CSE 466 – Software for Embedded Systems

- **Instructor:**
  - Bruce Hemingway
    - CSE 464, Office Hours: 1:30-2:30 p.m., Monday, Wednesday,
    - or whenever the door is open
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- **Teaching Assistant:**
  - Tom Sommerville

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CSE 466 – Software for Embedded Systems

- **Class Meeting Times and Location:**
  - Lectures: EEB 045, MWF 10:30-11:20
  - Labs: CSE 003E, Tuesday/Thursday, 2:30-5:20

- **Exams**
  - Midterm: Wednesday, 10 November, EEB 045, 10:30-11:20
  - Final: Monday, December 13, 2010, 830-1020, EEB 045
CSE 466 – Software for Embedded Systems

- Grading Policy
  - There will be two exams, as shown on the class schedule.
  - Lab reports: Demo usually required, sometimes questions

- Ratios:
  - Lab: 50%
  - Exams total: 20%
  - Homework: 10% (reports)
  - Class Participation: 20%

Recommended Textbook:

**MSP430 Microcontroller Basics**

By John H. Davies

U Bookstore doesn’t have it.
Embedded systems

- Definitions
  - A device not independently programmable by the user.
  - Specialized computing devices that are not deployed as general purpose computers.
  - A specialized computer system which is dedicated to a specific task.
  - An embedded system is preprogrammed to perform a narrow range of functions with minimal end user or operator intervention.
Embedded system – from the web

What it is made of

- Embedded systems range in size from a single processing board to systems with operating systems.
- A combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated function.
- In some cases, embedded systems are part of a larger system or product, as is the case of an anti-lock braking system in a car.
- A specialized computer system that is part of a larger system or machine.
- Typically, an embedded system is housed on a single microprocessor board with the programs stored in ROM.
- Some embedded systems include an operating system, but many are so small and specialized that the entire logic can be implemented as a single program.

Embedded system – from the web

Examples

- Virtually all appliances that have a digital interface -- watches, microwaves, DVD players, cars -- utilize embedded systems.
- A computer system dedicated to controlling some non-computing hardware, like a washing machine, a car engine or a missile.
- Examples of embedded systems are medical equipment and manufacturing equipment.
- While most consumers aren't aware that they exist, they are extremely common, ranging from industrial systems to DVD players and many net devices.
What is an embedded system?

- Different than a desktop system
  - Fixed or semi-fixed functionality (not user programmable)
  - Different human interfaces than screen, keyboard, mouse, audio
  - Usually has sensors and actuators for interface to physical world
  - May have stringent real-time requirements
- It may:
  - Replace discrete logic circuits
  - Replace analog circuits
  - Provide feature implementation path
  - Make maintenance easier
  - Protect intellectual property
  - Improve mechanical performance

What do these differences imply?

- Less emphasis on
  - Graphical user interface
  - Dynamic linking and loading
  - Virtual memory, protection modes
  - Disks and file systems
  - Processes
- More emphasis on
  - Real-time support, interrupts (very small OS, if we’re lucky)
  - Tasks (threads)
  - Task communication primitives
  - General-purpose input/output
  - Analog-digital/digital-analog converters
  - Timers
  - Event capture
  - Pulse-width modulation
  - Built-in communication protocols
What is an embedded system? (cont’d)

- Figures of merit for embedded systems
  - Reliability – it should never crash
  - Safety – controls things that move and can harm/kill a person
  - Power consumption – may run on limited power supply
  - Cost – engineering cost, manufacturing cost, schedule tradeoffs
  - Product life cycle – maintainability, upgradeability, serviceability
  - Performance – real-time requirements, power budget

Example: a temperature controller

Task: Tachometer (external interrupt)
now = getTime();
period = then - now; //overflow?
then = now;
return;

Task: FanPWM (periodic, hard constraint)
count++;
if (count == 0) PD6 = 1;
if (count > Thi) PD6 = 0;
return;

Task: TempControl (periodic, soft constraint)
if (Temp > setpoint) Thi++;
if (Temp < setpoint) Thi--;
if (period<min || period>max) PD0 = 1;

Task: Main
Thi = 0;
setup timer for 1ms interrupt;
setup timer for 100ms interrupt;
while (1) ;
Capacity

- Assume:
  - 8 MHz processor @ one instruction/cycle
  - Assume fan runs between 30Hz and 60Hz
  - Assume 256ms period on speed control PWM, with 1ms resolution.

