Supervision and Control Tool for Collaborative Virtual L@boratory

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***Abstract*—The objective of this article is to model and implement a learner Supervision and Control Tool during a remote learning session of practical work. This tool will be integrated in our Collaborative Virtual L@boratory. It serves the users (learners, teachers, tutors) of our virtual laboratory during the assistance and evaluation process. It allows the tutors to be aware of the work-progress status and makes a model for the average learner based on his/her actions and interactions. The functionalities supported by this system are: synchronous supervision (tutors and learners are connected simultaneously), asynchronous supervision (using the activities' history) and guiding the learners.**

***Index Terms*—Virtual Laboratory, Collaborative Learning, Evaluation, Assistance, Control, Supervision**

I. Introduction

In many areas, particularly in experimental sciences, laboratory experiments play an essential role in the learning process and bring an important dimension to theoretical education. The question that arises is how to recreate a generic concept of a laboratory in the context of a virtual campus, to achieve the learning practices inherent in scientific and technological disciplines, taking into account certain barriers such as the impossibility of directly manipulating the physical tools, and the possibilities and limitations of sensory observation.

The challenge is to create distributed learning environments to achieve remotely, not only teaching and research activities similar to those achievable in conventional laboratories (real), but also various other activities not available in the latter [1], [2]. How to use the infrastructure of broadband networks to facilitate access, presentation and exchange of information between learners involved in this particular type of e-learning activities?

In Distant Practical Work instances [1] [2], teaching/learning can be regarded as dynamic or evolving situations, i.e. they can evolve even without the involvement of the instructor who leads this process. This dynamic characteristic requires from the tutor in charge of these instruction practices (whether the learners are present or distant), a certain number of specific activities to build cognitive competences (capacity to act in an efficient and competent way within a given context).

Any dynamic situation leads the person in charge of instruction to supervise (through observing the state of relevant indices) and control (through acting on certain variables, so that the situation's critical variables values remain within acceptable margins) [3].

Information and Communication Technology offers to the tutor means of supervising, controlling learning situations, and making effective feedbacks. This work lies within the scope of developing a Collaborative Virtual L@boratory (CVL@b) [4] [5] [6]. One of its subsystems is dedicated to the tutor, so that he/she can supervise and manage the activities of a group of learners involved in traditional practical work (where learners are present). For distant supervision, this tool is developed along two modes: synchronous supervision (real-time training activities being held on line), and asynchronous supervision (held in differed time frame, where the supervisor examines preselected logs to evaluate the progress of the learner). The control/guide part is carried out via synchronous communication tool of "Chat" type (some textual hints related to the task, some adaptive textual advices depending on the learners' actions and/or questions/answers).

This article is organized as follows: Section II presents the motivations and objectives; section III describes the context of our work and related work, section IV discusses the proposed model of the LMS-SCT tool, section V presents a detailed conceptual view of a supervision and control tool using the agent approach, Section VI, explains the supervision process and its different components, Finally, section VII discusses the conclusion.

II. Motivations and Objectives

Skills to manage, guide, and supervise learners during the learning process, are necessary elements for an efficient teaching and learning.

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There are two possibilities to support a learner; either by integrating a fully-fledged computer system based on Intelligent Tutoring Systems (ITS), or by using the traditional help of human as tutors.

Given the ITS limitations summarized in the impossibility of building a knowledge model of learning used to fit the learner and provide the support needed; these systems can not entirely replace human teacher. Human tutoring can be seen as the best solution despite the temporal constraints (availability of the tutor throughout the activity of the learner). From a technical point of view, it is the best way suited to adapt to the learning process, but from a theoretical point of view, the human tutor is essential; given that the relation teacher-learner is essential in the socio-constructivist approach of learning. Human tutor helps the learner to overcome isolated problems, stressed by social distance.

Among the previous research which contributed to monitoring distance learning approaches, we mention SAAD: a model for Synchronous Monitoring of education proposed by Desprès & Leroux [7]. They define it as: "a form of distance tutoring where the tutor works with students and monitors the progress of their activities". This model is integrated into a tool for individual monitoring of several learners. Guéraud & Cagnat proposed FORMID; a monitoring tool for the overall activities of a class [8]. In both of the above cases, the tutor has two main roles:

- A Supervisor: The tutor monitors closely the progress of learner's activities during the synchronous session, focusing on a learner, a group of learners, or the entire class.
- And, Observer ready to intervene: The tutor responds quickly when he/she thinks is necessary (if a learner requests assistance of the tutor, or when the tutor notices a deadlock situation), and appropriate for the learner (based on learner's activities progress).

However, these works are interested in tracking individual's activities of several learners, and are based on synchronous support.

