RESOURCE MANAGEMENT STRATEGIES FOR REMOTE VIRTUAL LABORATORY EXPERIMENTATION

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Abstract - This paper presents a software system for resource management designed for remote virtual laboratory experimentation. This resource management system is part of a joint effort called SynchroMédia involving researchers from INRS (Institut National de Recherche Scientifique), UQAM (Université du Québec à Montréal), TÉLUQ (Télé-Université), ETI (École de Technologie de l'Information) and ETS (École de Technologie Supérieure), educational and research institutes, to integrate new multimedia technologies in postsecondary teaching methodology. Besides traditional videoconferencing and data sharing, a special emphasis is given to virtual laboratories where students can perform experimentation remotely using either Local Area Network (LAN), Wide Area Network (WAN) or standard Internet and Intranet communication links. A distributed resource management system is being proposed to simplify the tasks involved in the preparation and execution of remote laboratory experimentation.

Index terms- Laboratory innovations, Teamwork, Learning Environment, Computer-aided remote data acquisition systems.

INTRODUCTION

The remote and virtual laboratory team of the SynchroMédia project aims at perfecting a virtual laboratory concept [1] & [2] that integrates in a coherent way a whole gamut of capabilities able to support engineering laboratories, even from a remote site. These capabilities will be developed by making use of the possibilities offered by Internet. This initiative aims at filling the gap in the field of training for those living in remote areas, since presently this approach utilizes mainly the transmission of text or televisual images, video teleconferencing or Internet text-images, without offering a true interactive approach in engineering training. The key elements of a laboratory are based on simulation, manipulation, access to measurement and query devices, sharing resources and exchanging data, collaboration, and technical support for experimental procedures, as well as the required tools and capabilities.

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Also, it enables students to access these resources regardless of their geographical location. The main motivation for virtual laboratory experimentation is that it facilitates resource sharing among the participating institutions. Also, it enables students to access these resources regardless of their geographical location. However, virtual laboratories can be very difficult to manage especially when they involve hardware and software resources from different institutions. Student management can also be a problem. Since not all academic institutions share the same curriculum, the student profile can vary greatly among institutions. A distributed resource management system is being proposed to simplify the tasks involved in the preparation and execution of remote laboratory experimentation. This distributed management system contains a hierarchical resource allocation module where hardware and software resources are grouped together according to their characteristics and functions. A heuristic scheme is then used to allocate these resources. Class tutors are responsible for requesting these resources. A successful request is granted by the management system if there are no scheduling conflicts. However, when resource contention arises, the management system may offer "replacement resources". These replacement resources are guidelines for class tutors and offer alternatives to resolve the problem.

THE ARCHITECTURE OF THE VIRTUAL LABORATORY

The virtual laboratory is based on a client-server architecture that makes the exchange of data between heterogeneous systems possible. This architecture is capable of integrating basic tools and capabilities in the form of entities that can be easily transmitted to users in remote areas. One can utilize a platform such as Internet that will act as an interface between the client and the server. Using processes such as "multi-threading" will be essential for parallel operations. The virtual laboratory proposed is based on the following architecture shown in Figure 1 .

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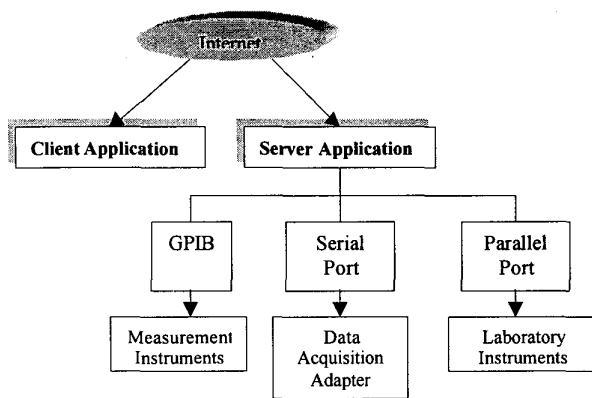[3] École de Technologie Supérieure, Montréal, Québec

Figure 1 Client-Server Remote Laboratory Architecture

The client, who in this case is the learner or student, will have access to laboratory instruments via Internet. Thanks to this laboratory, a group made up of several students will be able to participate in a laboratory session. Tutors and instructors will manage and supervise these groups.

