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## **Perspectives of a human-machine system modelling by a logical approach: Contribution of technics issued from Distributed Problem Solving**

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### INTRODUCTION

The automation and computerization of industrial processes have been linked with a concern for the improvement of the Human-Machine System. Within this context, the researchers attempt to solve the problems which are related to the human in a complex environment. Let us quote, for example, the studies about the human-machine Cooperation, often based on concepts of the human operator modelling. At present, some studies turn towards the notion of assistant operator and towards the operator team modelling.

Parallel to this work on human operator modelling, researches are carried out into the Distributed Artificial Intelligence Domain, and particularly into distributed problem solving one, in order to modelize a group of heterogeneous agents cooperating in a complex environment. According to a global approach, the term agent is related to either a semi-autonomous or autonomous intelligent system - that is to say integrating its own knowledge bases and control modules - or a human operator. This agent is integrated in a multi-agent environment. Thus, these ones attempt to coordinate their actions so as to solve together a problem. This approach allows to a human-machine system modelling under the form of a multi-agent world where the agents are defined either by operators or by intelligent systems (robots, decision aids tools, and so on...).

The first part of the paper underlines recent works on human operator models, but which are especially developed in a mono-agent world. Therefore, in a second part, we describe some present researches in Human sciences, particularly those related to the analysis of a cooperative work, opening up essential ways for our works towards modelling a group of agents. Finally, in the last part, our contribution deals with the multi-agent world modelling for the cooperation at middle term between agents, where these ones may be operators or intelligent systems.

### HUMAN OPERATOR MODELLING

At present, pluridisciplinary teamworks contribute to the realization of intelligent aids for the operators, based on a cognitive model of the human operator. So, models are becoming more and more sophisticated. Let us quote for example the model COSIMO (COgnitive SIMulation MOdel), developed at ISPRA and using a blackboard architecture. Cacciabue, Decortis and Drozdowicz (1990) accept at present two finalities for this type of model : (i) "to bend systems and interfaces conception, very often for systems which do not exist yet, and which can therefore not be observed ; in particular to contribute to the conception of intelligent decision aid system"; (ii) "to progress in the understanding of operators mechanisms and cognitive strategies in complex environments". Several works on

modelling could be found in the literature, such as Mitchell 's OFMspert framework (Operator Function Model expert system), described by Rubin, Jones et Mitchell (1988). Part of these ones include explicitly or implicitly the Rasmussen's (1980) problem solving concepts.

#### CONTRIBUTION OF HUMAN SCIENCES TO AN AGENT TEAM MODELLING

In a first time, we must note that the works of Distributed Problem Solving based on Mental States Concepts, beliefs and intentions stemming from psychology, have been considered by them as "popular psychology". So the Distributed Artificial Intelligence researchers have extended logical formalisms for distributed problem solving applications according to different approaches. For example, Konolige (1983) developed a set of formula in a formal language, with a deductive process in order to provide the consequences of the agent's beliefs. More recently, Cohen & Levesque (1987) developed a formal theory for reasoning about the agent's intentions in a multi-agent world. Rosenschein (1983) developed, a multi-agent planning theory which allows the existence of the other agents and their mental states as a part of the environment.

The researches on dialogue understanding are also relevant as far as the distributed solving is concerned. In fact, the communication is a crucial aspect of multi-agent worlds. Among these approaches, stemming from linguistics, the more complex is based on the notion of the speech acts (Searle, 1969). This approach is built on the principle that the meaning of utterance is essentially defined by the effect it may have on an interlocutor. This model can reflect the speaker's beliefs in relation to the world in general, as well as to those taking part in the dialogue. Recently, this approach has been integrated to the Cohen & Perrault's (1990) works.

Moreover Sociology is a science which by nature may improve the started researches in distributed problem solving. For example, the Schmidt's works (1989) about the forms and modes of cooperation may be a precious supply for modelling a set of intelligent agents. In the same way, De Terssac's works (1990) about the negotiation during the work may improve the studies for modelling the exchanges of information (Smith, 1980) undertaken in Distributed Artificial Intelligence. Finally, psychology of work, thanks to the studies on the collective representation that the operators have of a system through a problem (see De Keyser's works) may contribute to defining and exploiting a collective representation of a system by "intelligent" agents.

