Lecture Goals

Review course logistics
- Assignments & quizzes
- Policies
- Organization
- Grading Criteria

Introduce key concepts
- Role of Abstraction
- Software versus Hardware
- Universal Computing Devices
- Layered Model of Computing

Logistics

Lectures: See syllabus
Staff: See syllabus
Recitations: See syllabus
Help desks: See syllabus
Office hours: See syllabus

Materials on the website:
- http://www.cs.colostate.edu/~cs270
- Piazza: access through Canvas, or directly

Assignments & Quizzes

Assignments
- Posted on Progress page of the course website
- Programming (C, LC-3) or Logisim circuit designs
- See Canvas for due dates
- Submit via Checkin before 11:59 PM (unless otherwise specified).
- There is no late period - don’t play Clock Chicken.
- Regrading requests in Piazza (see the syllabus for policies).

Quizzes:
- Can be on-line (canvas) or in-class (using iClicker)

Policies

Grading Criteria
- Assignments (20%)
- Recitations (10%)
- Quizzes and iClicker (10%)
- Two Midterm Exams (20% each)
- Final Exam (20%)

Late Policy
- None accepted

Academic Integrity
- http://www.cs.colostate.edu/~info/student-info.html
- Do your own work
- Cannot copy and paste any code, unless provided by us

People

Instructors:
- Russ Wakefield

Graduate Teaching assistants:
- Fahad Ullah
- Zahra Borhani
- Hari Hara Kumar Rajanala

Undergraduate Teaching Assistants:
- Nick Odell
- Keagan Strawn

Office hours/locations
- See course website
Organization

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

Top Down Perspective

- Multilayered view:
  - Higher layers serves as the specification.
  - Lower layer implements provides the implementation
- We will see
  - How a higher level language (C) is implemented by a processor instruction-set architecture (ISA), LC-3 in our case?
  - How an ISA is implemented using digital circuits?
  - How are digital circuits implemented using transistors?
  - And so on...

Grading Criteria

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Points</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>≥90%</td>
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<tr>
<td>B</td>
<td>≥80%</td>
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<tr>
<td>C</td>
<td>≥70%</td>
</tr>
<tr>
<td>D</td>
<td>≥60%</td>
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</tbody>
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- We will not cut higher than this, but we may cut lower.
- Your average score on exams must be ≥65% to receive a passing grade in this course.

How to be successful in this class

1) Read the textbook.
2) Attend all classes and recitations.
3) Take the in-class and on-line quizzes as required.
4) Do all the assignments yourself,
   - ask questions (early! (but not too early!)) if you run into trouble.
5) Take advantage of lab sessions where help is available from TAs,
   - but try to do it yourself first, too much help can be harmful.

Text book:
Introduction to Computing Systems: From Bits and Gates to C and Beyond
2nd Edition
Yale N. Patt and Sanjay J. Patel

Slides based on G. T. Byrd, NCState, © McGraw-Hill,
With modifications/additions by CSU Faculty
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,
  you should understand capabilities and limitations of both.

Big Idea #1: Universal Computing Device

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

Hardware vs. Software

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)

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)

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

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

Digital Circuits

Devices
How do we solve a problem using a computer?

A systematic sequence of transformations between layers of abstraction.

- Problem
- Software Design: choose algorithms and data structures
- Algorithm
- Programming: use language to express design
- Program
- Compiling/Interpreting: convert language to machine instructions

Deeper and Deeper...

- Processor Design: choose structures to implement ISA
- Instr Set
- Architecture
- Microarch
- Logic/Circuit Design: gates and low-level circuits to implement components
- DigCircuits
- Devices
- Process Engineering & Fabrication: develop and manufacture lowest-level components

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 processor (CPU) 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

iClicker Quiz (trial)

Registration

- Please register your iClicker using canvas and bring it every time
- Ensure you are using the right channel

Quiz: Pick one: Instruction Set Architecture (ISA)

- A. specifies the set of instructions the CPU can perform
- B. Architecture of a high level language
- C. How transistors are used to form digital circuits
- D. Architecture of a C program
- E. All of the above

iClicker Quiz (trial) Answer

Quiz: Pick one: Instruction Set Architecture (ISA)

- A. specifies the set of instructions the CPU can perform
- B. Architecture of a high level language
- C. How transistors are used to form digital circuits
- D. Architecture of a C program
- E. All of the above
Many Choices at Each Level

Solve a system of equations

- Gaussian elimination
- Jacobi iteration
- Multigrid
- Red-black SOR

Tradeoffs:
- cost
- performance
- power
  (etc.)

Course Outline

Bits and Bytes
- How do we represent information using electrical signals?

C Programming
- How do we write programs in C?
- How do we implement high-level programming constructs?

Instruction set architecture/Assembly language
- What operations (instructions) will we implement?
- 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?

Digital Logic and processor architecture
- How do we build circuits to process and store information?
- How do we build a processor out of logic elements?

Computer systems: what is next?