

From the Collaborative Environment of the Remote Laboratory NetLab to the Global Collaboration

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Abstract—The remote laboratory (RL) can be considered as a modern collaborative learning environment, where students acquire skills required for efficient collaboration and communication on a local and global scale, both today and in the near future. The majority of current existing RLs are not constructed to allow the involved participants to collaborate in real time. This paper describes the collaborative RL NetLab, developed at the University of South Australia (UniSA), which allows up to three onshore and/or offshore students to conduct remote experiments at the same time as a team. This allows the online RL environment to become very similar, if not nearly identical to its real laboratory counterpart. The collaboration in the real laboratory is replaced by the “global” on-line collaboration.

Index Terms—NetLab, Internet, Remote experiments, Collaboration

I. INTRODUCTION

The assertion of the Internet as a mechanism for communication, collaboration and interaction among individuals as well as institutions of industry, commerce, education, government and science is tremendous and invaluable. Today the Internet is seen as one of the integral components of a global community and can be considered the major component responsible for the formation of today’s modern information technology society. The key change that revolutionised the Internet was the use of electronic mail with the development of user-friendly, front-end mailing system. Lately, the problem of ease of use and applicability has been solved by the development of the World Wide Web (www), which supports hypertext linking and full media delivery of data [1]. Yet in the beginning of www in 1992 there were only 50 pages in existence [2].

In less than two decades the unpredicted development of the Internet has been phenomenal. Today, in 2008, the Internet is involved in every field of human activity. It has spread from universities and government institutions into everyday and everybody’s lives. What can we predict about the development of the Internet in the next two decades? What will become available and how will it be presented and delivered? From the sharing of letters, pictures and files at the beginning we have advanced to the instant communication among users and control of the hardware at any location and at any time. Globally distributed systems could be and will be interconnected to function concurrently. Such systems will be controlled by

a global team of specialists also distributed worldwide. Members of this team have to collaborate and communicate effectively to achieve the required objectives. Remote laboratories, which started their development about two decades ago, are currently seen as the humble beginning of the future global systems. They can be considered as a good structure and teaching environment for developing of skills required for the efficient collaboration and communication on the local and global scale. Currently there are about 120 RLs worldwide [3], yet only a few are constructed in such way they allow involved participants to collaborate in the real time, such as RLs developed as part of the MARVELL (Virtual Laboratory in Mechatronics: Access to Remote and Virtual e-Learning) project [4], DIESEL (Distance Internet – Based Embedded System Experimental Laboratory) project [5] and WebLab at MIT (Massachusetts Institute of Technology) [6]. In our paper we describe the remote laboratory NetLab, which has been developed at the University of South Australia and incorporated into curriculum of engineering courses [7]. The laboratory enables students and visitors from different locations to conduct experiments in a collaborative way. It is used with our onshore local students as well as with our offshore students in Singapore, Malaysia and Sri Lanka.

II. COLLABORATION AND COOPERATION

Students’ collaboration and cooperation skills can be acquired via conducting projects with an embedded remote experiment and working as a part of a team. Collaborative learning or cooperative learning are types of situated learning, that include group activities with emphasise on cooperation rather than competition among students. These types require students to have additional skills such as the ability to work in groups. Cooperative learning is distinguished from collaborative learning. In cooperative learning teachers take most of responsibility for decisions about what is to be studied and how the groups are to cooperate. While in collaborative non-competitive learning group activities, students are engaged in making decisions about what is learned and how [2]. Collaborative learning has been defined in a number ways, but generally understood to refer to small group learning, where the group members actively support the learning processes of one another [8]. The introduction of the Internet also established online cooperative environment [9]. The range from the small group learning confined to the classroom or laboratory, advanced to the cyber space, where the computing and information technology

increasingly assumed a dominant importance [10]. Collaborative work has always been anchored in engineering practice and as engineers they seldom work in isolation. Great engineering projects must be created by a team of engineers and consequently collaborative learning is most suited and a must in preparing engineering students for the challenges that lie ahead.

The application of collaborative learning approaches is a highly valued scholarly activity which the UniSA encourages and facilitates in various ways including through teaching awards, promotions criteria and professional development activities.

