Welcome!

Comp 411 Spring 2017
Computer Organization
Gary Bishop
Lecture 1
Topics for today

★ Course Mechanics
★ Course Objectives
★ What is Information?
★ Computer Abstractions
Some of these slides were developed by Leonard McMillan and adapted by Gary Bishop and Montek Singh.
Course Mechanics

*Grading:*

- **Problem sets:** 25%
  - 5-7 problem sets
  - Lowest one will be dropped
- **In-Class Quizzes:** 15%
- **Three Exams:** 35%
- **Lab:** 25%
  - 9-10 lab assignments focused on assembly, C, and Linux
  - Fridays
Course Mechanics

★ Policies:

- **Problem Sets:**
  - Will be distributed on the web. You will typically have 1 week to do them, but sometimes more or less time.
  - Late problem sets will not be accepted, but the lowest problem-set score will be dropped.

- **Honor Code:**
  - The honor code is in effect for all homework, labs, exams etc. Please review the policy on the course website.

- **Lecture Notes:**
  - I will attempt to make Lecture Slides, Problem Sets, and other course materials available on the web either before class, or soon after, on the day they are given.
Prerequisites

**COMP401: Foundations of Programming**

- This is a hard prerequisite

You must know at least the following concepts:

- basic data types: integers, characters, Boolean, etc.
- basic arithmetic operators and expressions
- “if-then-else” constructs, and “while”/“for” loops
- function and procedure calls
- basic Boolean operators (AND, OR, XOR, etc.)
How to do well in this course

★ Attend lectures (stay awake!)
★ Read the book!
  ● Big mistake = only reviewing lecture slides
★ Do all homework
  ● Start early. Many problem sets are too hard to attempt the night before.
★ Ask questions in class
★ Discuss with other students
  ● But all work handed must be your own (see Honor Code)
★ Use all materials from this semester only
  ● Much of the material (lecture slides, homework) has changed
  ● Looking up solutions from earlier semesters = cheating. Not worth it.
Welcome

Welcome to the site for Comp 411 section 2 for spring 17.

Published: Wed 11 January 2017
By Gary Bishop
In Announcements.
Who I am

I am a Professor of Computer Science at the University of North Carolina at Chapel Hill. My students and I develop software designed to enable people with disabilities to participate fully in education, literacy and play.

Quick Links

- Comp 411
- Comp 580
- Tar Heel Gameplay is our new site with games everyone can play.
- Check out Tar Heel Reader, our site with books for beginning readers.
- UNC Open Web Project
- Accessible YouTube choose and play YouTube videos using only 2 keys.
- Download the older, windows only, Hark the Sound, sound games for kids who are blind or visually impaired.
- Read about our work on enabling technology
- Look for ideas for enabling technology projects
- Check my calendar to find an open time we could meet
Who are you?

* Too many to do here...
* I’ll send a form to help me get to know you.
Goal 1: Demystify Computers

* Strangely, most people (even some computer scientists) are afraid of computers.

- We are only afraid of things we do not understand!
  - I do not fear computers. I fear the lack of them.
    - Isaac Asimov (1920 - 1992)

  - Fear is the main source of superstition, and one of the main sources of cruelty. To conquer fear is the beginning of wisdom.
    - Bertrand Russell (1872 – 1970)
Computers Everywhere

* The computers we are used to
  * Desktops
  * Laptops

* Embedded processors
  * Cars
  * Mobile phones
  * Toasters, irons, wristwatches, happy-meal toys
Goal 2: Power of Abstraction

🌟 What is *abstraction*?

- Define a function, develop a robust implementation, and then put a box around it.

🌟 Why is abstraction useful?

