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An Active Environment to Assist Individual and Group Decision Making Process

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***Abstract*- The accomplishment of daily tasks comprises a continuum decision-making process. In this paper we propose a model to assist both individual and group decision-making processes. Intelligent assistant and search agents are the basis of our model.**

I. INTRODUCTION

Most human tasks require a rational decision-making process to be effectively performed. We decide upon the adequate cloth to put on, the restaurant to visit with your boss, the workers to be hired or fired, the projects to be finished, the decisions to hold or to yield in a negotiation, and the responsibilities to commit yourself in a discussion. Independently of the topic importance, some decisions may be taken alone or in a group. In both cases, relevant information is fundamental to understand a problem and analyze its alternative solutions. The needed information may be available locally, formally indexed in an in-house database, or remotely, freely indexed at the Internet.

Individual decision-making is an introspective process; making explicit explanations unnecessary. Decision-makers may do the entire analysis only in their minds. Concise documentation are prepared to assist a possible requirement. Being aware of the problem amplitude, as well as the pros and cons of each alternative solution consist the individual decision-makers' needs.

On the other hand, a decision made by a group requires a more explicit and justified process [1] [2], since participants may have different perspectives on the problem leading to different bets. Independently the method to reach a solution (consensus, by vote, or imposition), the participants need to share and agree upon the issues to look at in a problem. In order to support group decision-making, we identify five key issues to be addressed:

1) a trustworthy and fast mechanism to exchange information among participants;

2) synchronous and asynchronous communication mechanisms;

3) a shared ontology among participants;

4) a negotiation forum; and

5) a conflict resolution model.

The need for tools to support individual and group decision-making allied to the technological maturity on intelligent agents and groupware ([1], [2], [3], [4], [5], [6]) motivated us to design, develop and implement an integrated working environment to assist people doing their job either alone or in a group. Our proposed model is based on active design documents (ADD) [7] where assistant agents, information search agents and group support agents monitor the users' actions (individually or as a group), help the task completion, and document the entire decision-making process.

In this paper, ADDManager (Active Design Documents to Assist Managerial Decision-making) is presented as a model to support both individual and group decision, applied to engineering domains. Our work has five important characteristics as described bellow:

1) A friendly interface that facilitates users to perform their tasks usually accomplished without a computational system;

2) The existence of expert assistant agents to help task completion;

3) The existence of intelligent information search agents to automatically build queries, search and filter information based on contextually perceived users' needs;

4) The existence of a discussion mediator agent to assist group work reaching a solution; and

5) The existence of a documentation agent to record and generate the decisions' explanations.

Related research topics include agents [8], [9], intelligent interfaces [4], [10], [11], knowledge acquisition [12], [13] , cooperative work [1], [2], [3], [4], [6], [14], [15], and active design documentation[7]. Such researches are presented along this paper.

A prototype of ADDManager, discussed at the end of this paper, was implemented in a Intranet of an oil company to assist its annual strategic planning. Initial results have showed a potential improvement in the strategic planning process, as well as have pushed us to install it in an open environment such as at the Internet.

II. APPLICATION DOMAIN

The strategic plan of a company consists of defining goals and objectives to be accomplished in a specific period of time. These goals and objectives can be further refined in a set of criteria that guide the company's resources application (money, time, equipment, and human). There are different scenarios where this process may occur. We consider a scenario, which the following features hold:

1) Limited resources;

2) Pre-defined, although changeable, goals and objectives;

3) Competition among project's proposals;

4) Individual proposal formulation;

5) Only true information in a proposal;

6) Fair evaluation by the committee;

7) Consensual selection; and

8) Cooperative behavior among selection committee group, since they work for the same company.

The strategic plan process can de divided in two distinct phases: project's proposal elaboration and projects' proposals analysis and selection.

A. *Proposal Elaboration*

To elaborate a proposal, a proponent, first, need to understand the fullness of the problem being solved by the proposed project, as well as the economical significance of it to the company.

Empirical studies on companies developing their strategic plan have shown the benefit of an expert person helping proponents to elaborate their proposals. However, the bigger the company and the more geographically apart their employees are, the bigger the difficulties to give this kind of help.

