



## An ITS Modeling based on adaptive hypermedia and multi-agent systems

S.Boukil, C.Daoui, B.Bouikhalene

Information Processing and Telecommunication Team

FST, Sultan Moulay Sliman University

Beni Mellal, Morocco

---

**Abstract**— *The systems of distance education (e-learning) have become increasingly important in the academic community through the opportunities offered by information and communication technologies, which facilitates the process of learning and makes it possible anywhere and anytime. This paper presents a modelisation of a dynamic adaptive Intelligent Tutoring System based on a multi-agents system. Our system dynamically generates hypermedia course pages, adapted to the personal needs of the learner. It uses pedagogical activities to present multiple views of the same concept and also to specify the tasks defining the structure best suited to understand the concepts taught.*

**Keyword**— *Intelligent Tutorial System (ITS), multi-agents system, dynamic adaptive hypermedia, pedagogical activities, communication between agents, KQML.*

---

### I. INTRODUCTION

From the onset of computing education systems in the sixties, they have undergone a major evolution, until the appearance of hypertext and hypermedia; educational hypermedia emerged in an attempt to exploit these technologies in education.

To address the problem of personalization and adaptation of information to different users, researches produce dynamic systems and technologies referred to orient the user and reduce the cognitive overload. These systems establish a profile and a user model, and use this knowledge to simplify navigation by guiding the user in a hyperspace modeled by a domain model to find the right information.

Our goal is to model, based on multi-agent system and adaptive hypermedia system, an Intelligent Tutoring System (ITS) adaptive to the profile and the goal of the learner, generating hypermedia pages dynamically, with multiple views of the same concept.

This work is organized in three parts: the first part presents the e-learning systems namely Intelligent Tutoring Systems and Adaptive Hypermedia Systems (AHS). The second part provides an entry to the agent concept and multi-agents system. The final section describes our approach, the detailed architecture of our system, different models and different agents.

### II. ENSEIGNEMENT PAR ORDINATEUR

#### A. Intelligent Tutoring System (ITS)

Very strong association with the development of the first Artificial Intelligence expert systems, ITS were born in the 80s. Generally, ITS architecture has four independent components: the expert domain model, the student model, the model tutor and the interface model [1]. The expert has control of the area to teach, tutor monitors and manages the acquisition of knowledge and reasoning, the learner model can integrate the behavior of the learner in the ITS and the interface ensures the dialogue between the learner and the system.

#### B. Adaptive hypermedias

Adaptive hypermedia systems are hypermedia systems which reflect some features of the user in a user model and use this model by adapting various aspects of the system to the user [2]. Most adaptive hypermedia systems are constituted of three components [3]:

- Domain Model containing a representation of the content of hyperspace.
- User profile for each user.
- Adaptation model, which determines how to produce adaptation using the domain model and the user's profile.

### III. MULTI-AGENTS SYSTEMS

#### A. Concept of Agent :

We can define an agent as a computer system located in a certain environment, able to exercise actions independently on this environment in order to achieve its objectives [4]. According to this definition an intelligent agent is characterized by autonomy, responsiveness, ability to act and sociability.

#### B. Multi-agents system

A multi-agent system can be seen as a set of weakly interconnected agents that work together to solve a problem based on the capabilities and knowledge of each individual entity. Multi-agent systems are characterized therefore by [5] [6]:

- A partial perception of the environment by each agent
- Limited skills for each agent, ie insufficient to fully solve the problem
- A lack of central control of the overall system.
- Decentralization of data.
- Treatments asynchronously.

#### C. Communication between agents

For an agent to cooperate with other agents and react to its environment, it needs language of communication between agents. Two main strategies have been used to support communication between agents [7]:

- Sending message: the agents can exchange messages directly.
- Resource Sharing: Agents can access a shared database (called blackboard) data in which the information is posted.

#### D. Communication language between agents

The ACL (Agent Communication Language) was created by ARPA to ensure interoperability between autonomous and distributed agents. The ACL has three components "Fig. 1, "a vocabulary (ontology), a communication language between agent called KQML (Knowledge Query and Manipulation Language) and a language to specify the content called KIF (Knowledge Interchange Format)

KQML provides linguistic layer to make effective communication by considering the context of the messages [8].