- enables us to create unfathomable machines called computers
- imagine a billion --- 1,000,000,000
Abstraction is key to building systems with >1G components

- **Personal Computer:** Hardware & Software
- **Circuit Board:** ≈8 / system 1-2G devices
- **Integrated Circuit:** ≈8-16 / PCB 0.25M-16M devices
- **Module:** ≈8-16 / IC 100K devices
- **Gate:** ≈2-8 / Cell 8 devices
- **Cell:** ≈1K-10K / Module 16-64 devices

MOSFET = “transistor” = “device”

Scheme for representing information
Our Plan of Attack…

- Understand how things work, by alternating between low-level (*bottom-up*) and high level (*top-down*) concepts
- Encapsulate our understanding using appropriate abstractions
- Study organizational principles: abstractions, interfaces, APIs.

- Roll up our sleeves and design at each level of hierarchy
- Learn engineering tricks at each level
A Computer System

- What is a computer system?
- Where does it start?
- Where does it end?

Compiler

```
for (i = 0; i < 3; i++)
    m += i*i;
```

Assembler and Linker

- `addi $8, $6, $6`
- `sll $8, $8, 4`

CPU

Module

Cells

Gates

Transistors

 valves

Gates and Transistors

Cells

Module

CPU

Compiler

Assembler and Linker

for (i = 0; i < 3; i++)
    m += i*i;

addi $8, $6, $6
sll $8, $8, 4

What is a computer system?

Where does it start?

Where does it end?
Computer Layer Cake

- Applications
- Systems software
- Shared libraries
- Operating System
- Hardware – the bare metal

Computers are digital Chameleons

<table>
<thead>
<tr>
<th>Apps</th>
<th>Systems S/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Libraries</td>
<td></td>
</tr>
<tr>
<td>Operating System</td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td></td>
</tr>
</tbody>
</table>
Under the Covers

- Input
- Output
- Storage
- Processing
  - Datapath
  - Control
Issues for Modern Computers

- GHz clock speeds
- Multiple instructions per clock cycle
- Multi-core
- Memory wall
- I/O bottlenecks
- Power dissipation
- Implementation tech changes

http://www.hotchips.org/
Implementation Technology

- Relays
- Vacuum Tubes
- Transistors
- Integrated Circuits
  - Gate-level integration
  - Medium Scale Integration (PALs)
  - Large Scale Integration (Processing unit on a chip)
  - Today (Multiple CPUs on a chip)
- Nanotubes?
- Quantum-Effect Devices?
- DNA?
Implementation Technology

• **Common Links?**
  - A controllable switch

• **Computers are wires and switches**

![Diagram showing a controllable switch in open and closed states with control signals](image)

- **open**
- **closed**
- **control**
Chips

 Silicon Wafers

• Chip manufactures build many copies of the same circuit onto a single wafer.
  ➢ Only a percentage of the chips will work; those that work will run at different speeds. The yield decreases as the size of the chips increases and the feature size decreases.

• Wafers are processed by automated fabrication lines.
  ➢ To minimize the chance of contaminants ruining a process step, great care is taken to maintain a meticulously clean environment.
Chips

🌟 Silicon Wafers

IBM photomicrograph

- Metal 2
- M1/M2 via
- Metal 1
- Polysilicon
- Diffusion
- Mosfet (under polysilicon gate)
What is “Computation”? 

🌟 Computation is about “processing information”
- Transforming information from one form to another
- Deriving new information from old
- Finding information associated with a given input

🌟 “Computation” describes the motion of information through time

🌟 “Communication” describes the motion of information through space
What is “Information”?

**information, n.**
Knowledge communicated or received *concerning a particular fact or circumstance.*

*Carolina won again.*

Tell me something *new...*

**A Computer Scientist’s Definition:**

Information resolves uncertainty. Information is simply that which cannot be predicted. The less predictable a message is, the more information it conveys!

“10 Problem sets, 2 quizzes, and a final!”
Real-World Information

Why do unexpected messages get allocated the biggest headlines?

... because they carry the most information.
What Does A Computer Process?

- A Toaster processes bread and bagels
- A Blender processes smoothies and margaritas
- What does a computer process?
  - Information
  - Bits
- What is the mapping from information to bits?
Next Lecture

- We meet next on Wednesday 18 Jan
- No lab this Friday
- Computer Representations
- How do computers represent:
  - Text?
  - Numbers?
  - Everything else?