Virtual Interface for Collaborative Work with RECOLLVE

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***Abstract*—The world globalization process, the increasing demand of communication and information technologies creates an enormous demand for collaborative applications. Aiming to support communication, information change and collaboration between users geographically distants, many CSCW (Computer Supported Cooperative Work) systems like audio and videoconference, shared editors, shared whiteboard and CVEs (Collaborative Virtual Environments) were developed. Collaborative Virtual Environments represent an important category of CSCW systems that use 3D shared spaces in order to support collaborative activities. We find also many systems that integrate collaborative applications to satisfy specific needs of users. We detailed in this article the potential of RECOLLVE to represent in the virtual scene a very large set of collaboration activities, including their social aspects.**

I. Introduction and Related Work

Users geographically distant need to exchange information, to communicate and to cooperate. This context creates a demand for collaborative applications. The number of collaborative tools (CSCW systems) has increased over the past years. Currently, many collaborative applications are available for users, such as audioconference and videoconference tools, shared whiteboard, shared text editors, etc. The challenge is to make these tools work together to support real cooperative work.

We find groupwares such as the PLATINE [1] system that groups a set of specific tools, trying to anticipate users needs. However, groupwares like Platine find difficulties to be accepted by work groups, because it is practically impossible to predict the way how people work together. Consequently, it is practically impossible for developers to predefine real users collaboration needs and artifacts to work in group [2]. In this context, the integration tools play a very important role, because they allow to integrate different CSCW systems to support collaborative work. This fact explains the increasing number of systems to integrate collaborative applications, such as the LEICA system [3], for example. This kind of system provides users with a great flexibility to establish collaborative sessions, allowing them to customize tools according to their needs and preferences.

We categorized the CSCW systems as Collaborative Tools, Integration Tools and Applications Scenarios, as shown in Figure 1

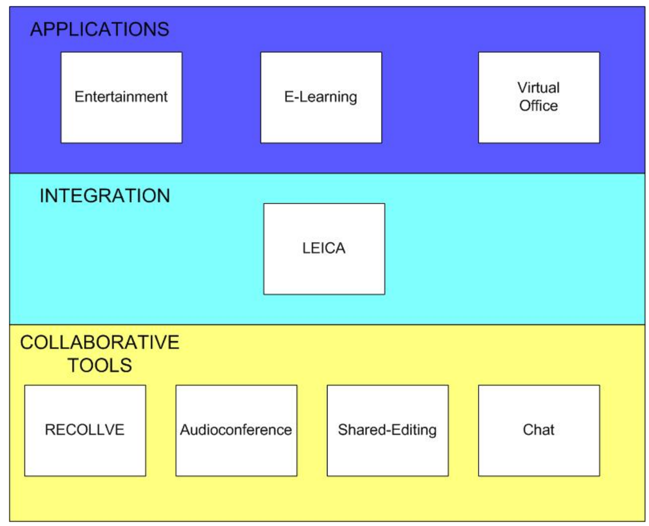

Fig. 1. Classification: Application Scenarios, Integration Tools and Collaborative Tools

The CSCW domain is multi-diciplinary, because there are different kinds of problems. On the technique plain, we have to consider that a CSCW is an interactive, multi-user and distributed application. Thus, differents aspects such as concurrent access to shared resources, access control of users, network communication synchronization, among others, should be considered for this kind of system.

On the sociologic plain, the CSCW systems should consider humain aspects of cooperative work. We have to consider, for example, how to start a collaborative activity, i.e., how users starts to make a collaborative work. The management of user roles and group awareness are equally importants.

Awareness represents the common conscience of a work group that knows the general context of a given work. This group conscience corresponds to the understanding a user has about: i) which whom he works with; ii) what each user does; how do users interacts [5].

One of the most critical problems on the deployment of cooperative work systems is exactly to provide users with a real perception of presence (awareness) of any user he or she cooperates with. Virtual reality allows to represent the real world by metaphors, making awareness more natural, with the possibilities of interaction very close to those in the real world. In this context, the CVEs play a very important role, because they allow users over many network points to communicate and to interact in a shared 3D environment, often called “virtual environment”.

