Using Agents for Improving Interpersonal Communication in Virtual Environments

Tatiana Aires Tavares[1], Samuel Oliveira[3], Anne Canuto[2], Luiz Marcos Gonçalves[2], Guido Souza Filho[3]

[1]Programa de Pós-Graduação em Informática – Universidade Católica de Pelotas (UCPEL)
Campus I -Félix da Cunha, 412 – 96.010-000 – Pelotas – RS – Brasil

[2]Departamento de Informática e Matemática Aplicada (DIMAp)
Universidade Federal do Rio Grande do Norte (UFRN) – Natal, RN – Brasil

[3]Departamento de Automação e Computação (DCA)
Universidade Federal do Rio Grande do Norte (UFRN) – Natal, RN – Brasil

[3]Departamento de Informática
Universidade Federal da Paraíba (UFPB) – João Pessoa, PB – Brasil

tatiana@ucpel.tche.br, samuel@natalnet.br, anne@dimap.ufrn.br, lmarcos@dca.ufrn.br, guido@di.ufpb.br

Abstract. *A virtual cultural space can present to visitors any kind of artistic manifestation represented in a digital format. In this paper we propose a multi-agent architecture for cultural environments. Our proposal is based on a 3D environment where users are represented by avatars. Each avatar has a personal agent that captures all the relevant user actions. We have also others types of agent which are responsible for providing services. Also, we present a study case showing how these concepts were implanted in the ICSpace (Internet Cultural Space) environment.*

Resumo. *Um centro cultural virtual pode apresentar a milhares de visitantes qualquer tipo de manifestação artistica representada num formato digital. Neste artigo apresentamos uma arquitetura multiagente para ambientes virtuais culturais. Nossa abordagem é baseada em ambientes virtuais tridimensionais onde os visitantes são representados por avatares. Cada avatar possui um agente pessoal que observa suas ações e captura o que for relevante. Além disso, os agentes especializados por prover serviços são chamados de agentes de serviço, onde destacamos os serviços para comunicação interpessoal. Por fim, apresentamos nosso estudo de caso baseado no ambiente ICSPAce (Internet Cultural Space).*

1. Introduction

Multimedia applications have been increasingly developed throughout the world. It is very common to find a large number of museums and libraries that expands their walls through Internet. Museums such as the Louvre [01] in Paris and Van Gogh [02] in

Amsterdam are some examples. People can visit those cultural centers inside their homes. It is a nice way for popularizes this kind of cultural manifestations that used to be closed to physical buildings. Moreover, other advantage of this service is the possibility to visit (through an on-line collection) exhibitions that are no longer active in a real museum. Also we are helping to preserve cultural artistic collections to other generations.

Recent innovative initiatives are incorporating multi-user and Virtual Reality technologies to those approaches, approximating the user interface of end-users and turning the interaction more attractive and natural.

An example of that is ICSpace (Internet Cultural Space) [03] . This virtual space has been proposed in order to go further a presentation-based environment by supporting the interaction between users visiting a same place. The main features of ICSpace are: (1) The user ability to submit their works; (2) The user ability to evaluate and rank exposed works; (3) Communications tools enabling the interaction between the users visiting a same place, and; (4) Software agents support to implement information, guiding and suggesting mechanisms.

In this work we are pointing out some challenges to build a virtual space that can put people together in an effective way. More than perception and communication mechanisms we are considering interpersonal communication. Interpersonal communication differs of conventional communication tools because focuses other goals as establish conversational channels between people, approximating and evaluating the communication effectiveness. But how we can explore these functions into computational systems? Our solution uses Communications theories associated with an agent-based approach.

This paper focuses on the last aforementioned feature. The development of agent- based mechanisms that will be responsible for taking the user into an interactive tour through a museum. They are able to show the same exposition for each visitor in a personal way. According to the places visited by the user, they can suggest either to see a work or to interact with other user with a similar profile. This paper is structured as follows: In Section 2 we describe related works. Section 3 shows the conceptual view for the proposed MAS architecture overview by explaining each agent category. Section 4 discusses further details of the communication agent organization structure, including functional and structural analysis as well as communication issues. Section 5 presents the study case – ICSPace, considering the main aspects of this experience. Finally, Section 6 summarizes the obtained results and discusses future research topics.