In the context of our virtual laboratory CVL@b, the followed pedagogical approach is APA (learning by action) [9], where activities take the form of practical work. These activities are carried out in groups; Group members share the space, where the experiment is performed, and write together a common report. During the manipulation process of a remote lab, the group of learners needs a tutor to help them performing their duties. In this situation several problems will arise:

1. Since we adopted human tutoring, the tutor must be available during the time when learners are doing practical work. The question is how to overcome this temporal constraint?
2. The practical work is done collaboratively; tutor needs to know the status of each member vis-à-vis the assigned task, any difficulties encountered, and the common result of different members so that he/she can take necessary steps to intervene or lead. In this case, the tutor's role becomes very complicated.

In this research, we seek to provide a solution to the question of how to provide support to group of learners performing a practical work remotely. This solution must solve the problems encountered in this new situation (synchronous/asynchronous support of a group of learners instead of only one learner).

Our contribution is to design a computer system which allows a tutor to provide educational supervision. This system supports tutor's interventions to assist learners, and allows them to perceive learner's activities remotely to respond to their requests, or make a decision to when to intervene. Our system features the following:

- Supervision of the activities of distant group of learners that includes consulting, and productions.
- Control of group of learners on how to communicate, share the workspace and collaborate in intra-groups.

III. Context

CVL@b is as an environment for distant teaching and learning, to help learners perform their distant practical work. Introduced in 2008, CVL@b offers learners the opportunity to register, consult the description of the practical work, and perform the practical work. Also it offers teachers/tutors a space for the management of educational content. CVL@b is structured based on three architectural levels (GUI, CVL@b kernel, and storage space).

Our earlier architecture described in [4] allows us to restructure the kernel as shown in Figure 1. The new kernel is composed of two main systems CVL@b-LCMS (Learning Content Management System) and CVL@b-LMS (Learning Management System). CVL@b-LCMS is designed around a learning content management (LCMS-PWS) [10] and documents management literature embodied in an electronic library (LCMS-EL) [11]. CVL@b-LMS is responsible for the management of learning processes through a set of sub-systems: (1) 3D environment for practical work, (2) supervision and control system, (3) evaluation system and (4) collaboration system.

In this paper, we focus on CVL@b-LMS, particularly on the supervision and control system (LMS-SCT). It is a monitoring tool for groups of learners and related control operations of their activities. This tool is dedicated to the tutor in order to supervise and control group of learners in a synchronous (real-time monitoring) and asynchronous modes (delayed time monitoring).

IV. Model of the LMS-SCT

In this section we describe our supervision and control model that allows:

- Supervising a group of learners who share the same workspace.
- Reducing the tutor's load: instead of supervising the group members individually, tutor can monitor group's activities, since members share the same workspace.

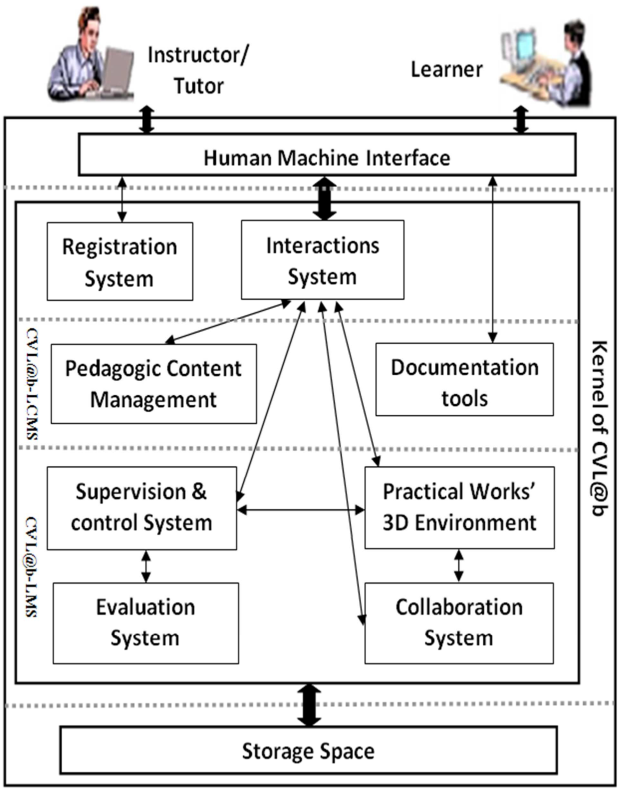

Figure 1. The New CVL@b Architecture

- Strengthening collaboration and thus improve learning quality.
- Solving temporal constraint through tutoring in asynchronous mode.
- Having the possibility to go back to the activities performed by group of learners during the time when the tutor was offline using archived scenes.

This model describes the features to be included in CVL@b, in order to support synchronous/ asynchronous tutoring remotely. It is based on the following two components: First: the supervision of the group's activities, and Second: the control of the group (see Figure 2). Each component works in two modes: synchronous and asynchronous.