Collaborative virtual environments have been used in many applications type, such as: e-learning, training, war simulations, etc.

EVE[6], *BrickNet*[7], *INVITE project* [8], *DIVE* [9], *VREng* [10] and *VNet* [11] are examples of CVEs where users can share a 3D environment and interact with other users and objects.

DIVE is a virtual reality desktop system where users can dynamically program behaviors to objects and avatars. However, avatars have no knowledge about objects inside a virtual scene. DIVE provides a very restricted integration with other collaborative applications.

VREng (*Virtual Reality Engine*) [10] is a virtual reality distributed system that allow users to interact and move in 3D world. *VREng* provides also a closed integration of its virtual world with other collaborative tools such as a whiteboard. However, user actions are not represented in the virtual scene by avatar actions.

Soares et al. [12], propose a 2D-3D hybrid interface. User actions on 2D application shared interface in a populated virtual world are represented in the 3D space.

NETICE [13] allow to share a whiteboard in a 3D interface and provides avatars with a set of facial and body expressions. But, these avatars actions are realized from an actions menu, independently of actions realized on the *whiteboard*.

The main idea in *VEPersonal* [14] is to construct virtual environments user knowledge level adapted. A same virtual scene presents different details for users with different knowledge level. However, *VEPersonal* does not represent collaborative applications.

Second Life [15] and *There* [16] provide their users with very detailed and advanced avatars that are often also extremely customizable. Users choose among many virtual worlds to navigate and interact with other users through a chat system. However, the avatar-object interaction possibilities are limited to a reduced set of predefined actions.

INVITE system is a platform for tele-learning that provides a shared whiteboard, supports multi-modal interaction among users by text, video and audio communication. Users have different roles. *INVITE* provides an integration of a virtual environment with other collaborative tools in a closed system. The *INVITE* system is more closed than RECOLLVE, but it does not consider access rights by users.

A. *Comparative between CVEs*

	Integration	Roles	Rights	Awareness
INVITE	•	•		•
DIVE	•			
VREng	•			
Netice	•			
EVE		•		•
Soares et al	•			
Second Life	•			

From a comparison among CVEs early referred, we conclude that there are virtual environments able to represent specific collaborative applications, as a white board, for example, but no one provide users with mechanisms to represent any kind of collaborative activity, including their social aspects.

We also found agent-based systems like InViWo [17], Agile [18] and PAR [19]. All of them have interesting characteristics, but no one focuses on representing collaborative activities. In this article, we present RECOLLVE - a collaborative virtual agent-based environment that provides users with mechanisms to represent colaborative applications.

This article is structured as follows: Section II presents our multi-agent architecture; after that, in Section III, two integration scenarios are related; in the last section, some perspectives about future works are presented.

II. RECOLLVE - The Architecture

The aim of RECOLLVE is to be used as a virtual platform to represent the dynamic of collaborative tools. Therefore, is extremely important to manage user roles and the access rights associated to them. We are not engaged in defining user access polices, but at representing them into the virtual scene. This aspect is very important because its aim is to transcribe to the virtual scene a natural aspect of real systems: the social protocol mastering the real collaborative work.

User rights are represented in the virtual scene by handling 3D objects. A user could handle an object depending on its role, its scene position, or another constraint defined. Regarding to the roles, users playing different roles could have different access level to a same object, like happens in real life. For example, a student cannot sit down at the theacher chair. This is a social protocol. The aim is to represent into RECOLLVE the dynamic of a collaborative actitivity including their social protocols. In RECOLLVE, the access control is object-centered, i.e, the object defines if a user can handle it and what actions he or she can make on it. The idea is associate to each object a set of access rules. This idea make us to choose the Agent Paradigm to model the RECOLLVE system.

The great advantage of using Agents is its capacity to take decisions from a user interaction with its environment, by sensors, and to make an action based on the collected data.