- What percent of the available cycles are used for the temperature controller?
  - \[ \text{total instructions in one second} / (8 \text{MInstr/sec}) \]

- How much RAM do you need?

- How much ROM?

### Resource analysis of temp controller

<table>
<thead>
<tr>
<th>Task</th>
<th>ROM</th>
<th>RAM</th>
<th>Instructions/Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachometer (external interrupt)</td>
<td>~4</td>
<td>2 (period, then)</td>
<td>4 * 60 = 240</td>
</tr>
<tr>
<td>FanPWM (periodic, hard constraint)</td>
<td>~8</td>
<td>1 (count)</td>
<td>8 * 1000 = 8000</td>
</tr>
<tr>
<td>TempControl (periodic, soft constraint)</td>
<td>~10</td>
<td>1 (THI)</td>
<td>10 * 2 = 20</td>
</tr>
</tbody>
</table>

Total Instructions/Sec = **8260**, at 8MIPS, that's only 0.1% utilization!

Other resources? local variables, stack
Class logistics – see course web

- Class structure
- Business matters
- Grading
- Syllabus
- What we’ll be doing

**Class structure**

- Lecture
  - Closely linked to laboratory assignments
  - Cover main concepts, introduce laboratory problems
- Lab
  - Implementation of two projects
  - Lab reports due prior with 30 minutes of start of next lab section
- Exams
  - Two, based on lecture, lab, and datasheet reading
  - Open datasheets, open notes
- Final demo
  - During last class time – participation required
Business Matters

- Lecture slides will be online after class (links in several places)
- Random lab partner assignments, changed mid-quarter
- Sign up for CSE466 mailing list (soon)

Grading

- Lab reports:
  - Demonstration(s) required
  - Brief answers to questions embedded in assignment
  - Sometimes hand-in code
  - Do with your partner

- Distribution:
  - Labs: 50%
  - Exams: 20%
  - Homework: 10%
  - Class Participation: 20%
CSE466 Lab Projects

- Two multi-week projects
  - Four lab assignments each
  - Different lab partners
- First project
  - Familiarize with low-power microcontroller
  - Learn how to interface various devices, including Chronos
  - Testing and debugging
  - Solar energy harvesting with MSP430
- Second project
  - Arm-9 with touch-screen
  - Embedded Linux talks to Chronos
  - And maybe Android
  - Implement an app

Project 1 – power-harvesting w. Chronos

- Platform: MSP430 microcontroller
- Powered via Solar cell- read sensor data
- Send data to Chronos via 915 MHz radio
- Chronos collects data, then dumps it to PC
CSE466 Lab Projects (cont’d)

- Project 2 – Using the Micro2440 Platform: 405 MHz Samsung S3C2440A ARM920T
- RAM 64 MBytes SDRAM,
- Flash 1 GByte of NAND
  2 MBytes of NOR with BIOS
- Four USB Host connectors
  One USB Device connector
- Audio Stereo Out with mini phone jack.
  Audio In with cable connector on PCB
  Condenser Mic on PCB
- One standard SD Card socket.
  Ethernet RJ-45 10/100M
  RTC Built in Real Time Clock with battery.
- Runs Linux 2.6.31, Android, WinCE, and uC/OS
- LCD NEC 3.5 inch with Touch Screen, 240x320

Assignment for Friday:

- Review the MSP430x2xx Family *User’s Guide*
  - *Chapter 1: Introduction and*
  - *Chapter 2: System Resets, Interrupts, and Operating Modes*

Download here:

http://www.ti.com/litv/pdf/slau144e

(link is on the Textbook page...)