Computer Science 210
Computer Systems 1

Lecture Notes

Lecture 2

Introduction

Credits: Slides adapted from Gregory T. Byrd, North Carolina State University

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Introduction to Computing Systems:

From Bits and Gates to C and Beyond

2nd Edition

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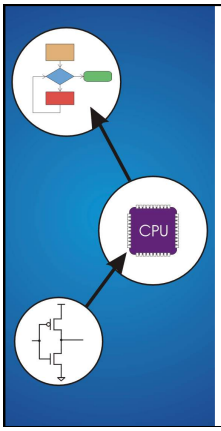
Based on slides originally prepared by
Gregory T. Byrd, North Carolina State University



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 – no magic!
- Approach:
- Build understanding from the bottom up.
- Bits ➨ Gates ➨ Processor ➨ Instructions ➨ C Programming

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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.
- Hardware vs. Software
  - It's not either/or – both are components of a computer system.
  - Even if you specialize in one, it is important to understand capabilities and limitations of both.

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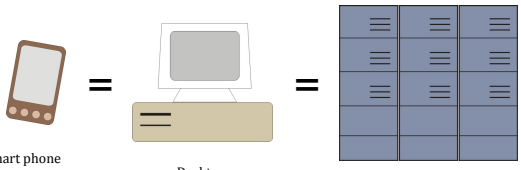
Big Idea #1: Universal Computing Device

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



Smart phone = Desktop = Supercomputer

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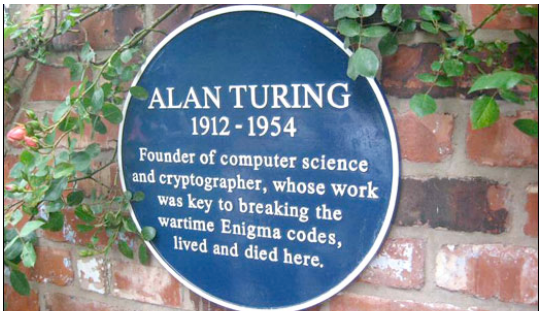

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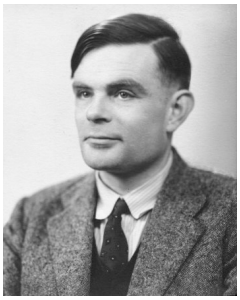
Alan Turing



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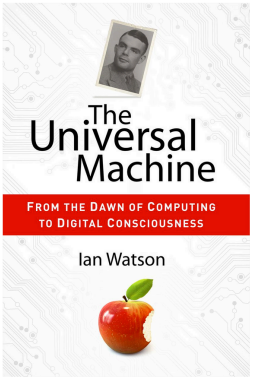
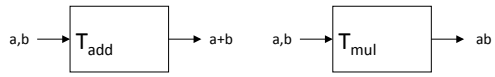


Turing Machine

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/

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

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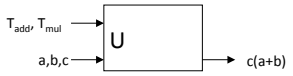
Universal Turing Machine

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



Universal Turing Machine

U 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
Video http://vimeo.com/33559758

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From Theory to Practice

In theory, computer can *compute* anything that's possible to compute
- (Caveat) 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, ...

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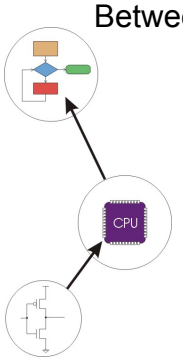
Big Idea #2: Transformations Between Layers



Problems

Algorithms

Language

Instruction Set Architecture

Microarchitecture

Circuits

Devices

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How do we solve a problem using a computer?

A systematic sequence of transformations between layers of abstraction

Problem

Algorithm

Program

Instr Set Architecture

Software Design: choose algorithms and data structures

Programming: use language to express design

Compiling/Interpreting: convert language to machine instructions

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Deeper and Deeper…

Instr Set Architecture

Microarch

Circuits

Devices

Processor Design: choose structures to implement ISA

Logic/Circuit Design: gates and low-level circuits to implement components

Process Engineering & Fabrication: develop and manufacture lowest-level components

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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

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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

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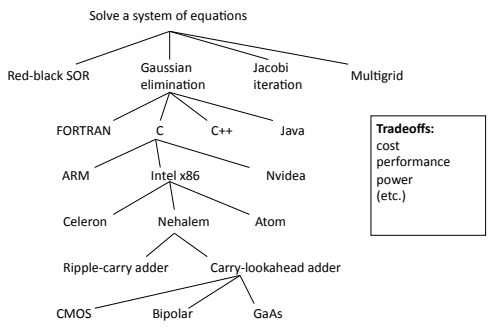
Many Choices at Each Level



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Course 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?
  - How do we implement high-level programming constructs?

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