

# Introduction to Computing Systems: From Bits and Gates to C and Beyond 2<sup>nd</sup> Edition

Yale N. Patt  
Sanjay J. Patel

Original slides from Gregory Byrd, North Carolina State University  
Modified slides by Chris Wilcox, Colorado State University



## Lecture Goals

- ◆ Review course logistics
  - Assignments
  - Policies
  - Organization
  - Grading Criteria
- ◆ Introduce key concepts
  - Role of Abstraction
  - Software versus Hardware
  - Universal Computing Devices
  - Layered Model of Computing

## Logistics

- ◆ Lectures: Tue and Thu from 9:30-10:45am in Glover 130
- ◆ Recitations (COMSC 225)
  - Tue 1:00-1:50pm, Chris Wilcox
  - Wed 10:00-10:50am, Ferydoon Vafaei
  - Wed 11:00-11:50am, Ferydoon Vafaie
  - Fri. 11:00-11:50am, Awad Younis
- ◆ Lab Hours: To Be Announced
- ◆ Materials on the website and RamCT:
  - <http://www.cs.colostate.edu/~cs270>
  - <http://ramct.colostate.edu>

## Assignments

Assignments and quizzes are posted on RamCT:

- ◆ Weekly assignments (mostly) alternate between written and programming assignments
- ◆ Homework assignments are due in hardcopy on original handout on Thu. at 10:00pm
- ◆ Programming assignments are submitted in electronic form Thu. at 10:00pm
- ◆ Late submission for both is Fri. at 11:59pm, under my office door (COMSC 256)

## Policies

- ◆ Grading Criteria
  - Assignments (40%)
  - Recitations (10%)
  - Peer Instruction (5%)
  - Midterm Exam (20%)
  - Final Exam (25%)
- ◆ Late Policy
  - On-time = full points, up to 24 hours = 20% penalty
- ◆ Academic Integrity
  - <http://www.cs.colostate.edu/~info/student-info.html>
  - Do your own work
  - Be smart about Internet resources

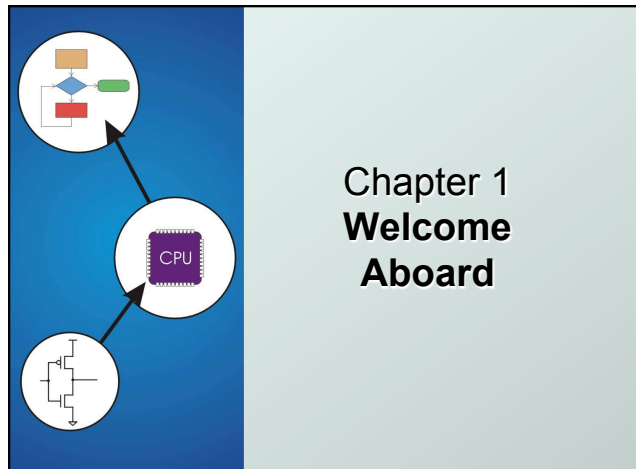
## Organization

- ◆ 1/3 computer hardware: numbers and bits, transistors, gates, digital logic, state machines, von Neumann model, instruction sets, LC-3 architecture
- ◆ 1/3 assembly code: instruction formats, branching and control, LC-3 programming, subroutines, memory model (stack)
- ◆ 1/3 C programming: data types, language syntax, variables and operators, control structures, functions, pointers and arrays, memory model, recursion, I/O, data structures

## Grading Criteria

How to be successful in this class:

- 1) Attend all classes and recitations, info will be presented that you can't get anywhere else.
- 2) Do all the homework assignments, ask questions (early!) if you run into trouble.
- 3) Take advantage of lab sessions where help is available from instructors.
- 4) Read the textbook, work through the end of chapter problems.



**Chapter 1  
Welcome  
Aboard**

## Introduction to the World of Computing

- Computer: electronic genius?
  - NO! **Electronic idiot!**
  - Does exactly what we tell it to, nothing more.
- Goal of the course:
  - You will be able to write programs in C and understand what's going on underneath.**
- Approach:
  - Build understanding from the bottom up.
  - Bits ⇒ Transistors ⇒ Gates ⇒ Logic ⇒ Processor ⇒ Instructions ⇒ Assembly Code ⇒ C Programming**

## Two Recurring Themes

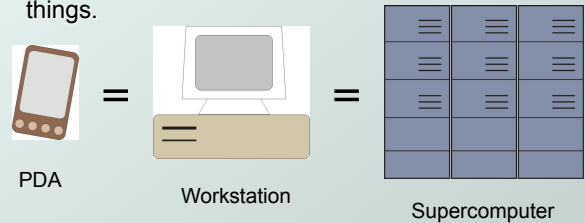
- Abstraction**
  - Productivity enhancer – don't need to worry about details...
    - Can drive a car without knowing how the internal combustion engine works.**
  - ...until something goes wrong!
    - Where's the dipstick?**
    - What's a spark plug?**
  - Important to understand the components and how they work together.

## Two Recurring Themes

- Hardware vs. Software**
  - It's not either/or – both are components of a computer system that cooperate.
  - Even if you specialize in one, you should understand capabilities and limitations of both.
  - The best programmers understand the computer systems which run their programs.
  - Computers are an entire ecosystem with multiple levels of abstraction.

