# AMACA: A Multi-Agent Collaborative Architecture

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**ABSTRACT:**

*Autonomous agents that incorporate pedagogical capabilities provide excellent opportunities for the design of new tools for learning and intelligent assistance. This paper describes a multi-agent architecture nameda AMACA. AMACA is a pedagogical agent capable of coordinating multiple activities and providing explanatory advice in response to changing problem-solving contexts in learning environments.*

Keywords: Multi-Agent Learning; Agent Models and Architectures; Cooperative Problem Solving,;Intelligent Learning Environments.

## 1.Background:

A distinct thread of research within the field of AI has focused on the development of autonomous agent technologies. Agents are currently being applied in domains as diverse as information retrieval and filtering, user interface design, virtual environments, computer games and interactive learning environments [2,3,4,5,6,7,8,9,10,11]. AI techniques are appropriate when the agents must perform complex behaviors in a wide variety of situations. According to Boy [2] the use of software agents as *intelligent assistant systems* would facilitate human-computer interaction, as well as human-human interaction through knew IT. Boy claims that software agents technology enables the understanding and learning of various kinds of concepts, since they involve active behavior of the users. Boy expresses this view as follows: "They enable users to center their interactions at the content level (semantics), partially removing syntactic difficulties. They also enable users to index (contextualize) content to specific situations that they understand better (pragmatism)".

***Learning is embedded?*** Learning will take place in a situation - we learn out in the real world where the knowledge is needed to solve problems-. As Brown puts it (1989): "We must, therefore, attempt to use the intelligence in the learning environments to reflect and support the learner's or user's active creation or co-production, in situ, of idiosyncratic, hidden models and concepts, whose textures is developed between the learner/user and the situating activity in which the technology is embedded."

***Learning (and knowing) is a constructive process?*** As indicated by the fact that learning is embedded, we should view learning as a constructive process rather than a passive absorption of facts. The view that the learner should acquire the expert's knowledge does not acknowledge this perspective. Knowledge is gained and regained over and over in an on-going process between the learner and situations in which the knowledge is required.

***Learning is a social process?*** Several researchers (Dillenbourg and Self, 1992; Brown, 1989), point out that learning is a social process, it happens in collaboration between people or together with technology. So when introducing technology the view should be shifted from seeing it as a cognitive delivery system to seeing it as means to support collaborative conversations about a topic (Brown,1989).

## 2.Software Agents for Learning:

Autonomous agents that incorporate pedagogical capabilities provide excellent opportunities for the design of new tools for learning and intelligent assistant [4,11]. Thus, agent technology can be used to monitor student's progress and provide guidance and assistance when needed in a computer based learning environment.

These concepts are described by Boy [2] as follows: " *The use of the new IT leads to the creation of new artifacts enabling the management of knowledge. It seems that n of the human memory to external memories. Computer technology enables knowledge management and storage. New concepts such as corporate memory or organizational memory are emerging*".
To make possible the development of the teaching-learning process a software agent must necessarily be adapted to different models of the user, this process is based in the learning by example theory.
A Pedagogical Agent can adapt their behavior to user profile, to improve making a best assistance. The user profile attempt to get the best learning model for the user according to theirs interests and to your domain.
A difference between *help agents* and *tutor agents* is that the main objectives are helping a user in performing a specific task, and giving a personalised "education" to user in a specific domain of knowledge, respectively [14].
GALOIS [3], we developed an agent that mediates in the learning process. By classifying the user and thereby using this knowledge base, GALOIS assists students in finding appropriate solutions for problem solving. From our experience in this domain, the design and implementation of pedagogical agents posed many interesting questions: How does the agent interact with the user?; How learning theories must be incorporated into the design of the desired architecture?; How cognitive, personal, social and physical aspects must be considered when implementing a pedagogical agent?; How does the agent interact with the users?; How do the different agents decide?; How does the user ask for agent intervention over certain tasks?; How does an agent communicate with each other?
Investigate some of these issues, we continue our research during two years, developing an enhanced version of GALOIS. The current focus of our work is developing a pedagogical agent capable of providing coordination of multiple activities and explanatory advice in response to changing problem-solving contexts in learning environments. AMACA is the result of our research and the proposed system architecture is presented next.
Social Learning is defined like the change of actions of others modelers agents (or agents representing users); thus, we can offer a second definition of social learning as "the adjustment process of each agents' individually rational behavior" [15] for all members of society (agents); in this way, the social learning process may converge to the optimal social behaviors.
The Social Context of the learning according to Galois III' paradigm can interpret like a coalition' structure for a cooperative game n-agents, where each subassembly of the *implicit behavior characterizing traditional culture is evolving towards explicit behavior with the use of new IT. A major issue is the extension* coalition structure (or parts' conjunct) conform a coalition where are definite the partners (agents), making possible the learning concept like improve of theirs capabilities.