The First component: "supervision of the group's activities": is to perceive the various activities realized by the group of learners. In synchronous mode, the tutor has directed access to shared workspace used by group that allows her/him to visualize the interactions of group members, and to follow the progress status of the current practical work and the degree of collaboration. In asynchronous mode, the tutor consults the database of the scenes in order to check the activities performed by the group of learners.

The second component: "group control": In synchronous mode, the tutor supports the group through shared workspace and a communication tool "Chat". In asynchronous mode, the tutor consults the database of scenes describing the sessions already completed by the learners, and uses email to send instructions and guidelines so that the group of learners consider them in the future.

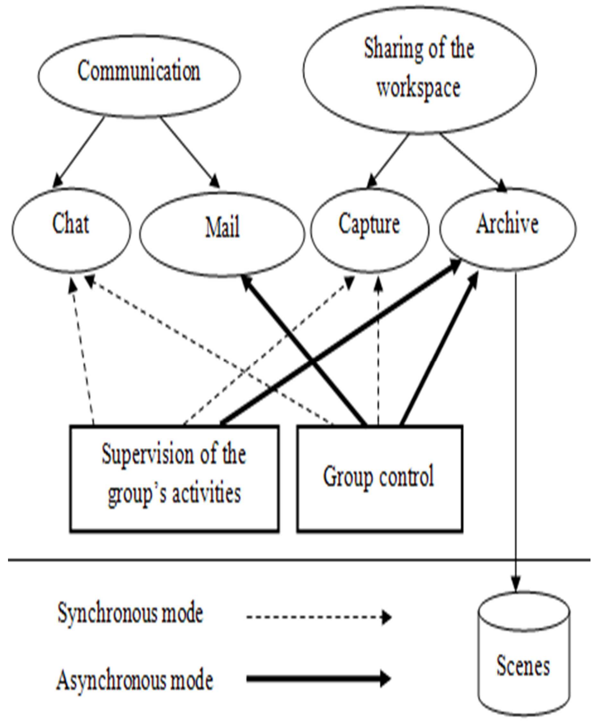

Figure 2. LMS-SCT Model

V. System Analysis and Design

We propose a system which allows a tutor to provide educational supervision, this system supports tutor interventions to assist learners and allows them also to perceive learner's activities remotely to respond to their requests, or to make a decision to when to intervene. Our system is based on the following features:

- The perception of distant learner's activities, which includes the activities and the learning path followed by the learner.
- Learners' Support: it is concerned with the communication, shared workspace and collaboration attributes within the same group.

In order to design our supervision and control system of distant PW activities, the agents and the multi-agents systems (MAS) paradigms [12] are used. An agent is widely understood to be a software entity situated in an environment, autonomous, reactive to changes in its environment, and proactive in its pursuit of goals [13].

The multi agent systems are very suitable to the design of our virtual laboratory because:

- The distance learning systems are open, dynamic and complex;
- Agents represent a natural metaphor of human acts;
- The distribution of the data, control and the expertise is self-embedded;
- Agent has a high-level representation of behavior.

To develop our agent-based environment, we used the Multi-agent System Engineering (MaSE) methodology [14]. It is a goal-oriented approach, where roles are identified from the analysis of system goals. MaSE is independent from any particular agent architecture, programming language, or communication framework. It consists of two phases: Analysis and Design.

A. Analysis Phase

The goal of this phase is to define a set of roles that can be used to achieve the system level goals.

A goal hierarchy diagram: is the result of this phase which mainly summarizes and organizes the system's functionalities in a tree structure as shown in Figure 3.

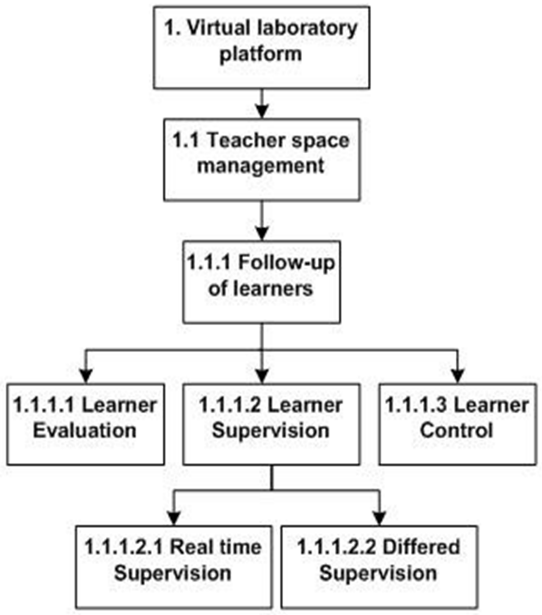

Figure 3. Goal Hierarchy Diagram

Use Cases: they are basic scenarios that the system supports. Figure 4 shows the various Use Cases inferred from our system.

Sequence Diagrams: in this step, we define a set of roles and different interactions between them. We associate each goal to a specific role, which eventually is played by at least one agent in the final design.

