MASCARET: Multi-Agents System for Virtual Environment for Training.

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Abstract: This study concerns virtual environments for training in operational conditions. The principal developed idea is that these environments are heterogeneous and open multi-agent systems. The *MASCARET* model is proposed to organize the interactions between agents and to provide them reactive, cognitive and social abilities to simulate the physical and social environment. The physical environment represents, in a realistic way, the phenomena that learners and teachers have to take into account. The social environment is simulated by agents executing collaborative and adaptive tasks. These agents realize, in team, procedures that they have to adapt to the environment. The users participate to the training environment through their avatar. In this article, we show that *MASCARET* allows the establishment of models necessary to the creation of Intelligent Tutoring System. We interest notably to its use in pedagogical aspects.

Keywords: Virtual Environment for Training, Multi-Agents Systems, Collaborative Work, Pedagogy.

1 Introduction.

This study concerns virtual environments for training in operationnal conditions. We want to simulate and to immerge the learners in their professional environment. This enables them to manipulate the environment so that they can *"learn while doing"*. This idea is driven by the "constructivism" paradigm defined by Piaget [Pia76] and can find a good implementation in virtual reality technics as presented by [Fuc01, Bur93]. Our definition of Virtual Reality is the one proposed by [Tis01] which proposes to give autonomy to models involving in the virtual environment by giving them the "triple mediation of sens, decision and action". So, the main developed idea is that virtual environments for training are heterogeneous and open multi-agent systems. Those Multi-Agents Systems (MAS) has been presented by [Dem95] using the *VOWELS* model considering a MAS with four vowels: **A**gent, **E**nvironment, **I**nteraction and **O**rganisation. From our point of view, we consider the user of a virtual environment as other autonomous agents because he can interact with the environment and with other agents or users in the same way. Then, as [Tis01], we propose to add a last vowel, the letter **U** for **U**ser, in the *VOWELS* model.

Our perspective is to create an Intelligent Tutoring System (ITS). Its aims at providing students with dedicated tutoring. Its goal is to communicate knowledge effectively. ITS can be composed of fourth components. First, the model of the domain is the representation of the teacher's expertise. Second, the model of the learner allows knowing at each instant the state of the student's knowledge. Then, the pedagogical model refers to the methods of instruction. Using student's behaviour and his model, the pedagogical model allows selecting learning strategies. Finally, the interface model permits the communication between the system and the student.

Our objective is to place learners in operational positions in their simulated physical and social environment. We show the *MASCARET* model, proposed to organize the interactions between agents and to provide them reactive, cognitive and social abilities to simulate the physical and social environment. Then we see that *MASCARET* offers mechanisms to implement the functions present in existing ITS. We interest notably to its use in pedagogical aspects. Finally, we conclude and envisage futures work.

2 The *MASCARET* model.

Our goal is to train teams to collaborative and procedural work in a physical environment. In this case, we have to simulate in a *realistic* way this physical environment and the *collaborative* and *adaptive* team member's behavior in the social environment. Evolution of those environments results from simulation of autonomous agent's local behavior and their interactions. We propose a model call *MASCARET* where we use multi-agents systems to simulate realistics, collaboratives and adaptives environments for training. This model aims at organizing the interactions between agents and provides them abilities to evolve in this context.

2.1 The organisational model.

As the users has to be integrated both in the social environment (member of a particular team) and in the physical environment (to undergo a lick of gaz for exemple), we propose, first a generic organisational model allowing to represent the physical and the social environment. The model we propose is founded upon the concepts of organisation, roles, behavioral features and agents (Figure 1). [Han99] has already proposed an organisational model for multiagents systems, but this model, dedicated to the collaborative realisation of procedures, is not enougth generic to solve our problem. [Gut99] has also proposed such a model called Agent/Group/Role, but this model seems to be more a pattern for conception than a model which really formalizes the concepts of organisation and roles. In our model, the aim of the organisation is to structure interactions between agents; it enables each agent to know its partners and the role they are playing in the collaboration. The concept of role represents the responsabilities (behavioral features) played by agents in the organisation. Agents have then an organisational behavior which permits them to play or abandon a role in a organisation. This behavior enables also agents to take into account the existence of other members.

This model is a generic model in the way that all the resulting classes are abstract. The organisational model is then derived to implement two concrets organisations representing physical and social environment that have to be simulated in the virtual environment for training.