A TYPICAL ENGINEERING VIRTUAL AND REMOTE LABORATORY CONCEPT

The virtual and remote laboratory as applied to engineering should allow learners to execute the following tasks:

- carry out experiments by interacting with instruments;
- come up with results derived from simulation experiments by using digital models;
- analyze simulation results obtained and present them in a laboratory report;
- take measurements or execute control operations via user-friendly software interfaces and tools allowing for interaction;
- have access from a remote site, via Internet, to a tutor in regard to resources and pedagogical or technical assistance for experiments to be carried out;
- share data and applications with other learners located at various sites;
- utilize video teleconferencing for laboratory operations.

This virtual and remote laboratory concept demonstrates how various learners who are geographically dispersed can have access to resources available at several remote sites. In this case, it will therefore be possible to count on access to material, software and human resources in order to carry out experiments that would otherwise be impossible in a local context. The learner can, depending on his field of study, carry out experiments on how an elevator works, in order to also understand models that allow for related simulation and interaction between the control parameters. The same applies for experiments on how a robot works. These experiments are carried out in collaboration with all members of a team set up within the framework of laboratory sessions.

RESOURCE MANAGEMENT FOR LABORATORY SESSIONS

The virtual laboratory system includes not only learners, but also tutors for various tutorials as well as a manager. Each of the actors has a well-defined role. The most important role is that encompassing the organization of laboratory sessions. This role is left to the discretion of the tutors who, based on material, software and human (teacher) resources, proceed according to heuristic methods suitable to the organization of laboratory sessions. Tutors should therefore establish scenarios while keeping several aspects in mind, such as:

- general information aimed at determining:
  - the approximate duration of the session
  - team size
  - the title of the course linked to the laboratory session
  - assigning roles to learners during a laboratory session
  - the date and time of the laboratory experiment
  - the name of the person in charge of the laboratory session
  - defining the material resources needed to carry out the experiments for laboratory sessions
- Prerequisite knowledge is essential before carrying out the operations for the laboratory session, for thus, students are able to take stock of what is necessary and indispensable to execute various tasks. We foresee that for future versions of this prototype, an intelligent advisor taking into account the user-expertise modeling will be implemented.
- Theoretical aspects related to holding a laboratory session should be kept in mind. We have used the learning systems engineering method (MISA) [3] developed at the Centre de recherche LICEF [4]. MISA is based on a design approach including four main lines, namely learning objects, a pedagogical model, a media model and delivery model. Each segment is modeled separately, and the representation facilitates linking the four models. The domain knowledge for a given tutorial is represented using the MOT software (acronym for Modélisation par Objets Typés), that is, Object-oriented Modeling Tool, developed at LICEF [4]. A detailed description of MISA and MOT is beyond the scope of this paper. Figures 2 and 3 show how we have used them in our case of a mechatronic course laboratory project.
- One can see in Figure 3 that tasks to be completed and the required tools to achieve them should be clearly specified, as is the case for the experiment on fundamentals of operational amplifiers to be carried out.
- Once the experiment is completed, one must then analyze results and present them in a laboratory report document.
- Tools facilitating communication, such as "chat" sessions and E-mail, will also be essential for completing tasks in a remote virtual laboratory.

With these criteria in mind, one can organize a laboratory session in the same way as for a given local laboratory.
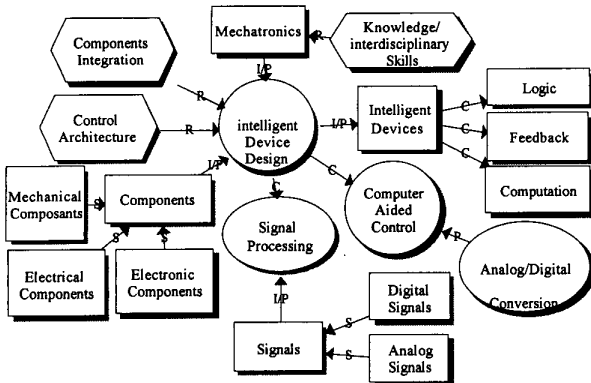
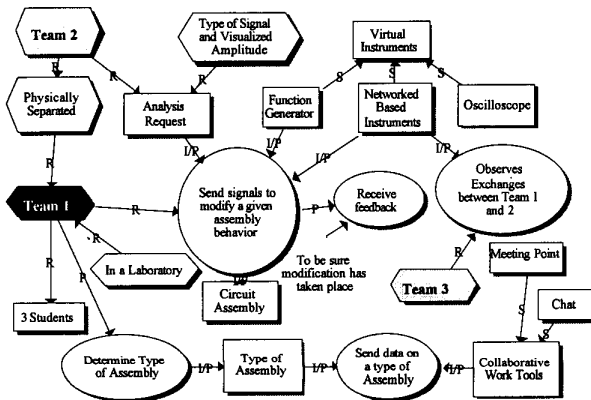**Figure 2 Knowledge Model for the First Level of a Mechatronics Course**

Figure 3 Pedagogical Model: Team 2 Operations and Links with Team 1

INTERFACES FOR A REMOTE AND VIRTUAL LABORATORY

. Here we will be focussing on the various interfaces that allow all other users (learners or students, tutors, teachers, researchers and manager) of the remote laboratory system to have access to and to execute various operations: namely, interfaces for students, researchers, teachers and the manager and finally the interface located on the Home Page when each of the actors involved in the remote laboratory opens the Main Page.