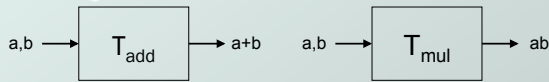
## Big Idea #1: Universal Computing Devices

- All computers, given enough time and memory, are capable of computing exactly the same things.



## Turing Machine

- Mathematical model of a device that can perform any computation – Alan Turing (1937)
  - ability to read/write symbols on an infinite “tape”
  - state transitions, based on current state and symbol
- Every computation can be performed by some Turing machine. (*Turing’s thesis*)



Turing machine that adds

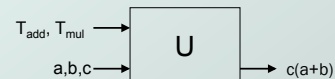
Turing machine that multiplies

For more info about Turing machines, see [http://www.wikipedia.org/wiki/Turing\\_machine/](http://www.wikipedia.org/wiki/Turing_machine/)

For more about Alan Turing, see <http://www.turing.org.uk/turing/>

## Universal Turing Machine

- A machine that can implement all Turing machines -- this is also a Turing machine!
  - inputs: data, description of computation (other TMs)



Universal Turing Machine

Universal machine is **programmable** – so is a computer!

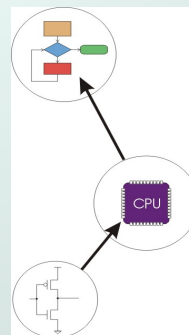
- instructions are part of the input data
- a computer can emulate a Universal Turing Machine

**A computer is a universal computing device.**

## From Theory to Practice

- In theory, computer can **compute** anything
- that’s possible to compute
  - given enough *memory* and *time*
- In practice, **solving problems** involves computing under constraints.
  - time
    - weather forecast, next frame of animation, ...
  - cost
    - cell phone, automotive engine controller, ...
  - power
    - cell phone, handheld video game, ...

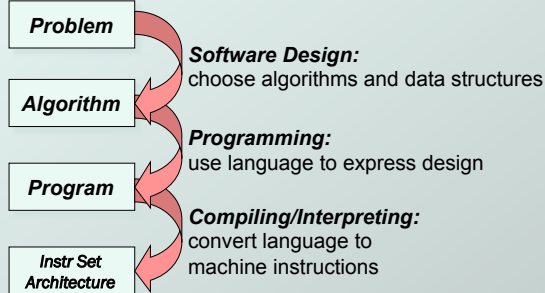
## Big Idea #2: Transformations Between Layers



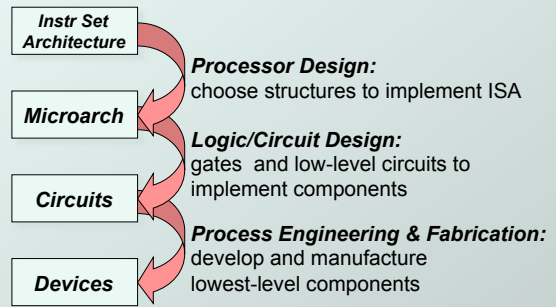
- Problems
- Algorithms
- Language
- Instruction Set Architecture
- Microarchitecture
- Circuits
- Devices

## How do we solve a problem using a computer?

- A systematic sequence of transformations between layers of abstraction.



## Deeper and Deeper...



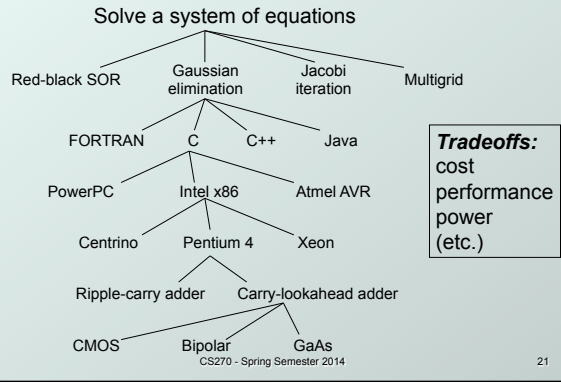
## Descriptions of Each Level

- **Problem Statement**
  - stated using "natural language"
  - may be ambiguous, imprecise
- **Algorithm**
  - step-by-step procedure, guaranteed to finish
  - definiteness, effective computability, finiteness
- **Program**
  - express the algorithm using a computer language
  - high-level language, low-level language
- **Instruction Set Architecture (ISA)**
  - specifies the set of instructions the computer can perform
  - data types, addressing mode

## Descriptions of Each Level (cont.)

- **Microarchitecture**
  - detailed organization of a processor implementation
  - different implementations of a single ISA
- **Logic Circuits**
  - combine basic operations to realize microarchitecture
  - many different ways to implement a single function (e.g., addition)
- **Devices**
  - properties of materials, manufacturability

## Many Choices at Each Level



## Book Outline

- ◆ **Bits and Bytes**
    - How do we represent information using electrical signals?
  - ◆ **Digital Logic**
    - How do we build circuits to process information?
  - ◆ **Processor and Instruction Set**
    - How do we build a processor out of logic elements?
    - What operations (instructions) will we implement?
  - ◆ **Assembly Language Programming**
    - How do we use processor instructions to implement algorithms?
    - How do we write modular, reusable code? (subroutines)
  - ◆ **I/O, Traps, and Interrupts**
    - How does processor communicate with outside world?
  - ◆ **C Programming**
    - How do we write programs in C?
- CS270 - Spring Semester 2014 22