RECOLLVE is an agent-based CVE focused on representing collaborative applications in virtual environments. Figure 2 shows its multi-agent architecture. In RECOLLVE, all entities are represented by agents which communicate and interact among themselves. Objects and avatars are handled in the same way due to the communication facilities among agents provided by standard languages.

We use the JADE [20] plataform to model and simulate our multi-agent architecture. Each running instance of the JADE runtime environment is called a Container as it can contain several agents. The messages exchanged by JADE agents have a format specified into the ACL language defined by the FIPA - Foundation for Intelligent Physical Agents - [21] an international standard for agent interoperability.

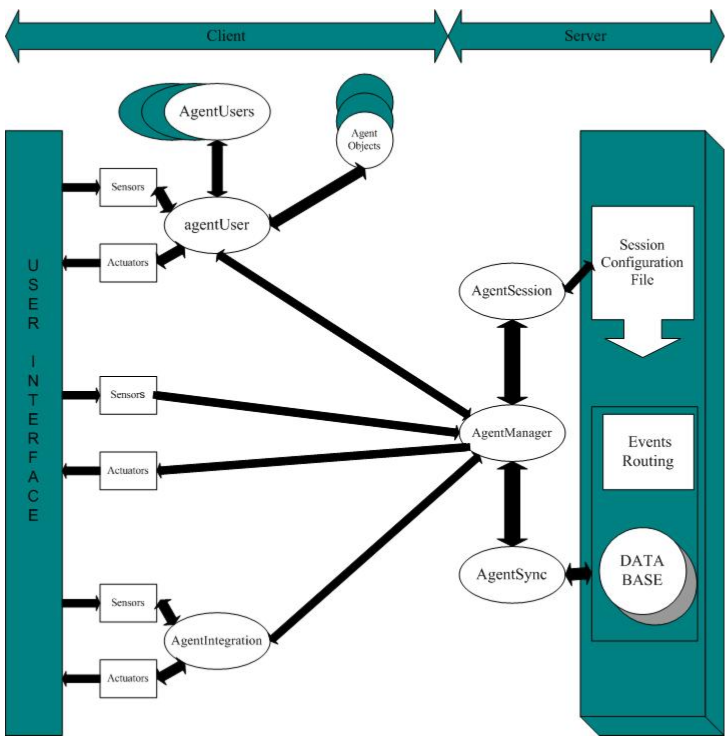

Fig. 2. Multi-Agent Architecture of RECOLLVE

We have defined six types of agents:

- user-agent: users are represented into the virtual scene by embodied *User-Agents*, referred as avatars. The *User-Agent* model is very simple: when an avatar is coming near to an object or another avatar, it sends a message to that agent informing its profile. When an avatar receives some message from other agent, it presents the message contents to the user.
- object-agent: objects are represented into the virtual scene by embodied *Object-Agent*. Objects define what actions an avatar can realize on it, based on early defined rules. Figure 3 shows the interaction between an avatar and an object agent. The avatar sends a message to the object which it wants to handle informing its profile. The object, based on established rules, evaluates what actions that avatar can realize on it. It sends back a message to the avatar with the available actions set. Then, an actions menu is presented to the user and he or she make a choice. In this way, it is possible to transcribe to the virtual scene the access control rights of users, according to his profile.

