Introduction to Computer Engineering

ECE/CS 252, Fall 2011
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University of Wisconsin – Madison

Computers!

- Engineers and scientists of all disciplines rely on computers for many aspects of their work
  - Not just word processing, spreadsheets, CAD, etc.
  - Computational methods, data mining, analysis/synthesis are fundamental to advances in many fields
- Many of the advanced techniques used in today’s microprocessors were invented right here at UW
- Some of the most renowned computer design researchers in the world are on our faculty
- There is a near-100% likelihood that a Wisconsin graduate helped design the computer or processor that you own

What is a Computer?

- Computers!

Many of the advanced techniques used in today’s microprocessors were invented right here at UW

1987 vs. 2010

<table>
<thead>
<tr>
<th>System</th>
<th>IBM PC/AT</th>
<th>Motorola Droid X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>1987</td>
<td>2010</td>
</tr>
<tr>
<td>Cost</td>
<td>$2000</td>
<td>$199 w/contract</td>
</tr>
<tr>
<td>Form factor</td>
<td>½ desktop</td>
<td>Pocket</td>
</tr>
<tr>
<td>CPU</td>
<td>12 MHz 80286</td>
<td>1GHz TI OMAP</td>
</tr>
<tr>
<td>Memory</td>
<td>512KB</td>
<td>512MB</td>
</tr>
<tr>
<td>Storage</td>
<td>20MB hard disk, 1.2MB floppy</td>
<td>8+ GB</td>
</tr>
<tr>
<td>Display</td>
<td>80x25 monochrome text</td>
<td>480x804 pixel color</td>
</tr>
<tr>
<td>Peripherals</td>
<td>Keyboard</td>
<td>Camera, phone, web</td>
</tr>
<tr>
<td>Connectivity</td>
<td>5000 baud dialup modem</td>
<td>3G, WiFi</td>
</tr>
</tbody>
</table>

1987 vs. 2010

$10 base; 60% growth

<table>
<thead>
<tr>
<th>Year</th>
<th>Salary</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$10</td>
<td>Base</td>
</tr>
<tr>
<td>3</td>
<td>$40</td>
<td>Still live at home</td>
</tr>
<tr>
<td>16</td>
<td>$18K</td>
<td>Buy car</td>
</tr>
<tr>
<td>21</td>
<td>$193K</td>
<td>Buy median house in Madison</td>
</tr>
<tr>
<td>36</td>
<td>$223M</td>
<td>Need fundamentally new ways to spend money</td>
</tr>
<tr>
<td>51</td>
<td>$2.5T</td>
<td>Replace US Federal Government</td>
</tr>
</tbody>
</table>

Performance Growth

Unmatched by any other industry! [John Crawford, Intel]

- Doubling every 18 months (1982-1996): 800x
  - Cars travel at 44,000 mph and get 16,000 mpg
  - Air travel: LA to NY in 22 seconds (MACH 800)
  - Wheat yield: 80,000 bushels per acre

- Doubling every 24 months (1971-1996): 9,000x
  - Cars travel at 600,000 mph, get 150,000 mpg
  - Air travel: LA to NY in 2 seconds (MACH 9,000)
  - Wheat yield: 900,000 bushels per acre
**This Course**

This course will:
- Help you understand the significance and pervasiveness of computers in today's society and economy
- Teach you how computers really operate and how they are designed
- Introduce you to concepts that students in the Computer Engineering and Computer Science degree programs learn in depth over four years
- Prepare and motivate you for study in these degree programs (CMPE, EE, CS)
- Counts towards GCR introduction to engineering requirement

**Course Outline**

- **Prerequisite** – none
- **Major topics in course**
  - Introduction to computers and computing
  - Information representation and manipulation
  - Logic elements and combinational Logic
  - Sequential Logic and Memory
  - Simple computer organization, design and operation
  - Machine language and instruction set architecture
  - Assembly language
  - Programming constructs

**Typical Weekly Structure**

- **Monday lecture Ani Sci 212**
  - Prepare by reading text beforehand
- **On your own**
  - Watch online lecture + examples
- **Wed discussion**
  - Individual & team quiz
  - Review
- **Fri discussion**
  - Quiz or applied homework
  - Review, homework help

**Web Page & Syllabus**

- [http://ece252.ece.wisc.edu](http://ece252.ece.wisc.edu)
- Instructor & TAs
- Textbook
- Lecture Notes
- Discussion sections
- Schedule
- LC-3 Simulator
- Grading
- Exams
- Homework