## 3. AMACA: A Multi-Agent Architecture:

In this section we describe the architecture of **AMACA**, an improvement of **GALOIS** and **GALOIS II** [21]. GALOIS was conceived in terms of a knowledge-based approximation that includes an interface agent endowed with an extensive specific domain about an application and its user [3]. The Model is supported by a paradigm with the description of a society of agents based in cooperative learning.
**AMACA** is based on a multi-agent architecture that dynamically provides explanatory advice in response to changing problem-solving contexts in learning environments.
The theoretical foundation of our design is based on the following definition of learning: "*Learning, is an active, constructive, cognitive and social process by which the learner strategically manages available cognitive, physical, and social resources to create new knowledge by interacting with information in the environment and in integrating it with information already stored in memory*" *(Shuell, 1988)* [12,13].

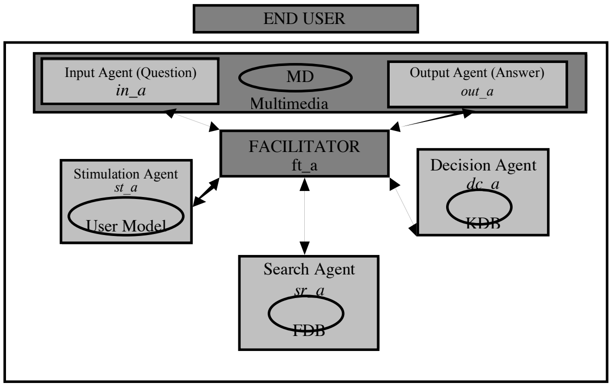
### 3.1. Society of Agents:

#### 3.1.1. Foundations:

The component agent features of the architecture is considered exclusive of them, such statement express a difference from system treatment as a agent set, making emphasis in the cooperative multi-agent systems.
The agent paradigm used in our model is related to the concept where an entity take user goals and carry out actions in base of them, expressing that is extended a part of big collaboration, with itself, a tool, other human beings and other agents mainly.

#### 3.1.2 *Operative Structure*:

Each modules of AMACA is an agent, where the assistance is the result of the interaction between them [14].
The arquitecture is the following:




### 3.1.3. Description of Components*:*

***-Multimedia Interface:***

Allows a direct approach to the end-user by presenting different types of media. The multimedia interface is responsible to assist the user by providing explanatory advice based on different types of knowledge objects (text, an animation, a video film, an image).This include an **input agent** and an **output agent**. Both manage the Media base. The media used by the input agent to get data are defined by the especific implementation of the arquitecture.

***-Stimulation Agent:***

Collects, interprets and conceptualize the user's model. In GALOIS [3] these models are defined.

***-Decision Agent:***

This agent uses the KDB to solve the needed assistance.

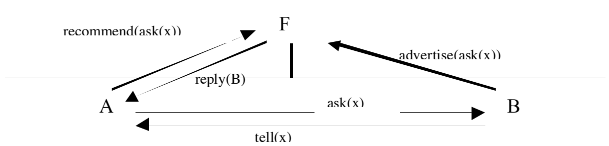
***-Search Agent:***

It is used for seeking information in the fact base.

***-Facilitator***:

In base of the KQML mining, the facilator manages the communication between system agents thought a process call advertise , using a performative to this. We can say the facilitator know communicate the agents know to do .

