Coping with collaborative and competitive episodes within collaborative remote laboratories

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***Abstract*—In this paper, we provide an original approach to the support of group awareness within collaborative remote laboratories. Computer Supported Collaborative Learning sessions present successively collaborative and emulation episodes. The idea developed here is the elaboration of an architecture for dealing with those two aspects of collaborative sessions for practical remote hands-on approaches. Our purpose is to manage and enhance the learning experience brought to the students who are using collaborative remote laboratories by managing several synchronous accesses made on the remote laboratories platform itself. This contribution relies on an original domain ontology and the associated knowledge management system.**

***Index Terms*—Computer Supported Collaborative Learning, Distance Learning, Ontologies, Remote Laboratories, Semantic Web.**

I. Introduction

In this paper, we are primarily interested in computer science artefacts to deploy for the management of collaborative remote laboratories sessions. Not only must those mechanisms allow to maintain "group awareness" and communication among students, they must also be able to orchestrate concurrent access during the learning session.

Collaborative Remote Laboratories (CRL) were born as an answer to the lack of sociability of Remote Laboratories platform [1]. CRL are the result of the encounter between Computer Supported Collaborative Learning (henceforth CSCL) and standard Remote Laboratories as SBBT[1]. Indeed, constructivism and auto-constructivism undoubtedly lead to the increase of interaction between students in distance learning situations, because students are lead to share experiences, knowledge, competencies around a problem they are all facing. They are then trying to build knowledge as a group of persons, and no more as isolated users. This shared bound is hooked during problem resolution phases. Back in 1982, Magin actually wrote:

"This is interesting to notice that learners think that taking group decision to solve problems is part of the exercice." [3]

During the last decade, our community faced the problem of bringing the lab right to the student's door. The main issue was to cope with the distance and the associated students' feeling of "social closure" (Figure 1). Although most of Remote Laboratories aim at reproducing online what occurs in local laboratories [4], fewer present "social exposure" (social interactions) between students. While we lack implementations of CRL, we also suffer from the way the few current implementations deal with collaboration.

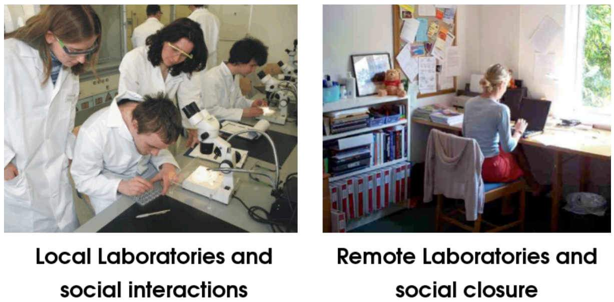

Figure 1 : Collaborative Remote Laboratories aim at breaking the social closure established by the original Remote Laboratories platforms.

From our experience, the main issue of CRL lies in the alternation of collaborative and competitive episodes. That is the reason why CRL are difficult to model, implement and manage in practice: we are continuously moving from collaboration among students when they need it, to competition between learners when they can manage the problem by themselves.

In this paper, our main goal is to provide a number of ideas for CRL platforms about the representation of both collaboration and emulation episodes. Because we distinguish those two kinds of situations during the same collaborative remote hands-on approach, we will therefore bring two distinct propositions.

This paper is organized as follows. Section 2 addresses the management of collaborative episodes while section 3 covers how we deal with the competitive episodes. Section 4 gives some figures on a questionnaire filled by students during a CRL, which implements our propositions. Section 5 concludes.

II. Collaborative episodes

To begin, we will discuss the notion of collaboration for CRL. We acknowledge the approach[2] of Dillenbourg for collaboration. Dillenbourg emphasizes the difference

[1] SBBT stands for "Second Best to Being Here"[2]

[2] His definition is not necessarily focused on the field of distance learning, but learning experience in general.

between cooperation and collaboration during learning experiences:

"In cooperation, partners split the work, solve sub-tasks individually and then assemble the partial results into the final output. In collaboration, partners do the work 'together'" [5]

While this definition may not necessarily apply to distance learning, some studies demonstrate that computer supported learning sessions do not suffer, after a short period of adaptation, from the usage of computer media. For example, Hobman confronted learning situations in 39 different groups, where 20 groups involved face-too-face students interactions (FTF) and 19 used computer-mediated communications (CMC). In substance:

"There was more process and relationship conflict in CMC groups compared to FTF groups on Day 1. However, this difference disappeared on Days 2 and 3. There was no difference between CMC and FTF groups in the amount of task conflict expressed on any day." [6]

From our point of view, the support of two specific elements is mandatory for the enforcement of group awareness in a collaborative context:

- a communication tool for the social interaction between students (group awareness through communication),
- a group awareness enforcement service for the students to be able to easily identify the author of an action (group awareness through actions).