2 Related Works

In this section we briefly consider related research with regard to other architectures that are based on software agents approach. Today we can say that agent-based approach is being incorporated to a great variety of computer systems. Intelligent agents are useful for different areas of application. We can use this concept adopting a individual solution or a collective one. In the last case we call a multi-agent system (MAS), a set of agents that divides functions and responsibilities to compose a solution for a problem. In this section we are presenting some examples.

2.1 MAS for Market Application

Electronic commerce is a large application area of distributed systems. MAGMA is an open architecture for agents interested in buying or selling. MAGMA also includes both manual and automated negotiation mechanisms. The proposal of MAGNET (Multi Agent Negotiation Testbed) uses many of the features of MAGMA architecture to improve a variety of types of transactions. MAGNET defines an ontology-based approach for characterizing the market place and the agents involved in the process. This proposal also uses a protocol specification for formalizes the types of negotiation supported. The MAGNET system is implemented in Java and CORBA. Both MAGMA and MAGNET specify classes for agents and its properties and communication rules (negotiation). Using diagrams define the MAS architecture for presenting the structure of the agents and the communication protocols between them [04].

2.2 MAS for Medical Application

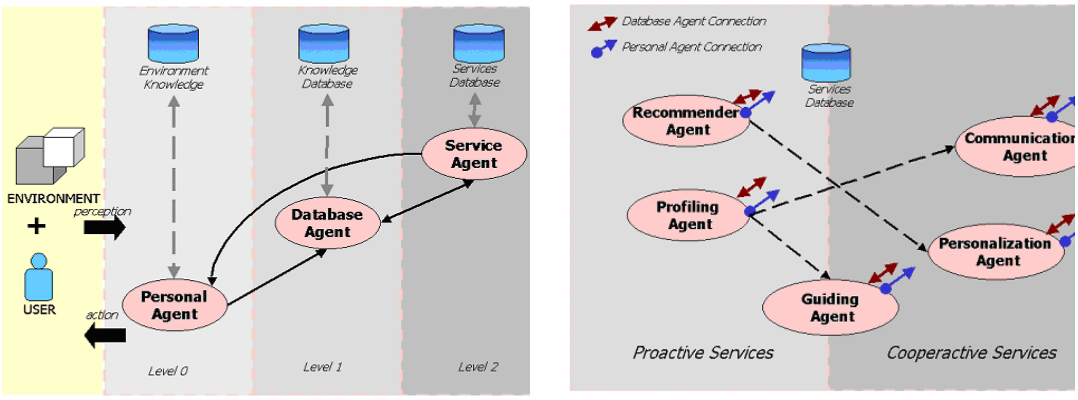
Alsinet [05] points out other interesting example of applying MAS approach to real systems design. In this case, MAS architecture is used for specify and monitor medical protocols. A medical protocol specifies sequences of actions that could be performed to determinate a particular pathology. The main idea is to model medical services in hospitals as specialized domains agents. For describing the proposed MAS architecture they first defined the fundamental services that the system should provide. The next step was to describe the agents' categories and the communication interface. The last one is characterized by a security requirement. So they provide privacy, integrity and authentication during the process of exchanging information between agents [05].

3 A Multi agent System Architecture for Cultural Spaces Assistance

In this paper, we are considering a cultural space domain. So what we are presenting a MAS architecture for support cultural spaces assistance . In this section we are summarizing some concepts of the whole MAS architecture.

The architecture is a hierarchical structure composed of three layers that define three categories of agents, which are: reactive (level 0), intermediate (level 1) and services (level 2) as shown in Fig.1-a. The main goal of the reactive layer is to perceive user actions into the environment. In this layer there are the personal agents (PA). Other important PA function is the interaction with the users. The intermediate layer is responsible for maintaining the knowledge database (KD) using the Database Agent (DA) to do this work. Finally, the service layer is capable of processing information and provides services to users. This layer is divided into Cooperative and Proactive layers detailed in Fig. 1-b.

The difference between these agents is the dependency relationship between the agents. If an agent depends on the result processed by other agent to execute its actions we call it a cooperative agent, otherwise we call it a proactive agent.



(a) (b)

Fig. 1. (a) MAS Architecture for Cultural Spaces Assistance. (b) Service Agent categories.