III. THE REMOTE LABORATORY NETLAB

The remote laboratory NetLab has been developed at the UniSA from 2002, when it started as the University teaching and learning grand supported project [11]. Since 2003 the remote experiments conducted via the NetLab have been incorporated into 3 undergraduate onshore courses [12]. From the year 2007 the NetLab started to be used also for our offshore transnational programs. The booking system was modified in such a way that international students could book their experiment time slots in their local time.

The NetLab is situated in the Sir Charles Todd building, where the School of Electrical and Information Engineering (EIE) is located at the Mawson Lakes Campus of the UniSA. The picture of the remote laboratory is shown in Fig. 1.

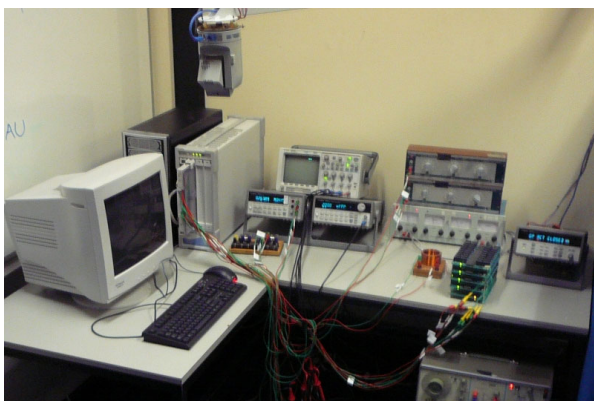


Figure 1. The NetLab configuration

The NetLab is accessible at <http://netlab.unisa.edu.au>. The NetLab home page can be seen in Fig. 2.

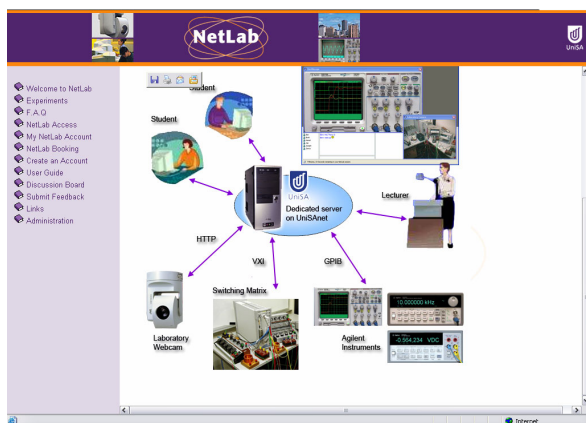


Figure 2. The NetLab home page

The NetLab architecture is described in the graphical way there, with the remote laboratory server in the middle, surrounded by pictures of the real hardware, including the web camera, located in the remote laboratory, and possible users located globally. The connection and communication is via the Internet. The server was originally written in LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench) and redeveloped using Java in 2006. The real equipment is connected to the server via IEE 4888.2 interface, otherwise known as GPIB (General Purpose Interface Bus).

The menu on the left side of the NetLab page allows users to enter different parts of the remote laboratory web site like NetLab Booking, My NetLab Access, NetLab Access etc. Students or visitors can create their own user name and password, then they can book their time slot using the time in their time zone, which is then translated into the South Australia time zone. The User Guide there is divided into 8 different chapters, each giving detailed description and help for different components of the remote laboratory. Users then can use the NetLab individually or as a team of users up to three users at the same time. As NetLab is a Java based application, it will run on any operating system provided it has an installation of the Java SE runtime environment, version 6.0 or later. Various vendors provide Java SE 6 implementations. Sun Microsystems' implementations for Microsoft Windows, Linux and Solaris operating systems are recommended. These are available for free download. The main Graphical User Interface (GUI) is shown in Fig. 3.