### IV. ARCHITECTURE OF OUR SYSTEM

Our system is composed from standard components of adaptive hypermedia [9] and hypermedia generating pedagogical activities [10] [11] [12] namely: learner model, domain model, pedagogical activities model and multimedia documents database. By coupling with hypermedia-based agents [13] and ITS-based agents [14] [15] we have developed an architecture of a collaborative multi-agent system consisting of four agents: interface agent, pedagogical adaptation agent, learner' model agent and filtering agent. [16]

#### A. Système's modeling

##### 1) Learner's model

To model the knowledge of the learner on the field, the most common paradigm of knowledge representation of the learner is the model layers (overlay model) [17]. Its principle is to reflect the individual knowledge of the learner as a

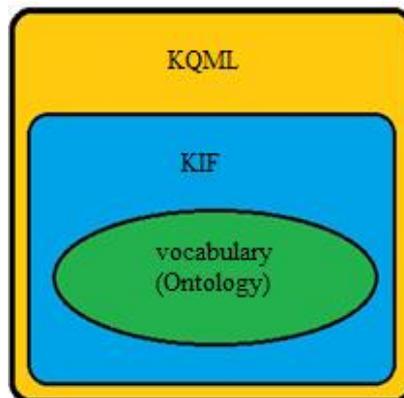


Fig. 1. The ACL components.

layer of a certain thickness of the domain model. Each concept of the domain model, is associated with an estimated value of knowledge of the learner on this concept, this estimate may be a binary value, a qualitative measure or probability. All couples "concept - value" constitute then the knowledge of the learner on the field. We shows the qualitative measurement; we estimated a value of knowledge of the learner to each concept of the domain model; "Concept - value" (value: low, medium or well), which will be assigned to each action a pedagogical activity. Therefore,

we will have the following correspondences: "low - familiarization", "medium - clarification" and "well - Reinforcement." These correspondences are used to trigger the appropriate educational activity.

2) *Domain model*

The domain model is the component of the system, which allows the computer to know what will teach the student. [9] This model is defined by domain experts. To have an effective personalization of the course, the material must be well structured and granulated. The domain model is represented by a graph contains nodes (concepts) and arcs (relationships between concepts).

3) *Pedagogical activitie model*

This model consists of pedagogical activities that allow the system to present the concepts in a different way in order to find the best possible presentation. From these activities, the system deduces all the tests that should be presented to the learner in order to enhance his knowledge. The pedagogical activities are [10] [12]:

1. Familiarization: Allows the learner to manipulate the concept, its tasks are: Introduction, Simplification, Comparison, Recall and Digression..
2. Clarification : Necessary to clarify the concept, its tasks are: Observation, Demonstration, Description and Reformulation,
3. Reinforcement: Useful to consolidate the concept, its tasks are: Illustration, Justification, Discussion, Summary and Corroboration.

4) *Multimédia documents database*

Multimedia documents are the fragments of the course to introduce to the learner, they are stored in the multimedia documents database. Each document is linked to a concept or to a pedagogical activity (ie a level of the learner).

*B. System architecture*

Based on the models presented above, we can propose a multi-agent architecture consists of four agents "Fig. 2, "; Interface agent (IA), pedagogical adaptation agent (PAA), learner model agent (LMA) and filtering agent (FA), communicating with each other to succeed in their tasks.

