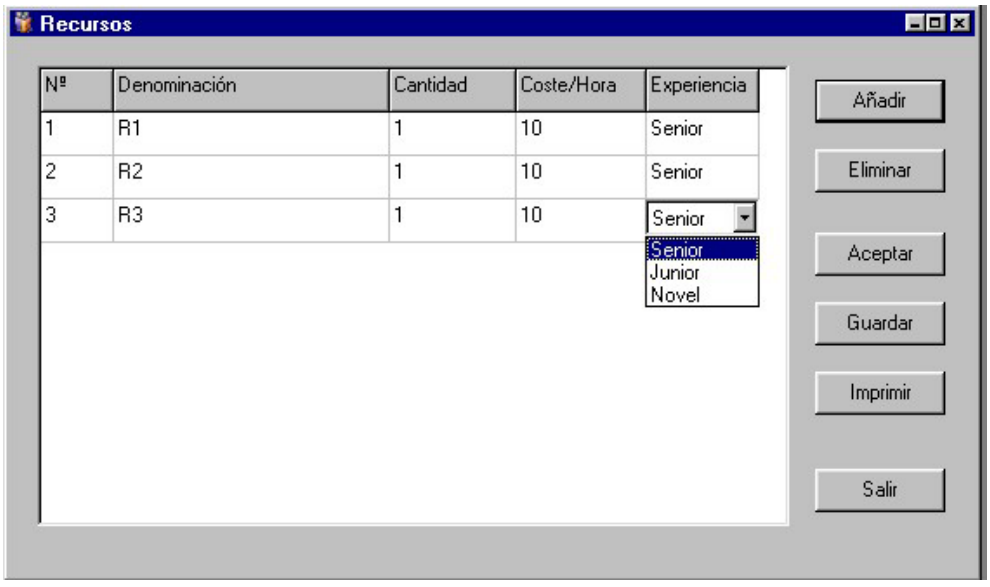


Figure 4: Project Plan.

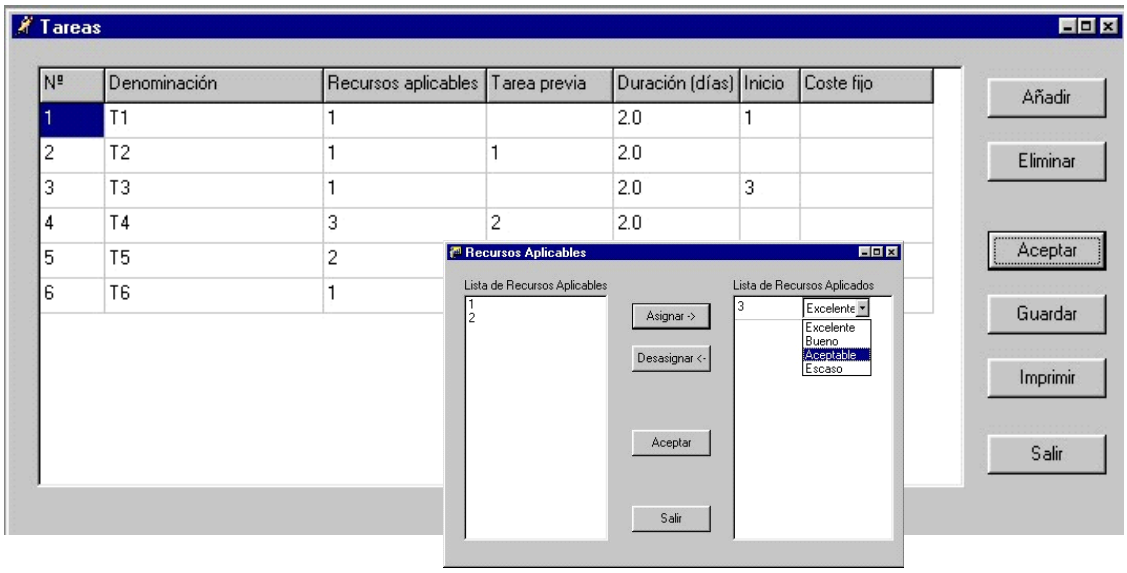
Example of Use

To use the software prototype it is necessary to accomplish four steps:

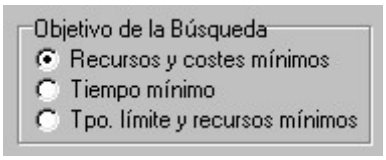
1) To generate/load the resources list



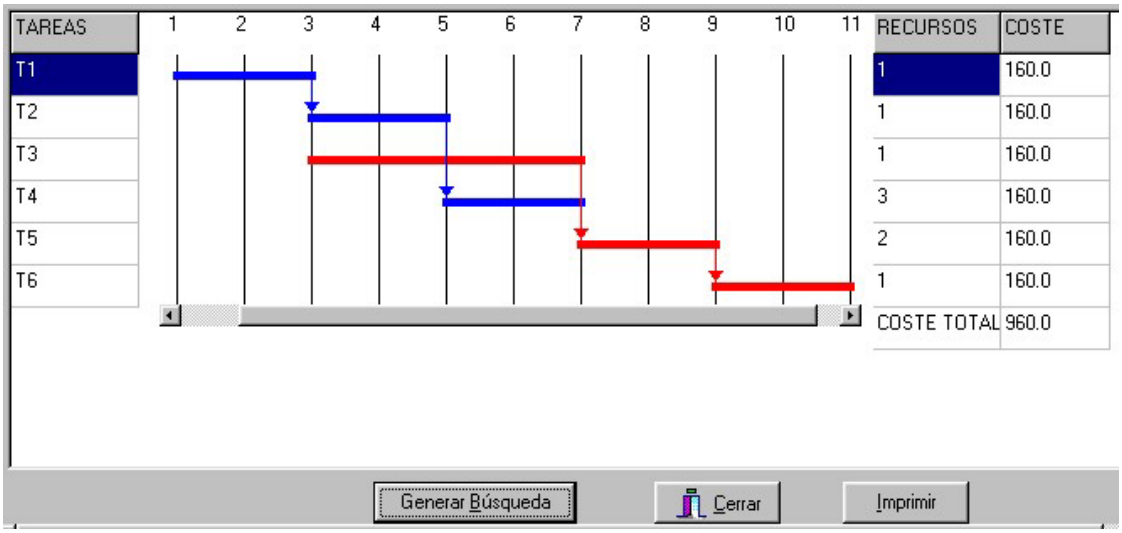
2) To generate/load a tasks list



3) To define the goal



4) To search the solution



Developing the Project

One of the most important advantages that this work can offer is having a plan with computer aided control. This characteristic implies the automatic reorganisation in real time if the scenario changes unexpectedly while the project is being developed. Therefore, we can obtain in a few milliseconds a new plan that fits the requirements of the new project scenario.

CONCLUSIONS

This paper presents a conceptual model for tactical planning. Under the same conceptual model we have built two prototypes in different contexts: Field Artillery Planning and Project Management. The model have been built on the base of Artificial Intelligence techniques.

The advantages and development of the Field Artillery Planning prototype are described in detail in the proceedings of the NMSG symposium held in Breda (Nov. 2001).

