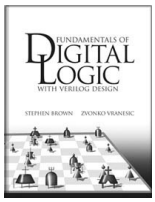
Welcome to CSE370

- Instructor: Bruce Hemingway
  - TAs: Bryan Nelson and John Hwang
  - Tool Specialist: Cory Crawford
- Class web
  - http://www.cs.washington.edu/education/courses/370/CurrentQtr/
  - Add yourself to the mailing list→ see the web page
- Today's lecture
  - Course overview
  - The Digital Age

Special Thanks!

Lecture Materials:

- Chris Diorio
- Gaetano Borrielo
- Carl Ebeling



- **Stephen Brown and Zvonko Vranesic, *Fundamentals of Digital Logic with Verilog Design*, 1st Edition, McGraw-Hill, 2003**

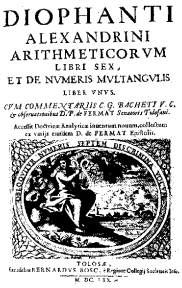
Why you are here

- Required class
- To learn about digital design
  - Design process and techniques
  - The basis for digital computing
- Exposure to new ideas
  - Emergent behavior
    - Complex functions from simple elements
    - With only NORs and wire you can build a computer
  - Parallel computation
    - Digital hardware is inherently parallel

The Digital Age

- Computing is in its infancy
  - Processing power
    - Doubles every 18 months
    - Factor of 100 / decade
  - Disk capacity
    - Doubles every 12 months
    - Factor of 1000 / decade
  - Optical fiber transmission capacity
    - Doubles every 9 months
    - Factor of 10,000 / decade
- The bases are mathematics and switches
  - How did we get here?

Diophantus of Alexandria b. ~200 BCE


DIOPHANTI
ALEXANDRINI
ARITHMETICORVM
LIBRI SEX,
ET DE NVMERIS MVLTANGVLIS
LIBER VNVS.
CVM COMMENTARIIS C. G. BACHETI V. C.
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Known as the "father of algebra"

***Arithmetica* is a collection of 130 problems that gives numerical solutions of determinate equations, which have a unique solution, and indeterminate equations.**

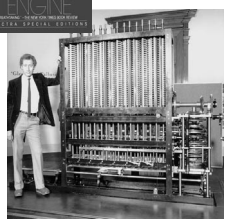
The Later Alexandrian Age was a time when mathematicians were discovering many ideas that lead to our concept of mathematics today.

850 AD

- Abu Ja'far Muhammad ibn Musa **al-Khwarizmi**
- Lived in Baghdad, 780 to 850 AD. One of the first to write on algebra (using words, not letters) and also Hindu-Arabic numbers (1, 2, 3, ...).
- From his name and writings came the words "algebra" and "algorithm".
- Book: *Hisab **al-jabr** w'al-muqabala*

1822

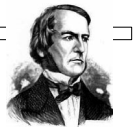
- Charles Babbage
  - Father of computing
- 1822 Difference Engine
  - A calculator
- 1834 Analytical Engine
  - A computer
  - Programmable



Analytical Engine

1854

- George Boole
  - Boolean algebra
- Number system with 2 values
  - 0/1 ⇔ false/true
  - Do math on logic statements
  - 3 operations (NOT, AND, OR)



All computers use Boolean algebra

NOT

A	Out
0	1
1	0

AND

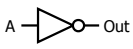
A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1

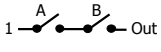
OR

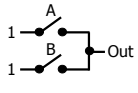
A	B	Out
0	0	0
0	1	1
1	0	1
1	1	1

1938

- Claude Shannon
  - Implemented Boolean algebra using switches
  - Described information using binary digits (bits)







NOT

A	Out
0	1
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AND

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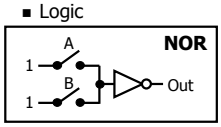
0	1	0
1	0	0
1	1	1

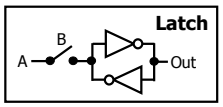
OR

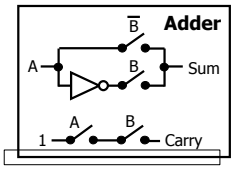
A	B	Out
0	0	0
0	1	1
1	0	1
1	1	1

Computer Hardware

- Components
  - Logic
  - Memory







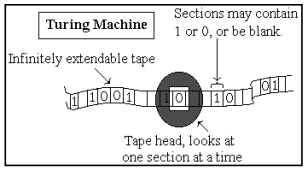
Adder

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

1937

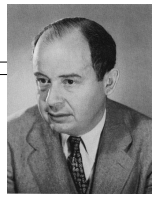
- Alan Turing
  - Turing Machines
- Simple computer model
  - Can something be computed?