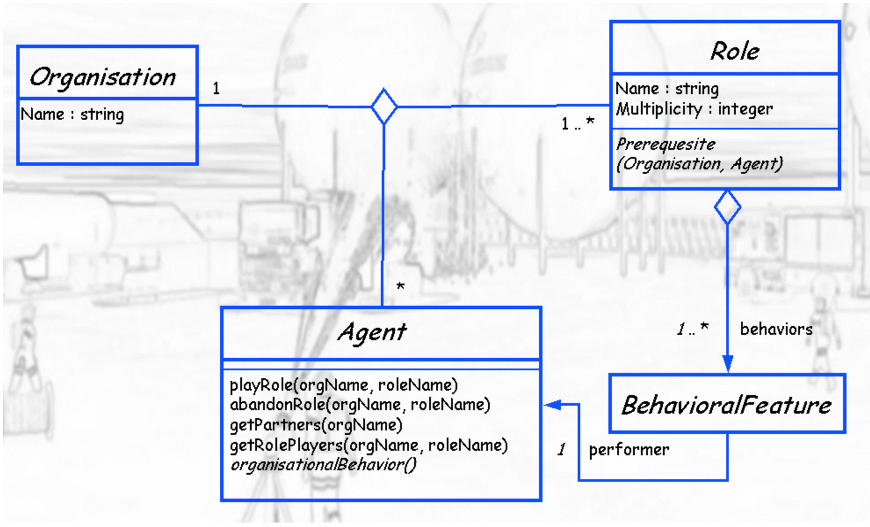

Figure 1: The organisational model.

2.2 The physical environment.

In a virtual environment for training, the users's (learner and teacher) physical environment must be realistic, interactive and act in "real-time". Then, to reach the constraints of virtual reality, models we use to simulate physical phenomena are obiously simplified. Therefore, the teacher may wants, for pedagogical reasons, inhibates some phenomena. For that, we must propose models which are compatible to a disconnection between the phenomena. Moreover, althought all interactions have potentially effects on the two agent involved, in most cases the effect of one agent is more important. We consider then that the interactions between agents have a privileged direction.

Then, the reactive agents' behaviour evolving in physical environment is to percieve situations where there is interactions and to act consequensly. A practical limit of the individual based models is that each agent can potentially percieve all others. The complexity of the algorithm is in this case $O(n^2)$. Then, we have to design rules to organize thoses interactions between reactive agents. For that, we use then the generic organisational model we have proposed before. The organisation is, in this case, a network where agents are connected together when they are in interaction. We call this organisation an interaction network (InteractionNet, Figure 2). To represent the concept of privilieged direction in interactions, we define two particular roles called source and target. The goal of source agents is to give information on their internal states to other agents (targets) so that they can compute the interaction's value and their internal state. The interaction can be detected by the two agents involved, but, for "real-time" computation reasons, it's better if only one agent detect it (one of two agents or another one else). We then define a recruiting role which has the responsability to maintain the knowlege of each agent upon the structure of the organisation. This means that an agent playing this role has to detect the interactions situations. The internal architecture of reactive agents match the constraint of physical phenomena disconnection presented before, because an agent can have several reactive behavior, each one participating in a different interaction network. This elementary behavior consist in the computation of a vector of internal state variables after the evaluation of inputs (from the interactions where the agent is a target) and presents a pertinent internal state to other agents (potentialy targets of an interaction where the former agent is a source).

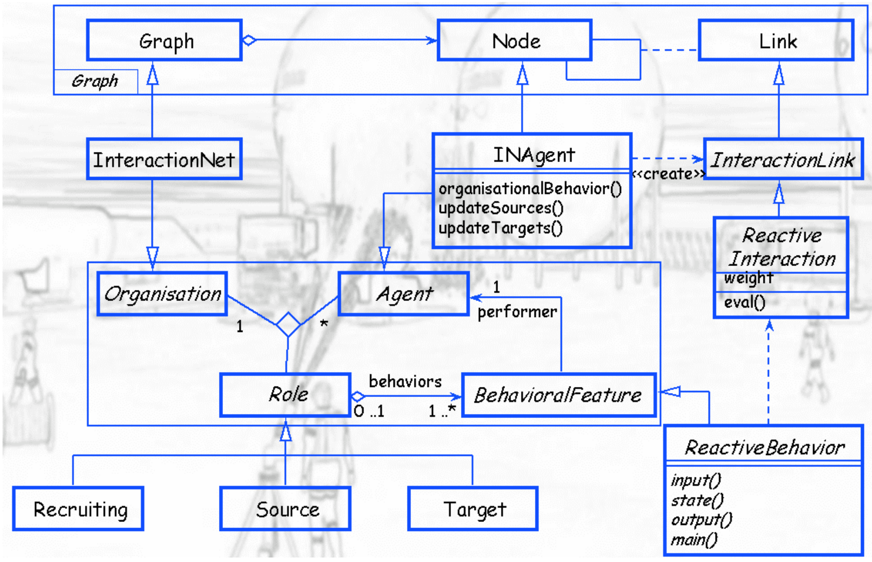

Figure 2: The Interactions Network.