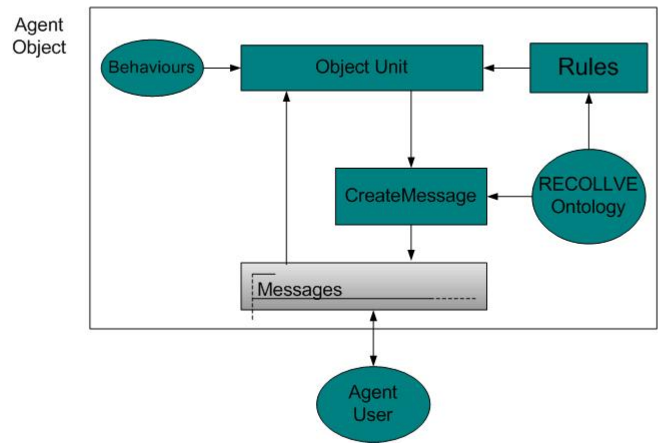

Fig. 3. Architecture of Agent-Object

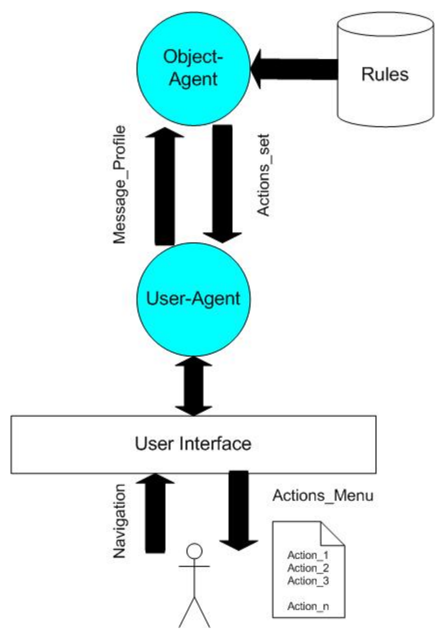

Fig. 4. Agent-user and Agent-object interaction

When an object is handled by an avatar, it may be moved by the avatar. In our agent-model, each agent has a mailbox where the message from user agents are posted and the agent is notified. The Object-agent picks-up the message from a message queue to process it. Thus, two or more Users-agent cannot handle the same object at the same time.

- manager-agent: the Manager-agent coordinates actions of other agents; it sniffs actions from users and from their agents and it also keeps the virtual scene synchronized among all users. Moreover, it makes actions due to user actions. For example, the manager-agent can exclude an avatar, excluding the user from a virtual session, if it does not respect any rule into the virtual world; or it could order the integration-agent to mute the microphone of a misbehaviour user.

