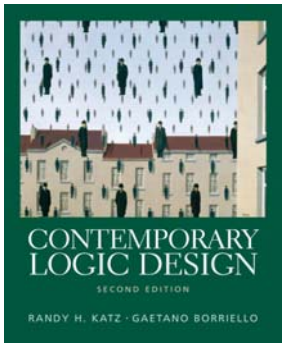
CSE 370 Spring 2006
Introduction to Digital Design

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:

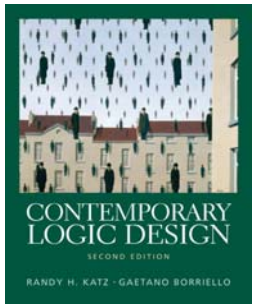
`http://www.cs.washington.edu/cse370`

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

1. **Lectures:** 28 lectures. Attend, participate.
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.
4. **Homework:** Weekly assignments.
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.

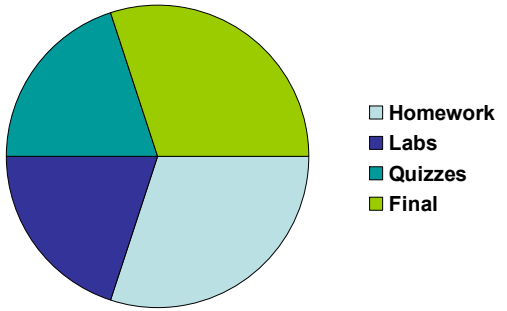
Grading

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 latei

(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


DIOPHANTI
ALEXANDRINI
ARITHMETICORVM
LIBRI SEX.
ET DE NVMERIS MVLTANGVLIS
LIBER VNVS.
Nunc primum Græcè & Latinè editi, atque absolutissimis Commentariis illustrati.
AVCTORE CLAVDIO GASPARE BACHETO
MEZIRIACO SEBVSIANO, V.C.
LVTETIAE PARISIORVM,
Sumptibus SEBASTIANI CRAMOISY, via Iacobæa, sub Ciconiis.
M. DC. XXI.
CVM PRIVILEGIO REGIS

1691 version of *Arithmetica*

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"

Muḥammad ibn Mūsā al-Ḵwārizmī

page from *al-Kitāb al-muḫtaṣar fī ḥisāb al-ğabr wa-l-muqābala*

محمد بن موسى الخوارزمي
Persian, circa 850 CE

al-Kitāb al-muḫtaṣar fī ḥisāb al-ğabr wa-l-muqābala

Systematic solution of linear and quadratic equations

"Father of Algebra"

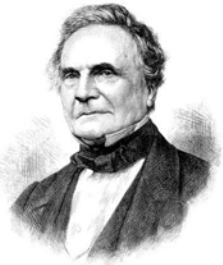
Words: "Algorithm", "Algebra", "Algorism"

Latin, *Algoritmi de numero Indorum* introduced Hindu-Arabic positional number system.

Charles Babbage and Ada Lovelace

- Difference Engine (never completed)
  - Calculator
  - 1822

Andy Carol's Lego Difference Engine



Charles Babbage

- 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.

Ada Lovelace

Leibnitz and Boole

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

Gottfried Leibnitz

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

NOT

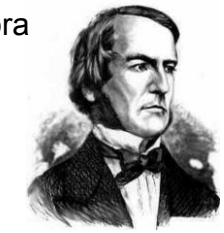
A	Out
0	1
1	0

AND

A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1

OR

A	B	Out
0	0	0
0	1	1
1	0	1
1	1	1

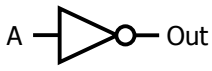


Geroge Boole

Claude Shannon

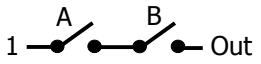
- Claude Shannon
  - Master's Thesis 1938: *A Symbolic Analysis of Relay and Switching Circuits*
  - Realized Boole's algebra could be used to simplify telephone relay networks
  - Realized that electromagnetic relays could be used to implement Boolean algebra

