4. Quiz 1, Lab 1, Gumstix Introduction

18-349: Embedded Real-Time Systems

Costas Akrivoulis

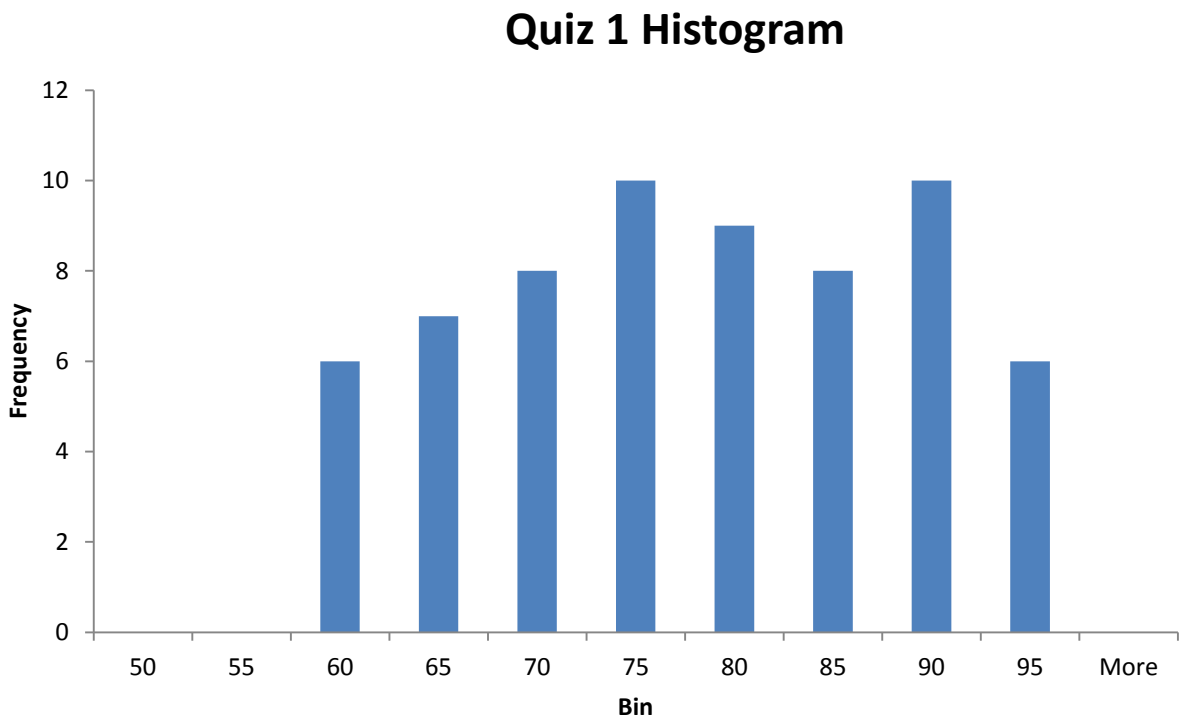
Carnegie Mellon University

September 14, 2012

Agenda

- Quiz 1 solutions
- Lab 1
- Hardware (Gumstix)
- Software
  - Toolchain, workflows
- Hand out quizzes, hardware kits

Quiz 1 Statistics



N	64
Min	56
Max	95
Mean	76.13
Std Dev	10.48

Quiz 1 Solutions

- Review solutions to Quiz 1

- If there are questions, please contact the TAs
  - Email, office hours

Lab 1 – Introduction to Gumstix and ARM

- Out: Tonight! (September 14, 2012)
- **Due: Saturday, September 29, 2012 @ 11:59pm**
- Official handout on course website

- You'll be able to practice the ARM you've just learned by writing some code!

Lab 1 – Lab Contents (1/2)

- Version Control
- Getting acquainted with the Gumstix
  - Making microSD bootable, installing system files
  - Setting up serial communication
    - Used for interactive session, file transfer
    - Bonus: Bluetooth
  - U-Boot, Gumstix OS

Lab 1 – Lab Contents (2/2)

- Writing some ARM code
  - Hello world
  - Low-level optimizations (assembly)
  - High-level optimizations (C)
- Tools for working with ARM code
  - `make`, `objdump` / `readelf`, `gdb`
  - **Bonus: cross compilation, emulation, workflow**