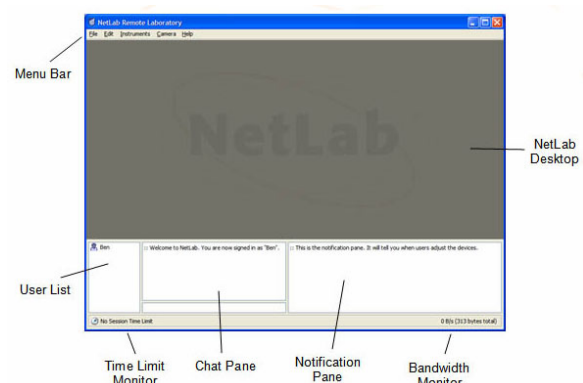


Figure 3. The NetLab main GUI

The same GUI, but in the stage when it is fully used, looks on the user's monitor as in Fig. 4

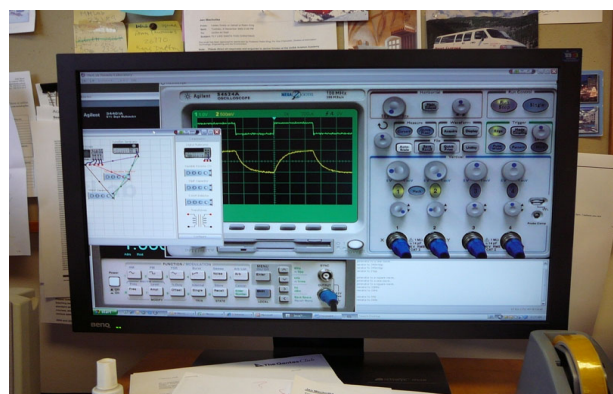


Figure 4. The NetLab GUI on the user monitor

IV. COLLABORATIVE REMOTE EXPERIMENTATION WITHIN NETLAB

The laboratory experiments have been the vital and non separated part of science and engineering education since the beginning. In most cases students were and still are coming to the laboratory to test the theory they learnt during lectures or had gained from different knowledge sources. In most cases they work in groups and ideally they learn how to collaborate and cooperate as a team. In some cases they just follow instructions from their supervisors. The collaboration in the remote laboratory, which allows more students to work simultaneously, can be very similar to the real laboratory except that one entity could be missing. The supervisor might not be on hand. However in some cases the supervisor's help is still available via the communication channel. To develop skills which are required for the local or global collaboration, the supervisor's presence is an obstacle. Students have to establish a team, they can establish a leader role for one student, but what is most important, is that they have to collaborate and cooperate effectively without any additional help.

Before students start their experiment they have to book their time slot for the experiments and choose their partners. The NetLab booking system window is shown in Fig. 5.

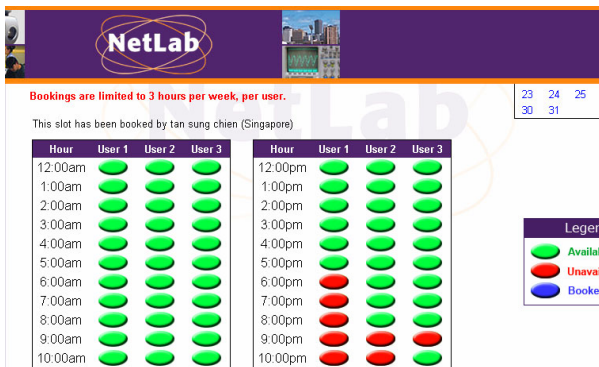


Figure 5. The NetLab booking window

For the collaborative experiments the course coordinator can set up the booking structure for students. In the example shown, the configuration is arranged for a group of up to three students. The green buttons show the available time slots, the red buttons show slots already booked and the blue buttons show slots booked by the user. Time slots can be also unbooked. The course coordinator can limit student access per week, for example 3 hours per week, per user. As the collaborative mood is not compulsory, it can be seen that some students still prefer to work alone. As from our example, the student Jason (Singapore) has booked for himself three consequent time slots, at 6:00pm, 7:00pm and 8:00pm. If he discovers that anything went wrong, he will not have another opportunity to repeat the experiment until the following week. The course coordinator can also check the location and the user name of the student by moving the cursor across it. The setting in Fig. 1 displays that the middle booked slot at 9:00pm is quote: "This slot has been booked by tan sung chien (Singapore)." The course coordinator, as the administrator, has the opportunity to join any session without booking the time slot and without "being seen" by current users.