Claude Shannon



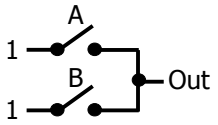
NOT

A	Out
0	1
1	0



AND

A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1

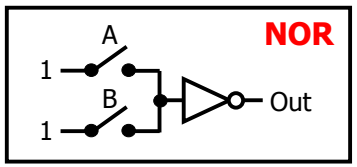


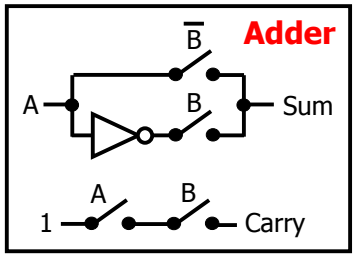
OR

A	B	Out
0	0	0
0	1	1
1	0	1
1	1	1

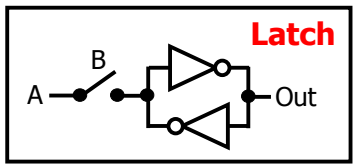
Computer Hardware

Logic





Memory



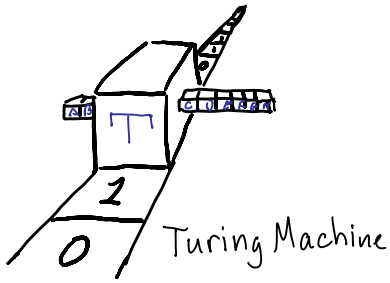
Adder

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Alan Turing

Alan Turing

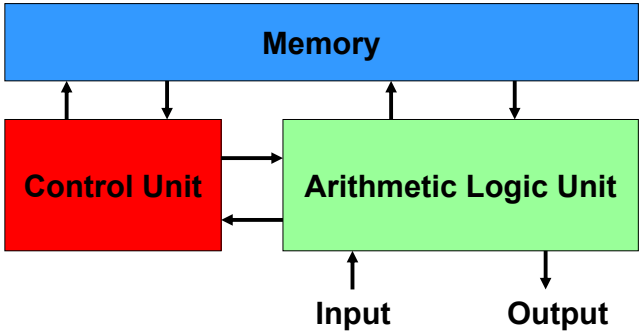
- Alan Turing
  - 1936: *On Computable Numbers, with an Application to the Entscheidungsproblem*
  - Codified a model of computation, the Turing machine.
  - Universal Turing machine
  - There exist functions which are not computable!



John von Neumann

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

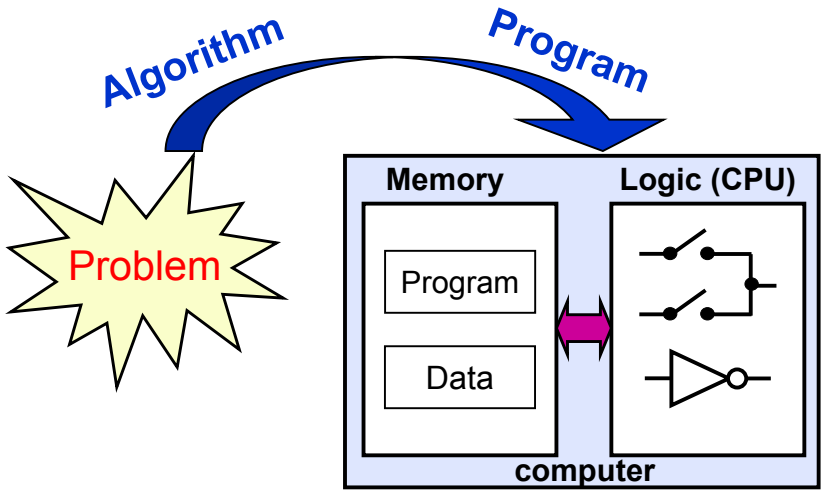
John von Neumann



Stored Program = Software

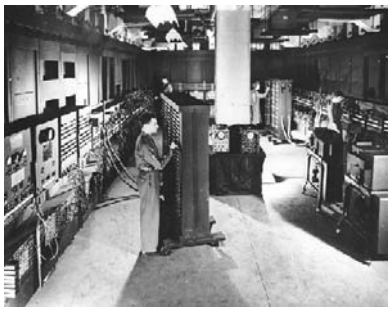
Bill Gates and Paul Allen, Lakeside, 1968

Hardware + Software



ENIAC

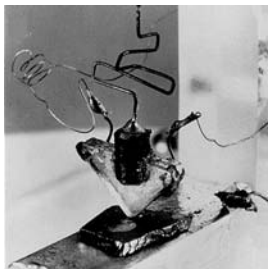
- 1946, First electronic computer
  - 19000 vacuum tubes
  - 200 kilowatts
  - 360 multiplies per second
  - 27 tons
  - failed once every 2 days