Regarding the Project Management Prototype, it introduces some advantages compared to the CPM and classical planning methods. This prototype improves the planning model approach of Castillo [10], by using a new agent responsible for the quantification of some linguistic patterns. The general advantages that this work presents can be 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 fits the aim of the project.
- Capacity of reorganization of the plan in the execution phase of the project.

FUTURE PROJECT

After the results obtained in the field of Tactical planning, we are working on building a conceptual model to support Strategic planning. We expect to use successfully a neuro-fuzzy network in charge of reproducing the human knowledge and experience in making up a scenario by studying the influence among events. By using this procedures, we would talk about possibilities instead of probabilities and we will avoid using complex probabilistic techniques rather unclear for the human expert group in most cases.

Other problem that we are working on consists of determining which events we can influence on, in order to obtain a desired scenario. We are trying to implement an intelligent search to make the sensitive analysis of variables (in this case events) that can help us to get an ideal scenario.

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

If we obtain some results from the use of the strategic planning prototype we could offer other alternative to classical paradigms like the Prospective method.

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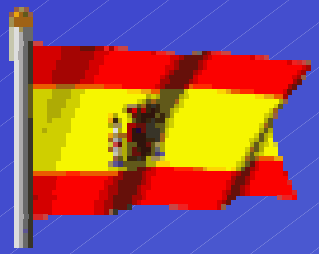

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AGENDA

- Overview
- Tactical vs. Strategic Planning
- Conceptual Model for Tactical Planning
- Tools: A.I. procedures
- Prototype 1: Artillery Planning
- Prototype 2: Project Management
- Conclusions
- Future work

Overview

- Conceptual Modelling: NMSG activity
- Planning and Simulation: Necessity to predict the future
- Planning taxonomy regarding the scope:
  - Tactical and Strategic
- Goal:
  - To build a Conceptual Model able to solve the problem of planning in tactical environment
  - Check the suitability of the project by making software prototypes

Tactical vs. Strategic Planning

- Tactical planning: How?
  - Combination of tasks, resources and objectives in order to achieve a goal.
- Strategic planning: What?
  - Related to a distant future and consists of studying past and present events in order to extrapolate the future. Statistical studies of Tendencies and Prospective are techniques used in the military, economics, industry, sociology or politics in order to obtain a strategic plan.

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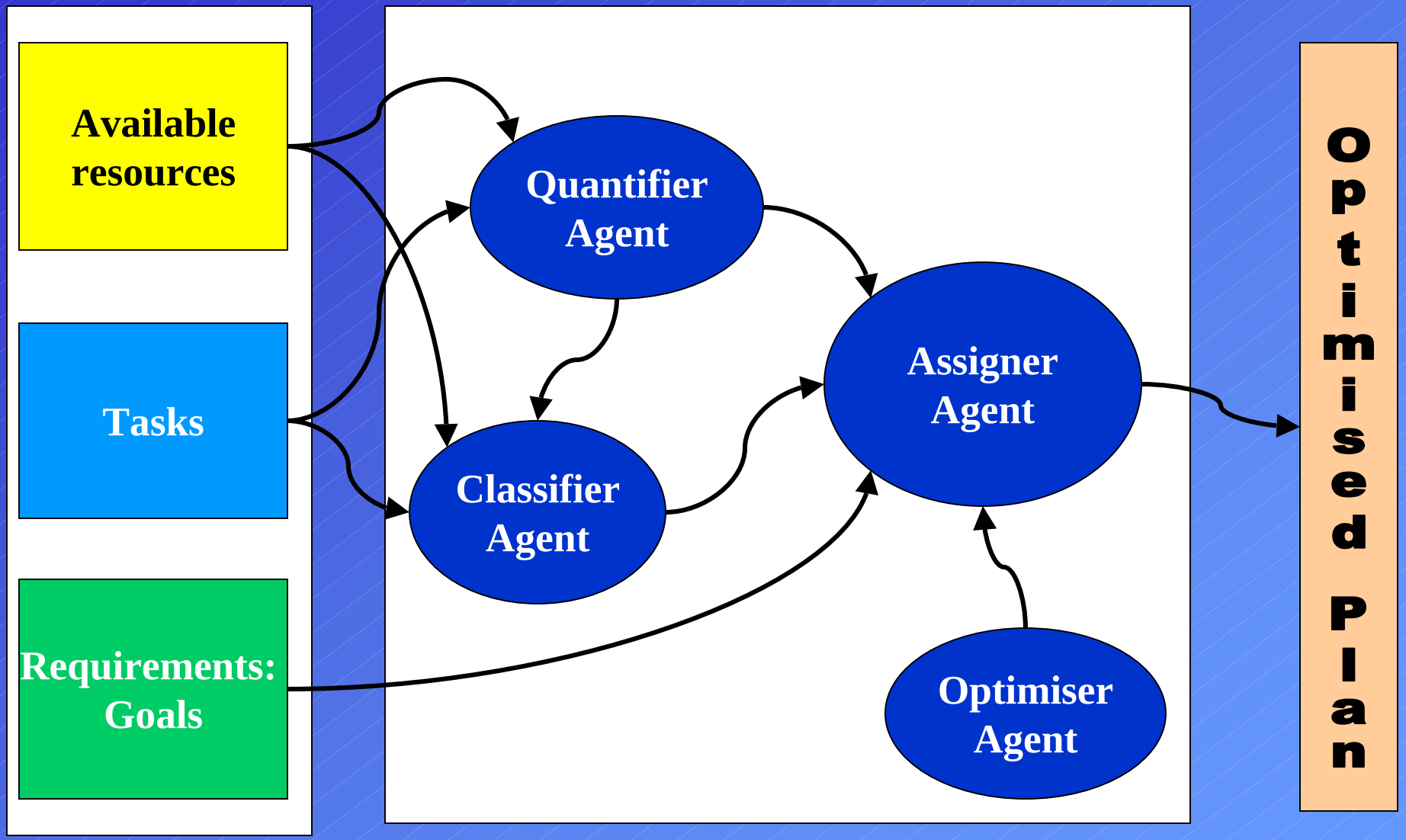
Elements for Tactical Planning

- Resources or tasks characteristics:
  - Difficulty to quantify
  - Normally expressed in terms of linguistic tags
  - Need of classification
- Need to define the goals to achieve
- Necessity to have a clear definition of the rules to build the plan

Conceptual Model for Tactical Planning



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Tools: A.I. Procedures

- Multiagent based model
- Neural Networks: Classifier
- Fuzzy logic: Quantifier
- Intelligent searches: Assigner
- Heuristics or Genetic Programming: Optimiser