At least, the following service agents' sub-categories should be considered:

Profiling Agents. This agent is responsible for elaborating the user profile. This task of defining a profile can become very difficult and complex, depending on the way it is implemented. We are using two approaches: static and dynamic information. The first one refers to personal information entered by the user. Dynamic information refers users actions in the environment.

Personalization Agents. This kind of agent gets the user profile from the user-profiling agent and based on this profile, it organizes the works disposed in the environment. In this way, each user can have its own view of the environment. In other words, it allows the system to present the same information in different ways to different users.

Recommender Agents. This agent carry out a role similar to that of as the personalization agent, but it is a bit simpler. The recommender agent provides services based on the audience of the works and the rooms. It processes simple tasks such as "Visit Room 2" or "Visit Work 4" that are sent to all users.

Guiding Agent. Guiding agents represent the guides of real life. The main function of this agent is guiding the visitors in the environment rooms, telling useful information and assisting them.

Communication Agents. It encourages interpersonal communication between users through the use of communication tools. Furthermore, this agent aims to approximate people inside a multi-user environment using Communication theories and defining some protocols used for users communication. These protocols are called social communication protocols and are used to improve interpersonal communication. In the following sections we describe the Communication Agent development process.

4 The Communication Agent Organizational Issues

According to [06] the description of a MAS organization involves: functional and structural analysis and communication issues. We are including other concepts (mainly from Software Architecture approach) to design the agent organizational issues. In this section we detail the conceptual and functional analysis, communication issues, components and implementation views of organization issues emphasizing the communication agent.

4.1. Conceptual and Functional Analysis

"Putting people together"… it is our main goal. But how to develop a system for do that? Our answer is based on Levy [07] ideas about communication tools and how to take advantage of the Internet native structure for implement communicational mechanisms. So, we use an agent-based system for connect users and stimulate the creation of conversational groups. Fig.2 shows the main use cases for the communication agent. Basically, when a user is connected, the MAS is activated. While the user actions are monitored, the system is processing for forming groups and suggesting conversations. The last step is to evaluate a formed group or suggest other group.

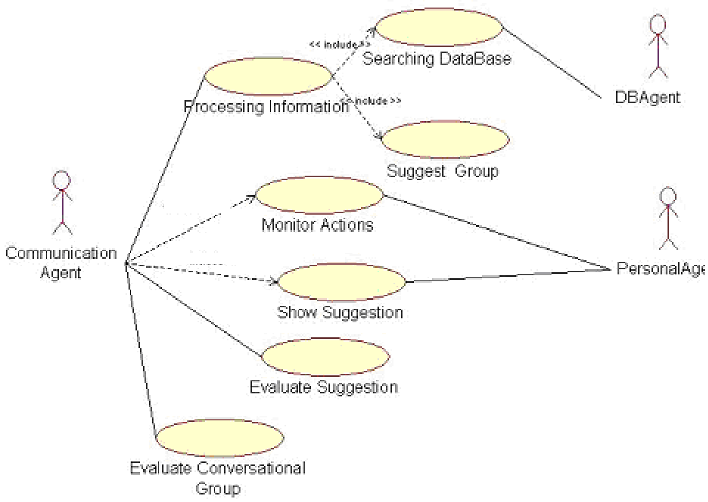


Fig.2: Usecase diagram for representing communication agent behavior.

The main use case of the communication agent is to "*processing information*". This use case symbolizes the agent intelligence and the capability of taking decisions. For do that we are using some Communication theories assumptions [08,09] and a neural network server .

Other important offered functionality is the evaluation. Evaluating the process is a way for better its. We have two levels of evaluations: the formative and the somative ones. What differs these evaluation levels is the feedback to users. In the formative way the feedback is offered immediately while the somative evaluation not. The both methods are processed while the user is interacting.

The formative evaluation is represented by the "*Evaluate Suggestion*" use case. In this case we are evaluating how the users are answering to the agent suggestions. If the user always rejects them, the system gives a break. In this case, the evaluation parameter is the number of accepted and rejected suggestions.