- Real-time supervision: if a tutor wants to observe a learner in real-time (while learner is doing his/her practical work) to either help or take some notes for evaluation purposes. As shown in Figure 4, R_Tutor sends a supervision message in real-time to R_Supervisor. The latter sends a message towards R_Coordinator to locate the learner, and to R_Sensor to capture the screen of this owner. R_Sensor sends the captured scene to R_Tutor, which will be displayed on the tutor's interface. If the learner is off-line or did not start working on practical work, R_Coordinator sends a failure message to R_Tutor because R_Sensor is not in service.

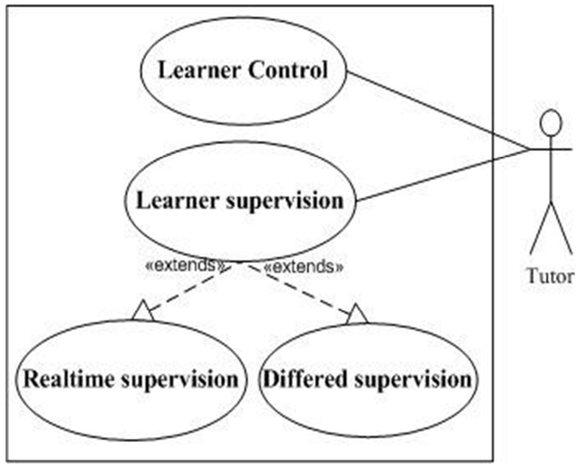

Figure 4. Use Cases Diagram

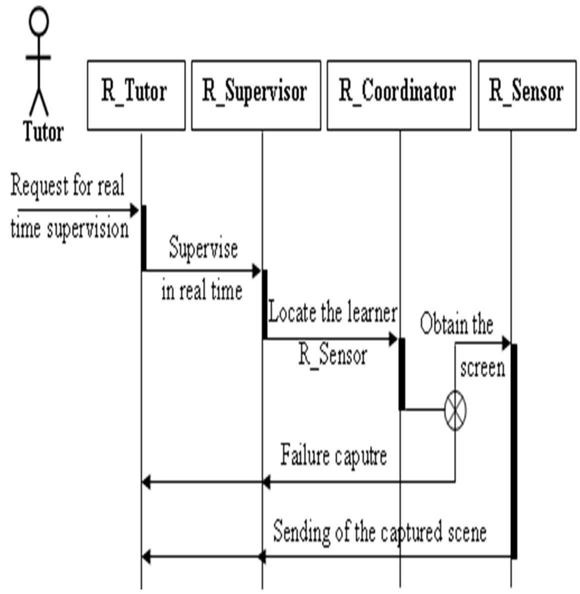

Figure 5. Real-Time Supervision Diagram

- Differed supervision: in the case where the tutor wishes to see the history of a particular learner during the process of a practical work. He/she selects the practical task carried out by the concerned learner as shown in Figure 6. Then, R_Tutor sends a message to R_Supervisor to require supervision in a differed-time, the latter sends a message to R_Archivor requesting the list of the scenes related to the corresponding practical work. R_Archivor extracts the scenes of this practical work, which were collected by R_Sensor automatically in predefined time intervals. At the end of this operation, the scenes are sent to R_Tutor so that they are displayed on the tutor's interface.

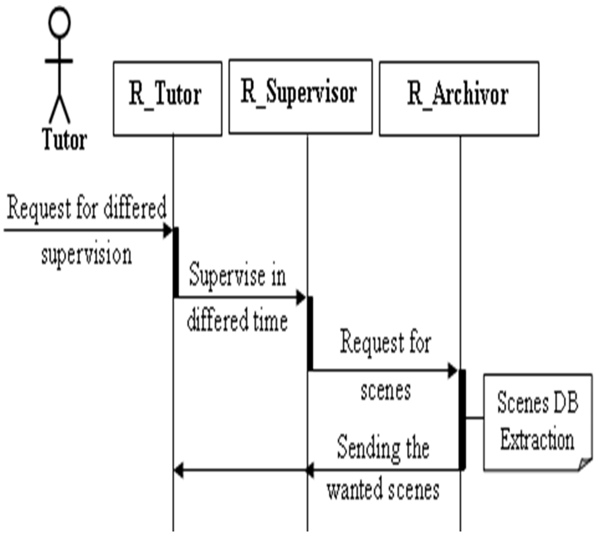

Figure 6. Differed Supervision

Next, we present the transition states of the various agents involved in the supervision process.

