CSE 370 Spring 2006
Introduction to Digital Design
Lecture 1: Introduction

Today
- Course overview
- Intro to Digital Design

People
Instructor: Dave Bacon

Teaching Assistants:
Adrienne Wang
Benjamin Ylvisaker
Firat Kiyak

Things Internet
Website:
http://www.cs.washington.edu/cse370

Mailing list:
signup:
http://majordomo.cs.washington.edu/mailman/listinfo/cse370
archives:
https://mailman.cs.washington.edu/mailman/private/cse370/

Signup! Signup! Signup! Signup! Signup! Signup! Signup!

Things Textual
Contemporary Logic Design (2nd Edition)
Randy H. Katz
University of California, Berkeley
Gaetano Borriello
University of Washington
Class Components

2. Reading: Weekly assignments, posted on website
3. Laboratory Assignments: 9 labs, starting this week. Last lab, two weeks. Although you will be able to access the lab all week, attendance at one of the scheduled times is very important as that is when the Teaching Assistants will be available. Attend the laboratory session for which you are registered.
5. Quizzes: Four quizzes. Unannounced. No make-ups. 15 to 20 minutes. Lowest of four scores will be dropped.
6. Final Exam: Monday June 5, 8:30-10:20 in 231 Mary Gates Hall.

Grading

- 30% Homework
- 20% Labs
- 20% Quizzes
- 30% Final exam

We would like nothing better than to give everyone a 4.0

Homework and Quizzes

Homeworks:
Due at beginning of class.

Penalties:
- 10% for handing in on due date, during or after class
- 10% for handing in over the weekend
- 10% for each additional day late
(EX: due Friday: -10% for after class, -20% for weekend, -30% for Monday, etc.)

Quizzes:
No makeups. Drop your lowest (of four) scores.

Collaboration and Cheating

Collaboration
Collaboration on homework is encouraged provided that you first (1) spend fifteen minutes on your own working on the problem and (2) you write up each and every problem in your own writing, using your own words, and understand the solution fully. Copying homework without following these rules is cheating

Cheating
If you are caught cheating, you can expect a failing grade in the course and an initiation of a cheating case in the University system. Not good. So don't cheat. Repeat: don't cheat.

Don't email or post your solutions. Post general questions. If in doubt about what might constitute cheating talk or email me!
CSE 370 Intro to Digital Design

Why CSE 370?
- It’s required.
- An important set of skills
  - How do we design digital hardware?
- If you can’t derive it from the foundations, you don’t understand it:
  - The foundations of digital computing
- Learn
  - How does digital hardware work?

Information Processing Revolutions

How Old is the Information Processing Revolution?
- Invention of writing (~6000 years ago)
- Invention of human language (~100,000 years ago)
- Sexual reproduction (~1,000,000,000 years ago)
- Life on Earth (~4,600,000,000 years ago)
- Origin of the Universe? (~14,000,000,000 years ago)

Midst of A Great Revolution

The Digital Age
- Processing power
  - Doubling every 18 months
  - Factor 100 per decade
- Storage capacity
  - Doubling every 12 months
  - Factor 1000 per decade
- Optical fiber capacity
  - Doubling every 9 months
  - Factor 10000 per decade
- How do we get here?

Diophantus of Alexandria

Διόφαντος ὁ Αλεξανδρεύς
Hellenized Babylonian
circa ~200 BCE

Arithmetica
130 problems and their numerical solutions.

Alexandrian age was era when foundations of discrete math were laid.

“Father of Algebra”

1691 version of Arithmetica
Muḥammad ibn Mūsā al-Ḵwārizmī

Persian, circa 850 CE

_al-Kitāb al-muḥtaṣar fī ḥisāb al-ğabr wa-l-muqābala_

Systematic solution of linear and quadratic equations

“Father of Algebra”

Words: “Algorithm”, “Algebra”, “Algorism”

Latin, _Algoritmi de numero Indorum_ introduced Hindu-Arabic positional number system.

Charles Babbage and Ada Lovelace

- **Difference Engine** (never completed)
  - Calculator
  - 1822

- **Analytical Engine** (never completed)
  - First programmable computer design
  - 1834-Babbage’s death in 1871
  - Ada Lovelace wrote a detailed program, becoming the first computer programmer.