We believe a computational environment with expert assistant agents (in this case, proposals filling expertise) and information search agents can make feasible the proposals' standardization and intelligent support to the elaboration process.

B. *Project's Proposal Analysis*

The initial task of this committee is to understand and evaluate each project proposal, considering the company's selection criteria and available resources. The evaluation is comparative; i.e. each proposal must be compared to the others to be ranked. In addition to judging the proposals quality, the committee is responsible for finding similarities that may suggest joint ventures. The process is complex because the projects may solve different problems bringing benefits to different areas.

Again, a computational assistant would benefit the process of ranking projects, finding similarities and making a fair trial.

III. AGENTS

An autonomous agent is a computational system embedded in dynamic and complex environments capable of independent actions [8], [9]. The agents technology has been successfully applied on different domains that goes from engineering to movie production. Intelligent agents use Artificial Intelligence techniques to provide active assistance to users performing a task. They perceive, interpret and act within the medium they are built in, using domain knowledge for that.

To act, an agent should present autonomy to decide have a domain model, a rationale or performance model and a learning model.

The domain model contains knowledge about the elements and dependencies (causal or not) describing the task in a domain. The performance model defines when (by demand or autonomously), with what (local performance rules, extern sources or similarities with an other agent) and how the agent (suggesting answers, criticizing the user's actions or leading the user to reach a solution) helps an user.

Other important characteristic is the agent's learning ability. Agents can have a static or a dynamic knowledge base. A static knowledge base suggests the agent's behavior will never. A dynamic knowledge base requires that the agent to be able to learn during its interaction with its user agents may learn by watching user's performance, by direct feedback from user or by data mining

The agents can be classified according to the task they perform, such as:

1) *Task Specific Assistant Agents (TSA):* help users to perform specific task. As this kind of agent needs knowledge about the domain, it is domain-specific agents; for example, a computational agent helping users to make flight reservation, a computational agent helping the users to fill forms and a computational agent helping users engineers to document their projects.

2) *Intelligent Search Agents (ISA):* help users to access information. The information can be structured in databases, or not structured in the Internet [15], [16], [17].Web search engines, such as Altavista and Yahoo, have some characteristics of search agents that act in non structured domains. Intelligent search agents can also be used to find relevant information in structured database. In this case they are called structured search agent (SSA).

3) *Cooperative Group Work Agents (GWA):* help users to work together; they can be more or less active in the group's conflict resolution [2], [6]. It is important to observe that the members can be geographically apart, requiring extra communication means. We are interested in agents that stimulate cooperation.

4) *Documentation Agents (DA):* help users construct documentation and explanation about a task [7]. The role of a documentation agent is to represent users.

IV. COOPERATIVE WORK

Group work involves a set of people with similar goals, but not necessarily with the same objectives and working methods. They can work in a cooperative, collaborative or competitive way [1], [2], [6]. Write a scientific paper, develop an exercise list, develop a engineering power plant, select employees to work in a company and decide upon a company's strategic plan are some examples of work done by groups of people.

Internet offers the communication medium and the Web provides an integrated technology to allow group to work [15]. However, enabling people to work together needs organizational models to guarantee that the group effectively works together. Researches on Computer

Supported Cooperative Work (CSCW) have studied means to allow people work together either synchronously or asynchronously. Prescriptive models of interaction [1] have organized discussion but imposing a not natural means of communication. On the other hand, lack of organization leads to misunderstandings among the group.

Issues to be considered when proposing a group work environment include the group behavior (cooperative or competitive), group participants' profile (background and interests), the task characteristics (common or conflicting objectives), the decision solution means (by vote or by imposition), the conflict resolution methods (conflict identification, negotiation and solution), and the documentation authoring in the group.

A computational environment to support group work is needed but complex to be effectively used by a group. The cost of following a prescriptive model of communication is very high, because it requires the user to think in a different way. On the other hand, a free communication may not bring any support to the group. Our proposal is to have an assistant agent that interprets the group context and offers help when needed.

Active Design Documents [7] have used autonomous agents technology with great success assisting users in specific domain areas such as Heating, Ventilation and Air Conditioning design, and Oil Process Plant design tasks.