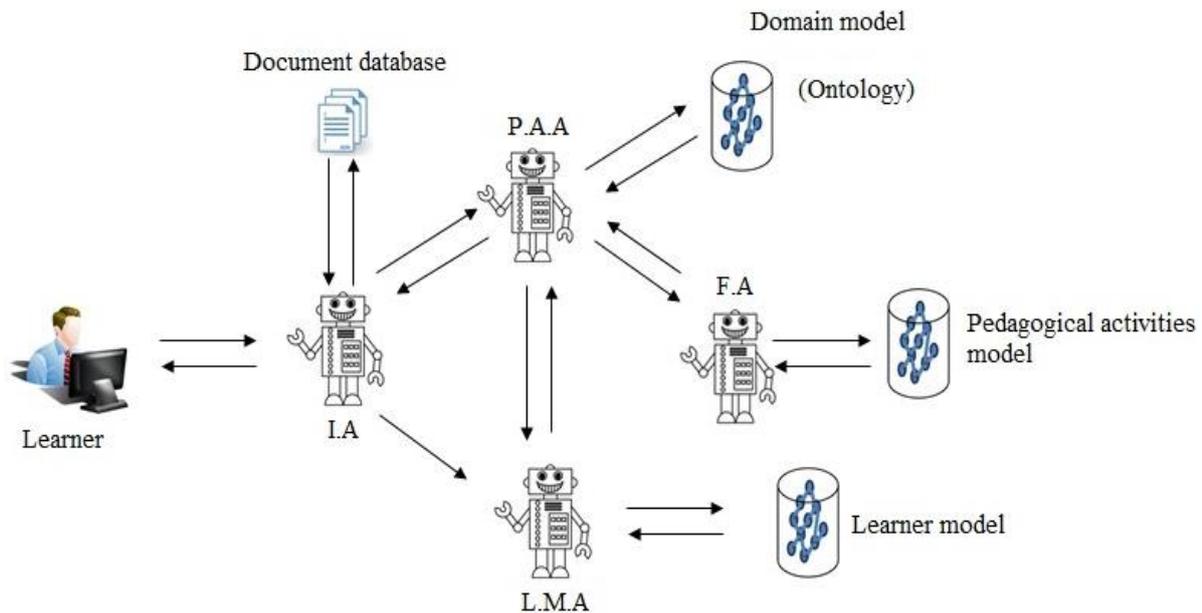


Fig. 2. System architectur

1) *The langage used in our communication system*

The language used for communication between the agents of our system is KQML. among the standards performatives of KQML we used a subset, allowing interaction between the agents of our system. The performatives that we used are:

- **Acheive** : the sender requests the receiver to make the content of the message “true” in his environment (receiver’s environmental). That is, to achieve the task of making the contents of the message true.
- **Tell** : the message content is true in the environment of the sender.
- **Ask-if** : the sender wants the receiver sentence that matches the message content.
- **Reply** : the sender believes that the message content is an appropriate response to a request or a previous question.
- **Ask-about** : the sender wants all sentences that match the message content.

TABLE I : EXAMPLE OF MESSAGE KQML

Parameter	Value
Performatif	Achieve
Sender	IA (Interface Agent)
Reciever	PAA (Pedagogical Adaptation Agent)
Ontology	MyOntology (vocabulary)
Language	Java
Content	generatePageConcept(programming, 1)

## 2) Interface agent (IA)

The interface agent acts as an interface between the learner and the rest of the system. It uses two means of communication; the HTTP protocol to communicate with the learner and the KQML language for communication with other agents "Fig. 3".

It receives the request of the learner in the form of an HTTP request, it makes a KQML request and sends it to the pedagogical adaptation agent. After the response of the pedagogical adaptation agent containing the addresses and ordered links of documents, the interface agent retrieves documents from the database, generates the page and sends it to the learner.

It receives the application for registration of a new learner or the connection request of a learner already registered (HTTP request) and sends it to the learner model agent as a KQML message, it also sends the result evaluation exercise to change the model of the learner.

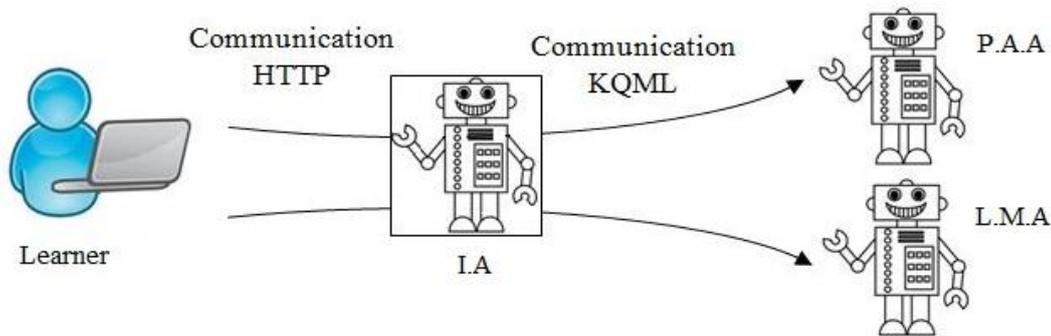


Fig. 3. Communication from and to interface agent

## 3) Pedagogical adaptation agent (PAA)

The role of the pedagogical adaptation agent is the pedagogical structure of the page according to the relationships between concepts in the domain model, the pedagogical activities model and pedagogical level of the learner by request to the learner model agent.

Responding to an interface agent request, it specifies the pedagogical structure of the page by defining the tasks to use according to the model activities.

It asks the learner model agent about the level of the learner concept(s), then asks the filtering agent to filter the relevant documents with criteria already specified, after the response of the filtering agent, it creates the page structure and then sends it to the interface agent in response to the request page concept (or index page of the course)

## 4) Filtering agent (FA)

The role of the filtering agent is the filtering of multimedia documents according to the criteria specified by the pedagogical adaptation agent, and he replies by sending the addresses of these documents. When receiving a request filter, it applies four filters:

- 1- To filter document about the selected concept.
- 2- To filter, from the result set of the first filter, the documents satisfying the cognitive level
- 3- To filter documents tasks induced pedagogical activity requested
- 4- For each task, it filters the appropriate document to the physical media type preferred by the learner.