Leibnitz and Boole

- **Gottfried Leibnitz**
  - _Explication de l'Arithmétique Binaire_ 1705
  - Binary arithmetic, 0/1
  - Machine for adding, subtracting, multiplying

- **George Boole**
  - _Explication de l'Arithmétique Binaire_ 1854
  - Boolean Logic 0/1 ↔ True/False
  - Math of logical statements, Boolean Algebra

Claude Shannon

- **Claude Shannon**
  - Master's Thesis 1938: _A Symbolic Analysis of Relay and Switching Circuits_
  - Realized Boole’s algebra could be used to simplify telephone relay networks
  - Realized that electromagnetic relays could be used to implement Boolean algebra

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\[ \text{OR} \quad A \lor B \rightarrow \bar{A} \bar{B} \]
Computer Hardware

Logic
- NOR
- Adder

Memory
- Latch

Adder
A | B | Sum | Carry
---|---|-----|-----
0 | 0 | 0   | 0
0 | 1 | 1   | 0
1 | 0 | 1   | 0
1 | 1 | 0   | 1

Alan Turing
- 1936: On Computable Numbers, with an Application to the Entscheidungsproblem
- Codified a model of computation, the Turing machine.
- Universal Turing machine
- There exist functions which are not computable!

John von Neumann
- Stored program computers
  (an idea had earlier by Zuse, Mauchley, Eckert, Brainerd, and others)
- von Neumann architecture

Stored Program = Software
- Bill Gates and Paul Allen, Lakeside, 1968
Hardware + Software

Algorithm

Program

Memory

Logic (CPU)

Problem

Program

Data

ENIAC

- 1946, First electronic computer
- 19000 vacuum tubes
- 200 kilowatts
- 360 multiplies per second
- 27 tons
- failed once every 2 days

Invention of the Transistor

Bardeen, Shockley, Brattain

1947:

Nobel Prize in Physics, 1956

1958:

Mark Bohr (Intel)

Integrated Circuit

Jack Kilby

Robert Noyce

1958:

Nobel Prize in Physics, 2000

2000:

Courtesy Yan Borodovsky, Intel
Microprocessor

1968-1971: microprocessor invention

Ted Hoff

Intel 4004
- 2300 transistors
- 3mm by 4mm
- As powerful as ENIAC

Moore’s Law

Moore’s Law
- Number of transistors on an integrated circuit doubles every 18 months

Moore’s Law

Gordon Moore

Feature Size (nm)

Year

Personal Microcomputers

Apple II

IBM PC

“Prediction is very difficult, especially if it’s about the future.”

Niels Bohr
Into the Future

- Ubiquitous computing
  - Computers everywhere

- BusBuddy (Jeff Lin, Artem Zhurid, Beltran Ibarra Davila-Armero, UW)
  - Real time updates of bus information

What Is Digital Design?

- Using digital logic…
  - The underlying basis is Boolean algebra
  - The physical basis is transistor switches

  …to solve a problem
  - Within size, cost, and other bounds
  - Within the constraints imposed by our bases
    - Encode as logic statement
    - Compile into physical hardware

  …with logical values encoded as physical quantities
  - If \(0V < \text{voltage} < 0.8V\) then symbol is a “0”
  - If \(2.0V < \text{voltage} < 5V\) then symbol is a “1”

Some Terminology

- Digital: discrete-valued
  - Usually binary, 0 or 1.
  - Transistor switches have two states (on-off)

- Combinatorial
  - Without memory, output depends on present input

- Sequential
  - With memory, output depends on present and/or past

- Synchronous
  - Values change at discrete timesteps (clocked)

What You Will Learn

- CSE 370
  - Physical devices (transistors, resistors, wires)
  - Switches
  - Truth tables
  - Boolean algebra
  - Combinational logic
  - Sequential logic
  - State in digital systems
  - Finite-state machines
  - Hardware description languages
  - Register-transfer description
  - Concurrent abstract specifications
Your To Do List

- Things Internet
  - Familiarize yourself with the website
  - Sign up for mailing list

- Things Reading
  - Week 1 reading (on website): pp.1-27, Appendix A, pp.33-46

- Things Homework
  - Homework 1 posted on website (due this Friday)

- Things Laboratory
  - Attend first lab session