Also pioneered artificial intelligence



1945

- John von Neumann
  - First stored computer program
- A sequence of operations
  - Read from memory
  - Operate using logic gates
  - Store result into memory

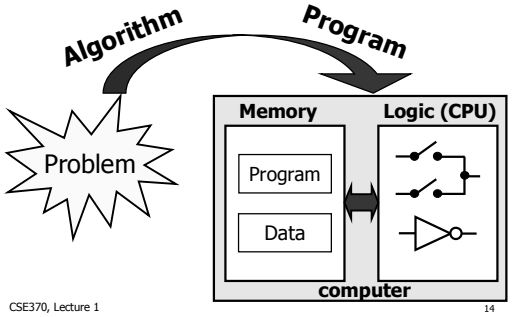


Other contributions:
Quantum Mechanics
Cellular Automata
Game Theory

Stored Programs = Software

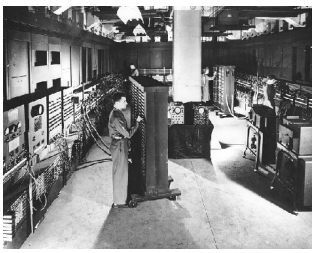
Bill Gates and Paul Allen, Lakeside, 1968

Hardware + Software



1946

- ENIAC…the first computer
  - Vacuum tubes for switches



1000x faster than anything before...

19,000 tubes

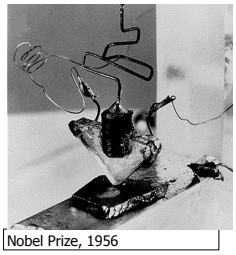
200 kilowatts

357 multiplies per second

1947

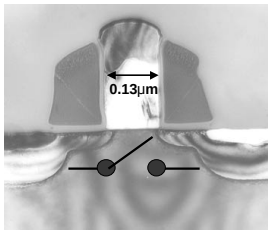
- Bardeen, Brattain, Shockley invent the transistor

1947



Nobel Prize, 1956

2000



Courtesy Mark Bohr, Intel

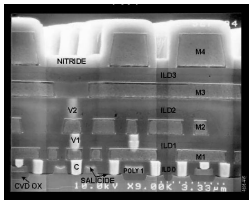
1958

- Kilby and Noyce invent the integrated circuit

1958

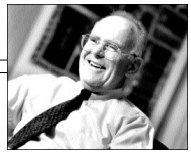
Nobel Prize, 2000

2000

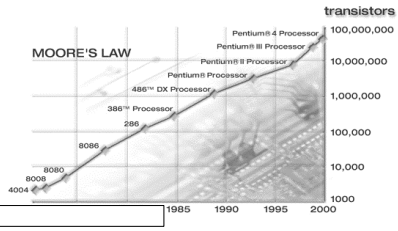


Courtesy Yan Borodovsky, Intel

1965



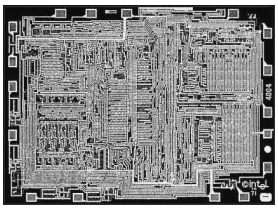
- Gordon Moore
  - Moore's Law: The transistor density of silicon chips doubles every 18 months



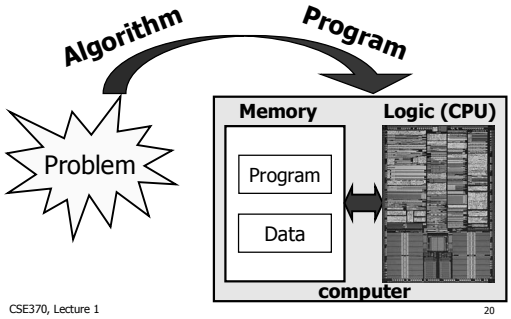
1971

- Ted Hoff invents the microprocessor

- Intel 4004
  - 2,300 transistors
  - 3 mm by 4 mm
  - As powerful as the ENIAC

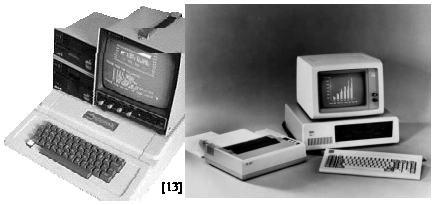


Hardware + Software + Technology



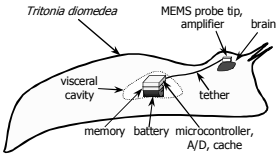
1977 and 1981

- Apple II and IBM PC
  - The first microcomputers



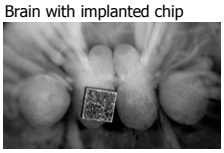
A modern example

- Goal: Interface a computer to an animal brain
  - Measure brain signals in intact animals



Tritonia and seapen

Brain with implanted chip



Courtesy Jim Beck and Russell Wyeth

More modern examples

- Computing everywhere
  - Wireless/wired networking
  - Wearable devices
  - Smart sensors

What is logic 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 logical statements
    - 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"

Terminology

- Digital: Discrete-valued
  - Usually binary
  - Transistor switches have 2 states (on/off)
- Combinational: Without memory
  - Output depends on present input
- Sequential: With memory (state)
  - Output depends on present and/or past inputs
- Synchronous: Values change at discrete timesteps
  - Synchronous ⇔ clocked

What you will learn in CSE370

- 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