Group work involves a set of people with similar goals, but not necessarily the same objectives and working methods. They can cooperate, collaborate or compete [1], [2], [6] during a group task, but need organizational models to guarantee that the group effectively works together.

Researches on Computer Supported Cooperative Work (CSCW) have addressed issues including group behavior (cooperative or competitive), group participants' profile (background and interests), task characteristics (common or conflicting objectives), the decision solution means (by vote or by imposition), the conflict resolution methods (conflict identification, negotiation and solution), either synchronous or asynchronous communication needs and documentation authoring in the group proposed models to allow people working together.

V. The ADDManager Model

In this section we present ADDManager, a decision-support system environment that assists both individual and group work. ADDManager is based on agents technology and active design documents [7].

Fig. 1 presents ADDManager individual decision support model. To support individual decision-making, ADDManager includes four types of agents: TSA, SSA, ISA and DA.

ADDManager assist users to accomplish their individual task with the help of a TSA that based on its knowledge base will provide guidance to task development. An, always active, search agent (SSA) keeps updating the user profile to continuously search the company's databases to obtain relevant information to enrich the user's task completion or to find partners logged in the Blackboard to accomplish the job. Besides SSA, an ISA may enrich the user with relevant information brought from the Internet.

Explanations are always available since everything is recorded by an DA; consequently the task completion process becomes transparent.

To provide support to management, ADDManager includes an environment to support cooperative group work. In addition to providing a communication means for the group, ADDManager contains an agent to assist conflict mitigation. Its role is to identify conflicts, and to assist the group to reach a clear understanding of their rationale and a way to reach their common goals.