The inclusion of Facilitator in the agents society does not means that it centralice the activity of the agents. In this arquitecture use the agent F to search the "name"of other agents that could answer a query (by the performative *recommend).*




The reasoning metaphor behind AMACA can be expressed as follows: "the **user** carry out **actions**, based on previous knowledge, over **objects** through **resources (media)"** [3]. As shown in fig.1, the architecture of AMACA could be described as having a cognitive component, and a motor component. The cognitive component (represented by the stimulation and decision subsystems) is responsible for high-level control of behavior, e.g., determining whether to demonstrate or explain, and deciding what task steps to perform. The motor component (represented by the search subsystem) receives commands from the cognitive component to perform actions without conscious involvement such as, searching or filtering information.

### 3.1.4 Application:

In the development level, is used KQML [ 18, 19] to achieve the communication between agents. Its capability to isolates the communication level from representation level make it issues to this project. For example, the rules to represent the KDB are not issue to be used in the representation of user model, where are the frames theory used.

We use AMACA in order to help the visitors of a Virtual Museum navigate the whole collections of paints, ceramics and crafts by different ways (search, view, ask). The Virtual Museum is a multimedia interactive kiosk with a touch screen to interact with the users. It contains a complete collection with data, photos and quicktime VR movies.With a simple interface the system knows users profile and suggest actions during the tour, like view data of authors in relation with the style most recently choused; guide the visitor through the collection reducing the time needed to search the data base.

The following is a description of some actions executed by the user in a session:

- Collection_List
  - Text_View
  - Graphic_View
- Collection_Search
  - By_Tittle
  - By_Author
  - By_School
  - By_Style
  - By_Date
- Author_List
- Author_Search
  - By_Name
- Paint_Information
  - Paint_View
  - Paint_Zoom
- Session_Init

The agents in GALOIS are:

| | |
|---|---|
| In-a | Input Agent |
| st-a | Stimulation Agent |
| dc-a | Decision Agent |

out-a Output Agent

sr-a Search Agent

ft-a Facilitator Agent

When a user touch the screen (the system, and GALOIS are in sleep mode until an event is detected), the *input agent* try to identify him, and make a profile available to other agents:

Tell (user, in-a, st-a) in-a tells st-a that a new user (known as user) enters the museum

Advertise(ask_if(user), st-a,ft-a) the stimulation agent collects the user profile (by information saved or entered in this session) and communicate the facilitator that st-a knows the user (likes, actions, etc.)

If the user performed an action in the system, for example Collection_List then the agents take care of this:

Tell(user{Collection_List}, in-a, (st-a,dc-a))

Collection_List is a key word that is part of the Fact DataBase and GALOIS used it to compare the possible and valid set of museum actions.

After n actions of the user, the agent suggest to view the collection of Berni, because: the user's profile shows his interesting in authors like Berni, and this week at museum gallery, we can view his most popular works.

Advertise(Berni_Collection, dc-a,ft-a)

Tell(User(Author_List),in-a,st-a)

…

Tell(Berni_Collection,ft-a,out-a)

And out-a must select an interface media (movie of Berni, for example) to vinculates with the user interface and shows possible course of actions for the user: search his work, view his biography and others.

AMACA is an expert of the museum, all it knows is part of the Knowledge Base and it wants to help the user browse the collection in an attractive and educational way.

## 4. Conclusions:

We have described in this paper the architecture of AMACA, a pedagogical agent who has been designed to provide explanatory advice. AMACA maintains an episodic memory of the actions that it performs during an explanation, so it can explain the rationales for its previous actions as well as its current actions.

The generation of general assistance guidelines couldn't be done by managing knowledge from the interaction between the system and each one of the users in an isolated manner. According to our approach, on one hand, users are entities that interact with the system as individuals, on the other hand, behaviors / response patterns that are identified as the agent works, add strength to the *pedagogical capabilities* of the system, by combining them with those that emerge from the interaction of all the users [10]. (Concept of Collective Learning).