The somative one is expressed by the "Evaluate Conversational Group" use case. The feedback is directional to people who are studying the conversational groups formation and not necessary to people who is using the communication service. The somative evaluation tests the effectiveness of our communication strategies. So what, we can test the performance of different approximation strategies and analyse them.

For performing the somative evaluation we are adopting other evaluation parameters. These parameters are recorded while the user is interacting as a log register. Analysing this log we can extract the number of messages changed in a conversational group and the group duration.

Buy the way, the messages number is not sufficient to estimate the group effectiveness. Imagine a group of four people that changed thirty-five messages in ten minutes. Apparently it is an effective group. But, if just one user says "Hi!" thirty-five times, it is not. So, we decided to create a coefficient to measure the effectiveness of each formed group. This coefficient is specified by the difference between users-generated messages. We take the more active user (major number of messages) and subtract the minor generating a number. For a communicational group we suggest that this cannot be twice the media of changed messages in that group. At this way we can evaluate the effectiveness of each formed group and tests, which strategies are working better.

4.2. Communications Issues

The communication issues describe how the agents change messages between them. The agents implement a politics for maintaining its connections. The dynamic of this politics is very simple, when a new user logs in the system, a set of agents are created to support him. At this way, in the client side, we have a personal and a database agent for each user.

When the communication agent is activated it establishes its connections with other service agents. It occurs with the database agent where is recorded the user information. The communication agent staying processing while the user is interacting with the system and the other users connected in the system. When it takes a decision (a suggestion) it communicates to the personal agent, so what the suggestion can be passed to the end user.

4.3. Software Components Overview

The software architecture for the whole MAS architecture was designed as a framework. So, we have generic and reusable architectures for the personal and the service agents. We present the adopted solution for the communication agent.

Fig. 3 shows the software architecture for the communication agent implementation. We have two components: <<decisionmodule>> and <<internalknowledgebase>> and the interfaces for improve the communication with the external entities.

The main component is the <<decisionmodule>>, that processes the suggestions. The <<internalknowledgebase>> is responsible for choosing the most appropriated approximation function according with a user profile model. Using special components called interfaces details in section 4.4.1 makes the communication between these components and the external ones.

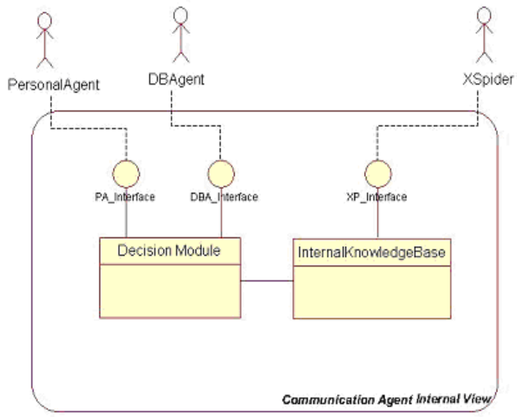


Fig. 3: Communication Agent Software Architecture.

4.3.1. Interfaces

When the Communication Agent is created, it creates a link to the Personal Agent, by using the <<PA_Interface>> component. So, <<PA_interface>> establishes the channel between the communication agent and the end user by sending and receiving information from the Personal Agent.

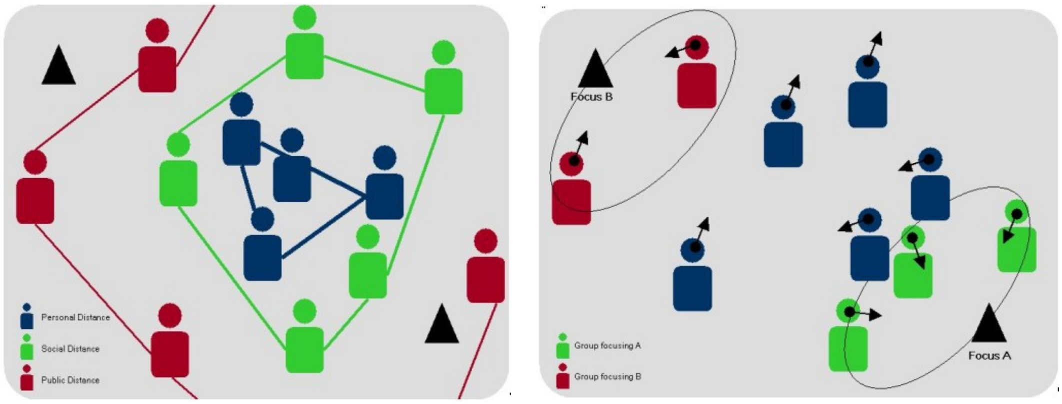
The <<XP_Interface>> is responsible for communicating with the Xpider Server [10] where a neural processing improves group creation. Finally, the communication with the database agent occurs when some database operation is required. The <<DBA_interface>> makes it.