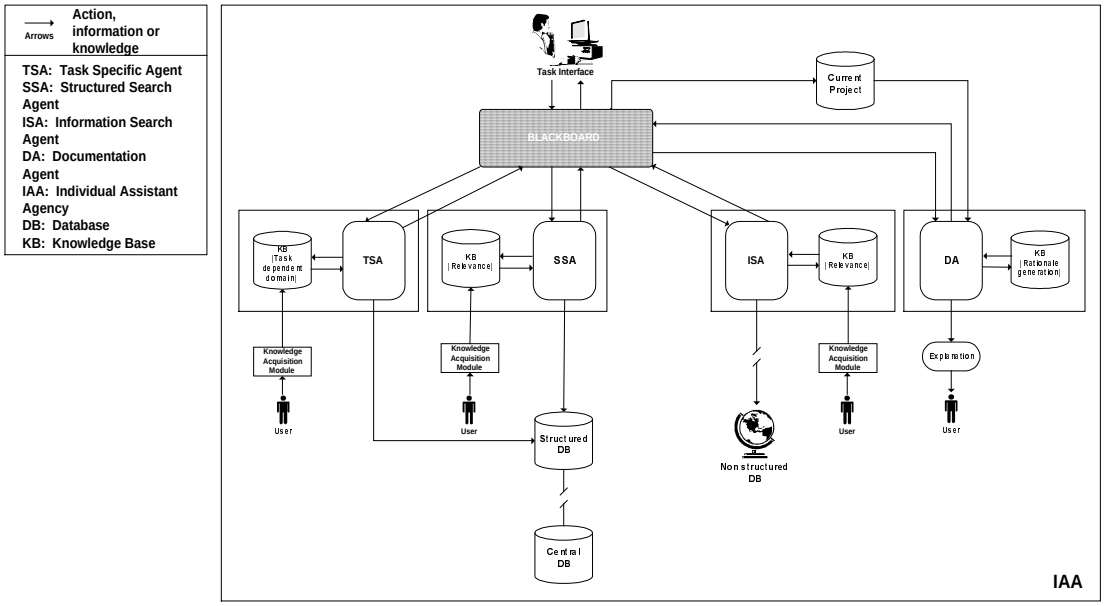

Fig. 1: ADDManager - Environment to support individual decision-making

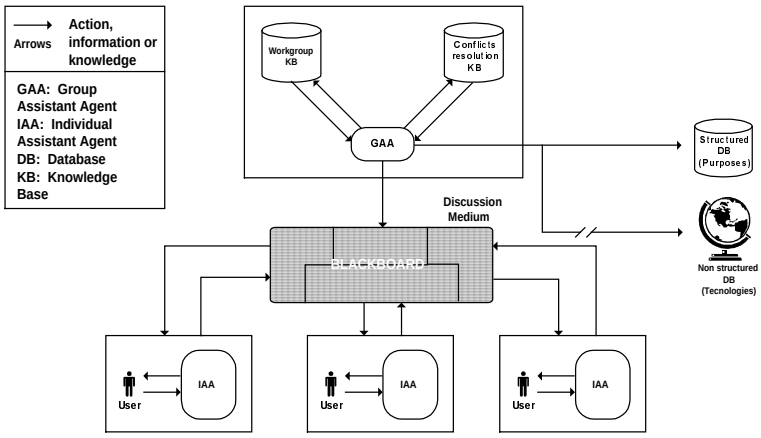

Fig. 2: ADDManager - Environment to support cooperative work

Fig. 2 illustrates ADDManager working group model. The degree of decision power may differ within the group, defining the information access and the decision power when in a conflict. Each participant may work in a private area (draft area) or public (Blackboard). These two working modes provide privacy to users.

The topics to be argued can be analyzed as a group by each participant assisted by a TAA. Group discussing brings to scene an *Discussion Interface*, where each participant interacts presenting arguments, questioning issues or negotiating changes. The communication may be done synchronously (such as by using talk) or asynchronously (such as using e-mail) with or without a computational agent. Our intention is to provide organization on the discussion to help the group to converge on a solution. This social environment, *Group Blackboard*, is monitored by a group work agent (GWA) responsible to identify conflicts, mediate communication, find information to illumine the discussion and help conflict resolution. This agent contains a knowledge base of conflict resolution techniques.

VI. ADDCTO: ADDMANAGER APPLIED TO THE STRATEGIC PLANNING OF NA OIL COMPANY

We developed a prototype system, ADDCTO, applying ADDManager to an oil company strategic plan process. ADDCTO assists the resources allocation and management, as well as project's proposal elaboration.

ADDCTO system contains five interaction modes:

1) company's goals and directives insertion;

2) project's proposal elaboration to obtain company's resources;

3) database and Internet information search;

4) projects evaluation and ranking;

5) projects selection by a committee.

The first option allows selection criteria elaboration that guide resource allocation process. Each project proposal should be described considering the current goals of the company. Fig. 3 presents *the Criteria Definition Interface*. As shown, the user is able to select and weight the criteria that will play important roles in the selection process. ADDCTO current implementation considers a set of predefined criteria with their respective evaluation methods. We are working on knowledge acquisition features to allow new criteria be included.

Each engineer may detect problems interfering with their work performance in the oil exploitation business. Whenever the problem cannot be easily solved either in-house or by buying technology for it, they elaborate a project proposals describing the problem and the benefits on finding a solution. Of course, each proposal requires human and financial resources. The proponent needs to elaborate their proposal looking at the set of criteria guiding the current company's strategic plan. To increase their chances each proponent needs to be clear and objective. The proposals compete for the resources; consequently the proponent needs to advertise well the needs without lying.

A proposal is described by fields. The user may simply fill in the fields with known values, look for information to justify their proposals or be helped by an AAT for filling in the proposal fields with "sound" information. AAT has knowledge about the domain; consequently it has methods for calculating the values to write in the fields. For instance, AAT may acquire the user information to calculate the benefits (very subjective field) the project will bring to the company.