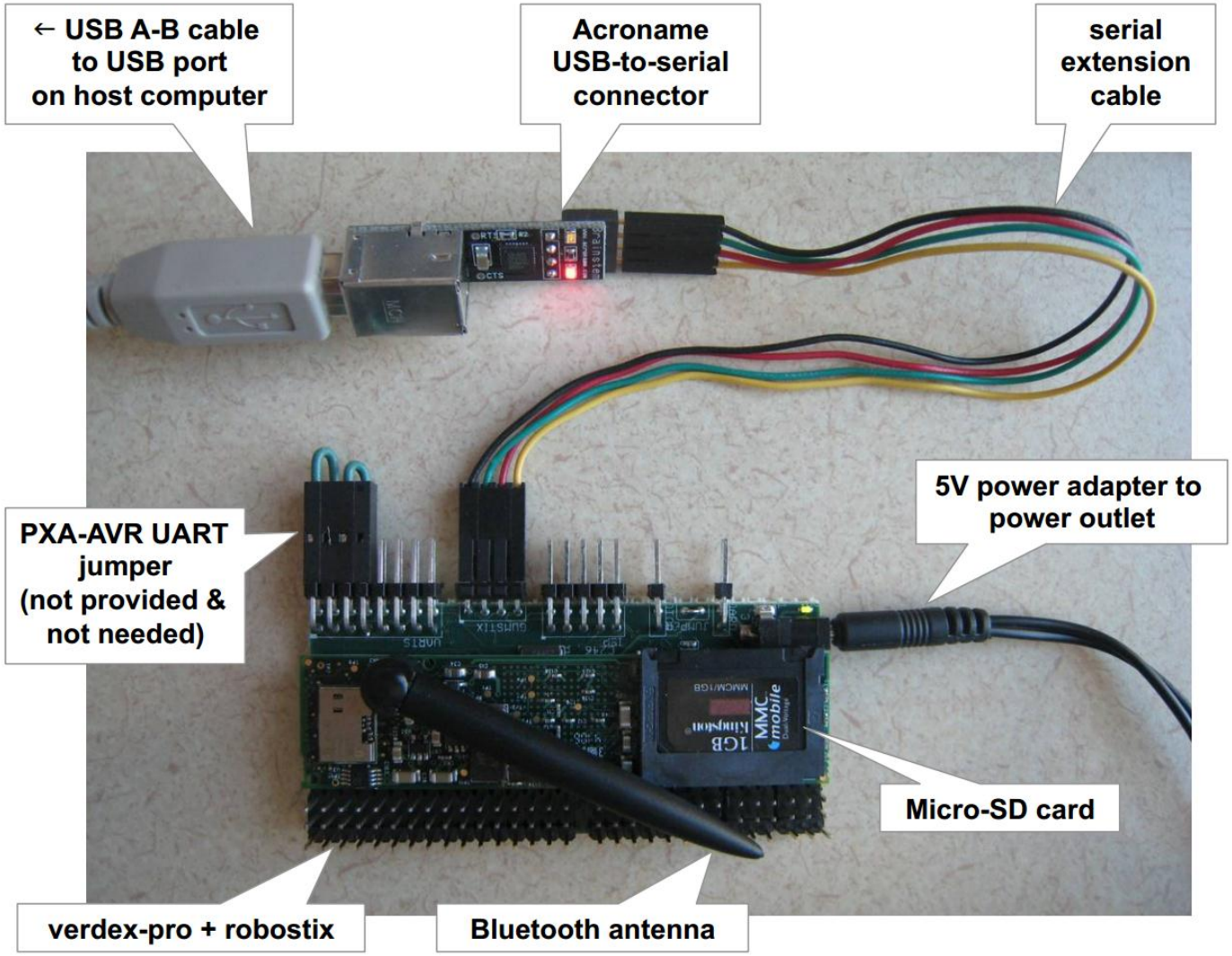
Lab 1 – Version Control

- Use version control to keep track of your code
  - You'll have to use SVN for part of the lab
    - Basic tutorial in lab writeup
  - Feel free to use whatever you're comfortable with
    - I strongly recommend using Git ☺
    - http://www.progit.org/book/

Lab 1 – Gumstix Hardware

- Gumstix Verdex-Pro 400xm-bt
  - Intel PXA270 processor (ARMv5), 16MB flash mem
- Robostix expansion board (mostly unused)
  - Atmel ATmega128 microcontroller
- 5V power adapter
- Acroname USB serial interface connector
  - Also serial extension cable + USB cable
- microSD card + SD card adapter
- Bluetooth antenna (optional)

Lab 1 – Gumstix Hardware



Lab 1 – Gumstix Operating System

- Separate handout describes how to set up OS
  - Link in lab write-up
- Use Linux machine to format and partition microSD card (with adapter)
  - Need root privileges to run disk tools… can't use CMU machines to do this
- We have a file system you can just drop in
  - And some boot scripts too