From now on, we will discuss in this section how we support those two aspects in our CRL platform.

A. Communication tool

Moore identified three major kinds of interactions within a computer supported collaborative system [7] :

- learner-to-content
- learner-to-tutor
- learner-to-learner

Of course, the social bounds between learners and tutors modify those interactions accordingly, and therefore the quality of the resulting work [8].

Northup [9] then Kreijins [10] proposed a different classification, based on the nature of the exchanged informations:

- task-oriented messages : sent to improve the overall knowledge of the group of learners and participate to the decision process for the next actions to perform,
- non task-oriented messages : message for the social interactions between students.

Based on those observations, which means should we put in front of those different way of communicating?

A recent literature review [1] about remote laboratories put the stress on the lack of communication tool in current remote laboratories. Moreover, the required tool depends on the learning situation. For example, regarding the distribution of students in a time window, synchronous tools differ from asynchronous ones. Given the frequency of usage, forum may be the heavily used asynchronous tool, whereas instant messaging (henceforth IM) may be the heavily used synchronous tool.

As our CRL present synchronous sessions between several learners, we study synchronous tool for communication between students. IM is actually a media, which allows a stronger participation of students in the distance learning session, according to [11]:

" [...] when comparing students that adopted the IM system with those that did not it was found that the adopters operated with a higher level of participation. "

This study echoes the original idea from [12]. IM systems are widespread in Distance Learning in general [13]. On the top of breaking social isolation of students, IM systems also favor modern learning theories such as constructivism, and we do not see major issues for the use of IM systems for CRL.

As a consequence, we choose a IM and Voice over IP (henceforth VoIP) system as a communication tool between students in our CRL platform. On the technical aspects, we rely on the eXtensible Messaging and Presence Protocol (XMPP) [14], which can be defined as follows:

"XMPP is to Jabber what HTTP is to the Web" [15].

We chose a Jabber server for two main reasons:

- it is an open standard
- it is supported by the Internet Engineering Task Force. It is therefore a widespread standard[3].

The XMPP implementation is OpenFire [16], which allows VoIP using XMPP, in addition to classical chat sessions. Chat and Vocal communications are encrypted thanks to Secure Sockets Layer (SSL). Authentication and authorization is performed against a LDAP directory, which allows the students to keep a single login, password and profile for the CRL platform and the communication tool.

B. Group awareness enforcement service

Whereas IM systems favor group awareness on the communication aspects (students are aware to be in a multi-users context), there is still a strong need for a group awareness enforcement service. We imagine such a service to allow the learner to identify the author of an action. Regarding the author of a given sequence, the learner can give the corresponding credit, which may not be the same if the author is a teacher, a learner known as having high skills or a learner with lower skills.

Learners need both the sequence of command entered and the result on the device's Graphic user Interface (henceforth GUI). That is the reason why using Internet Protocol TeleVision (henceforth IPTV), or even other devices such as Webcam, is not a good option in CRL. IPTV can only grant the vision of the result of a given sequence of command entered, but not the sequence of command entered itself.

We are therefore lead to imagine a new paradigm, which would allow the students to see:

- what was the sequence of commands entered,
- who entered that sequence of commands.

In order to reach those goals, a GUI artifact is mandatory for the identification of users on the CRL platform. Whereas some platforms propose the usage of avatars in 3D environments, we preferred a lightweight solution. We propose a tele-presence indicator, which associates a different color to each user entering the CRL session (Figure 2).

[3] For example, Googletalk service is based on XMPP [17].

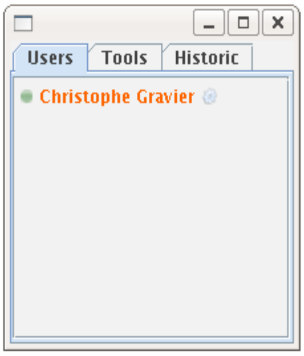

Figure 2 : Tele-presence indicator: a color is associated to each user in the CRL session.

Although this color allocation system is unsophisticated, however it perfectly fulfills the objectives of identification of the author of a sequence of actions on the CRL platform. Indeed, this color can be used to color an acknowledgment sent to all participant on their own remote GUI. For example, when a command is performed by the user “Christophe Gravier”, given the tele-presence indicator at Figure 2, the widget pressed is colored in red (color associated to this user for that session) on **all** connected clients' remote GUI.