Concepts about Agents

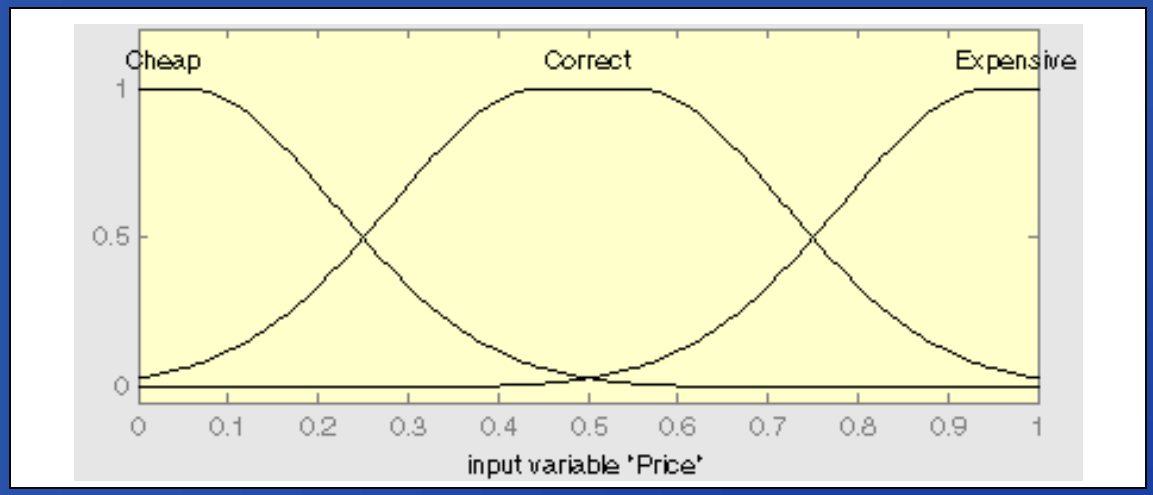
- Different labels for agents: autonomous agents, software agents, intelligent agents, interface agents, virtual agents, mobile agents and so on
- The term of agent is now used so frequently that there is no commonly accepted definition
- ‘Smith’ takes an agent to be a “persistent software entity dedicated to a specific purpose”
- ‘Riecken’ refers to “integrated reasoning processes” as agents
- In this work we refer to agents as “software entities in charge of reasoning processes”

Quantifying linguistic tags

Inputs →  → **Outputs**

- Inputs characteristics are defined with linguistic tags
- Fuzzy phase
- Logic rules can influence each other
- Defuzzy phase
- The knowledge is implemented in the Quantifier agent

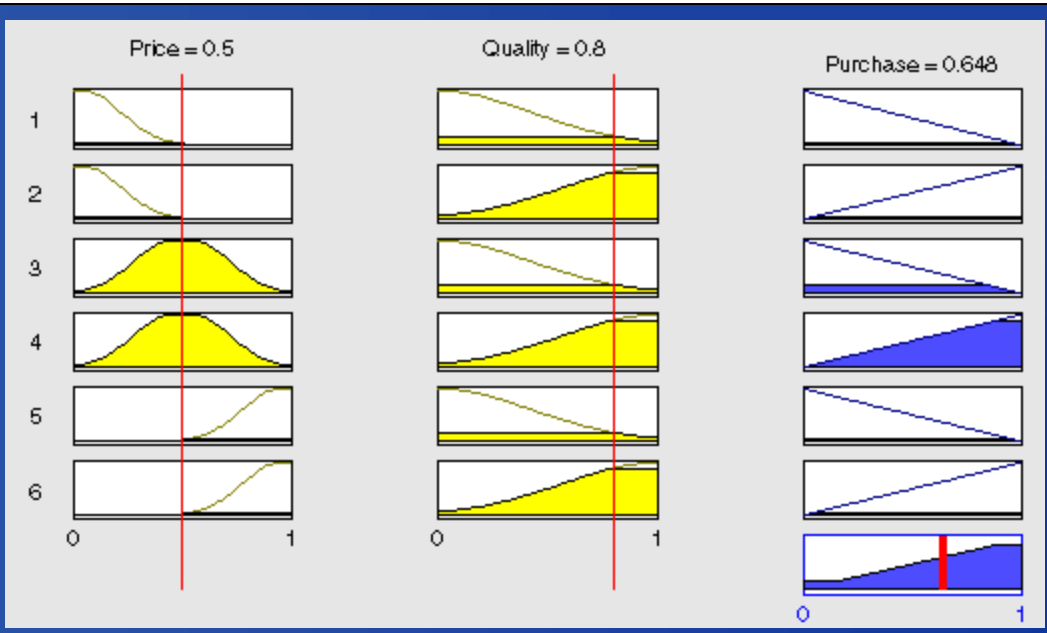
Fuzzy phase example



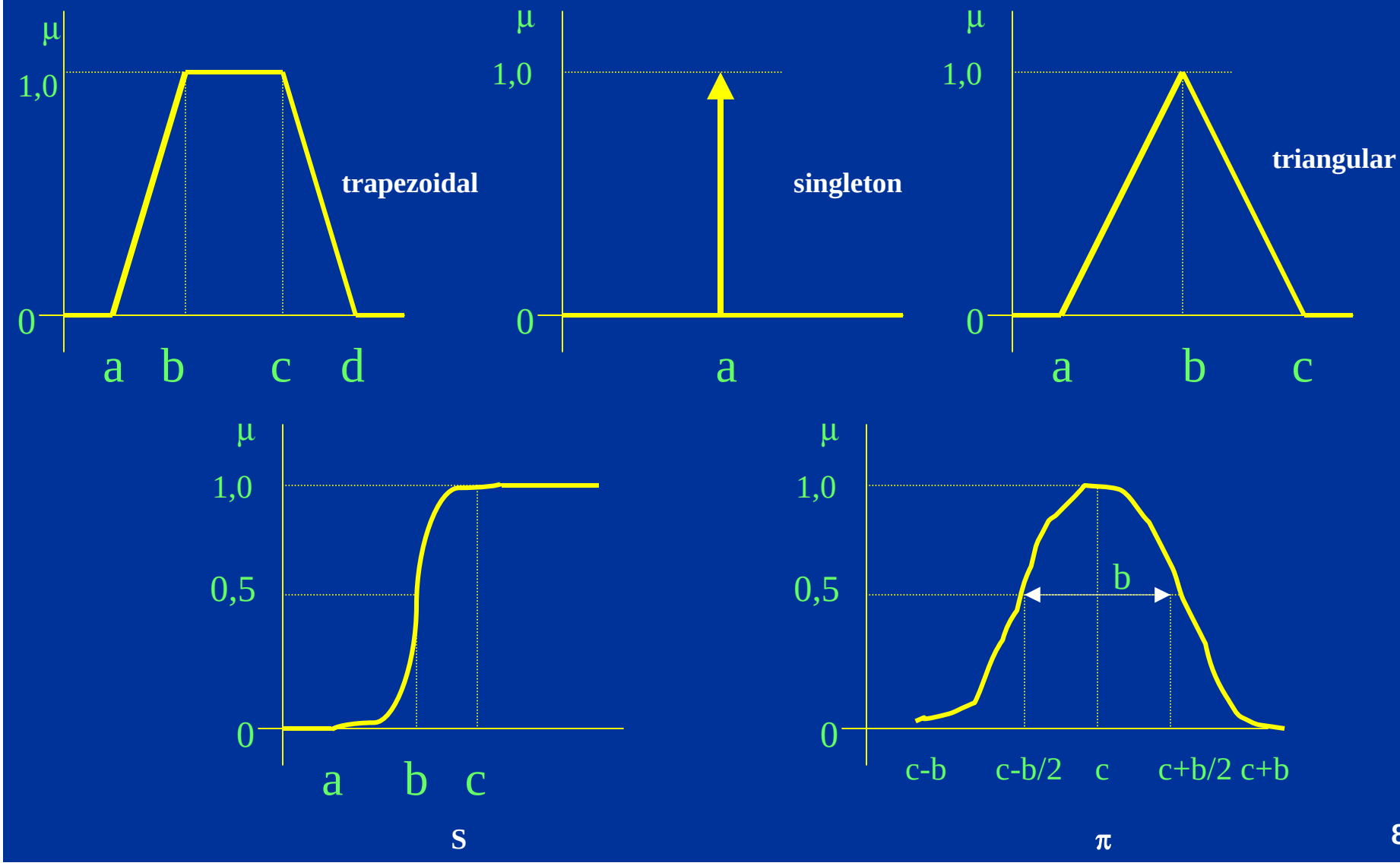
- Not all people have the same concept of ‘cheap’, ‘expensive’ or ‘correct’ when talking about prices
- We can group the concept around a quantified value
- When we talk about ‘correct’ we have to take into account the influence of ‘cheap’ and ‘expensive’