2.3 The social environment.

The social environment is also populated by more “intelligent” agents. They undergo it and they act on it as reactive agents, but the way they choose their actions is carried out on a higther level of abstraction. Those agents are various humans involving in the formation (learners and teachers) who are played by autonomous agents. In our case, the social environment is structured and each member knows its roles and those of its partners. The interactions between the team members are also structured and arranged by the mean of procedure known by all members. We thus derive our generic organisational model to formalize this concept of team. We are interested in the case where the action’s coordination between team members are already envisaged and written in procedure. On the other hand, the environment being dynamic, agents can need to adapt the scenario to the environment. The procedure must then have a semantic representation so that agents can reason above. To describe a procedure we use the temporal logic of Allen (logic on the intervals of time).

The reasoning of team members relates on organisation, procedures and actions. We propose a model of agent having local organisational knwoledge. An agent is divided into a decisional part and a part represented by modules of perception of the physical environment, communication and actions (Figure 3). The agent must carry out actions of the procedure and adapt to situations not envisaged. The procedure describes interactions between agents in an optimal case, and leaves to the agent the responsability to build implicit plans (not clarified in the procedure) considered as natural within an applicative situation. Moreover, the procedure organize actions of a semantic level which we call « actions trades » such as « sprinkling a fire » in the case of firemen procedures, whereas the implicit plans arrange actions of a generic semantic level for humans such as « going at a point ».

For that, the agent must be able to reason on actions and we propose a model of goal directed actions having pre-conditions and post-conditions. Thus, before carrying out an action, the agent must make sure that pre-conditions of this one are checked. If it is not the case, it builds itself a plan by back chaining on pre-conditions and post-conditions of actions. When an agent starts or stops actions, it broadcasts a message that enables other members to follow the evolution of the procedure. When this behavior is at fault, the agent calls it’s organisational behavior which can help it to find a solution with another team member. Thus, in a hierarchical organisation, when an agent has a problem which it cannot solve, it refers to its superior. Then, the superior has the responsability to find a solution among his subordinates. If it does not find any, it refers to its own superior about it. We represent this mechanism by a method like a *Contract Net Protocol*.

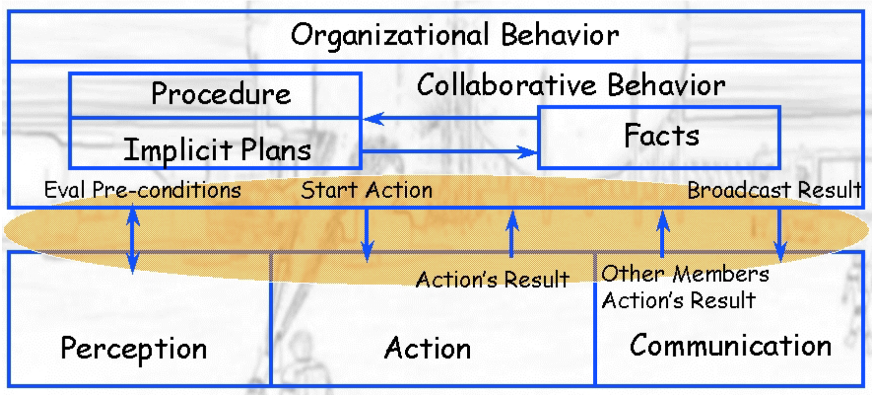

Figure 3: Architecture of rational agents.

2.4 The users.

The avatar is the representation of the user in the environment. The model of avatar we propose is the same as rational agents except for the inhibition of some messages. Indeed, all modules composing the avatar are active and thus remain potentialy usable; however certain communication are desactiveted. Thus the collaborative behavior does not call any more the organisational behavior (in case of a failure in an action) and the reasoning module does not communicate with the operative part to ask it to execute actions. These decisions are from the responsability of the learner. This model enables the avatar to follow the evolution of the procedure and the choice of the users. Having this capacity, the avatar of a learner can explain advice or show the realization of a task to the user.

3 *MASCARET* and Intelligent Tutoring Systems.