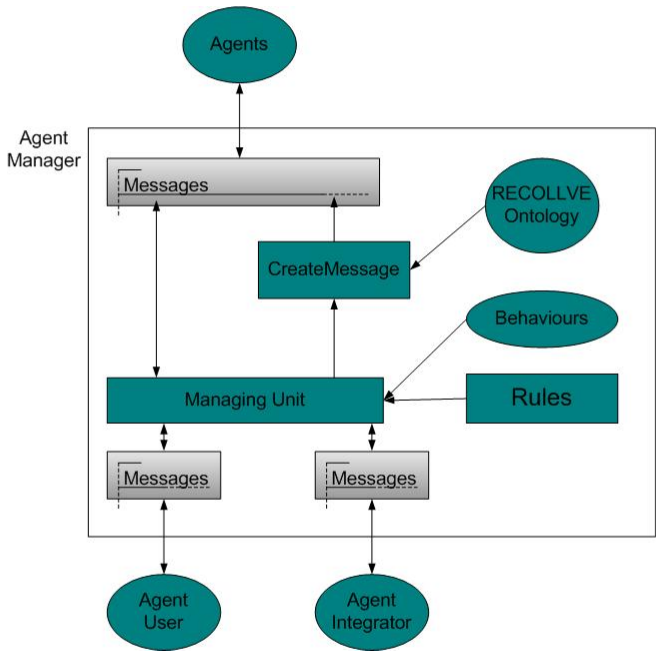

Fig. 5. The Manager-Agent

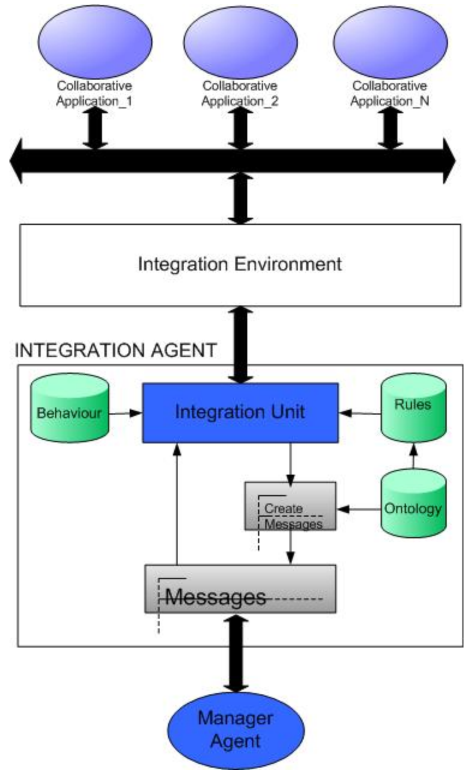

Fig. 6. The Integration-Agent

- integration-agent: serves requests from external applications to realize actions inside a virtual scene and vice-versa. When it receives a real event notification message from the *Integration-Environment*, it asks the Manager-Agent to make a specific action, for example: to put an object into the virtual scene; or when it receives a virtual event notification message from the Manager-Agent, the Integration-Agent asks the Integration-Environment to make a specific action. Figure 6 shows the interactions of the Integration-Agent with the Agent-Manager and the Integration-Environment.
- sync-agent: it synchronizes the virtual scene. The Agent-Sync is responsible for keeping the virtual scene synchronized in all clients.
- session-agent: it controls the collaborative virtual session. The Agent-Session is responsible for adding new users to the virtual session and for removing users that quit the virtual session. Moreover, it validates users login and password.

III. Supporting Awareness in Collaborative Apllications

The aim of this article is to show the potential of RECOLLVE as a virtual interface for collaborative work, mapping real actions into virtual actions, or mapping user actions into avatar actions. A virtual interface is more intuitive and makes awareness stronger, making the communication and the relationship among users easier.

We believe in the potential of RECOLLVE to support awareness communication and interaction among many different users. The implementation into the virtual scene of a real environment make users theirself feel more natural in this virtual environment. Consequently, the implementation of the social protocols make the interactions and communication among users as natural as possible.

The keyword at RECOLLVE is representation:

- collaborative tools are represented into the virtual scene by 3D objects. For example, an audioconferece tool is represented by a 3D ”Microphone”;
- user actions are represented into the virtual scene by avatars animations, respecting the object function;
- user rights access are represented into the virtual scene by permission to handle objects.

We choose two applications to represent into RECOLLVE: an *E-Learning* Environment and a Virtual Office. Regarding to the E-Learning environment, an audioconference and a collaborative browsing tools, under development, are integrated by the LEICA [3] system.

LEICA is a rule-based system of integration where applications (CVE and COLAB in this example) interact by message event notifications.

Figure 7 shows a possible E-Learning scenario of integration where three collaborative applications - our RECOLLVE prototype, an Audioconference tool and COLAB [22] - are integrated by the LEICA [3] system.

In the context of *E-leaning*, we can imagine a Virtual University, where students could share an entertainment space and where there is a course at each virtual class. The user

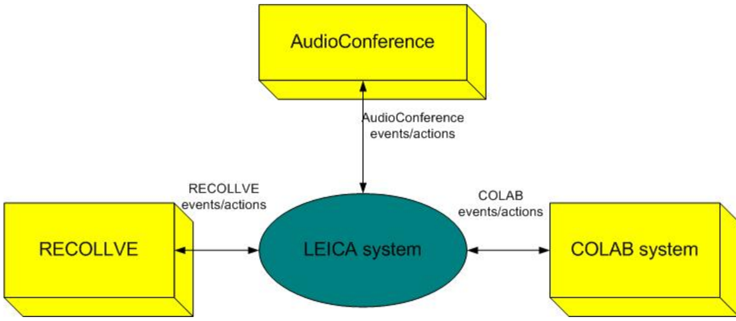

Fig. 7. A possible E-Learning scenario

control access is represented by the 3D door object, which control if a user has the right to access that room. If the user has the access right, the door open. Otherwise, the door keeps closed. Figure 8 shows this situation.