As a consequence, users can effortlessly associate the action to the user “Christophe Gravier”, so that they can assume which widget was just remotely actioned, and also accordingly give credit to the sequence of actions performed.

For example, the reader can see on Figure 3 a caption of our CRL running on a touch screen. At the center of this picture is a green acknowledgment: the “green” user has just actioned that widget and all users are currently being notified of this event (the notification is conveyed by the colored acknowledgment itself).

The reader can find an online video, which illustrates the actions/acknowledgments behavior of our CRL platform by browsing:

http://diom.istase.fr/satin/einst/einst_demo.avi

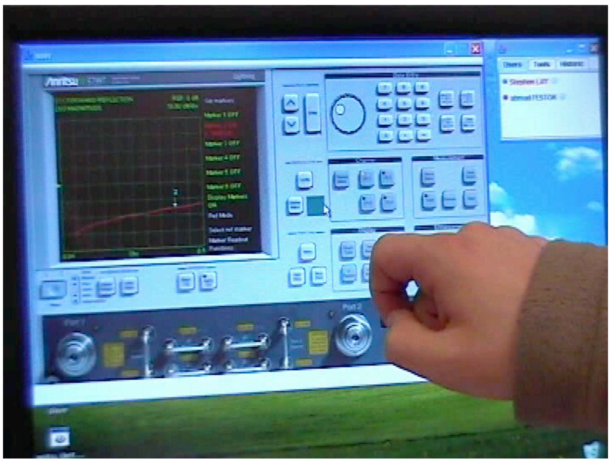

Figure 3 : Capture of the remote GUI notifying a user of an action through a (green) acknowledgment (see the widget pointed by the mouse pointer).

On the implementation issue, it has to be noticed that we rely on a Message Oriented Middleware (MOM), and since we developed our CRL in Java programming language, we turned to Java Messaging Service (JMS) standard, with the ObjectWeb implementation called Java Open Reliable Asynchronous Messaging (JORAM). Our middleware follows the publish/subscribe mechanism, which allows the colorized acknowledgment to be multicasted to all remotely connected users in the learning session.

This section was dedicated to the software artefacts, which allow students to collaborate with one another, according to Dillenbourg's definition of collaboration. We discussed group awareness from communications between students, as well as group awareness from actions performed by the connected users.

However, we rely on idealized vision of collaborative learning sessions. From our experience, although learners are strongly encouraged to act in collaboration, some episodes of emulation and competition do occur in collaborative learning sessions. The next section will deal with the management of such episodes, and especially how to manage competitive accesses to a CRL platform.

III. COMPETITIVE EPISODES

A. *Scheduling policies*

As computer scientists, the first idea in order to cope with concurrent accesses to a resource is to reuse already existing strategies, mostly inherited from process scheduling.

For example, we can imagine setting up one of the following well-known policies in order to settle the next user who will be authorized to operate on the CRL platform, in case of competition among several users:

- FIFO : First In, First Out,
- FILO : First In, Last out,
- RR : Round Robin,
- SPN : Shortest Process Next,
- ...

Nevertheless, those strategies do not take the pedagogy into account. For example, it would not be possible to give priority to the learner with lower skills (he would need more time). Moreover, the pedagogy strategy is subject to changes during the same remote learning session. Using the same example, a teacher may prefer to give priority to the student with less skills, while he would change his mind later in order to give more time to learners with higher skills (if they are near the end of the exercise: the earlier they finish, the earlier that gives a full access to late students).

B. *Modelize the mediation of competition during CRL sessions which take pedagogy into account*

For these reasons, CRL platform need to act between users regarding the collaboration and competitive context. In order to model the context, we create a domain ontology, which dress the elements that could be taken into account for the mediation of competitive accesses on the CR platform (Figure 4).

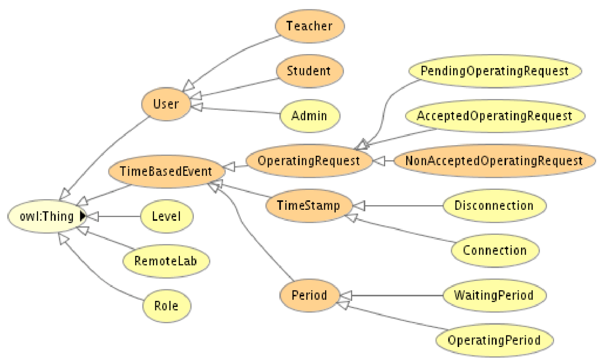

Figure 4 : Ontology involved in the mediation of competition during CRL sessions

The ontology is edited using Protégé software [18] and serialized in the Ontology Web Language (OWL) format. The corresponding OWL file is available online at:

