Embedded Systems Education using Remote Workplaces

Christian Trödhandl, Thomas Handl, Markus Proske and Bettina Weiss

part of
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Overview

- Motivation
- Requirements
- Case Studies
- Demonstrations
- Discussion

Motivation

Need to handle an increasing number of students in embedded systems lab courses

Three possible solutions:

- Increase the number of workplaces in our labs
- Utilize simulators instead of real embedded HW
- Provide means for distant learning from the student's home

Requirements

- Very specific requirements compared to more software-centered domains (e.g., Web, applications programming)
- Special software needed (Cross compiler, …)
- Additional drivers for target HW or ways for communication and visualization
- Development software should be easy to install and not come with restrictive licenses

Case Studies

Different approaches for home experimentation in our embedded systems courses:

- Microcontroller course
- Digital Design course
- Embedded Systems Programming (ESP) course

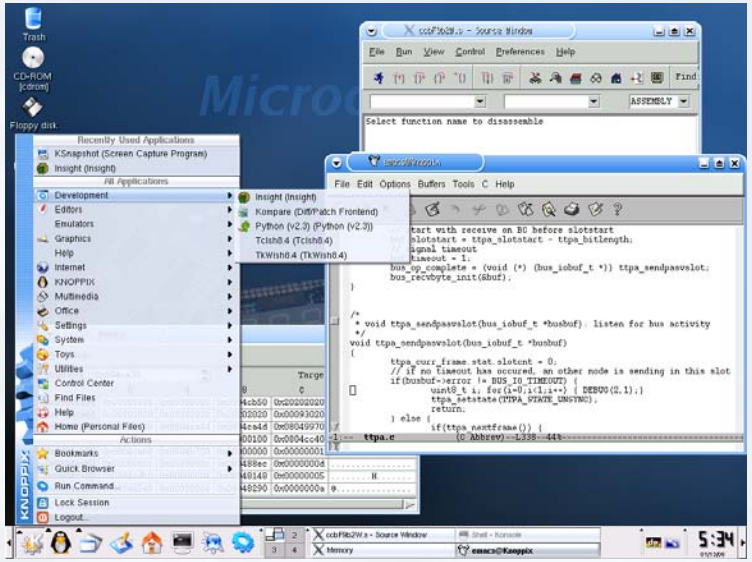
- Undergraduate courses (second and third year computer engineering)
- Up to 120 students in these courses

Microcontroller Course

- Students get impression on microcontroller and hardware-near programming
- 3 – 4 short exercises
- Programming in C or Assembler language
- Small 8-bit microcontroller board + I/O boards
- Students have to setup the hardware for each exercise
- Focus on hands-on experience

Microcontroller Course

- Knoppix CD: bootable Linux environment
  - Independent of installed OS
  - Zero installation effort
  - Contains all development software needed
  - All course materials (electronic slides) on CD



Digital Design Course

- Students are introduced in logic design and VHDL programming
- FPGA demo board as target hardware
- Four exercises:
  - Handling of logic analyzers
  - Design flow (simulation, synthesis)
  - VHDL programming (implement a VGA controller)
  - Debugging hardware designs