Home Page Interface

As in most other instances of this remote learning system, the Main Page of the remote laboratory will be as shown in Figure 4. Student, Teacher and Manager Menus will allow all those involved to have access to their own submenus.
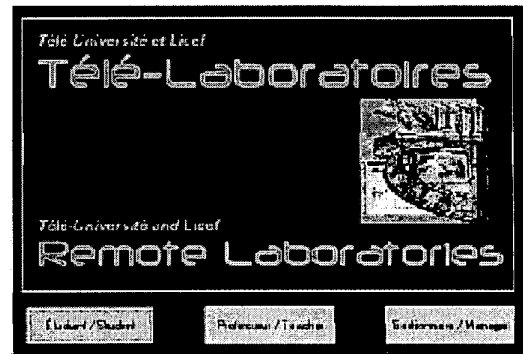
Figure 4 Home Page Interface

Student Interface :

As soon as the student opens the Main Page Menu, he can easily have access to various sub interfaces that let him participate in all operations in which he is enrolled. Access to these sub interfaces takes place in the following way:

- Once the Student Menu is selected, the student sees the login interface. It lets the student validate his personal ID number and password, thus giving him access to the student virtual space hosted by a computer on the network.

This virtual space interface contains data on the student, that is, his personal data file, as well as the tutorials and labs he is authorized to participate in. The interface is also made up of various menus, including:

- A **Tasks** Menu allows the student to participate in Drill & Practice and Lab sessions. The Practice Menu lets him enroll, cancel or execute labs. This menu also gives him access to other sub interfaces, namely:

- An **Enrollment** sub interface (Figure 5)

The Enrollment sub interface

Enrollment sub interface includes the following menus :

- A schedule that lets the user choose from among various Drill & Practice sessions
- The date that indicates the enrollment date for Drill & Practice sessions
- A **sub interface** that lets each student belonging to a group enroll. Given that for each Lab session, only one student is required to handle a piece of equipment depending on the learning scenario, there is a Handler Menu where this choice can be entered and finally, there are Confirmation and Cancellation buttons in regard to various Lab sessions. These Confirmation buttons give access to the **Confirmation or Cancellation sub interface.**
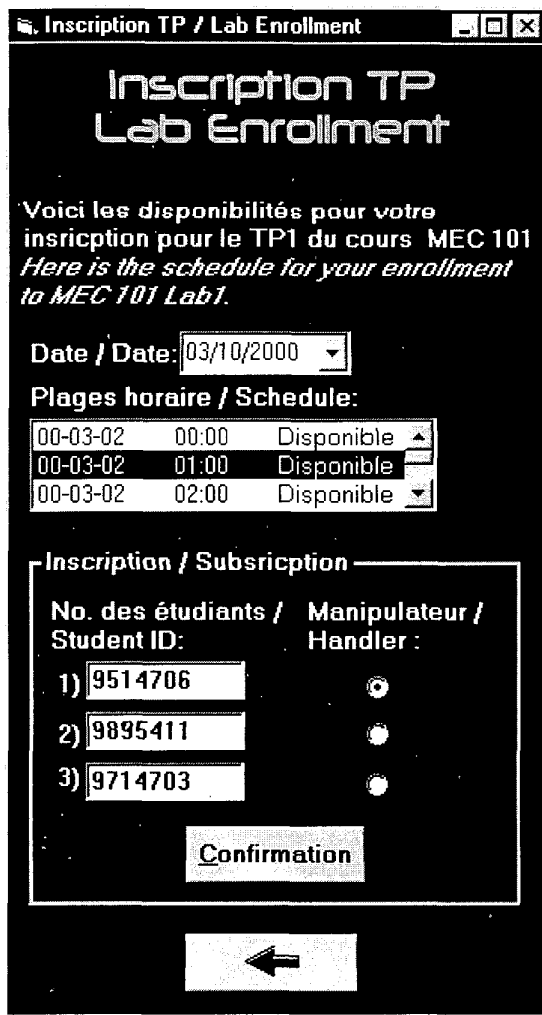
Figure 5 The Enrollment Interface

The **Execution** submenu lets students complete full lab assignments collaboratively. The execution of these Lab sessions is done within an environment made up of various menus that provide the option to send E-mail messages, to participate in video teleconferencing or in discussion groups with other members of the lab team as well as with teachers who, in turn, can follow the work in progress and intervene as needed.