Fuzzy phase: Influence among rules

1. If (Price is Cheap) and (Quality is Low) then (Purchase is Bad) (1)
2. If (Price is Cheap) and (Quality is High) then (Purchase is Bargain) (1)
3. If (Price is Correct) and (Quality is Low) then (Purchase is Bad) (1)
4. If (Price is Correct) and (Quality is High) then (Purchase is Bargain) (1)
5. If (Price is Expensive) and (Quality is Low) then (Purchase is Bad) (1)
6. If (Price is Expensive) and (Quality is High) then (Purchase is Bargain) (1)



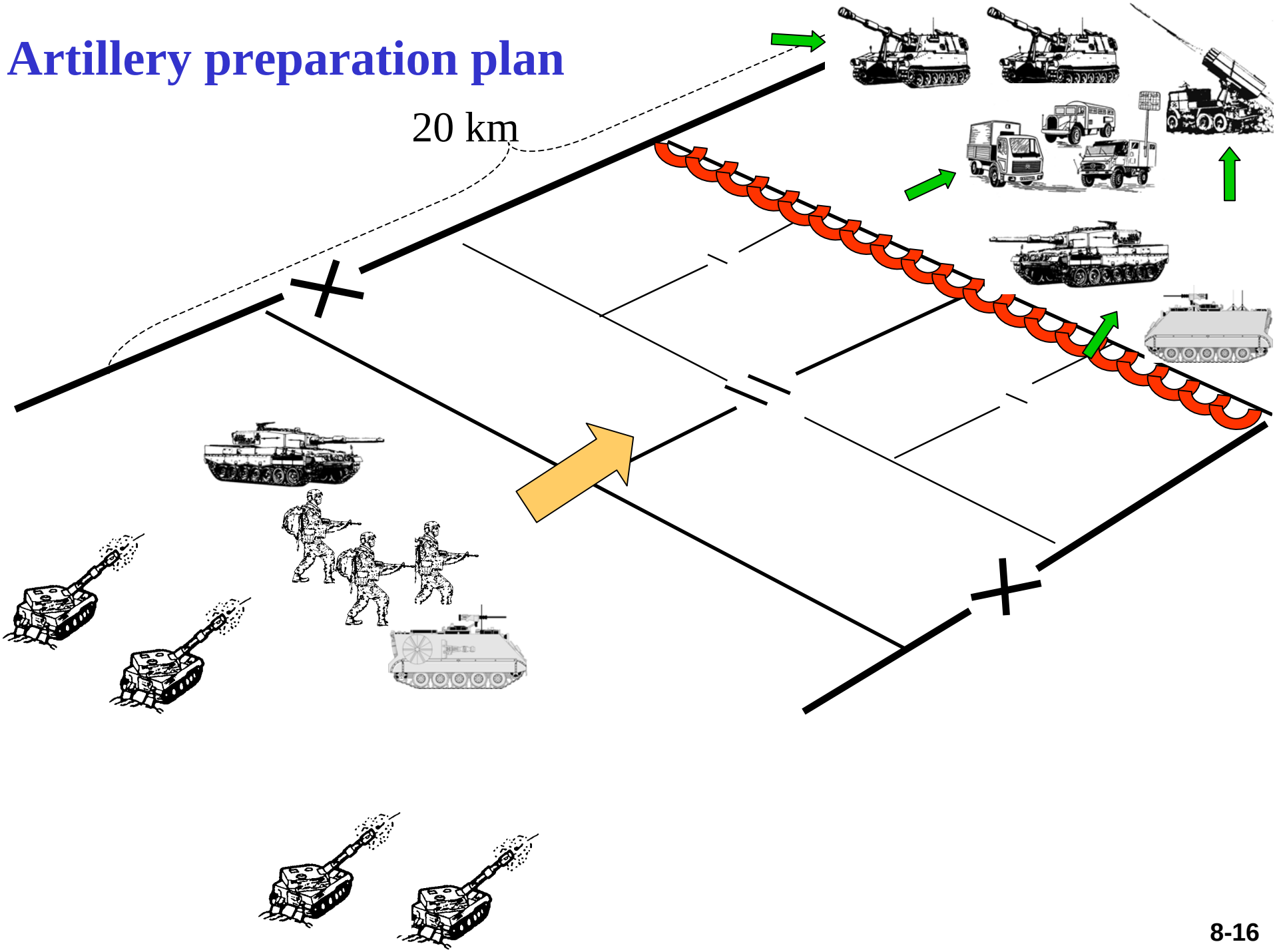
Membership functions



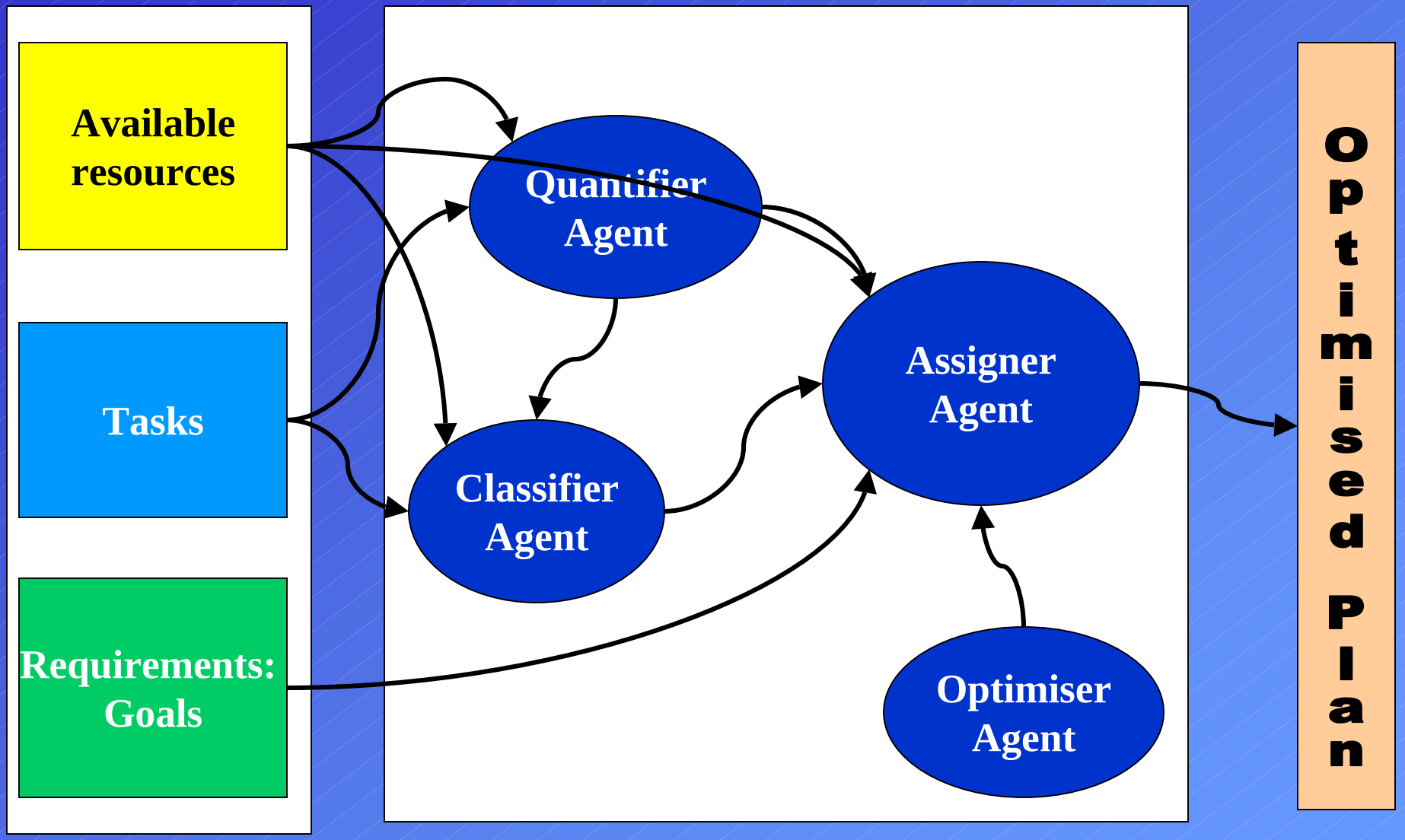
AGENDA

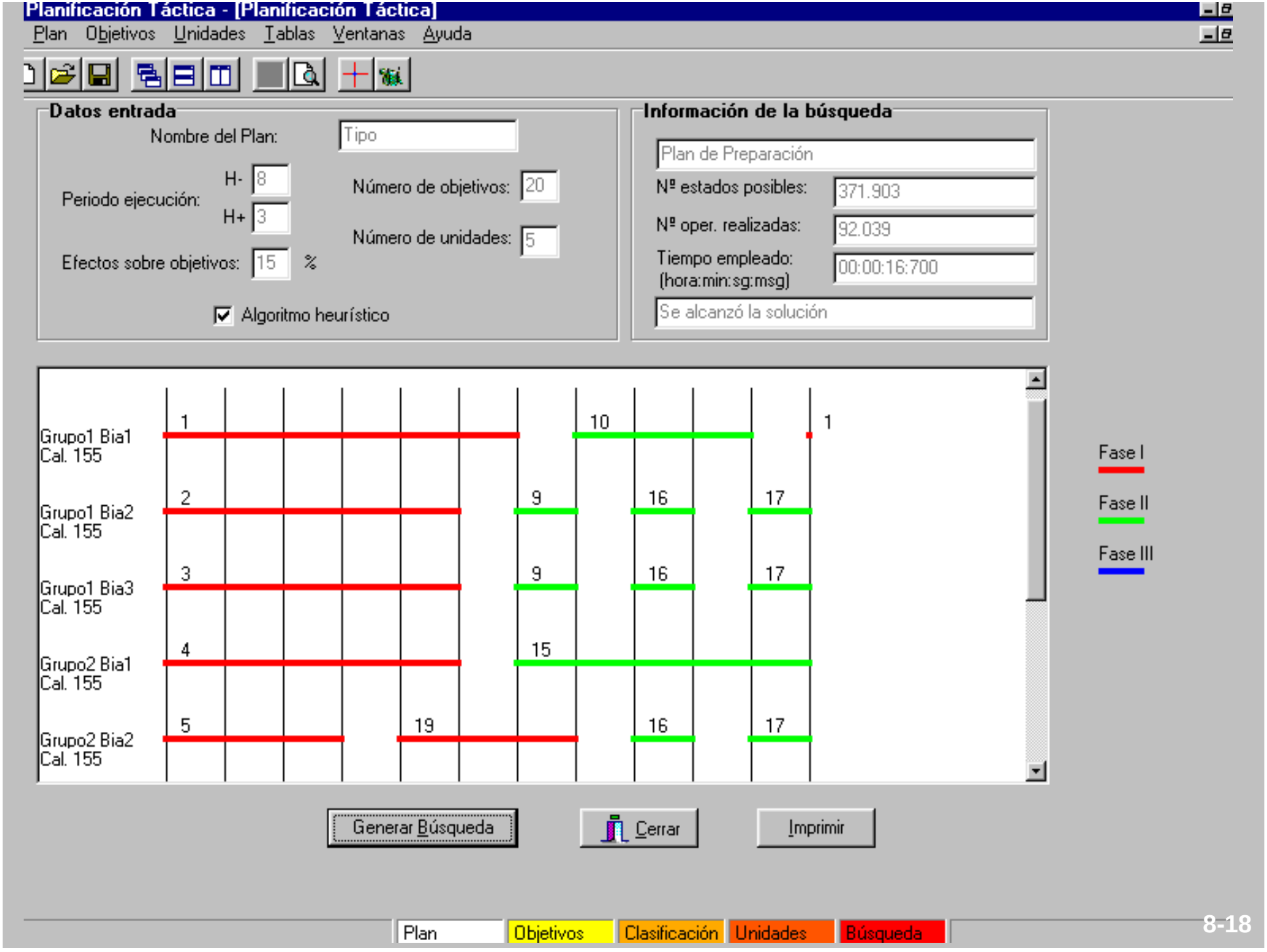
- Overview
- Tactical vs. Strategic Planning
- Conceptual Model for Tactical Planning
- Tools: A.I. procedures
- Prototype 1: Artillery Planning
- Prototype 2: Project Management
- Conclusions
- Future work

Artillery preparation plan



Conceptual Model for Tactical Planning




Planificación Táctica - [Planificación Táctica]
Plan Objetivos Unidades Tablas Ventanas Ayuda
Datos entrada
Nombre del Plan: Tipo
Periodo ejecución: H- 8 H+ 3
Número de objetivos: 20
Número de unidades: 5
Efectos sobre objetivos: 15 %
Algoritmo heurístico
Información de la búsqueda
Plan de Preparación
Nº estados posibles: 371.903
Nº oper. realizadas: 92.039
Tiempo empleado: (hora:min:sg:msg) 00:00:16:700
Se alcanzó la solución
Grupo1 Bia1 Cal. 155
Grupo1 Bia2 Cal. 155
Grupo1 Bia3 Cal. 155
Grupo2 Bia1 Cal. 155
Grupo2 Bia2 Cal. 155
1 10 1
2 9 16 17
3 9 16 17
4 15
5 19 16 17
Fase I
Fase II
Fase III
Generar Búsqueda
Cerrar
Imprimir
Plan
Objetivos
Clasificación
Unidades
Búsqueda