As in the above version, assisted users models are categorized in three (3) levels, similarly to COACH [20]. These categories are expressed in Novice, Intermediate, Professional and Expert in terms of their performance with the " **learnable**" aspects of the system.

One of the major differences between **AMACA** and its original version is the conception of the model as a *society of agents* [14], and the introduction of the concept *cooperative learning* [1,13]. The application of these concepts is very important for the functionality of the system since they define the different ways agents cooperate with each in order to provide the required assistance. Thus, the type of assistance provided by AMACA is based on individual and collective interactions of users of the system.

## 5.References:


[1] V. SHUTE. & J. PSOTKA. Intelligent Tutoring Systems: Past, Present and Future; D. Jonassen (Ed), Handbook of Research on Educational Communications and Technology, 1994.-

[2] Guy A. BOY. Software Agents for Cooperative Learning, From: Software Agents; MIT Press, 1997.-

[3] Jorge SAGULA, Martín PURICELLI, Gustavo BOBEFF, Gastón MARTIN, Carlos PIS DIEZ; GALOIS: An Expert-Assistant Model; Proceedings of First International Conference on Autonomus Agents, ACM Press, February 1997.-

[4] J. RICKEL & L. JOHNSON; Integrating pedagogical capabilities in a virtual environment agent, Proceedings of the First International Conference on Autonomous Agents, 1995.-

[5] B. STONE & J. LESTER; Dynamically sequencing an Animated Pedagogical Agent, Proceedings of the Thirteenth National Conference on Artificial Intelligence, 1996.-

[6] G. BALL, D. LING, D. KURLANDER, J. MILLER, D. PUGH, T. SKELLY, A. STANKOSKY, M. Van DANTZICH, D. THIEL & T. WAX; Lifelike Computer Characters: The Persona Project at Microsoft Research.

[7] D. ROUSSEAU & Barbara HAYES-ROTH; Personality in Synthetic Agents.

[8] R. KOZIEROK & Patti MAES; Learning Interface Agent for Scheduling Meetings, ACM SIGCHI International Workshop on Intelligent User Interfaces; ACM, January 1993.-

[9] B. SHETH & Patti MAES; Evolving Agents for Personalized Information Filtering; Proceedings of the Ninth Conference on Artificial Intelligence for Applications, IEEE Computer Society Press, 1993.-

[10] Patti MAES; Agents That Reduce Work and Information Overload, Communications of the ACM, Vol. 37, Number 7, July 1994.-

[11] J. LESTER, C. CALLAWAY, B. STONE & S. TOWNS; Mixed Initiative Problem solving with Animated Pedagogical Agents, 1996.-

[12] T.SHUELL. The role of the student in learning from instruction. Contemporary Educational Psychologist 13, Pp. 276-295, 1988.-

[13] G. KEARSLEY. Explorations in Learning & Instruction: The Theory Into Practice Database. (1994). See http://gvis2.circ.gvu.edu/~kearsley/.
[14] Marvin MINSKY; The Society of Mind, Simon & Schuster, 1986.-
[15] S. OHNO, A. NAMATAME; Learning of social behaviors in a society of economic agents; CMAS,1996.
[16] S.WATT, Z. ZDRAHAL & M. BRAY SHAW;Multiple agents systems for configuration system; Frontiers in artificial intelligence and applications; IOS Press, 1990.-
[17] A. KAY; User interface: A personal view; The art of human computer interface design; Addison Wesley, 1990.-
[18] Y. SHOHAM; KQML as an agent comunication languaje; From: Software Agents, Pp. 291-316, 1997.-
[19] T. FININ; Specification of the KQML Agent-Comunication Language; The DARPA Knowledge Sharing Initiative External Interfaces Working Group, 1993.-
[20] T. SELKER; COACH: A teaching Agent that Learns, Communications of the ACM, Volume 37, Pp. 92- 99, 1994.-
[21] J. SAGULA, M. PURICELLI, G. BOBEFF, G. MARTIN & M. MILRAD; GALOIS II: An Agent for Intelligent Assistance; Proceedings of INFO-NET'98, Argentina, 1998.-