Lab 1 – Serial Communication

- Used to get an interactive prompt, and to transfer files to the gumstix
- PuTTY, HyperTerminal, `minicom`, `screen`
  - kermit, zmodem to transfer files

- Use Bluetooth for a faster, wireless connection
  - completely optional

Lab 1 – U-Boot and Gumstix OS

- You'll likely spend most of your time in the Gumstix OS for Lab 1
  - You're writing user-mode code right now
  - Gumstix OS is a barebones Linux installation with compiler and related build tools
- U-Boot is the Universal Bootloader
  - Will allow us to run our kernel in later labs
  - Provides a basic Exports API for us to leverage later
    - Implements essential services like printing to the screen

Gumstix Demo

- Connecting to Gumstix (serial)
- Looking at U-Boot prompt, booting into Gumstix OS
- Sending a file
- Running some ARM code

Lab 1 – Writing ARM Code

- Hello World (ARM assembly)
- Basic calculator and library (C)
- Low-level optimization (assembly)
  - Optimize mysterious `strTable` function called 1000 times
- High-level optimization (C)
  - Naïve algorithm given to find missing Oddball integer among array of size *2n-1*
  - Optimize in two different ways at a high level while maintaining correctness
    - Write different algorithms, don't just tweak the naïve impl.

Lab 1 – Using Developer Tools

- Writing a basic Makefile and using `make`
  - Tool to automate your build process
- Analyzing binaries with `objdump` and `readelf`
  - Will dump ARM assembly of a binary so you can quickly examine what code is being executed
  - Prints binary information (headers, symbols)
- Debugging your code with gdb
  - Single-stepping, breakpoints

Gumstix Workflow (1/5)

- Remember, the Gumstix is a constrained, embedded system
  - Low-power, low-memory, slow serial link
  - Not always the most pleasant to develop on
- Thankfully, we have the tools to work remotely too

- Try out both on-line and off-line development

Gumstix Workflow (2/5)

- We ***highly*** encourage you to stick to off-line development
  - Much better tools
    - `vim` instead of `vi` (glorious undo), `git`
  - You and your teammates can work concurrently
    - Having one Gumstix can sometimes constrain the team
  - Faster iteration
    - Compilation takes less time
    - Less time wasted waiting for Gumstix to reboot
  - Less chance for data loss should disaster strike

Gumstix Workflow (3/5)

- How do we facilitate off-line development?
  - x86 and ARM are different architectures
    - You can't just run ARM code on your laptop!
- **Cross-compiling**: there *IS* a better way!
  - Toolchains targeting ARM, but running on x86
    - `gcc`, `gdb`, `objdump`, `readelf`, and friends
  - Cross-compiler available for CMU machines
    - Check out `cross-compilation.pdf`
    - Look for `*gnueabi*` and `*arm-linux*` in your favorite Linux distribution's package manager

Gumstix Workflow (4/5)

- Take it one step further and emulate!
  - Using QEMU, a machine emulator, you can emulate the Gumstix as a virtual ARM system
  - Debug your programs using gdb
    - Remote, symbolic debugging of the QEMU instance
    - Invaluable for kernel code debugging later on
  - Many thanks to *Alex Crichton* for the tutorial!
- Increases your team's throughput ☺

Gumstix Workflow (5/5)

- Recommended workflow:
  - Write code on desktop / laptop
    - Use version control if you'd like
  - Cross-compile and resolve compiler warnings
    - Can try targeting x86 if it's platform-independent code
  - Transfer to Gumstix once you're ready to test
  - Keep workflow consistent
    - Avoid editing files on Gumstix – you'll forget to transfer them back and end up clobbering changes

Demo – Gumstix Workflow

- Cross-compiling a C file on CMU machines
- `arm-linux-objdump` the resulting binary

Hardware Kits

- Write your team members' names on the hardware box
- Register with us with what kit you have
- Make sure all equipment is there

- Start Lab 1 early! – we want to make sure the hardware works sooner rather than later

Summary

- Quiz 1 solutions
- Lab 1
  - Technical details, logistics, plan of attack
- Hardware (Gumstix)
- Software (toolchain, workflows)
- Quizzes + hardware kits

Gumstix Hardware Kit Label

- Team number
- Team member names, andrew IDs

Team Number: ___

Member: Person 1 (andrewID)
Member: Person 2 (andrewID)
Member: Person 3 (andrewID)