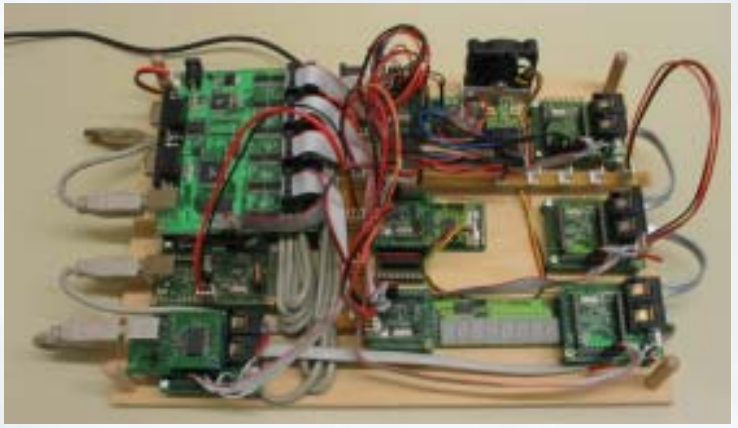
Digital Design Target Hardware

Digital Design Remote Workplace

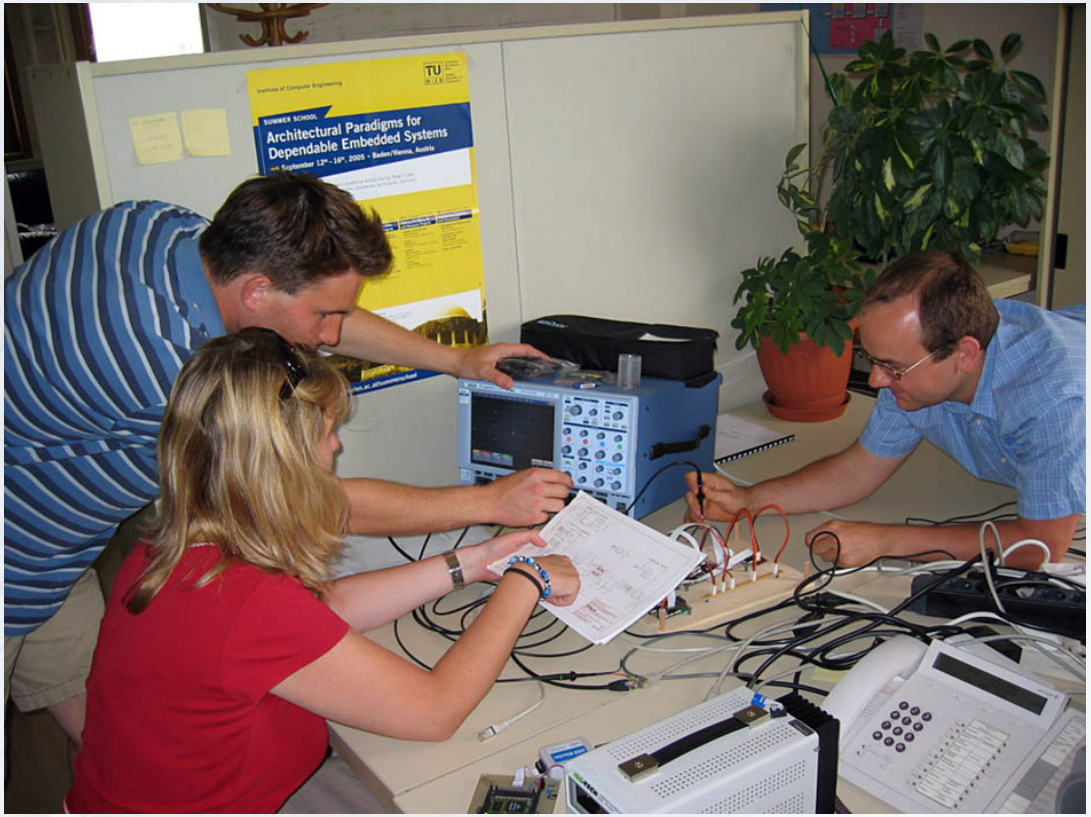
- Development software runs on Windows workstations
- Connected to the workstation is the target board
- Target board displays the output on a monitor that is filmed by a Web-cam
- Logic analyzer is connected to target board, displays its results on a window on the desktop
- Remote access to workstation is handled with VNC or Windows XP remote desktop

Embedded Systems Programming Course

- Builds on the contents learned in the Microcontroller course
- Design and programming of distributed embedded computer systems
- Multiple microcontrollers connected through fieldbus
- Hardware already set up
- 3 exercises in C language