**Reminders/Advice**

- **Textbook** – read BEFORE corresponding lecture
- **Online lectures** – view before discussion
  - Quizzes will assume that you have
- **Homework** – completed in groups (not hw1)
  - Will reinforce in-class coverage
  - Will help you prepare for midterm exams
- **Study Groups of ~4**
  - Assigned in your discussion section
  - Should meet weekly outside of discussion
  - Review material, complete homework assignments

**Technology**

- Technology advances at astounding rate
  - 19th century: attempts to build mechanical computers
  - Early 20th century: mechanical counting systems (cash registers, etc.)
  - Mid 20th century: vacuum tubes as switches
  - Since: transistors, integrated circuits
- 1965: Moore's law [Gordon Moore]
  - Predicted doubling of capacity every 18 months
  - Has held and will continue to hold
- Drives functionality, performance, cost
  - Exponential improvement for 40 years
Some History

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>1st transistor</td>
<td>Bell Labs</td>
</tr>
<tr>
<td>1958</td>
<td>1st IC</td>
<td>Jack Kilby (MSEE ’50) @TI</td>
</tr>
<tr>
<td></td>
<td>Winner of 2000 Nobel prize</td>
<td></td>
</tr>
<tr>
<td>1971</td>
<td>1st microprocessor</td>
<td>Intel (calculator market)</td>
</tr>
<tr>
<td>1974</td>
<td>Intel 4004</td>
<td>2300 transistors</td>
</tr>
<tr>
<td>1978</td>
<td>Intel 8086</td>
<td>29K transistors</td>
</tr>
<tr>
<td>1989</td>
<td>Intel 80486</td>
<td>1M transistors</td>
</tr>
<tr>
<td>1995</td>
<td>Intel Pentium Pro</td>
<td>5.5M transistors</td>
</tr>
<tr>
<td>2006</td>
<td>Intel Montecito</td>
<td>1.7B transistors</td>
</tr>
<tr>
<td>201x</td>
<td>IBM</td>
<td>50B transistors</td>
</tr>
</tbody>
</table>

Applications

- Corollary to Moore’s Law: Cost halves every two years
- Computers cost-effective for:
  - National security – weapons design
  - Enterprise computing – banking
  - Departmental computing – computer-aided design
  - Personal computer – spreadsheets, email, web
  - Smartphone – camera, calendar, email, web, games
  - Pervasive computing – computers everywhere
- Countless industries revolutionized

Abstraction and Complexity

- Abstraction helps us manage complexity
- Complex interfaces:
  - Specify what to do
  - Hide details of how
- Goal: Use abstractions yet still understand details

Programmable Computers

- Many computers today are embedded
  - Fixed functionality
  - Appliance-like
  - Not really programmable by end user
- Not the focus of this course!
  - Instead, programmable computers
  - Embedded/appliance computers still programmed!
  - Learn to think of computer as a programmable device
- Program?
  - Algorithm or set of steps that computer follows
  - Human brains wired to work this way

Additional Information

- Resources for Special Help
  - McBurney Center – alternative testing or other arrangements
  - Course problem consultation: Prof. Lipasti
  - Broader problem consultation: advisor or counselor
- Academic Misconduct
  - We really don’t expect it to happen
  - Please don’t disappoint us
  - Serious repercussions:
    - Academic record, dismissal from university
    - Only hurting yourself and your future

Wrapping Up

- Readings
  - Chapter 1: Welcome Aboard
- Homework 1 on the course web site
  - Due Monday 9/12 in class (week after Labor day)
- Schedule for next few weeks

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9/5, 9/7, 9/9</td>
<td>Labor Day</td>
<td>Ch 1 lecture</td>
<td>Ch1 discussion</td>
</tr>
<tr>
<td>2</td>
<td>9/12, 9/14, 9/16</td>
<td>Ch 2 lecture</td>
<td>Ch 2 discussion</td>
<td>Ch 2 discussion</td>
</tr>
<tr>
<td>3</td>
<td>9/19, 9/21, 9/23</td>
<td>Ch 2 lecture</td>
<td>Ch 2 discussion</td>
<td>Exam I review</td>
</tr>
<tr>
<td>4</td>
<td>9/26, 9/28, 9/30</td>
<td>Ch 3 lecture</td>
<td>Midterm I</td>
<td>Ch 3 discussion</td>
</tr>
</tbody>
</table>