## 5) Learner model agent (LMA)

Le rôle de l'agent du modèle de l'apprenant est de créer, initialiser, mémoriser et traiter le modèle de l'apprenant. Il ajoute le nouvel apprenant suite à une demande de l'agent d'interface et initialise son niveau par faible pour tous les concepts. Il modifie le niveau de l'apprenant sur un concept après l'évaluation de réponse de l'apprenant sur les tests et l'envoi de nouveau niveau par l'agent d'interface. Il consulte le modèle d'un apprenant pour spécifier son niveau pour un ou plusieurs concepts, réponse à une demande de l'agent pédagogique d'adaptation.

The role of the learner model agent is to create, initialize, store and process the learner model. It adds new learner response to a request of the interface agent and initializes its level as low for all concepts. It changes the level of the learner on a concept after the evaluation of his response learning on tests. He consults the learner model to specify the level of one or more concepts in response to a request from the pedagogical adaptation agent.

## V. CONCLUSION

We developed an architecture of an ITS based dynamic adaptive hypermedia and multi-agents. This architecture defines a multi-agent system coupled with the components of adaptive hypermedia allowing the generation of dynamically adaptive courses, and this by specifying the domain model and multimedia documents.

## REFERENCES

- [1] M. Baron, "EIAO, quelques repères. Technologie de l'information", culture et société, n°65, Editions Harmattan, 1994.
- [2] P. Brusilovsky, "Methods and Techniques of Adaptive Hypermedia". International Journal of User Modeling and User-Adapted Interaction. Kluwer Academic Publishers, Vol 6, 2-3, 87-129. 1996
- [3] H. Wu, "A Reference Architecture for Adaptive Hypermedia Applications" ; PhD thesis, Eindhoven, September 2002.
- [4] N. R. Jennings, M. Wooldridge, "Applications of Intelligent Agents in Agent Technology: Foundations, Applications, and Markets", (eds. N. R. Jennings and M. Wooldridge) Springer-Verlag : Berlin, Germany. 1998.
- [5] I. Jarras et B. Chaib-Draa, "Aperçu sur les systèmes multi-agents", Série scientifique, 2002s-67. Montréal, Juillet 2002.
- [6] F. Bourdon, "Systèmes multi-agents ; cours sur les systèmes multi-agents", université de Caen, 2001
- [7] B. Espinasse, "Communication et langages de communication dans les SMA, Aix-Marseille Université (AMU), LSIS UMR CNRS 7296, 2012
- [8] T. Finin., Y. Labrou and J. Mayfield, "KQML as an agent communication language. Technical Report". Computer Science Department. Maryland Baltimore County University. Baltimore, MD, 1995.
- [9] N. Deletstre, "METADYNE, un hypermédia adaptatif dynamique pour l'enseignement", Thèse doctorat de l'université de Rouen, janvier 2000.
- [10] Amar Balla, Med Tayeb Laskri, Soraya Laoudi, "HYPERGAP: un hypermédia éducatif dynamique générant des activités pédagogiques", Document numérique Volume 7, pages 39 à 47, n° 1-2/2003.
- [11] A. Balla, "Un modèle générique d'environnement de développement des hypermédiat adaptatifs et dynamiques générant des activités pédagogiques", thèse doctorat, Institut national d'informatique, INI, Alger. Décembre 2004.
- [12] S. Laoudi, "Structure d'un hypermédia éducatif générant des activités pédagogiques", mémoire de magister, Institut National d'Informatique INI, 2002. Algérie.
- [13] C.P Bailey, "An agent-based framework to support adaptive hypermedia". PhD thesis of Southampton university, United Kingdom. December 2002.
- [14] M. Hospers, E. Kroezen, A. Nijholt, R. op den Akker & D. Heylen, "Developing a Generic Agent-based Intelligent Tutoring System", Center of Telematics and Information Technology University of Twente, Enschede, the Netherlands, 2003.
- [15] N. Capuano, M.D. Santo, M. Marsella, M. Molinara, S. Salerno, "A Multi-Agent Architecture for Intelligent Tutoring", CRMPA, Salerno, Italy ; DIIIIE - Università di Salerno, Italy 2001.
- [16] M. Beggas, "Modeling by a multi agent system an educational adaptive dynamic hypermedia system", Proceedings of the international arab conference on information technology ACIT 2004, Constantine, Algeria.
- [17] N. Parcus, "Software Engineering for Adaptive Hypermedia Systems, Reference Model, Modeling Techniques and Development Process". PhD thesis, Munich university, Germany. October 2000.