Once the teacher enter into a virtual class, the Integration-Agent ask LEICA to starts the audioconference. Symbolizing the audioconference session, the Integration-Agent makes a ”Microphone” to appear in the virtual scene, as shown in Figure 9. Teacher and students talk through an audioconference tool, like the Skype system, for example. However, the main problem with audioconference systems is to coordinate the communication when there are many users participating: to identify the interlocutor and to identify who wants to talk.

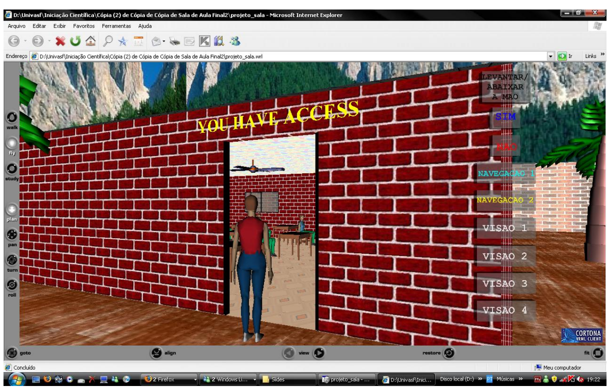

Fig. 8. The user has access rigth, then the door open

Fig. 9. The microphones symbolizes the start of an audioconference session

The main idea is shown in Figure 10. The context refers to a virtual classroom where there are two roles: teacher and student. *Teacher* and *students* are represented by avatars. In the first scene, the *teacher* keeps the ”microphone” symbolizing that he has the *token* to talk. In this situation, only the microphone of the teacher is turned ON. The microphones of all other users are turned OFF. Thus, we assure that no *student* will interrupt the *teacher* without permission. If a student has any question, he should keep his avatar arm up. When the *teacher* transfers the ”microphone” to the *student* which holds his avatar arm up (student_3), the Integration-Agent, according to established rules, sends a message asking LEICA to turn the microphone of that student ON, giving him permission to talk.

This example illustrates the social protocol mastering the collaborative work. The teacher can take the microphone at any moment. On the other hand, the students cannot do it without asking (holding their arms up) the teacher.

Note that the problems related to the audio/video communication are handled by the Skype system. RECOLLVE is just responsible for the scene synchronization: the avatar positions, for example.

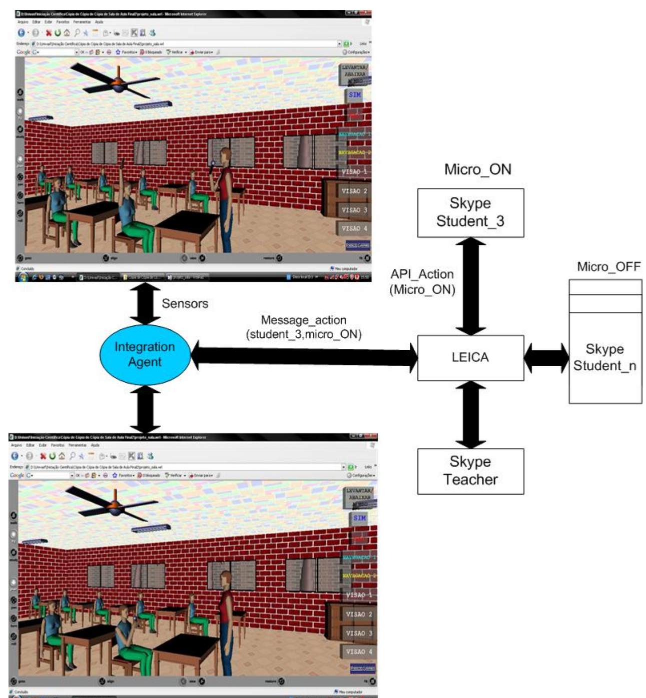

Fig. 10. Representing into the virtual scene an audioconference session

Another experience, shown in Figure 11, is to represent a Collaborative Browsing session using COLAB systems. COLAB is a Web collaborative browsing system. COLAB users can create and destroy all synchronization relationships on a dynamic and distributed way. A COLAB client is a JAVA applet which synchronizes and presents Web pages. In this way, COLAB allows users: to browse together in the Web (a user drives the browsing) or users to separately browse in the

Web, but having awareness of the other browsing users.