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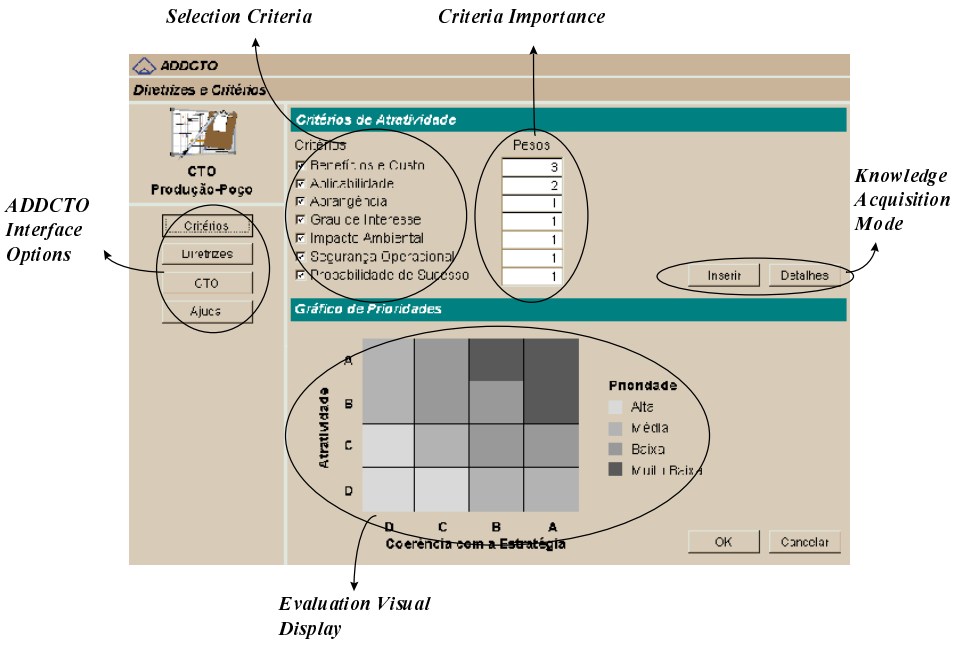

Fig. 3: ADDCTO goals and criteria definition interface

Fig. 4 illustrates the user interaction with ADDCTO, emphasizing the AAT assistance volunteered by the system. The user can also take advantage of the SSA and ISA, that searches for information to illuminate the content of the project's proposal. SSA looks at the company's database containing previous and current projects (to enrich and justify a proposal), as well as other current proposals (to find possible joint ventures). ISA looks at the non structured information existent at the Internet. Each field in a proposal is questionable. Therefore it is important to record the explanation to justify the content of a proposal. DA is a documentation agent that takes care of recording and explaining the entire proposal.

These agents may act autonomously (shown in Fig. 4 by the arrow) or by explicit user's demand (shown in Fig. 4 by the *ADD* icon). We are studying when the user may or may not be interrupted by agents, not to disturb the user's decision process.