Before using the remote experiment, students have to collaborate and complete the preparation work. This is very similar to real experiments in the laboratory where students, often as a team, have to organize their plans, strategies, formulas and documentation for conducting of the practical session. The great advantage of the remote laboratory is that student can learn how to control devices which they are going to use. From the NetLab web site help is available including video clips. In this case users can learn how to use the new modern equipment which they have never used before. This concept and use of remote experimentation is of the high importance for future professionals who will have to learn how to master and control the newest up-to-date available instruments, which will only be available globally, possibly at different locations. Students also have to communicate to each other and agree when to conduct measurements before they start. They also have to prepare the collaborative mode for the execution of the remote experiments and conducted them in an efficient manner. Some investigations results, based on remote experiments conducted by individual students and conducted by a group of students, suggest that remote collaboration also improves student performance and their learning outcome [6].

V. THE CASE STUDY: THE COLLABORATIVE PROJECT

The objective of this collaborative project is to create two different models of the inductively coupled system – the third order system as on Fig 6.

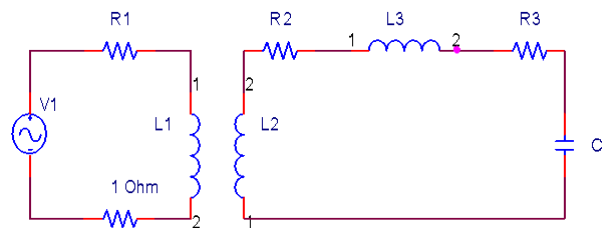


Figure 6. The inductively coupled system

The remote experiment is part of the whole collaborative project. The students are required to prepare, conduct and analyze the remote experiment and then use the results to design two different models of the system under investigation and conduct simulations. They have to compare the obtained responses and discuss possible discrepancies. All activities are conducted in a collaborative way, which requires students to work as a team. The whole experiment is designed in a different way from most conventional experiments in the real laboratory, where student follow written instructions, in most cases very detailed. They conduct experiments, usually as a team, but are guided and helped by the supervisor, they record obtained results and carry out the analysis later. In our project measured and calculated results are prerequisites for the next steps of the experiment. This leads to the better understanding of the whole process and thus students learning outcomes are enhanced.

Using the remote laboratory NetLab, students must at first connect real components using the Circuit Builder, the software developed in house [13] as shown in Fig 7.

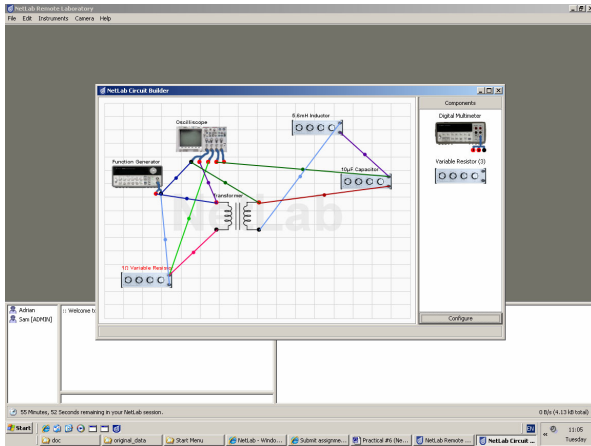


Figure 7. The computer screen showing the circuit created by the Circuit Builder

The next step is to propose proper tests to measure and/or calculate values of all components of the systems. This is one of the most demanding tasks, as the detailed instructions are not given to the students. They have to collaborate to find, agree on, and understand the possible tests, evaluation of tests and calculation of required values. The next stage is conducting of the agreed remote experiments. The last remote experiments are conducted to obtain the system step input responses. All stages require the real collaboration, as they require control of the function generator and the digital storage CRO. During the experiment the users must communicate via the chat window to achieve a successful outcome. After obtaining and saving all required data, the remote experiment is over and the next stage is to evaluate the results and to obtain parameters, which can be used to create two models of the system. The first model is the schematics for the PSpice (Simulation Program with Integrated Circuit Emphasis) simulation as shown in Fig.5 and the second model is transfer function used for MATLAB (MATrix LABoratory) simulation as in Fig. 8.

