ECE/CS 5780/6780
Embedded Systems Design

Lecture 1: Introduction

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Adapted from Prabal Dutta (prabal@umich.edu)

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For those with WiFi Enabled Device

• Every lecture will have an Etherpad
• Go to
  http://wiesel.ece.utah.edu/redmine/projects/ece5780-s12/wiki
• Click on the “Etherpad” link next to the lecture
• Password: ece5780pw
• Take notes, discuss, critique
• Ask questions (make them bold + italic)
  – Questions will be answered during lecture by TA or after lecture by Prof
• It’s anonymous
• You have to be on Campus Network
What is an embedded system?
How do we build embedded systems?
Demo Time...
Embedded, everywhere
What is driving the embedded everywhere explosion?
Outline

Technology Trends

Design Questions

Course Administrativa
Bell’s Law of Computer Classes: A new computing class roughly every decade

“Roughly every decade a new, lower priced computer class forms based on a new programming platform, network, and interface resulting in new usage and the establishment of a new industry.”

Adapted from D. Culler
Moore’s Law:
IC transistor count doubles every two years

Intel 10-Core Xeon Westmere-EX    2,600,000,000 2011 32 nm
AMD Tahiti                      4,310,000,000 2011 28 nm
Xilinx Virtex-7                 6,800,000,000 2011 28 nm
Flash memory scaling:
Rise of density & volumes; Fall (and rise) of prices
Hendy’s “Law”:
Pixels per dollar doubles annually

Credit: Barry Hendy/Wikipedia
MEMS Accelerometers: Rapidly falling price and power

ADXL345
[Analog Devices, 2009]

25 µA @ 25 Hz

Price

Power

O(mA)

10 µA @ 10 Hz @ 6 bits
[ST Microelectronics, ann. 2009]
Energy harvesting and storage: Small doesn’t mean powerless...

- Thermoelectric Ambient Energy Harvester [PNNL]
- Shock Energy Harvesting CEDRAT Technologies
- Electrostatic Energy Harvester [ICL]
- Piezoelectric [Holst/IMEC]
- Thin-film batteries
- RF [Intel]
- Clare Solar Cell
- Thermoelectric Ambient Energy Harvester [PNNL]
Bell’s Law, Take 2: Corollary to the Laws of Scale

Intel® 4004 processor
Introduced 1971
Initial clock speed
108 KHz
Number of transistors
2,300
Manufacturing technology
10µ

15x size decrease
40x transistors
55x smaller λ

UMich Phoenix Processor
Introduced 2008
Initial clock speed
106 KHz @ 0.5V Vdd
Number of transistors
92,499
Manufacturing technology
0.18 µ

Photo credits: Intel, U. Michigan
Outline

- Technology Trends
- Design Questions
- Course Administrivia
Learning happens when assumptions are challenged and invalidated, so…
Mobile phones: the most successful technology ever

U.S. Cell Phone Subscriber Growth 1990-2015

- Subscribers
- Tot US Pop
- Poly. (Subscribers)

© Bridge Ratings LLC
What happened elsewhere now happens on the phone.
What happens when you press the power switch on your mobile phone?
Why study 32-bit MCUs and FPGAs?
MCU-32 and PLDs are tied in embedded market share

Source: iSuppli
Why study the ARM architecture (and the Cortex-M3 in particular)?
Lots of manufacturers ship ARM products
What differentiates these products from one another?
The difference is...

Peripherals

Peripherals
Technology Trends

Design Questions

Course Administrativa
Instructional Staff
(see homepage for contact info, office hours)

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Office Hours: Wednesday 12:30pm - 2pm in MEB 3114
Prerequisites

- CS/ECE 3700 (Digital System Design) OR CS/ECE 3810 (Computer Organization)
  - Digital Systems
  - Computer Architectures
  - CPU organizations
  - memory systems
  - pipelining

- CS 2000 (Introduction to Program Design in C)
  - C programming
- CS 1410 (Introduction to Object-Oriented Programming)
  - Algorithms (e.g. sort) and data structures (e.g. lists)
- CS 4400 (Computer Systems)
  - C programming

- Graduate Students: Enrolled in graduate program.
Course Syllabus (tentative)

- See course homepage:
  - http://wiesel.ece.utah.edu/redmine/projects/ece5780-s12/wiki