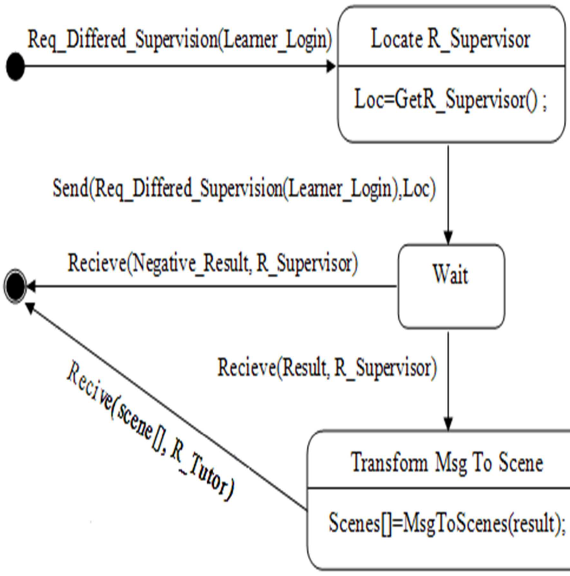

Figure 7. R_Tutor Transition States

When the R_Tutor agent receives a request for a differed supervision of a particular learner, it locates the supervisor agent as shown in Figure 7. Then, it sends a supervision message containing the learner's identification to be supervised and awaits an answer. The supervisor agent forwards the request to the Archivor agent. If there is a history of this learner, then all the traces in the form of scenes are sent to the tutor. If not, the tutor will be informed that the concerned learner did not perform the distant practical work yet.

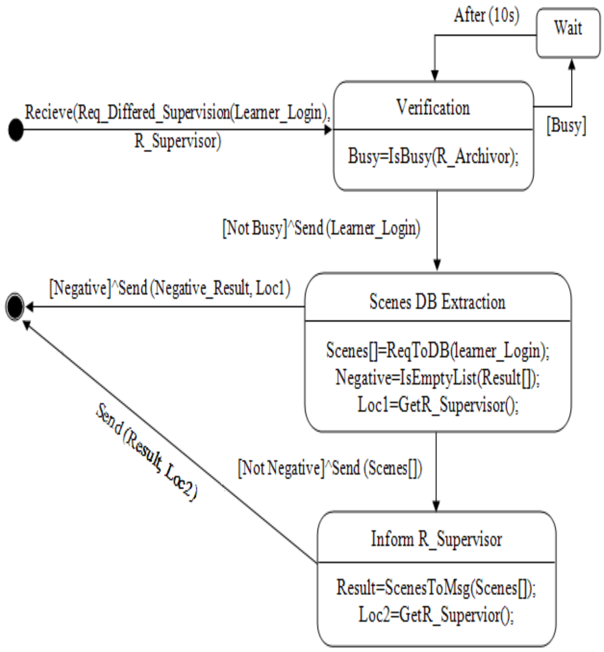

Figure 8. R_Archivor Transition States

When a supervision request is transmitted to the archivor agent, two cases arise (see Figure 8):

- If the archivor agent is busy, then the request is put on standby.
- In the case the archivor agent is free, it queries the scenes database to recover the requested scenes, and then it informs the teacher agent.

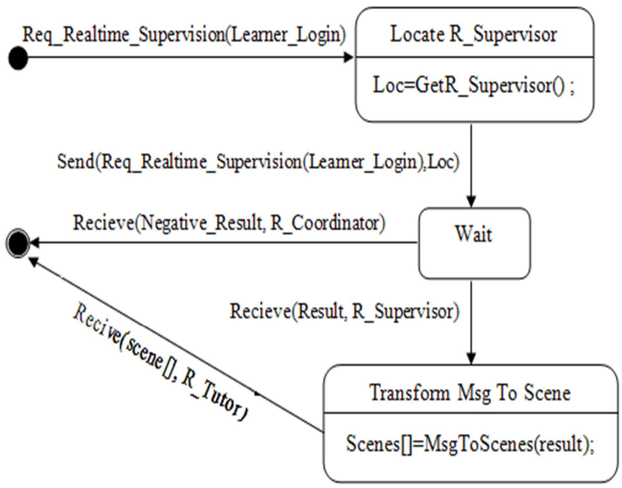

Figure 9. R_Tutor Transition States

In Real time supervision context, R_Tutor agent may receive a request for a learner supervision in real-time. It transmits the request to the supervisor agent. In collaboration with the coordinator agent, the supervisor agent recovers the captured screens of the corresponding learner (who is actually connected). If the learner is not connected, a failure message is sent.