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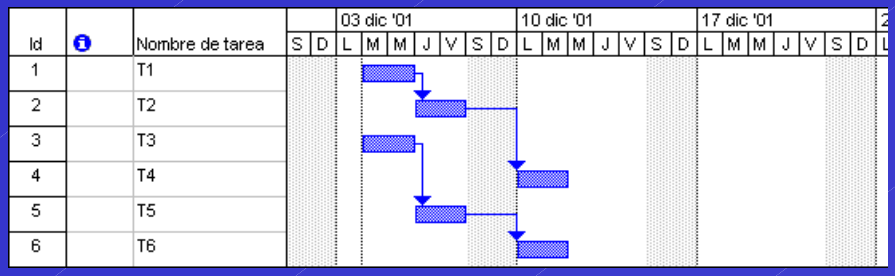
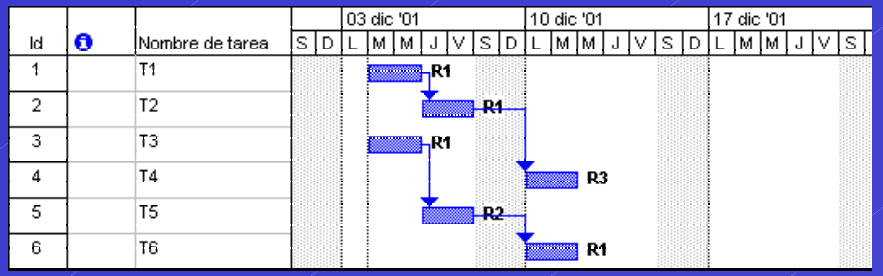
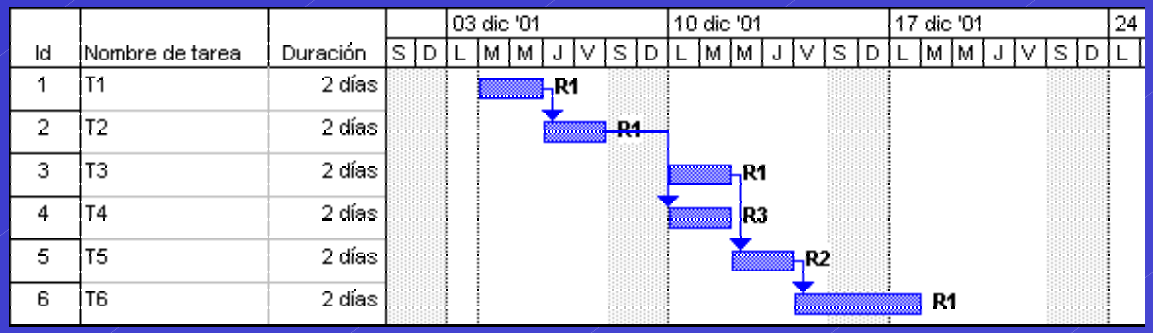
Prototype 2: Project Management



1. Defining tasks



2. Applying resources

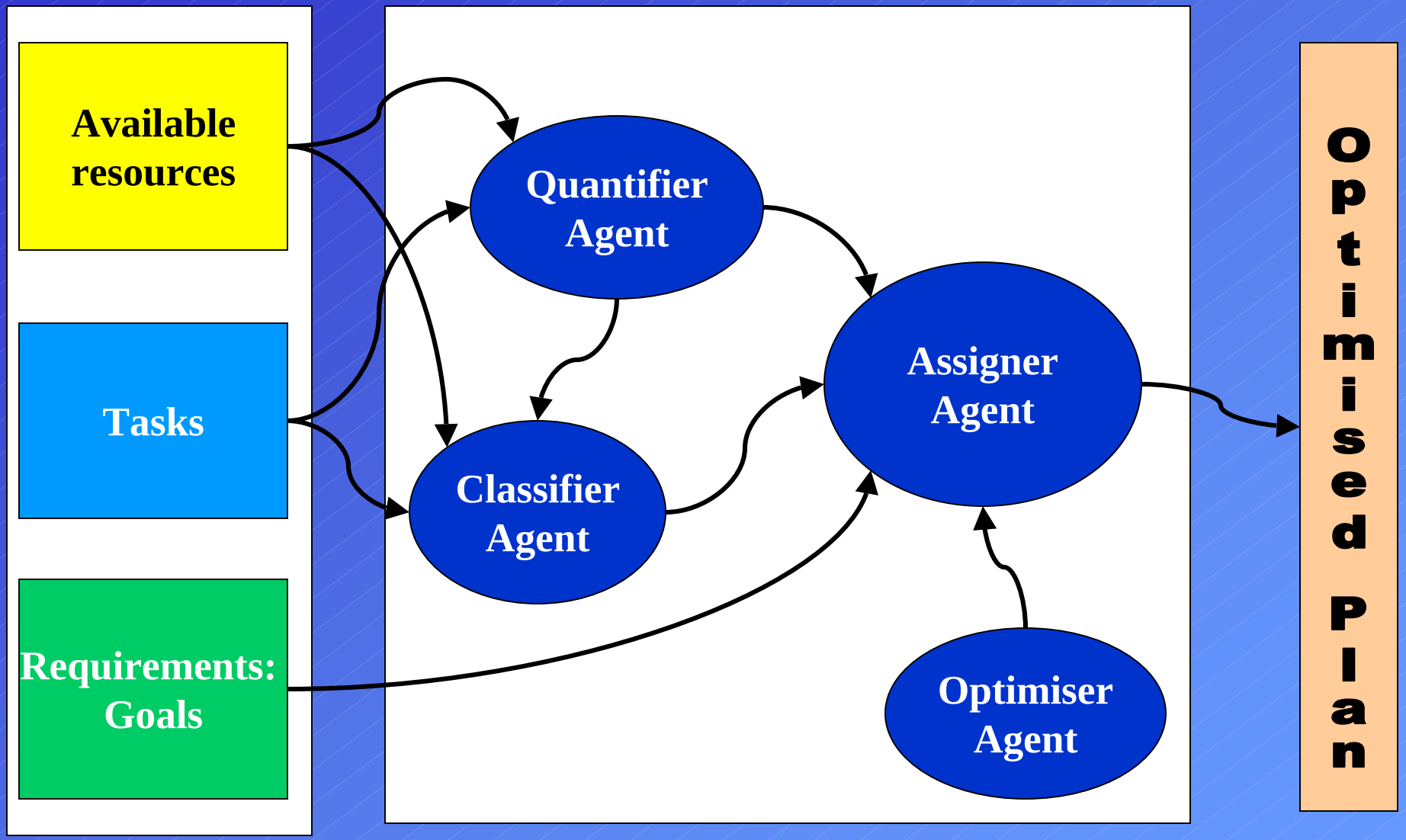


3. Redistributing over-assigned resources

Inputs' characteristics

- Tasks
  - Duration, Dependencies and Starting day
- Resources
  - Available resources per type, Experience in projects, Knowledge in solving a specific task and Cost
- Planning rules, goals
  - Number of work hours per day, selection of the goal (time, use of resources or cost)