The first step is to choose states which should be represented in RECOLLVE and the real world metaphors which will be associated with these representations. We choose two main aspects of COLAB:

- Browsing Synchronism - when browsing is synchronous, a user drives it and the other users follow him. This state is represented as an entity, represented by the URL indicator. When the browsing is asynchronous, this entity disappears.
- *Floor* - this expression indicates a unique attribute associated to a user, which allows him to drive a synchronous browsing. This attribute is represented by a 3D object (a token). Accessibility rules are established for the token, defining the user profiles which have access to it.

When COLAB alternates between synchronous and asynchronous mode, the Integration-Agent makes a token to appear and to disappear. When the URL is modified, its text indicator in the virtual scene is also modified. Figure 11 shows an interface COLAB-Web Page, where the text indicator is shown in the virtual scene. In COLAB, when a user pass the floor to another user, a token will be passed in the virtual scene too. Finally, if a user pass a token to another user in the virtual scene, the floor will be passed to the other user in COLAB too.

A virtual classroom could be also an application scenario. The teacher wants to show a WebSite to the students to explain a content, or he wants to show an experience. Then, the teacher can navigate through the Web and the users get the same URL which is shown into the virtual room. The avatar representing the teacher takes the token, symbolizing that he has the control at that moment. If a student has any question, he should keep his avatar arm up. When the *teacher* transfers the "floor" to the *student* which holds his avatar arm up, the Integration-Agent, according to established rules, sends a message asking LEICA to notify that a student is the leader now, and the other students and the the teacher will get the same URL. The teacher can at any moment take the "floor" again.

The second scenario of integration is a Virtual Office shown in Figure 12. Here again, three collaborative applications, under development - our RECOLLVE prototype, a Chat tool and a Shared Editing - are integrated by the LEICA [3] system.

In Chat systems, users share experiences, opinions and knowledge by exchanging messages. Representing this kind of application into a virtual scene, makes the awareness among users stronger. Figure 13 shows a representation of a Chat system scenario in a virtual scene.

Shared Editing is a kind of tool that allows two or more users to edit together a shared document. The main problem on the deployment of this kind of system is to manager concurrent tasks, when two or more users simultaneously edit the same document. Figure 13 shows, in the first scene, one scenario where three users, represented by their avatars, handle three different parts of the document. Meanwhile, other two avatars wait. The second scene shows that the yellow avatar finished to handle the part number two of the document and it waits now for the part number three. The other users could see that the part number two is now free.