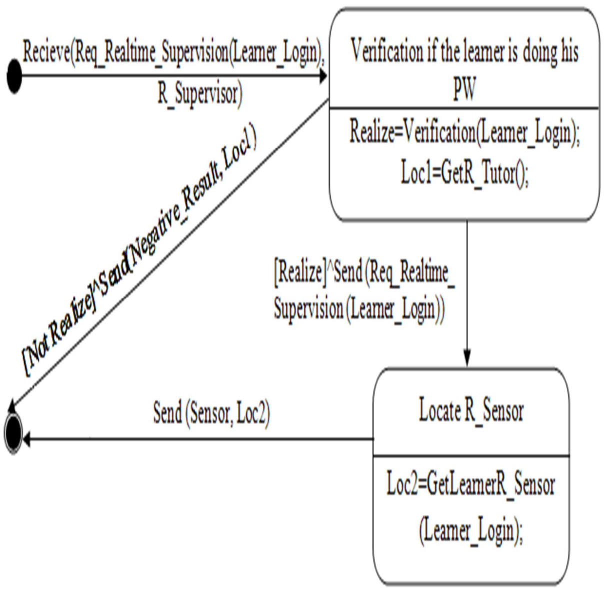

Figure 10. R_Coordinator Transition States

After receiving a supervision request, the agent coordinator, checks whether the learner is online doing his/her practical work. If it is the case, it locates the appropriate sensor agent for this learner so that it transmits the captured screen, If not (learner is disconnected), the request will be transmitted to the archivor agent.

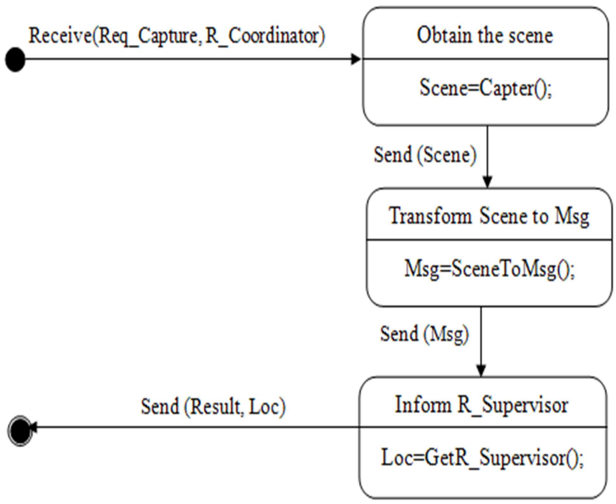

Figure 11. R_Sensor Transition States

The Sensor agent captures the learner's screens online and saves them in a scenes database. This operation is done automatically during each time interval (2ms in our system configuration). When the sensor agent receives a message from the coordinator, it sends the scenes via message to the teacher agent, which displays these scenes on the tutor's interface.

B. Design Phase

The purpose of the design phase is to consider roles and tasks, and convert them into a form more amenable to implementation, namely agents and conversations. In this phase, we will present only the most important diagrams, which is the agent class diagram shown in Figure 12. It represents the functional structure of the supervision and control system. It contains various agents present in the system and their mutual interactions.

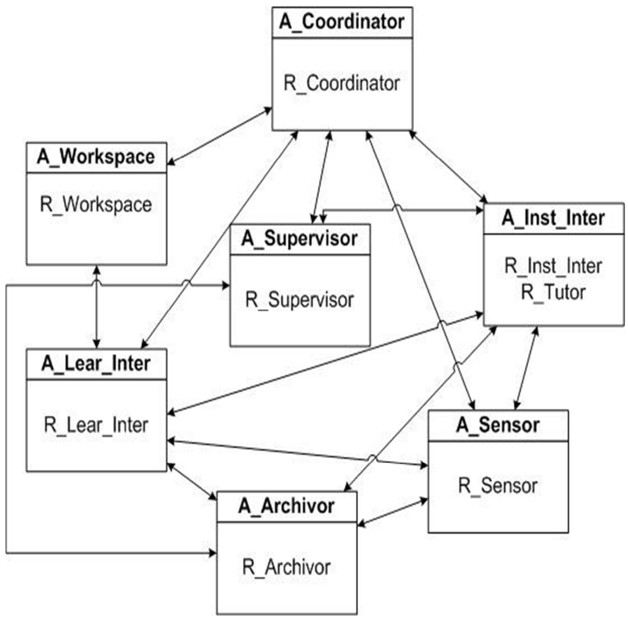

Figure 12. Agent Class Diagram

VI. Supervision and Control Process

In this section, we present the process of supervision and control shown in figure 13. It is composed of six modules, each of which is assigned to a specific agent.

- Capture Module: it captures screenshots of a workstation where the learner is connected from.
- Compression Module: The size of the captured screenshots is enormous which requires the use of compression techniques such as JPEG (image) or MPEG (video) [15]. These techniques will decrease the size, and consequently increase transmission speed and decrease the bandwidth requirements.
- Coding Module: Since we have a heterogeneous network, then the data presentation is not identical. In order to solve this problem, the standardization is essential and constitutes an appropriate solution with the help of coding/decoding algorithms.
- Display Module: supervisor agent is responsible for this module. This agent receives the captured screenshots and proceeds to their decoding and decompression. It splits up the screen of the teacher's station into 4 equal areas. Then, according to the number of supervised learners, it assigns the appropriate screenshots to each area.