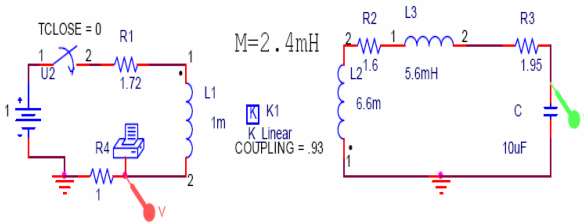


Figure 8. The schematics used for PSpice simulation

The second model is based on the calculated system transfer function used for the MATLAB simulation

$$\frac{V1}{I_1} = -\frac{(\omega M)^2}{Z_L + Z_{L_1} + Z_C} + (R_1 + j\omega L_1 + 1)$$

This phase of the whole exercise can be done in different ways. Users can split tasks and later compile their parts to obtain the overall results or they can work simultaneously on the same tasks and later compare their results. This requires effective communication and collaboration. Simulations system responses are compared with the real responses from the remote experiment. If there are discrepancies there, and there usually are, the

collaborative work takes place again. The “global” discussion about possible errors or mistakes should reveal suggestions where the mistakes and errors were found and/or made. If necessary, the remote experiment or its parts are repeated. This is a great advantage comparing with real laboratory sessions, where repeated sessions are usually not allowed.

Final graphical comparisons of the real responses and simulation responses are shown in Fig. 9 and Fig. 10. As can be seen there, if both simulations are executed in a proper way and they based on correctly measured and calculated parameters, their responses should be nearly identical. They are slightly different from the measured responses acquired via the NetLab measurements.

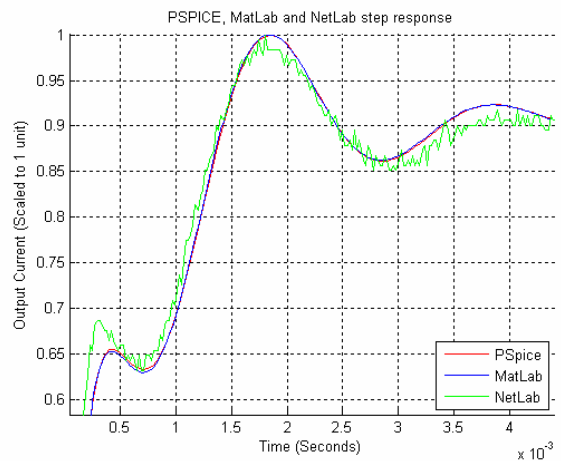


Figure 9. The graphical comparison 1

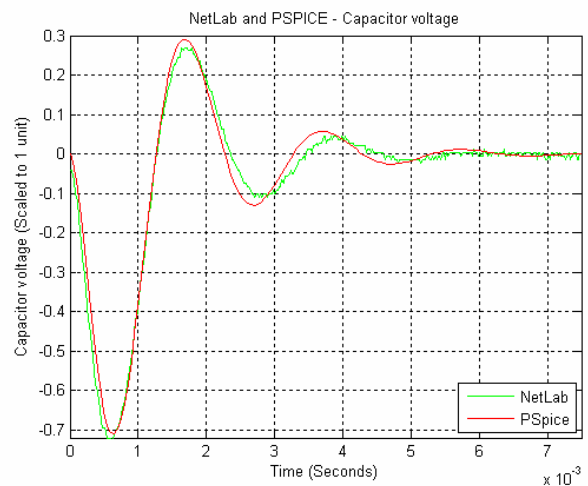


Figure 10. The graphical comparison 2

VI. CONCLUSION AND FUTURE WORK

As described in the previous parts, the remote laboratory collaboration in the NetLab is currently restricted to local students at UniSA or local students at Asia Pacific Management Institute (APMI) Kaplan at Singapore. The real global collaboration is intended to take place in the near future, when students from different countries shall participate in joint experiments. This can also result in enhancement of student international and intercultural perspective through collaborative projects, which will include remote experiments via the Internet.

The students' evaluation questionnaires are distributed to students at the end of each study period, then collected and analyzed. The responses indicate that students are aware that they have learnt additional skills during their online collaboration, which cannot be acquired during the experiments in the real laboratory.

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