4.3.2. Decision Module

The operational kernel of the decision module is the affinity function, which is a function that indicates users for getting connected, in order to compose a conversational group. The way the approximation works is defined by the internal knowledge base.

The affinity function is defined by two main parameters: area of interest and proxemic theory [08]. The last one is based on the physical proximity between people classified in personal, social and public distances. According with the position of each user in the virtual space we connect them forming a conversation group as shown in Fig.4-a. The area of interest is related with the focus of attention of each user.

In three-dimensional virtual environment we are taking orientation and position data as the way to classify users into conversational group. Fig. 4-b illustrates groups formed by focus A and B.



(a) (b)

Fig.4: .In (a) Grouped by Area of Interest Management. In (b) Grouped by "Proxemic" parameter.

4.3.3. InternalKnowledgeBase

The <<InternalKnowledgeBase>> represents the internal knowledge base of the agent. This component executes the behaviors (or methods) that group the users generating lists of users to be connected. These methods are:

GroupPublicProximity( ) – This method approximate all users distributed in the same "public area".

GroupSocialProximity( ) – The user list is made by using the users in the same room and in the same neighbore area.

GroupPersonalProximity( ) – Only the users distributed closely are selected to compose the list of names to suggest the conversation.

GroupInterestArea( ) – This method uses as the approximation parameter the focus of interest of each user, grouping users which are looking at the same point.

GroupGroupProfile( ) – The agent gets from the database agent a list of the users sharing the same room, at the same time, and selects only the ones who belong to the same group, which is defined in the neural server.

GroupPersonalProfile( ) - The agent gets from the database agent a list of the users sharing the same room, at the same time, and selects only the ones who activates the same neuron in the neural network.

Quiet( ) – This method stop the agents´ suggestions, when the suggestions are rejected for 6 times the agent gives a break.

4.4. Implementation View

The service agents, including the Communication one, are implemented using Java technology. Sockets implement the connections between the services and the personal agent. Each service is implemented as a server, a service server that can be added to the architecture.

The diagram on Fig. 5 shows the main components of the implemented MAS for ICSpace application (see Section 6). In this diagram we can note the whole system connections and how the Communication Agent is integrated with the other components. Looking that focusing the Communication agent we have: When the user connects to ICSpace, two applets are initiated: PersonalAgent and ClientVrml. ClientVrml connects with the server and the PersonalAgent initializes all the other agents, including the Communication Agent. The Communication Agent makes a connection with ServerXpider and with DBAgent, in order to compose his internal knowledge base and to use the Neural Network Server or the DataBase Server.