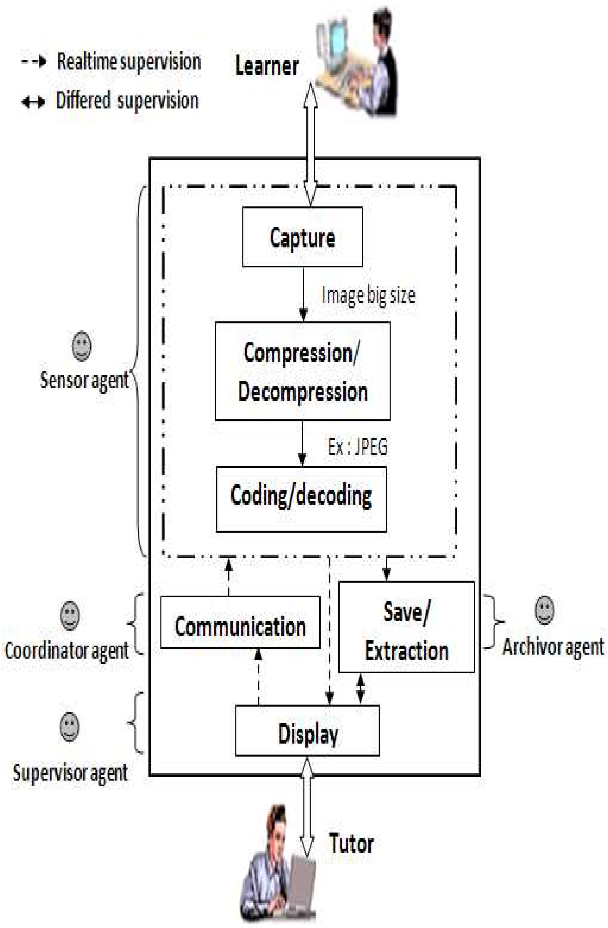

Figure 13. Supervision Process

- Communication Module: this module is carried by the coordinator agent. It establishes the connection between the various modules.
- Archiving/Extraction Module: it is concerned with storing and retrieving the tasks carried out by learners.

In order to implement our supervision and control system, we have chosen a distributed architecture. Our agents are implemented within JADE (Java Agent DEvelopment) framework [16]. The sensor agent, the supervisor agent and the archivor agent reside respectively on the learner's station, tutor's station, and the server.

According to both temporal and spatial dimensions in digital environments, there are many different pedagogical situations. In our case, we assume that tutors are distant from learners.

Figure 14 shows tutor's interface. The left side contains a tree of modules and their practical works. Once the tutor chooses the intended module, he/she determines the practical work he/she wants to observe, So, the right-side will be activated and offers two sub-screens; one contains a list of the group members and their status (online or not), and the other shows the different scenes of the group's shared workspace captured in real-time, The latter screen is also reserved for images where supervision is done in a differed time frame as shown in Figure 15.