Intelligent Tutoring System (ITS) aims at providing students with dedicated tutoring. We use ITS as a system allowing to communicate a know-how. ITS can be composed of fourth components: model of the domain, model of the student, pedagogical model and model of the interface. It usually uses only two models of those fourth components (domain and student). Pedagogical and interface model is not often well specified.

MASCARET allows the establishment of models necessary to the creation of Intelligent Tutoring System. Concerning the model of the domain, we propose as [Lou01] the use of the notion of procedure as describe in the social environment. Thanks to this formalism, an expert is able to provide such a model using semantics and temporal logic. There is no explicit modelling of the student in *MASCARET*. But the model of the student could be obtained using active detection of the student's actions and comparing their to the model of the domain.

The pedagogical model could take decision using the model of the domain and the model of the student. First, we propose to use the physical environment of *MASCARET* in a pedagogical way. In fact, thanks to different level of interaction network, physical phenomena could be adapted to the student level. It is not necessary to display every disturbing elements for a novice. As opposite, it is possible to add new physical disturbing phenomena for an experimented student in order to improve his skill. The physical environment of *MASCARET* also allows showing elements that are not visible in the real [Mel01]. For example, we could display wind curve or gasses cloud in order to specify to the student specific conditions. In addition, the architecture of rational agents can supply to the user the action plan needed to realize a task. Using the notion of procedure as describe in the social environment, the avatar can provide deductive reasoning and explications [Ric99]. In fact, the ITS reply to answers how and why something must be done during the exercise. The ITS can also reply to what should be done next and therefore a simulated tutor can show a demonstration of the next action in line. Finally, we propose the use of *MASCARET* to define the organisation of pedagogical role in a multi strategic pedagogical teaching. Our perspective is to integrate pedagogical actors, taking different roles. Therefore such actors have a common objective: to increase the student's skills.

4 Conclusion and future works.

Our objective is to place learners in operational positions in their simulated physical and social environment. Considering a virtual environment for training as a multi-agents system, we propose the model *MASCARET*. It allows the realization of a realistic, cooperative and adaptative virtual environment for training. In *MASCARET*, classical pedagogical functionalities expected in a virtual environment for training have not been formalized. The study of different training environments showed that *MASCARET* allows the implementation of the functions present in existing environments and offers mechanisms allowing them to be improved.

Thus, we wish to integrate the notion of "pedagogical program" proposed by pedagogues [Ric98]. It will be built around three phases: 1) the verbalisation, the learner is able to explain the objectives of the formation, 2) the transfer, the learner is able to abstract concepts present in the training and to transfer them to another context and 3) the reinforcement, the learner effectuates a series of exercices aiming to create automatism on the subject of the training. Our contribution will concern the realization of agent models allowing us to automatically distinguish these three phases in the learner program and to generate adequate exercises.

In order to improve the learner apppropriation of his role in the exercice, we also propose the integration of the notion of *"putting into operation"* and of *"pedagogical scenario"* [Cra99]. That way the learner will feel immersed in the context of the exercice and decides by himself to play a role. Thus exercise of the "program" begins by a phase of putting into operation of a pedagogical context. In addition, virtual reality and multi-agents systems allow the simulation of different elements (characters, physical phenomena…) allowing to trigger learner emotions, that is an important factor in pedagogy. Thus every exercise of the "program" begins by a phase of putting into operation of a pedagogical context.

We envisage the use, during the exercise, different strategies of pedagogical learning. For that, we propose to model pedagogical strategies by means of pedagogical actors. In this framework, we noticed the strategy of the critic, counselor, guardian, companion [Cha00] and troublemaker [Aim00]. We are particularly interested in the co-operative strategy, where the companion is a virtual actor that will cooperate for the realization of tasks, exchange ideas on the problem and share the same goals. We also are interested in the troublemaker strategy where the goal is to disturb the learner by proposing solutions that can sometimes be erroneous. That way, we force the learner to evaluate his self- confidence in his own solutions. We propose to the human teacher, means the human expert, to specify different pedagogical agent behaviors (companion, troublemaker ....). For that, we wish to endow such agents with the capacity of learning by imitation [Gau01] or by the exemple [Bim95]. The human teacher will take control of the pedagogical agents during the preparation phase of the exercice and they will learn a behavior adapted to the situation. If it is considered we are in possession of such different pedagogical agents, an ITS will be multi strategic [Men96]. That will necessitate a selection mechanism of strategy regarding the context (learner level, pedagogical opportunities ….).

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