A Collaborative Environment for Remote Experimentation

MJ. Callaghan, J. Harkin, C. Peters, TM. McGinnity, LP. Maguire
Intelligent Systems Engineering Laboratory,
Faculty of Informatics, University of Ulster,
Magee Campus, Northland Rd, Derry,
N. Ireland, BT48 7JL, UK.
Email: mj.callaghan@ulster.ac.uk

Abstract

Embedded systems have become common place in industry and domestic electronics, resulting in the need for educational institutions to teach advanced embedded systems design. Experience in teaching engineering subjects has shown that a complementary approach combining theoretical and practical exercises is vital for effective learning. Increasingly, teaching institutions are offering remote access to distant laboratories as part of an overall e-learning strategy. However the majority of remote laboratories developed to date have suffered from a major deficiency, namely the provision of a web based environment that accurately recreates the experience of traditional campus based laboratories. This paper addresses these issues and presents a supported collaborative learning environment for remote experimentation.

1. Introduction

Today's Electronic Engineers are experiencing the need to specialize and re-train in advanced fields, particularly in the area of embedded systems [1]. Developing practical experience in embedded system design is an integral aspect of this retraining. Exposure to actual embedded systems is necessary as simulators cannot accurately model the impact of real time constraints and second order effects on circuits [2]. Distance learning via the web offers students the flexibility to access educational material regardless of location or time constraints. Remote experimentation offered as part of a web-based learning approach allows remotely based students to develop skills which deal with real systems and instrumentation.

Current remote experimentation laboratories suffer from a major deficiency, namely the provision of a web based environment that accurately recreates the experience of traditional campus based laboratories particularly in the areas of supported student learning and collaborative working [3]. Traditional classroom based engineering laboratories nurture the development of essential team working and communication skills by facilitating collaboration between students, supported by lecturers to complete experiments. The students learn from and support each other, guided by lecturing staff where necessary. This aspect has being missing from remote laboratories until now.

The Engineering and Physical Sciences Research Council (EPSRC) funded distance learning project at the Intelligent Systems Engineering Laboratory [4] of the University of Ulster aims to develop a WWW remote-access laboratory to allow postgraduate distance learning students to gain practical experience in advanced embedded system design and test.

This paper presents a learning environment for remote experimentation, developed as part of the EPSRC project, that addresses the deficiencies of current remote access laboratories by integrating the ability to complete advanced embedded system experiments remotely with the facility of supported collaborative student learning. Section 2 briefly reviews previous work in the area. Section 3 presents the supported collaborative learning environment. Section 4 provides a summary and conclusions.

2. Review of online laboratories

Previous research by the authors reviewed and identified key deficiencies in current web based remote experimentation laboratories and concluded that existing laboratories have tended to be crude in nature and failed to fully utilize existing design, test and debug software and equipment [3], [4]. The authors proposed, developed and implemented an innovative solution to this problem using a Remote Desktop approach [5]. This approach involved the use of an ActiveX client to allow students scheduled access to remotely based workstations via the Internet through a web browser. These workstations housed all the necessary components needed to complete remote experiments e.g. compliers, virtual instrumentation and circuit interfaces, access to switching matrixes and experimental boards [4]. When granted remote access to these machines this approach allowed the user to fully utilize all applications, files and software resources on the remote workstation as if physically sitting in front of it. This approach avoided the redevelopment costs associated with adapting existing software tools and equipment with the extra functionality needed for remote access. Security safeguards were

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included to ensure laboratory and network resources integrity. Subsequent testing and usage of the remote laboratory identified other desirable features for inclusion in future implementations. In particular, the provision of a web based environment that accurately recreates the experience of traditional campus based laboratories particularly in the areas of supported learning and collaborative working.

The next section presents a learning environment for remote experimentation that addresses the deficiencies of current approaches by integrating the ability to conduct remote experiments with the added facility of supported collaborative student learning.

3. Collaborative learning environment

The learning environment detailed in this section is designed to extend the functionality of the authors' existing remote laboratory. This extension will facilitate remote collaborative experimentation between students and allow laboratory support staff or lecturers to provide live online remote assistance or guidance to students when required. The original remote laboratory was designed to be accessible through the ubiquitous web browser (Internet Explorer) and this approach is continued here.

The collaborative and supported learning environment is embedded in a web browser and navigated using a tab system developed in dynamic HTML. Functionally it has three distinct but interconnected sections comprised of learning support resources, remote experimentation facilities and collaborative working and communication tools.

The learning support resources include extensive lecture and laboratory notes complete with audio/visual content providing theoretical background material and guidance for experiments. A comprehensive interactive multimedia user help system is available outlining and demonstrating general laboratory operation and the conduction of experiments. A discussion forum has being added to the environment to allow students to discuss or comment on experiments, results and experiences with other students. A facility is also included to allow students to book laboratory access time, either individually or in conjunction with another student for collaborative experimentation. This feature will be extended to allow students to request tutor assistance with experiments when needed.

The remote experimentation facilities include the remote desktop feature which allows students to fully access all the resources of the distant workstations. A series of Macromedia Flash based executables provide a user interface front end to the experiments which control the switching equipment on the remote workstations [3]. This interface allows students to effectively wire up circuits and to connect test equipment for the taking of measurements or readings. Instrumentation control is provided by a series of virtual instrument interfaces built in Labview to closely resemble the physical characteristics of a range of test equipment e.g. oscilloscopes, digital multi-meters and function generators. The Labview interfaces allow the student full access and control of the test equipment and instrumentation connected to the remote workstation. To provide feedback to the students during experiments, a series of Labview interfaces have being designed to connect to data acquisition cards which take readings from a range of peripheral devices e.g. Stepper motors. This is augmented by the use of Web cams to provide visual feedback.

The collaborative working, support and communication tools include Microsoft Windows Messenger which allows interaction between students or between students and course support staff via audio/video and text. This software also includes a remote assistance and application sharing facility allowing course support staff access to a student's home machine during remote interactive help sessions. Collaborative working between students and lecturing staff is also facilitated by the use of the "Share" function in the remote access software Netsupport which allows joint control and access to all remote workstation resources [5].

4. Discussion & conclusion

This paper presented a collaborative and supported learning environment for remote experimentation that addresses a number of deficiencies of current remote access laboratories. A structured environment for remote experimentation was introduced which included comprehensive teaching and support material and integrated the ability to complete advanced embedded system experiments remotely with the facility of collaborative student experimentation and remote tutoring when required.

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