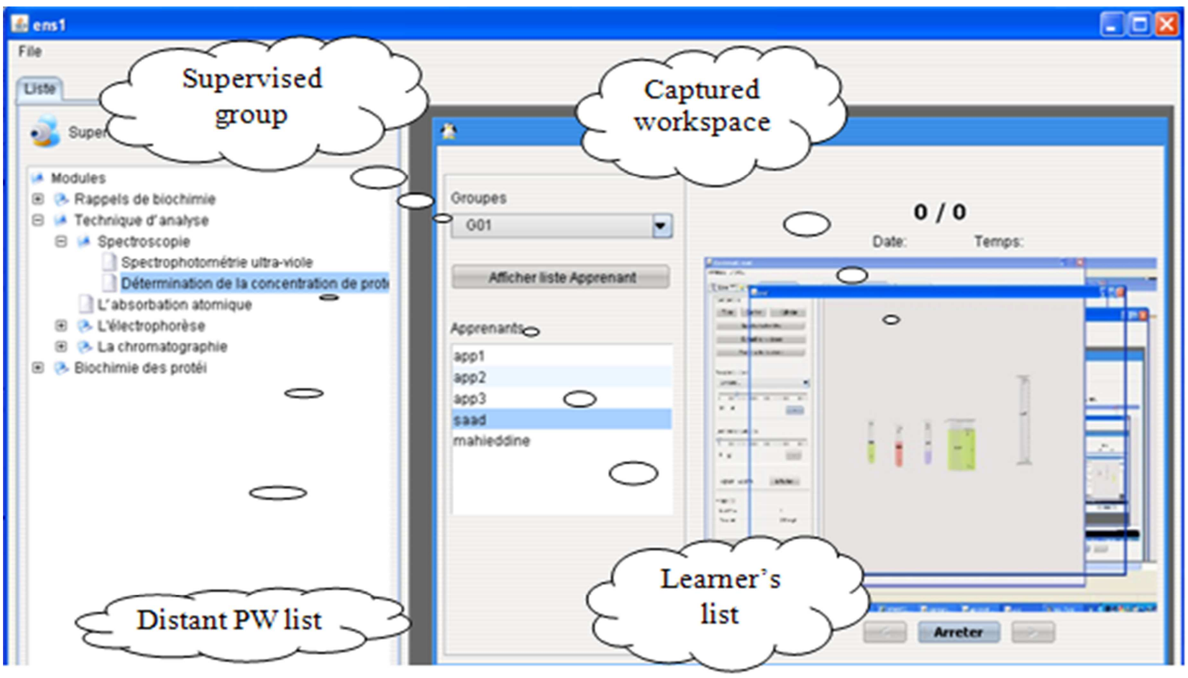

Figure 14. Tutor Interface (Supervision in real-time)

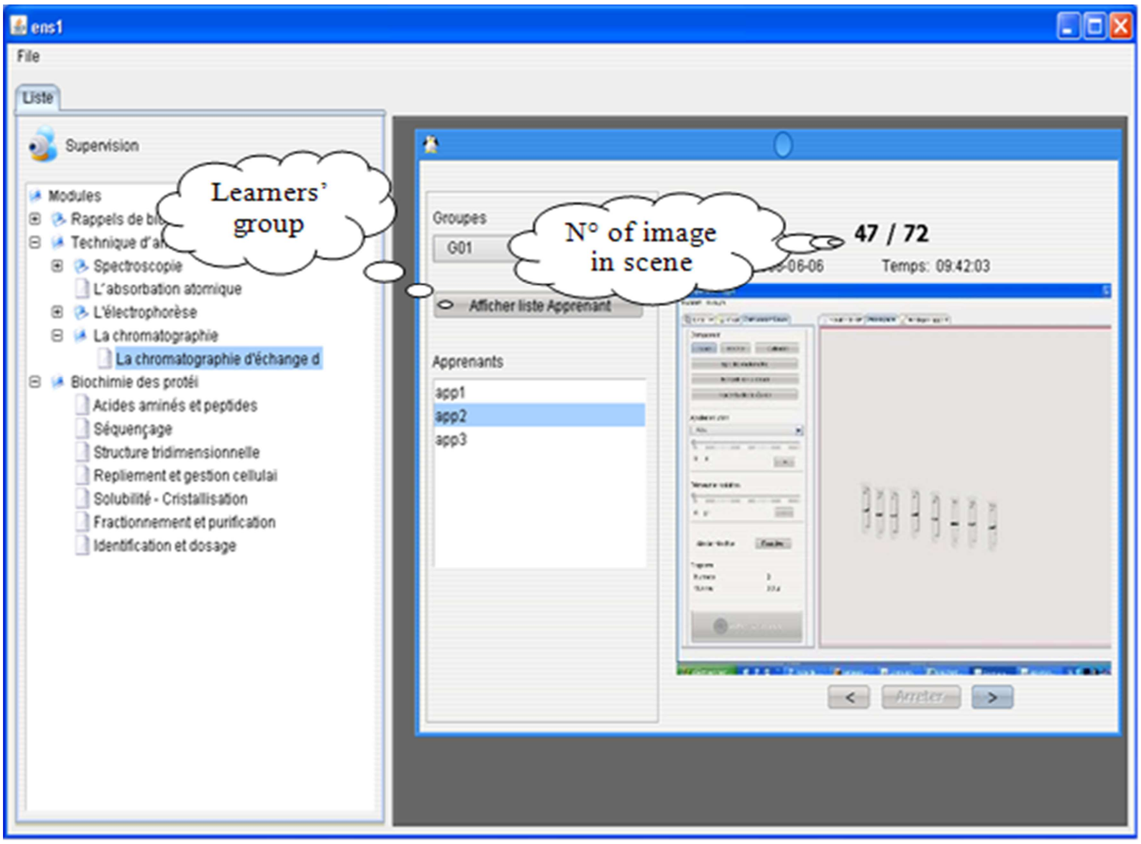

Figure 15. Tutor interface (Supervision in differed-time)

VII. Conclusion

In this paper, we have proposed a supervision and control tool for an E-learning Virtual Laboratory. It is designed using MaSE methodology and implemented within JADE framework. This tool helps instructors in the coaching and the evaluation processes of learners. It also enables instructors to follow the progress status of learners doing PW from a distant area, either via different scenes shown in real time or via historical trace (saved scenes) to be looked at a differed time. Also, the tutor has the possibility to give advices through this tool to the learners on how to perform the different tasks needed to complete the practical work.

Nevertheless, this tool has some shortcomings in the display and 3D environment consideration. These limitations constitute a major prospect for our future work.

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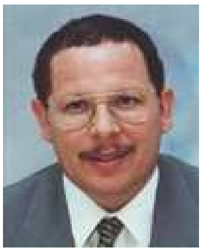

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