Invention of the Transistor

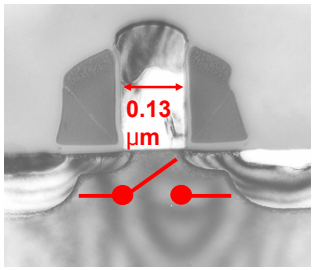
Bardeen, Shockley, Brattain

1947:



Nobel Prize in Physics, 1956

2000:



Mark Bohr (Intel)

Integrated Circuit

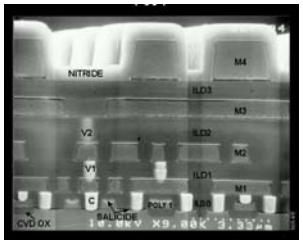
Jack Kilby

Robert Noyce

1958:

Nobel Prize in Physics, 2000

2000:



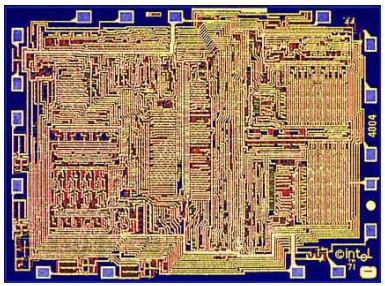
Courtesy Yan Borodovsky, Intel

Microprocessor

1968-1971: microprocessor invention

Ted Hoff

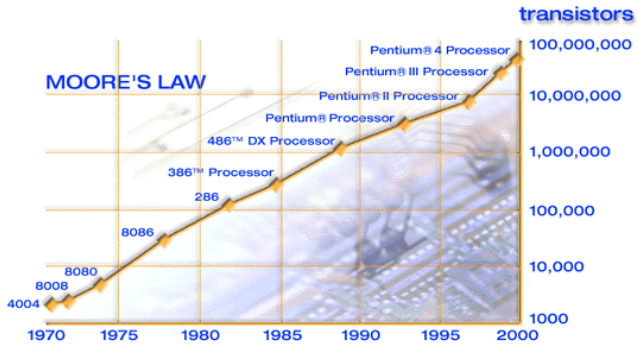
- Intel 4004
  - 2300 transistors
  - 3mm by 4mm
  - As powerful as ENIAC



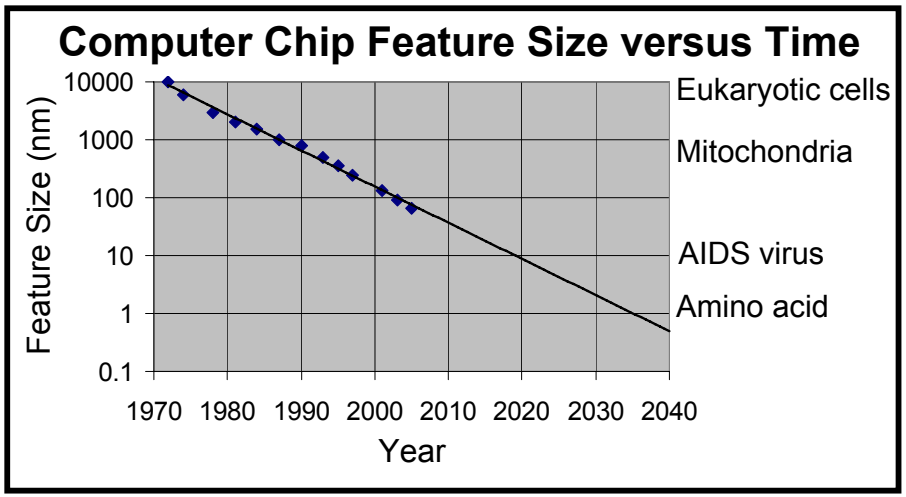
Moore's Law

Gordon Moore

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



Into the Future



"Prediction is very difficult, especially if it's about the future."

Niels Bohr

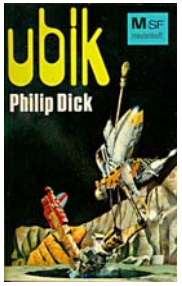
Personal Microcomputers

Apple II

IBM PC

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 < *voltage* < 0.8V) then *symbol* is a “0”
  - If (2.0V < *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