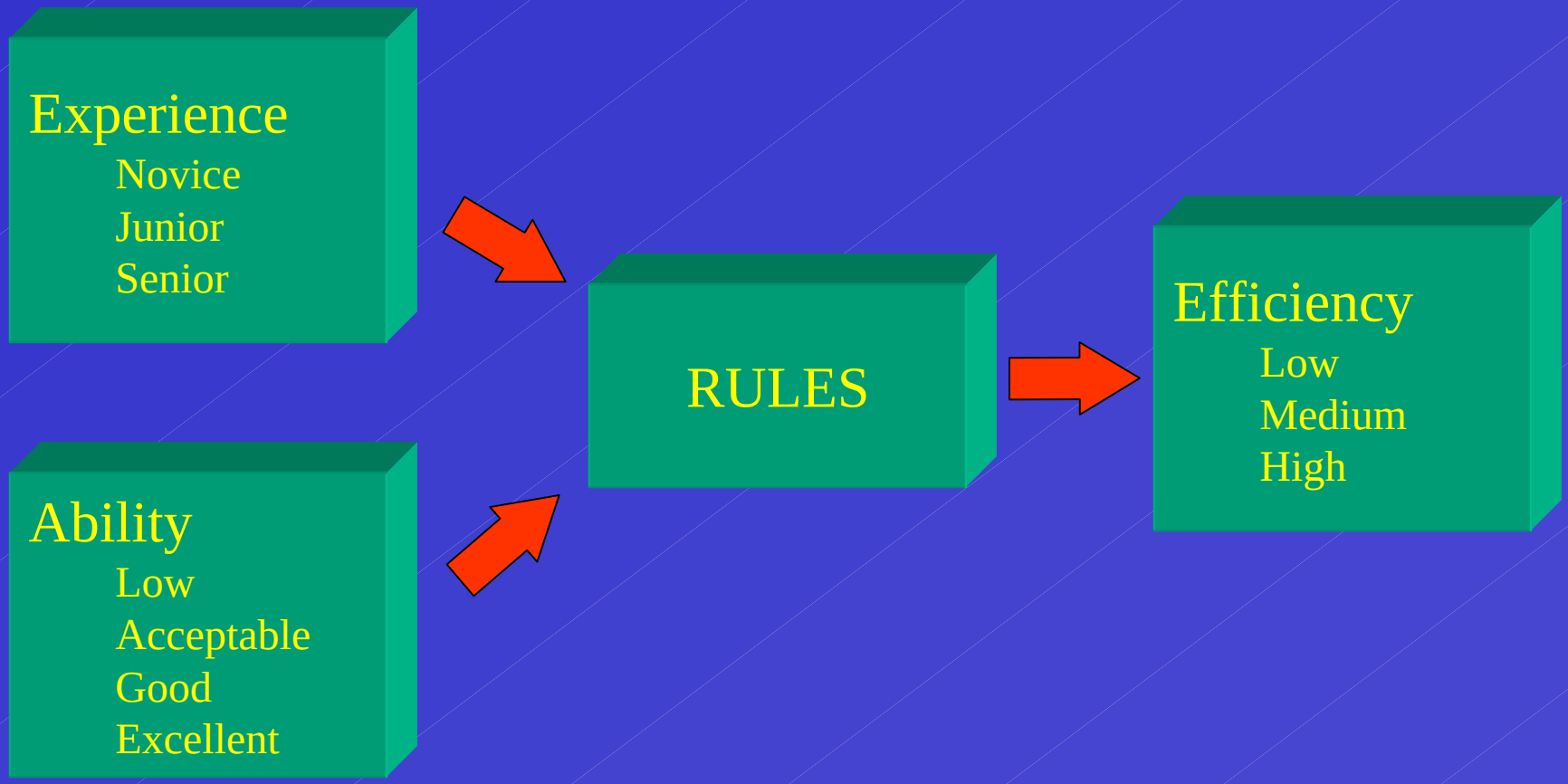
Conceptual Model for Tactical Planning



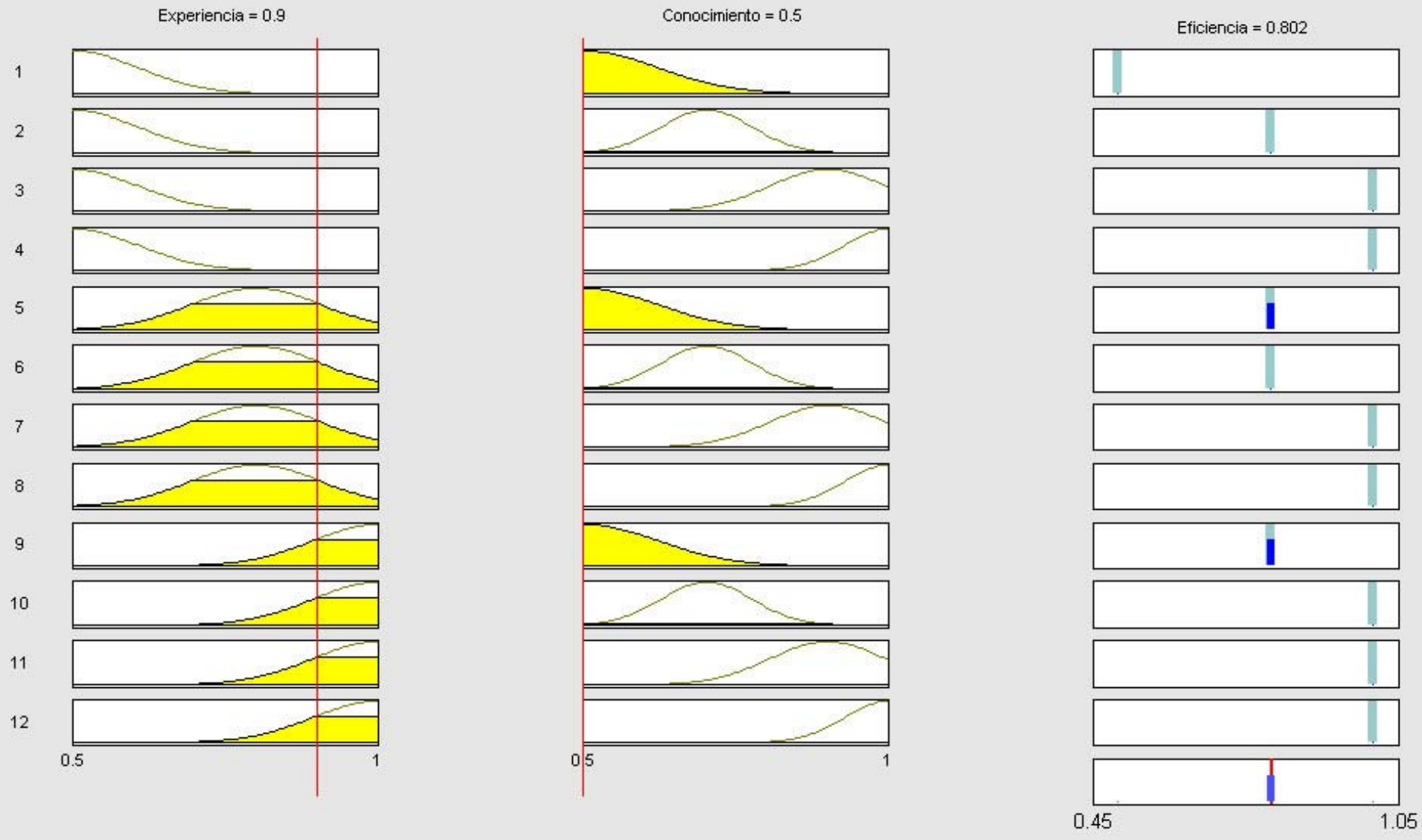
Resources & Tasks definitions

- Capability to be assigned to a task
- Experience in developing projects:
  - Novice, Junior and Senior
- Ability to carry out the task:
  - Low, Acceptable, Good and Excellent
- Output in terms of efficiency:
  - High, Medium and Low

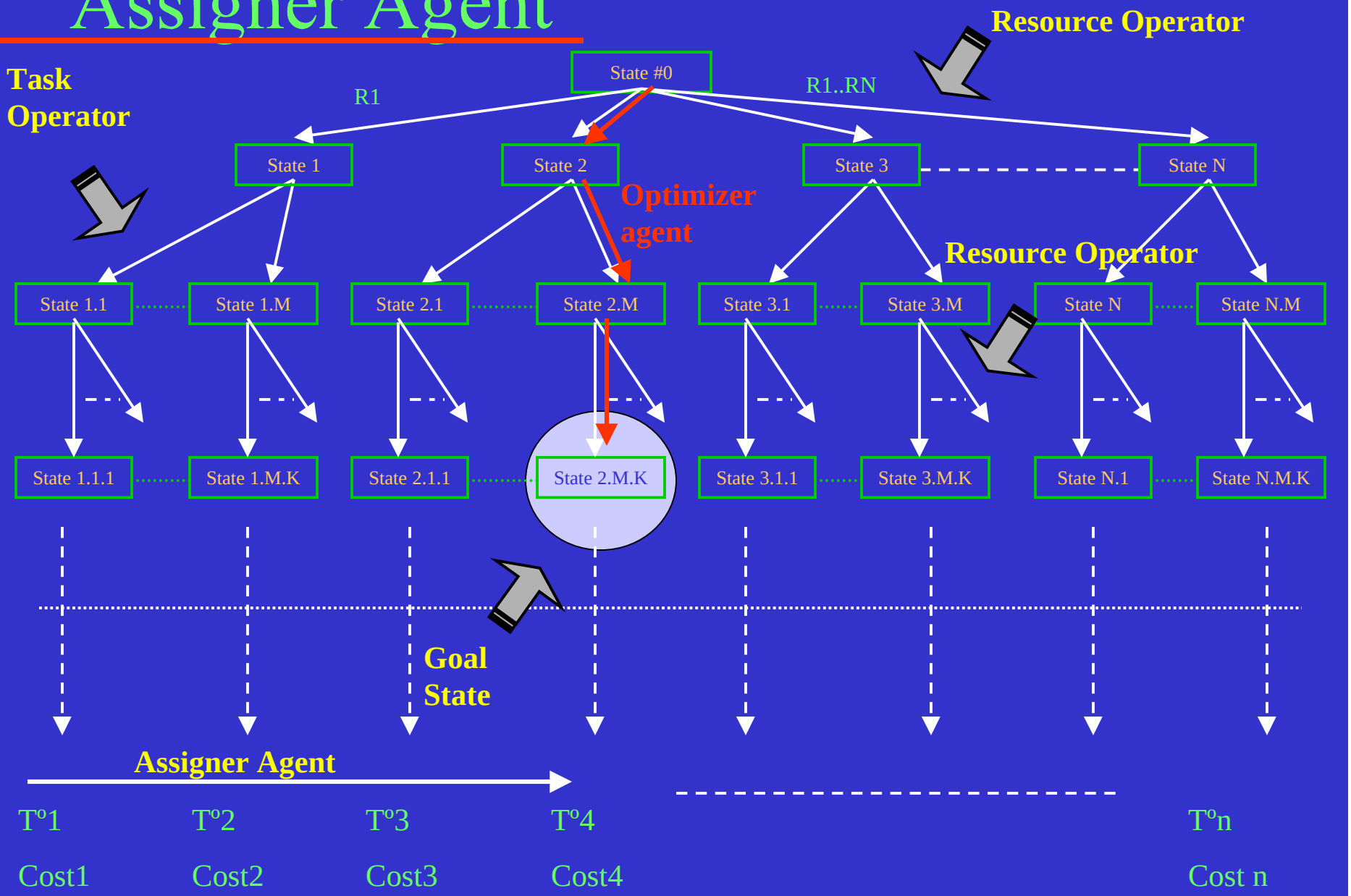
Quantifier Agent: Mapping Inputs and Outputs



Rules & Membership functions



Assigner Agent



Prototype Demonstration

- Make a project plan
- Resources: R1(1,10); R2(1,20); R3(2,30)
- Case 1: R1, R2 and R3 (Senior and Excellent)
- Case 2: R1, R2 and R3 (Novice); R2 (Excellent)
- Limited time: 10 days

Tasks	App. Res.	Prev. Task	Duration	Begining
T1	1,2		2 days	2
T2	1,2	1	2 days	
T3	1		2 days	2
T4	3	2	2 days	
T5	2	3	2 days	
T6	1	5	2 days	

Prototype Demonstration: results

- Case 1: R1, R2 and R3 (Senior and Excellent)
- Case 2: R1, R2 and R3 (Novice); R2 (Excellent)
- Limited time: 10 days

	Goal	Proj. Duration	Cost
Case 1	Min. Res. & Cost	12 days	1.440
Case 1	Min. Time	9 days	1.680
Case 1	Lim. Time	10 days	1.600
Case 2	Min. Res. & Cost	20 days	2.560
Case 2	Min. Time	12 days	2.560
Case 2	Lim. Time	No sol.	No sol.

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Conclusions

- This paper presents a conceptual model for tactical planning
- The model is based on AI procedures
- Two prototypes have been developed under the same conceptual model:
  - Field Artillery planning
  - Project management

Advantages of the Proj. Management Prototype

- Capacity to manage resources' characteristics with fuzzy terms
- Declaration of the goal of the project
- Search for the best solution
- Capability of reorganisation of the plan in the execution phase

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Future work

- We are working on making a conceptual model for Strategic planning
- Strategic planning is a highly topical tool useful for predicting dangerous scenarios, especially when security or economy are involved
- We are using similar Agents to build a model able to generate scenarios and make a sensitive analysis of events
- We think we are on the way to offering another alternative to classical paradigms such as Prospective