Embedded Systems Programming Course

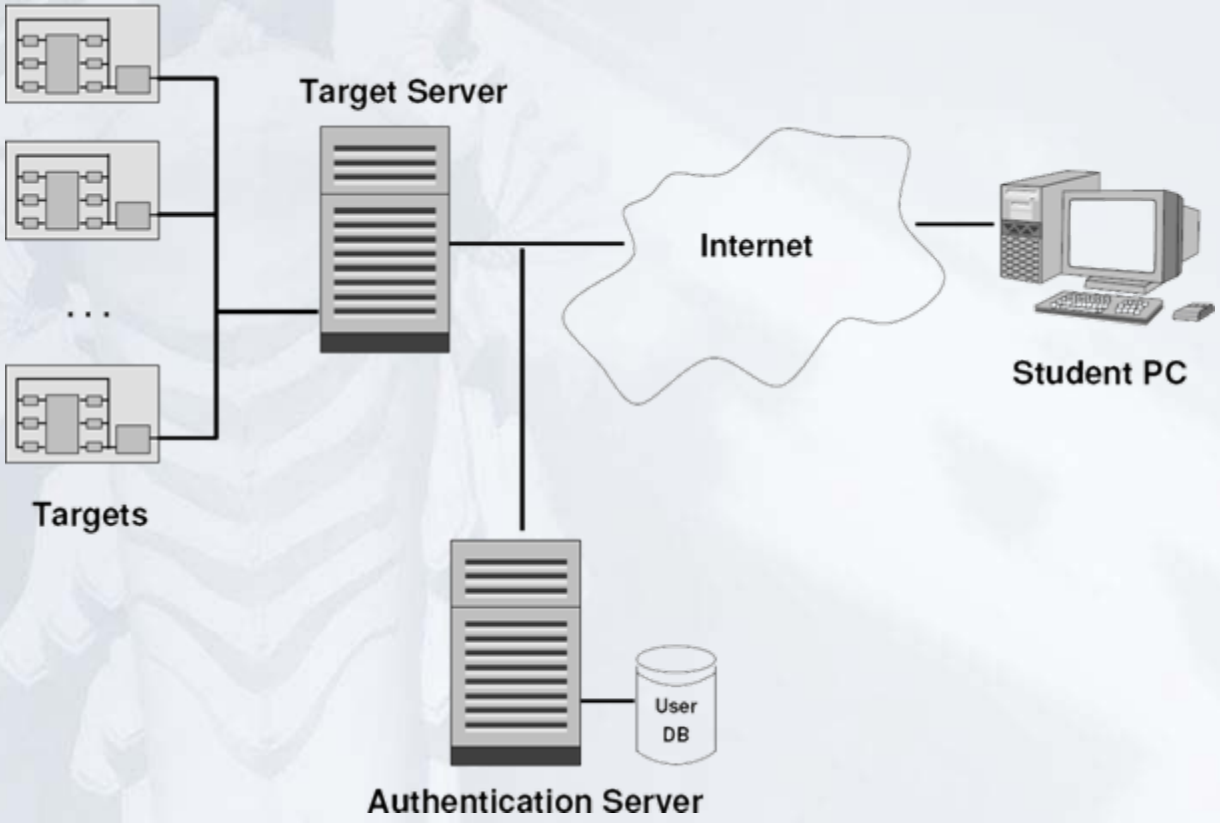


ESP Remote Workplace

Remote workplace with client-side visualization :

- Measurement hardware captures state of target
- Multiple targets are attached to target sever
- Target server transmits measured values to clients
- Client software visualizes data
- Development SW on client side (preconfigured Knoppix CD)

ESP: Remote Workplace Architecture



- Special target boards are equipped with a monitoring network
- Student logs in and connects to a remote target board
- Visualization at student‘s PC shows state of board in real time

Evaluation

- Lab kits approach:
  - Requires inexpensive and robust hardware
  - hands-on experience
  - no internet connection required
  - no investments in server hardware or rooms
- Remote workplace approach:
  - Central administration
  - For tasks that require no manual reconfiguration of HW
  - Requires non-restrictive SW license

Demonstration: Digital Design Remote Workplace

Demonstration: Microcontroller Lab Kits

Conclusion

- No “one-fits-all” solution for embedded systems home education
- For cases with inexpensive equipment / manual reconfiguration a lab kit approach is favorable
- For more expensive equipment where no physical interaction is necessary, a client/server solution showed to be more economical

Food for Discussion

- How to handle remote access
  - Limited number of targets
  - First come/first served or reservation
- How to encourage regular work
  - Freedom vs. irregular working hours
- Stay in touch with students
  - Less involvement in course ⇨ problems recognized late

Thank you for your attention!

Questions?