#### APPROACH FOR MODELLING AN AGENT

From these approaches, a logical formalism seems to be a promising way to model the rational agent's behaviour, based on intentional states such as beliefs, desires, intentions and commitments (Chaib Draa, 1990). So, our present works aims at developing an "intelligent" agent model which is being implemented into three levels, figure 1. It is implemented in Common-Lisp on VAXstation.

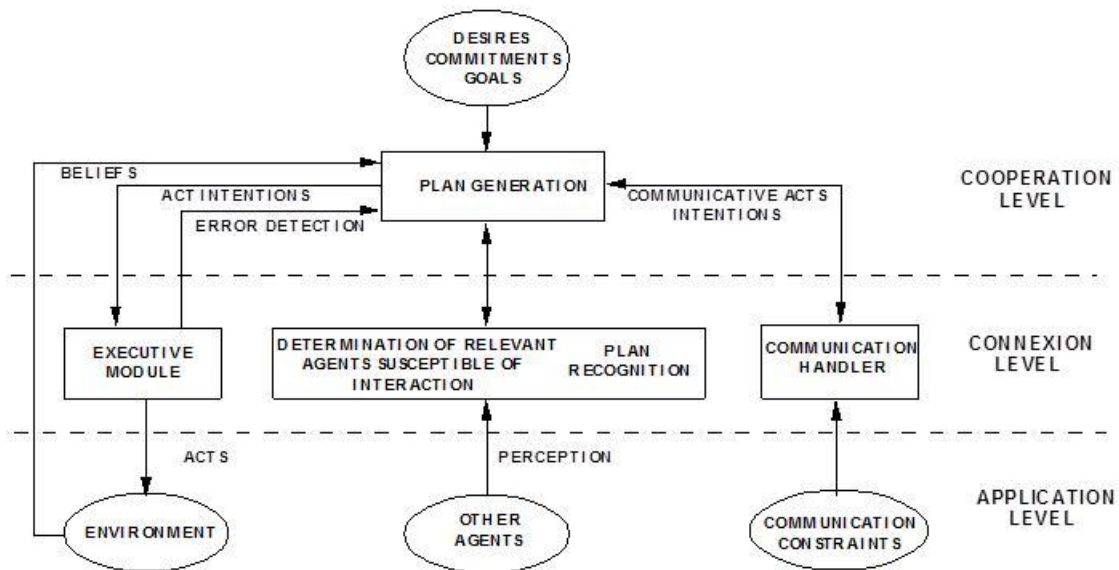


Figure 1 : "Intelligent" Agent Model

The highest level, called "cooperation" is essentially composed of a reasoning module. From the agent's desires, this module commits itself to realize the goals which have been selected either by the agent, or by a module which is hierarchically superior, for example the human operator. A goal is workable in consequence of the plan generation composed of intentions, commitments and beliefs about the world. Moreover, it is normal that its reasoning integrates the communication acts and the future actions of the other agents.

The "connexion" level is split up into three processes : an execution module, a plan recognition module and a communication handler module. After the development of the actions plan, the agent acts in order to achieve the selected goal (i) by the help of its execution module if the intention is an action or (ii) by the help of its communication handler if the intention is a communication act. We should point out that each communication act will be considered as a goal, and therefore, it has been worked out as a plan. Within a multi-agent world, in order to avoid negative interactions between the agents, the "plan recognition" module determines the agents which are liable to interact.

Finally, the last level is, as for it, dependent upon the application. It is composed of a data base about the environment, about the other agents, and about the communication constraints. So, the communication will be different whether the agents are perceived or not, whether they are nearby or not, and so on ...

## CONCLUSION

The modelling of an universe composed of intelligent agents opens ways of research in human(s)-machine(s) interfaces ergonomics. In fact, although it does not exist at present any industrial applications of distributed problem solving, the current works may envisage new workstations allowing human operators to cooperate with intelligent agents, indeed either other operators or systems in order to reach certain objectives. Moreover, it is here interesting to remind you of the Chang's first works (1987) concerning the "participant systems" : these ones consist in helping users of a bureaucratic system to exploit intelligently a centralized information on the other workstations. The implementation of such systems will undoubtedly require new techniques using of the ergonomic evaluation of workstation.

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