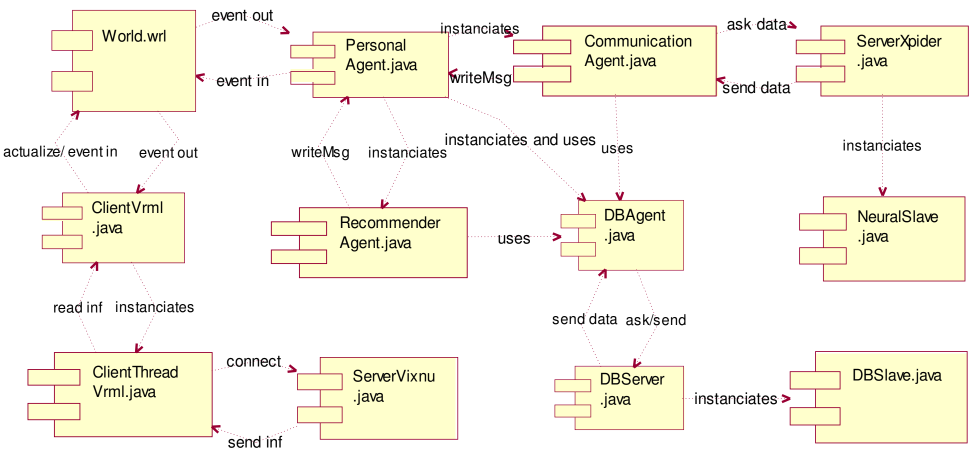


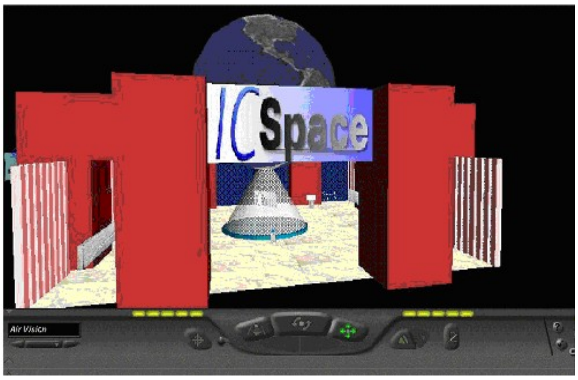
Fig. 5: Implementation View using Components Diagram.

5 Study Case: ICSpace – An Internet Cultural Space

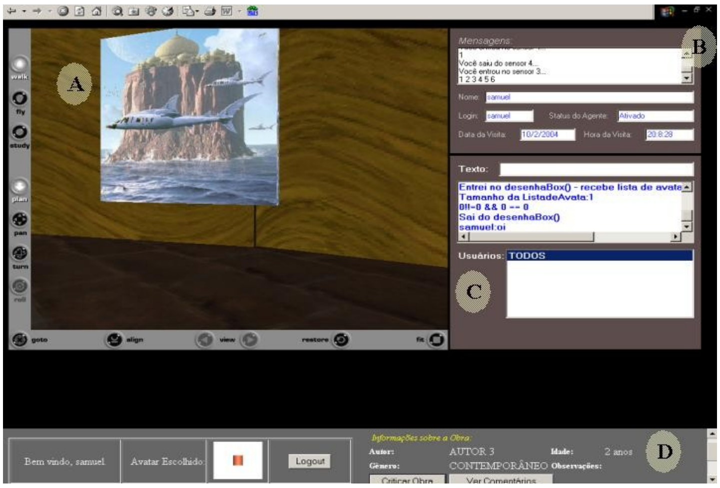
In order to implement the proposed MAS architecture in a real use situation, we use ICSPace , a virtual cultural space on Internet, where artists expose their work for visitor appreciation. The visitors can circulate in the space, look at exposed works, notice other visitors' presence, express their opinion and, eventually, communicate with each other. The works exhibited into ICSpace are any artistic manifestation represented in a digital way. For example, photography and paint are represented using images. But we can also use video, audio or 3D models for composing the ICSpace collection .

The main goal is to provide an open space in the Internet where artists can expose their works and everyone can see, comment and appreciate. ICSpace perception mechanism uses Vixnu multi-user VRML server . ICSpace offers a hybrid navigation form to users using both 2D-HTML and 3D-VRML (see Figure 6). More details about ICSpace implementation can be found in [11,12].

ICSpace has been redesigned to implement the MAS architecture introduced in this paper. The first requirement is the technological support for improving the ability to dynamically answer changes performed by the user. In the ICSpace implementation we are associating VRML, Java, JSP (Java Server Pages) and Database technologies. JSP allows the implementation of the dynamic aspects as managing the data entry and the communication with the database.



(a)



(b)

Fig.6: ICPace User Interface. In (a) Overview. In (b) Internal View.

The personal agent is presented to users using Java Applet. The environment knowledge is implement by a VRML event grammar, which is grammatical interpreted by the Personal Agent using the API EAI (*External Authoring Interface*), an API that enables Java applets to understand VRML events generated by user actions. So the agent perceives when the user moves or touches anything, for example.

We have been working in the Recommender Agent where we used audience information for suggesting visits to the users. Register audience in 3D environments is not an easy activity. We have to consider aspects as time and orientation for register relevant data. In order to implement this, we have used a timer associated with VRML proximity cubes and user position and orientation. We have implemented an evaluation mechanism for knowing the meaning of audience (negative or positive).