As for the **Drill & Practice** Menu, the student can complete Drill and Practice exercises in order to better grasp the theoretical content of the tutorials he's enrolled in. At the bottom of the interface seen on the screen, there are buttons that control all options described in this menu.

Interface for Teachers, Tutors or Researchers

As is the case for the student's interface, the interface for teachers, tutors or researchers is based on the same architecture. Access to the system is obtained through an interface where teachers, tutors or researchers enter their personal ID number, then their password. Once this information is validated, an interface appears, giving the personal user data. This interface lets teachers visualize their students at work, the tutorials and lab sessions they co-ordinate. The teacher can in fact update data and modify certain aspects of the tutorials via menus and buttons. The Connexions Menu lets the teacher disconnect from the system. The Tasks Menu lets teachers add, supervise or delete tutorials, drill & practice sessions or lab sessions, as desired. Lastly, the Option Menu allows teachers to modify their personal data file.

The Manager Interface

The manager controls all the system operations at the server level, so this role is very important in a virtual laboratory. Thus, in order to enhance all the manager's activities, we have proposed an interface as shown in Figure 6. This interface lets the manager manage student and teacher personal data files, that is, add, modify or delete the names of students and teachers from the list of users of the remote laboratory. Via this interface, the manager can also make data backups and generate reports on all users of the remote laboratory or give a priority to a task to be carried out by a team or any other participant according to the learning scenario.

THE CHALLENGES AND FUTURE WORKS

In order to realize the Virtual and Remote Laboratory resource management objectives mentioned above, the following technological considerations should be taken into account:
1. Automating a generic way of mapping a given learning scenario to the management strategy.
2. Adding a distributed intelligent laboratory advisor. Handling multi-user collaborative parallel sessions.

CONCLUSION

We have presented how to get around a remote and virtual laboratory to show that careful attention should be paid when thinking of riding a true collaborative virtual and remote laboratory involving interdisciplinary knowledge and skills. Operational research findings and Knowledge Based System approaches are then useful to improve the remote lab concept.
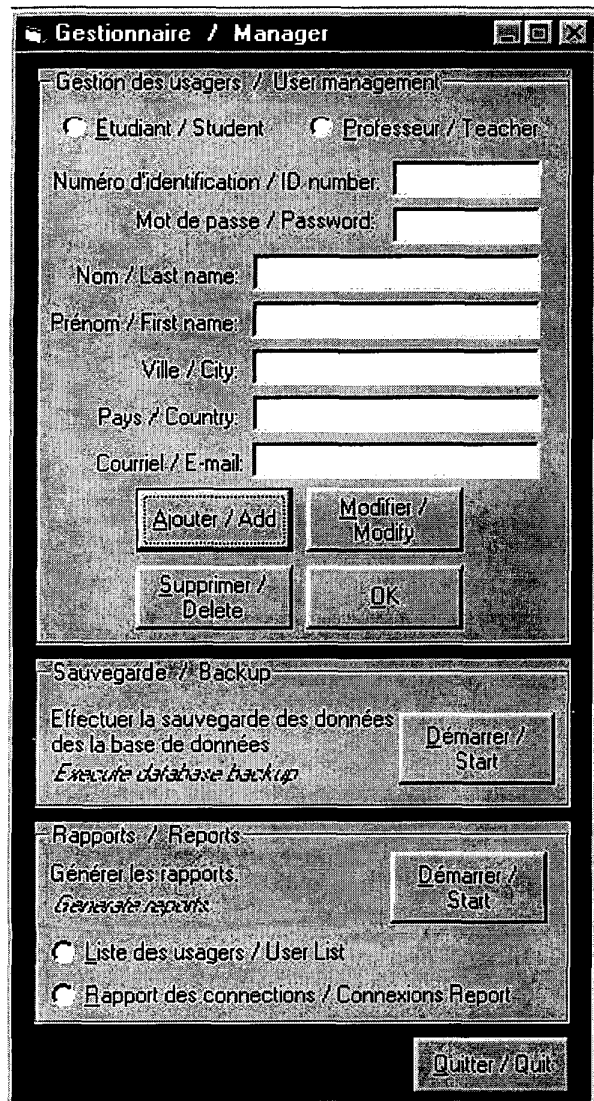
Figure 6 The Manager Interface

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