CS 31: Introduction to Computer Systems

August 30th 2016

Course Staff

Professor: Bryce Wiedenbeck (call me Bryce)

- I'm a Swattie (class of '08).
- My research is on algorithmic game theory.
- My primary hobby is ultimate Frisbee.

Ninjas:

Lu Min

Rachel

Jeff

Emily

Douglass

Meeting times

Lecture: Tue/Thu 1:15-2:30 SCI 199

Lab: Wed

- A: 10:30-12 Clothier 016 (bookstore lab)
- B: 1:15-2:45 SCI 240
- C: 2:30-4 SCI 240

Ninja Session: Sun 7-11pm SCI 240

Office Hours: M 11-1:30, Tu 2:30-4:30, Th 2:30-4

Ninja Sessions and Office Hours

- Lecture + Lab = 2 * 1:15 + 1:30 = 4 hours of class
- Ninja session: 4 additional hours every week
- Office hours: 6 additional hours every week

Take advantage of this time!

If all you do is come to lecture and lab, you are not getting the most out of this class.

Resources

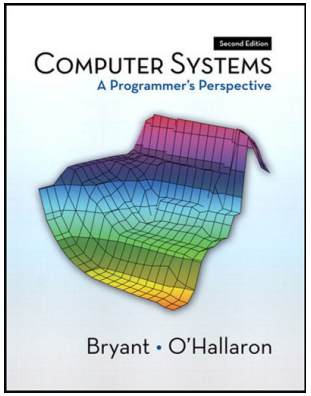
Course web page:

cs.swarthmore.edu/~bryce/cs31/f16

Piazza forum:

piazza.com/swarthmore/fall2016/cs31

Supplemental textbook (on reserve in Cornell)



Grading

35% Lab assignments (two late days total)
25% Midterm exam
25% Final exam
5% Written homework
5% Reading quizzes (lowest three dropped)
5% Class participation

Reading Quizzes

- Readings from online sources
- Target low difficulty: did you read?
- Goal: incentivize / reward preparation
  - Can be an easy 5%!
- You may bring handwritten notes.

Class Participation

General format:

- I will pose a question or problem.
- You will first answer on your own.
- You will then compare answers with your neighbors and discuss until you agree.
- You will then answer again (everyone in the group must submit the same answer).

This means you need to sit next to other people!

Class Participation

Why are we using this format?

Research shows that people learn better this way!

If I spent the entire class lecturing, I might be able to present more information, but you would retain less of it.

Clickers!

- Record which one you took.
  - Write it down.
  - Take a picture.
  - Email yourself.
- Register your clicker: clickers.cs.swarthmore.edu
- Return it to the correct bin after class.
- Use the same clicker every time.

Things you need to do this week

TODAY

- Register your clicker
- Complete Lab 0
- Attend *Using Unix* session (7-8 pm SCI 256)

TOMORROW

- Attend lab
- Reading for Thursday

Let’s get started!

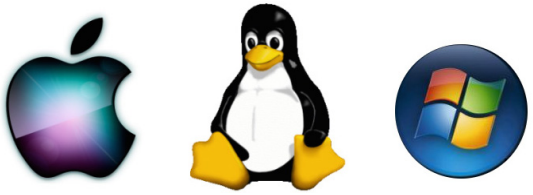
How does a computer run your program?

1. Compiler translates c code into an executable.
2. Shell forks a new process.
3. Operating systems allocates resources to the process.
4. CPU loads instructions and data from memory.
5. Instructions specify calculations to perform on the data.
6. Current passing through circuits carries out calculations.
7. Circuits are composed of gates, which are built from wires and transistors.

The system stack

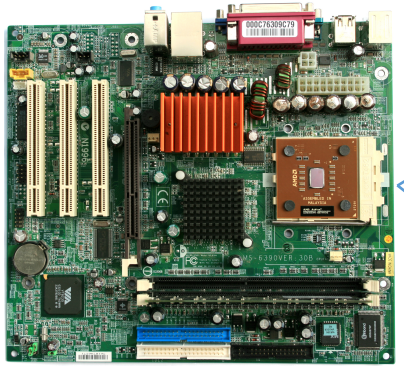
This class

software



- c program
- compiler
- shell
- operating system

hardware



- memory
- CPU
- circuits
- gates

electrical engineering

- transistors
- wires

This class builds from the bottom up

Order of systems topics:

- Binary representation of data
- Building simple circuits from gates
- Building a CPU from simple circuits
- Assembly language
- Memory
- Operating systems
- Processes
- Parallel Programming

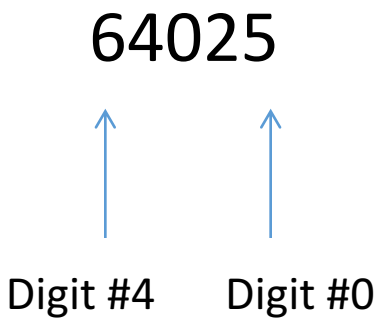
We'll also learn lots of c programming along the way.