Other interesting experience was the implementation of the Guiding agent [13]. We have worked with a proactive version where we integrate the virtual guide represented by a 3D avatar with a robotic agent that repeats the virtual guide actions in the real world.

6 Conclusions

In this paper we have brought together ideas from recent works in multi-agent systems architecture, with theories from Communication History; mixed into computing solutions in a cultural context.

We have presented a MAS architecture for putting people together in cultural virtual environments. We have defined different agents categories. Each category identifies a specific role in the MAS architecture with a special function in cultural environments context. We have adopted three main categories of agents: reactive (PA), intermediate (DA) and services (SA). However, we have divided services layers into specific roles: guiding, profiling, personalization, communication and recommender.

This work shows how the agent-based approach can be useful in real use cases. We proposed a MAS architecture for a kind of system that can be easily found in the Internet. So that, we can extend the conventional view, suggesting a more proactive system with other desire functions. For specifying the proposed architecture, we have unified the agent technology with software architecture, which is an innovative approach to MAS development.

We are currently exploring an implementation framework that could be used to facilitate the development of other agents' categories or other implementation solutions for the current ones. So, we are working in different implementations of each agent category (personalization, recommendation, communication) using different algorithms, in order to make possible to compare its performance.

Also, we are working in the somative evaluation results. We are processing them and structuring the method used for obtains the results. We are working in the tests planning for performing them in heterogeneous groups involving a great variety of users.

Referring the experiments, we are working hard to formalize the communication protocols for real-virtual worlds communication. We are planning other experiences for identify, describe and explorer them.

Acknowledgment

This research was supported by the project Icspace (http://icspace.natalnet.br). The authors wish to thank Natalnet Lab team for the collaboration during the realization of this work. Thanks to CNPq for supporting this work.

References

[01] Louvre Museum Website - http://www. culture. fr/ louvre/ louvrea.htm (Accessed in 10/04/2001)

[02] Van Gohh Museum Website - http://www.vangoghmuseum.nl (Accessed in 10/04/2001)

[03] T. Tavares, A. Araújo & G. Souza Filho. "ICSpace - An Internet Cultural Space". In: Active Media Technology – 6th Internacional Computer Science AMT2001. Honk Kong, China, Dezembro 2001. p. 389-402.

[04] John Collins et al. (1998) A Market Architecture for Multi-Agent Contracting. In: Autonomous Agents 98. ACM Proceedings: 285-292p.

[05] T. Alsinet, R. Béjar, C. Fernandez & F. Manya. A Multi-Agent System Architecture for Monitoring Medical Protocols. (2000) In: Agents 2000 Proceedings: 499-505p.

[06] P. Lévy. “CiberCultura”. Tradução de Carlos Irineu da Costa. São Paulo: Ed. 34, 1999, 264p.

[07] FERBER, Jacques. Multi-Agent Systems – An Introduction to Distributed Artificial Intelligence. Adilson Wesley 1999. 509 p.

[08] E. T. Hall. “Proxemic Theory” In: Theory of Communication (Chapter 6) – 60-67p.

[09] W. Schutz. “FIRO Theory of Needs” In: Theory of Communication (Chapter 9) – 93-101p.

[10] SILVA, O., TAVARES, T. A., RODRIGUES, M. J. N., SOUZA FILHO, G. L. Using Semantic Rules Database to Dynamically Set Up the ICSpace Virtual Building In: ER2002, 2002, Tampere. ER2002 Proceedings. , 2002.

[11] BURLAMARQUI, Aquiles; TAVARES, Tatiana Aires e SOUZA FILHO, Guido Lemos de. Vixnu - Um Servidor Multi-usuário com Suporte a Comunicação em Ambientes Virtuais Colaborativos. 2002, Fortaleza, CE, Brasil.

[12] TAVARES, T. A. et al. Playing with Robots and Avatars In: Symposium on Computer Graphics and Image Processing, 2003, São Carlos. Proceedings of SIBGRAPI. , 2003.

[13] TAVARES, T. A., GONCALVES, L. M. G., SOUZA FILHO, G. L. Using Agents for Improving Multimidia Virtual Environments Personalization. Scientia. São Leopoldo: , v.13, n.2, p.121 - 132, 2003.