Embedded Systems Programming

The Embedded Systems Programming course teaches advanced aspects of embedded systems programming, including real-time communication. Our distance lab approach for ESP consists of several target boards with integrated measurement hardware, which are connected to a central server. The server handles authentication and dynamically assigns each remote user one of the available boards. Between client and server, only measurement data and debugging information are transferred.

A custom visualization software displays the measurement data in a graphical visualization of the target board. All the software development is done on the local PC, with the ability to perform remote debugging over the Internet.

Key Features

- scalability
- optimized bandwidth-usage
- centralized administration possible

Publications

- A System for Automatic Testing of Embedded Software in Undergraduate Study Exercises (WESE 2005)
- A Case Study in Efficient Microcontroller Education (WESE 2005)
- Distance Labs — Embedded Systems @home (Edutainment 2006)
- Anytime, Everywere — Approaches to Distance Labs in Embedded Systems Education (ICCTA 2006)
- A µController Lab for Distance Learning (EWME 2006)
- Embedded Systems Home Experimentation (ICET 2006)
- Embedded Systems Exams With True/False Questions (ICET 2006)
- Far Beyond Simple Administration (ICEE 2006)
- A Sensor Network for Remote Target Monitoring in Embedded Systems Lab Course (IECON 2006)

Internet

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Our supporters

Austrian Ministry for Transport, Innovation and Technology (BMVIT),
http://www.bmvit.gv.at/
Austrian FIT-IT Embedded Systems initiative,
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Introduction
Embedded systems education has gained more and more importance in the last decade. Suitable courses are costly, however, both with respect to lab resources and staff. After all, specific hardware is usually mandatory, and hands-on experience is of major importance. A large number of students, in conjunction with our desire to better support handicapped and working students, further exacerbates the problem. These issues were addressed in our FIT-TT project “Seamless Campus: Distance Labs”, where we developed advanced distance labs supporting high-quality education in our Baccalaureat study "Technische Informatik" at TU-Vienna.

Concepts
Basically, we deployed two different concepts:
- Remote access to our hardware labs
- Carry-out equipment

Remote access is accomplished by means of two different approaches. In the first setup, we remotely control lab workplaces (also including special equipment like a logic analyzer), whereas in the second setup, remote clients directly control embedded system target boards made available by a central server.
For our carry-out equipment, we use self-developed microcontroller hardware bundled in our “lab kits”. The required development environment is provided to our students via a modified version of the Knoppix CD, a bootable Linux environment for standard PCs and notebooks. In order to use the SCDL tools, students do not have to install any software. They just have to insert the CD and reboot their computer — all software needed for development is already pre-configured and ready to use.

Digital Design Workplace
The Digital Design course is devoted to VHDL and the design flow for FPGA-based target boards. We implemented distance labs using remote-controlled workplaces, consisting of PC workstations with attached target board and measurement equipment. Working remotely provides exactly the same user interface as working locally in the lab. Keyboard and mouse inputs are transmitted in one direction, the screen’s content in the other.

Key Features
- full remote operability of the logic analyzer
- easy to deploy, local access in the lab remains possible
- development environment runs on local workstation — no licencing issues
- supports remote control of Windows from Linux machines

The Microcontroller Lab Kit
In our microcontroller course, students typically get their first experience with microcontrollers and programming with hardware-in-the-loop. Advocating "hands-on" experience rather than simulation-based approaches, we utilized the lab kit concept for this course. A lab kit includes all the special equipment (hard- and software) required for the course.

Key Features
- self-developed hardware
- cost-efficient (<100 EUR)
- no Internet connection required
- high scalability
- facilitates hands-on experience

Add-on Boards
Additional boards can be connected to the lab kit, e.g., a board equipped with different types of motors.