- Roughly
  - 50%: Lab-centric
  - 50%: Project-centric

- Labs
  - Schematics + PCB Design
  - FPGA + Hardware Tools
  - MCU + Software Tools
  - Memory + Memory-Mapped I/O
  - Interrupts
  - Timers and Counters
  - Serial Bus Interfacing / USB
  - Data Converters (e.g. ADCs/DACs)

- We don’t follow a particular book.
Labs

- Start TODAY!
- Tutorials to familiarize you with Altium, ARM, Microsemi tools
- Should be fun
  - Learn how to sense/control physical world
  - Build hardware (including PCBs)
- Should be instructive
  - Program in Verilog
  - Program in C, and assembly
  - Learn debugging skills
  - Learn how to interface peripherals to the CPU/MCU
- Are challenging and time-consuming - plan ahead
Lab Organization

• 4 Sessions, Digital Lab MEB 2265
  – Session 1: Tuesday 2pm - 5pm
  – Session 2: Wednesday 8am - 11am
  – Session 3: Wednesday 2pm - 5pm
  – Session 4: Thursday 7:30am - 10:30am (if necessary)
• TAs will be there to help you with the labs
• You can work in teams of 2
  – Try to have a mixed team CS/CE/EE/ME
• Choose a session this week. If no one shows up to a session, we will remove it from the schedule.

• You have to have a CADE account!
• There is a local printer in the lab.
• Introduction to PCB Design

• Two part homework
  1. Choose a MCU and make schematic using **Altium Designer**
  2. Layout PCB and verify it

• First part due this Thursday, **Jan 12 at 11:59pm**!

• You should have received an Altium Live account by now
  – Check your UMail account!

• Altium is installed on all computers in the Digital Lab, Analog Lab, and Computer Class Room
Lab 1 - 7

• Will be covered in next lecture

• You can check out the hardware from the lab staff
  – 1x Microsemi SmartFusion A2F-EVAL
  – 1x A2F-BREAKOUT board
  – 2x USB cables

• Keep it for the whole semester at no cost (unless you break it!)

• Be careful not to short the board
• Some testpoints are VCC, others are GND!!!
• Use antistatic mats and connectors in lab when handling the boards (ask TA if you don’t understand this)
Open-ended Project

• Goal: learn how to build embedded systems
  - By building an embedded system
  - Work in teams
  - Pick a problem of your own interest
  - Meet with instructors to discuss other ideas

• Should be related to the class and emphasize topics

• Scope of project must grow with size of team

• Encourage to have a mixed team of CS, CE, EE, ME
Sample projects from F’10 and their current status

- Energy-harvesting sensors → Sensys demo, TI project
- Wireless AC Power Meter → SURE project
Pushing projects beyond the university

• HiJack system to create mobile phone peripherals
Exams

• Midterm 1 (February 28, 2011)
  - Emphasize problem solving fundamentals

• Midterm 2 (Date TBD, Late in Semester)
  - Cumulative topics

• Minute Quizzes
  - Short, Random
  - Over previous day’s material
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<thead>
<tr>
<th>Item</th>
<th>Weight</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Labs</td>
<td>28%</td>
<td>7 labs, 4% each</td>
</tr>
<tr>
<td>Project</td>
<td>25%</td>
<td>Group project demonstrating understanding of major topics.</td>
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<tr>
<td>Exams</td>
<td>22%</td>
<td>Two exams: Midterm 1 (10%); Midterm 2 (12%)</td>
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<tr>
<td>Quizzes</td>
<td>10%</td>
<td>Approximately four 1-minute quizzes given at random (coin-flip)</td>
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<tr>
<td>Homework</td>
<td>10%</td>
<td>Two or three homework assignments weighted roughly equally.</td>
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<tr>
<td>Presentation</td>
<td>5%</td>
<td>Group presentation to instructional staff on project status</td>
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Thinking ahead: Letters of recommendation for graduate school

- Grad school apps will require supporting letters
- Faculty write letters and read “coded” letters
- Strong letters give evidence of research ability
- Weak letters are vague and give class standing
- Strong letters can really help your case
- Weak letters are useless (or even worse)

Want a strong letter?
- Do well in this class
- Pull off an impressive project
- Continue class project as independent research over Summer or F’12
Questions?
Comments?
Discussion?