Binary numbers

- How computers represent all data.
- Strings are represented as a sequence of characters, and each character is represented by a number.
- The screen is a collection of pixels, and each pixel's color is represented by several numbers.
- All numbers are in binary: they're made up of ones and zeros.

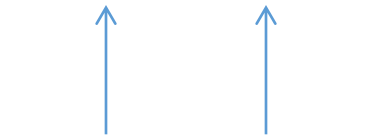
Let’s start with what we know…

- Decimal number system (Base 10)
- Sequence of digits in range [0, 9]



What is the significance of the N^{th} digit in this number system? What does it contribute to the overall value?

64025



Digit #4 d_4

Digit #0 d_0

A. $d_N * 1$
B. $d_N * 10$
C. $d_N * 10^N$
D. $d_N * N^{10}$
E. $d_N * 10^{d_N}$

Consider the meaning of d_3 (the value 4) above. What is it contributing to the total value?

Positional Notation

- The meaning of a digit depends on its position in a number.

A number, written as the sequence of digits

$d_n d_{n-1} \ldots d_2 d_1 d_0$ in base b represents the value

$$d_n * b^n + d_{n-1} * b^{n-1} + \ldots + d_2 * b^2 + d_1 * b^1 + d_0 * b^0$$

Decimal: Base 10

- Used by humans

A number, written as the sequence of digits

$d_n d_{n-1} \ldots d_2 d_1 d_0$ where d is in {0,1,2,3,4,5,6,7,8,9}

represents the value:

$$d_n * 10^n + d_{n-1} * 10^{n-1} + \ldots + d_2 * 10^2 + d_1 * 10^1 + d_0 * 10^0$$

64025 =

$6 * 10^4 +$ $4 * 10^3 +$ $0 * 10^2 +$ $2 * 10^1 +$ $5 * 10^0$

60000+ 4000 + 0 + 20 + 5

Binary: Base 2

- Used by computers

A number, written as the sequence of digits $d_n d_{n-1} \ldots d_2 d_1 d_0$ where d is in {0,1}, represents the value

$$d_n * 2^n + d_{n-1} * 2^{n-1} + \ldots + d_2 * 2^2 + d_1 * 2^1 + d_0 * 2^0$$

What is the value of 110101 in decimal?

A number, written as the sequence of digits $d_n d_{n-1} \ldots d_2 d_1 d_0$ where d is in {0,1}, represents the value

$$d_n * 2^n + d_{n-1} * 2^{n-1} + \ldots + d_2 * 2^2 + d_1 * 2^1 + d_0 * 2^0$$

A. 26
B. 53
C. 61
D. 106
E. 128

Converting Decimal → Binary

- Two methods:
  - division by two remainder
  - powers of two and subtraction

Method 1: decimal value D, binary result b (b_i is ith digit):

```
i = 0
while (D > 0)
  if D is odd
       set b_i to 1
  if D is even
       set b_i to 0
  i++
  D = D/2
```

Example: Converting 105

```
idea:    D = b          example: D = 105          a0 = 1
```

Method 1: decimal value D, binary result b (b_i is ith digit):

```
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```

Example: Converting 105

```
idea:    D = b          example: D = 105          a0 = 1
         D/2 = b/2               D =  52          a1 = 0
         D/2 = b/2               D =  26          a2 = 0
         D/2 = b/2               D =  13          a3 = 1
         D/2 = b/2               D =   6          a4 = 0
         D/2 = b/2               D =   3          a5 = 1
         D/2 = b/2               D =   1          a6 = 1
           0 =  0                D =   0          a7 = 0

                                  105   =  01101001
```

Method 2

$2^0 = 1$, $2^1 = 2$, $2^2 = 4$, $2^3 = 8$, $2^4 = 16$, $2^5 = 32$, $2^6 = 64$, $2^7 = 128$

- To convert 105:
  - Find largest power of two that's less than 105 (64)
  - Subtract 64 (105 – 64 = 41), put a 1 in d_6
  - Subtract 32 (41 – 32 = 9), put a 1 in d_5
  - Skip 16, it's larger than 9, put a 0 in d_4
  - Subtract 8 (9 – 8 = 1), put a 1 in d_3
  - Skip 4 and 2, put a 0 in d_2 and d_1
  - Subtract 1 (1 – 1 = 0), put a 1 in d_0 (Done)

$$\underline{1}\quad\underline{1}\quad\underline{0}\quad\underline{1}\quad\underline{0}\quad\underline{0}\quad\underline{1}$$

What is the value of 357 in binary?

A. 101100011
B. 101100101
C. 101101001
D. 101110101
E. 110100101

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