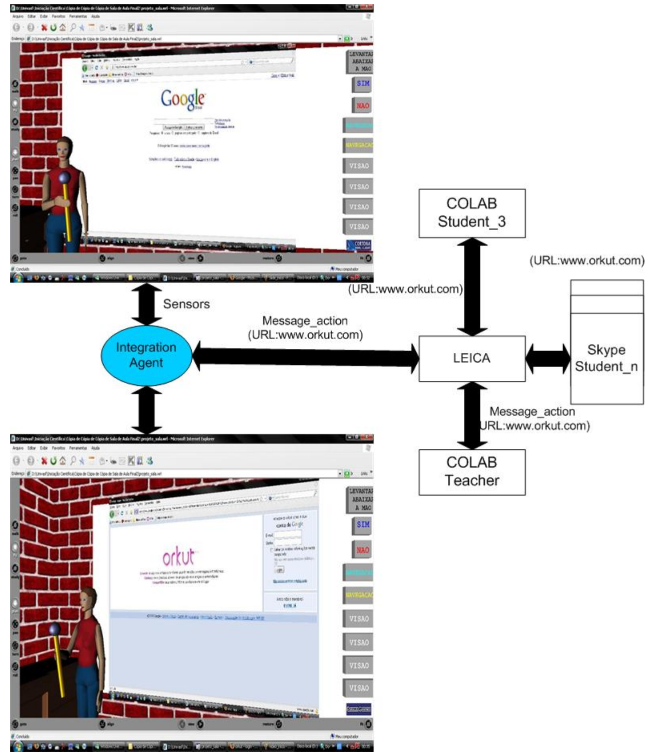

Fig. 11. Representing a virtual scene in a Colab session

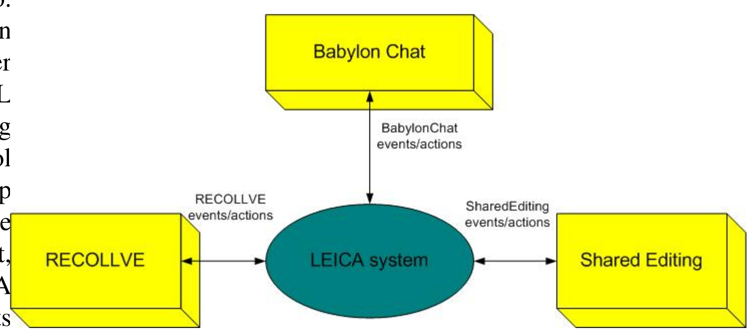

Fig. 12. An E-Learning scenario

This situation make stronger awareness of who are handling what part of the Shared Editor. Obviously, the number of parts (chapter, page, etc.) the Shared Editor allows to handle depends of its granularity.

When the yellow avatar finishes to handle the part number two of the document, the Integration-Agent, according to predefined rules, sends a message asking LEICA to release the user access to the Red_User, whose avatar starts the queue, to that part of the document. The part number two of the document remains blocked for other users and it only will be released by the Red_User.

These scenarios illustrated above show the potential of RECOLLVE to be used as a platform for many kind of collaborative work: *E-Learning*, entertainment, virtual office,

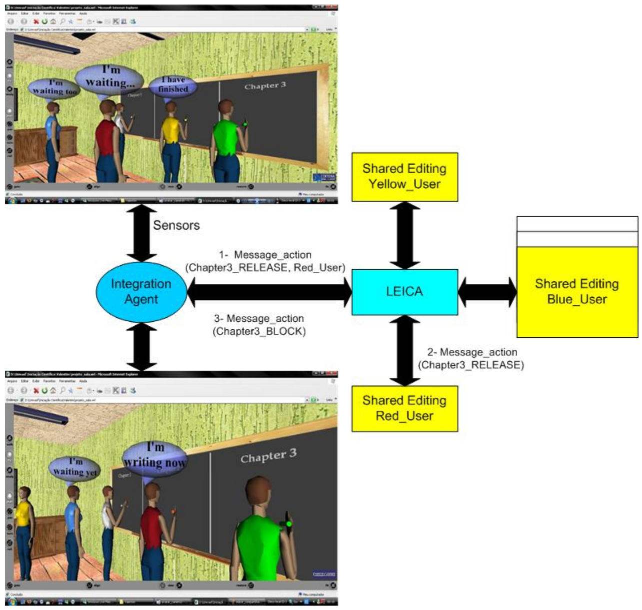

Fig. 13. Representing into the virtual scene a Shared Editing session

entertainment or training, among others.

IV. Perspectives for Future Work

In this article, we presented the potential of RECOLLVE as a Virtual Interface for Collaborative Work. Many scenarios were presented and were discussed the gain of awareness and representativeness with RECOLLVE were discussed. Moreover, we defined an API to collaborate beyond of virtual scene. We realized also a first integration experience to represent a collaborative navigation session inside a virtual scene. For future works, we intend to analyze and to evaluate the usability of this virtual interface and the degree of perception of users.

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