http://dev.istase.fr/satin/rlab/collaborativev4.swrl.owl

Using this ontology, we can build up rules that will represent a certain clearance of access for the operator status in the remote handling of a device. The motivation is that the collaborative context is highly volatile. Applying an ontology allows the environment to make the representation of the collaborative context evolves in time. Because the knowledge base may be altered (at least its specialization), an inference, performed at a given time, may not give the same result at a different time. The changes in inference are then based on the evolution of the collaborative learning context. In other words, users are able to perform commands in a group if the collaborative context satisfies a given policy. A collaborative policy is described in our platform as a set of rules based upon the collaboration within remote laboratories ontology.

For example, let us build the collaborative policy, which could be enunciated in natural language as:

"If a user has both the Administrate role and pending request for being the operator, then and only then, the remote laboratory considers this user as the new operator of the remote laboratory."

Indeed, we want to use ontologies to let administrators of Collaborative Remote Laboratories build their own policies, according to predefined contextual facts, which are factors involved in collaboration.

Because we use concepts, and more especially ontologies, it is important to choose a rule language, which is "ontologies aware". Due to the use of OWL, SWRL on the top of it is a natural choice, as it allows to express rules based on a knowledge base stored in an OWL model. SWRL follows Horn-like logic, which means it is able to describe a suite of conjunctions.

SWRL is used on top of the OWL ontology in order to achieve the representation of a collaborative policy. SWRL is said to:

"allows users to write Horn-like rules expressed in terms of OWL concepts to reason about OWL individuals . The rules can be used to infer new knowledge from existing OWL knowledge bases." [19]

This inferred knowledge is represented using assertions, especially property assertions or class memberships. The mechanism presented here uses such assertions in order to infer the operator of a remote collaborative hands-on session. A rule is composed by an antecedent and a consequent, each of which consists of a (possibly empty) set of atoms.

Because the example contains only conjunctions and atoms, we can translate the previously enunciated rule in SWRL as follows:

> RemoteLab(?y)^User(?x)^
> hasRole(?x,Administrate)^
> hasPendingOperatingRequest(?x, ?r)
> ⇒hasNextOperator(?y, ?x)

The corresponding SWRL file is available online at:

http://dev.istase.com/satin/rlab/policies/adminonly.swrl.owl

While we are able to modem such a simple strategies, it is also possible to create more complex policies, like, for example:

"Give the operator status to learners upon request, only if they had less cumulated operating time than the current user. This restriction does not apply to teachers and administrators, who are granted a preemptive access".

Such a collaborative policies can be easily written in our system, following SWRL representation (by making conjunctions). As it would be very readable on paper, it has not been reproduced but interested readers can browse the corresponding SWRL file online located at:

http://dev.istase.fr/satin/rlab/policies/studentminusoptime.swrl.owl

IV. USE CASE AND STUDENTS FEED BACK

We conducted some tests on our prototype at our engineering school. The tested CRL involved a network analyzer, which is used for component characterization, from 40 Hz up to 60 GHz. Figure 5 provides a picture of the real network analyzer used during the test phase.

Figure 5 : Vector Network Analyzer used for the test CRL.

During those tests, 19 536 commands were relayed by our middleware to the remote device. In average, students performed 155 actions per CRL sessions.

We put the platform to the test and to the feed back of students. Based on a questionnaire they had to fill up at the end of their sessions, it can be said that students are favorable up to 82% to CRL rather than local laboratories.

They are 64% to declare that the usage of a remote GUI facilitated their hands-on approach and 28% saying that the platform was at help, by means of few efforts. 92% of them recognize the utility of the GUI for their online practical works.

Students declare that discussing using VoIP and chat tools was useful for (in order of relevant answers): peer help, results confrontation, and social interactions (most answers on social interactions deal with "student parties").

Although more tests must be conducted, earlier results of deployment seems satisfactory regarding the use of this CRL platform for distance engineering education.

V. CONCLUSION

In this paper, we provided software solutions for the management of alternation of collaborative and competitive episodes during CRL sessions.

While we proposed artefacts for group awareness during collaborative episodes, we furthermore described the mediation of competition during CRL sessions, which take pedagogy into account for the competitive episodes.

This paper also gives primary results for the CRL platform, based on students' feedbacks (questionnaires).

Future works will consist in more tests in real conditions. Some tests are already scheduled with Africa (Lebanon, Chad and Morocco). We also began long-term works, which lead us to the convergence of CRL platform and Learning Management Platform (LMS) [20].

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