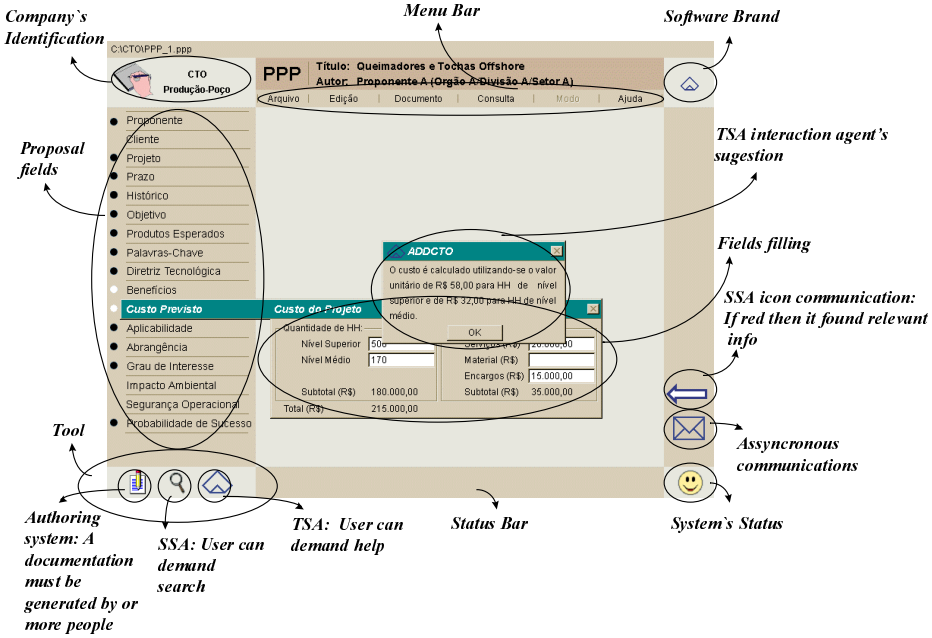

Fig. 4: ADDCTO proposal elaboration interface

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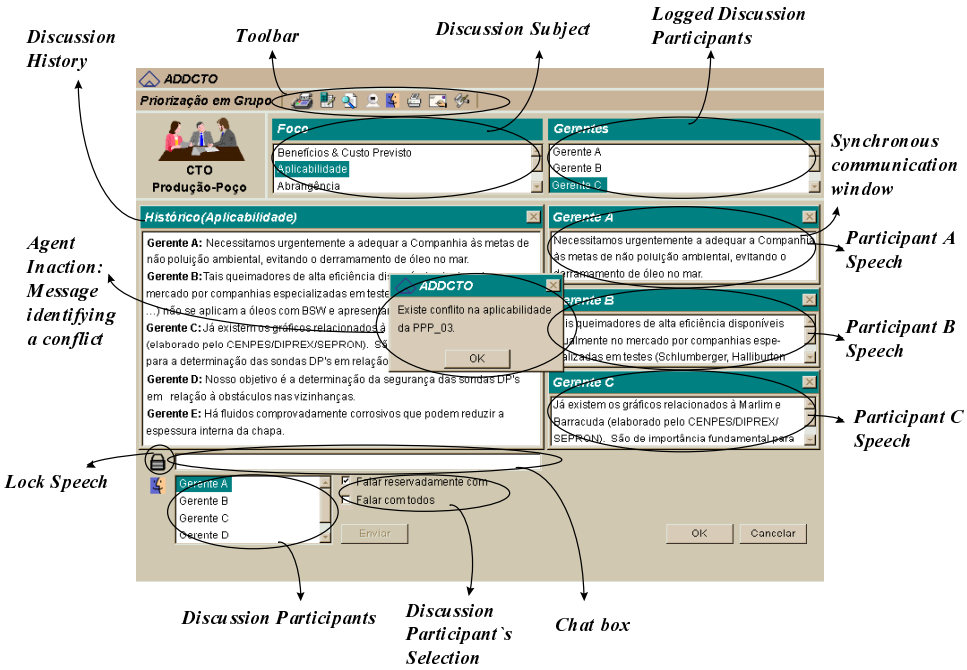

Fig. 5: The Group Work Interface.

Since the proposals compete and there is a committee to judge them, ADDCTO offers an environment to do this group evaluation. Each committee member can judge individually all proposals, but his evaluation is apt to be argued by the group. The group's goals is to select and order the set of proposals where the company's resources will be applied. Fig. 5 illustrates the *Group Work Interface* showing a group discussion. Participants are selected for the discussion, topics are chosen to be discussed and the group talks in a ordered way. Conflicts are identified by the GWA and justification from each participant is also presented. The group works in an open discussion forum, but in an organized fashion. The discussion is recorded, justifications are organized to later be presented to the proponents. Fig. 5 emphasizes the synchronous aspect of the group work communication. However ADDCTO environment also allows asynchronous communication through e-mail notes. It is important to note the active aspect of the ADDCTO environment configured by its agents performance.

VII. DISCUSSION

Knowledge-based systems are widely used to assist users in a specific task, such as, disease diagnostics, financial credit evaluation, and engineering proposals development. Task assistant agents can be constructed using this technology. These agents have knowledge about the task and about the task performance process. ADDManager includes assistant agents technology to help users during the interaction between the and system. Different works and tools that help users during the decision-making process emphasize the individual decision support. They can be autonomous activated by monitoring user's actions (ADD) or can be activated by an explicit demand from the user. ADDManager includes these two kinds of interaction with the user.

Besides helping the individual decision-making, ADDManager supports the group decision-making. Research in cooperative work [1], [2], [5], [6] emphasizes information communication and a prescriptive negotiation model. ADDManger adds structured negotiation to work group. Conflicts are identified, solutions are proposed or conducted.

The task performance can be enriched with information availability in databases or in the Internet. Search agents help this process.

VIII. CONCLUSION

In this paper we present an integrated environment to support individual and group decision-making process. ADDManager contains a natural interface where users perform their tasks. The information becomes available to five special agents: (TAA), (SAA), (ISA), (GSA), and (DA). In addition to presenting a model we presented an implemented prototype applied to a company´s strategic plan (ADDCTO). ADDCTO has shown feasible the ADDManager model.

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