A Little History...

CS 202 - Spring 2016
Professor Christopher Andrews
In the beginning...

- 300 B.C. - The Salamis Tablet
- 1200 A.D. - the abacus appears
An idea is born...

- 1630 - William Oughtred develops the slide rule
1624 - **Blaise Pascal** and the **Pascaline**

- a geared device that can add & subtract
- multiplication and division are added in the next two centuries
Punch cards

- 1800 - Joseph Jacquard develops the Jacquard Loom
Industrial Revolution

- Charles Babbage
  - The Difference Engine (1820) - steam powered device for generating mathematical tables
  - The Analytical Engine (1834) - essentially the first computer
Lady Ada Lovelace
- Considered to be the first programmer
- The concept of the loop is credited to her
The Dawn of Computers

- 1936 - Alan Turing
  - Writes a critical essay describing the Turing Machine

- 1938 - Konrad Zuse develops the Z1
World War II

- The Allies form a team of code breakers at Bletchley Park to crack the Enigma code
- Tommy Flowers designs the Colossus computer
The Mark I

- 1944 - **Howard Aiken** develops the **Mark I**
  - the first all electronic calculator

- The Mark I is half as long as a football field and contains 500 miles of wire

- Used electro-mechanical relays
  - calculations took 3-5 seconds *apiece*

- 1945 - The first actual computer bug is identified...
The ABC

- 1937 - **John Atanasoff** builds the Atanasoff-Berry Computer (ABC) at Iowa State
The First Generation (1946 - 1959)

- Vacuum Tubes
  - large, generated a lot of heat and not terribly reliable
The First Generation (1946 - 1959)

- Magnetic Drum
  - memory device that rotated under a magnetic head
The ENIAC

- **Electronic Numerical Integrator And Computer**
- Was developed to calculate trajectory tables for the military
  - work began in 1943 and finished in 1946 - too late for the war
  - in use until 1955
- Eckert and Mauchly working at UPenn
- Considered the first fully functional, *all electric, programable* computer
ENIAC Facts

- Worked on decimal numbers - not binary
- Programmed manually using switches
  - Think old time telephone operators...
- Used vacuum tubes rather than relays
- Contained 18,000 vacuum tubes, 70,000 resistors and over 5 million soldered joints
- Consumed 140 kW of power
- 5,000 operations a second
  - About 20,000 times faster than the Mark I
The ENIAC at Work
Repairing the ENIAC

Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.
von Neumann Architecture

1945 - John von Neumann
- Realized that there was no real difference between program instructions and data - it is all just bits (stored-program concept)

The Architecture
- I/O devices
- Main memory (short term)
- Secondary memory (long term)
- Central Processing Unit (the brains)
The Architecture
IAS computer

- Developed at Princeton’s Institute for Advanced Studies in 1946
  - Completed in 1952
- We can consider it to be a prototype of all subsequent general purpose computers
Structure of the IAS
## ISA Instruction Set

<table>
<thead>
<tr>
<th>Instruction Type</th>
<th>Opcode</th>
<th>Symbolic Representation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data transfer</td>
<td>00001010</td>
<td>LOAD MQ</td>
<td>Transfer contents of register MQ to the accumulator AC</td>
</tr>
<tr>
<td></td>
<td>00001001</td>
<td>LOAD MQ,M(X)</td>
<td>Transfer contents of memory location X to MQ</td>
</tr>
<tr>
<td></td>
<td>00100001</td>
<td>STOR M(X)</td>
<td>Transfer contents of accumulator to memory location X</td>
</tr>
<tr>
<td></td>
<td>00000001</td>
<td>LOAD M(X)</td>
<td>Transfer M(X) to the accumulator</td>
</tr>
<tr>
<td></td>
<td>00000010</td>
<td>LOAD ~M(X)</td>
<td>Transfer ~M(X) to the accumulator</td>
</tr>
<tr>
<td></td>
<td>00000011</td>
<td>LOAD</td>
<td>M(X)</td>
</tr>
<tr>
<td></td>
<td>00000100</td>
<td>LOAD</td>
<td>M(X)</td>
</tr>
<tr>
<td>Unconditional branch</td>
<td>00001101</td>
<td>JUMP M(X,0:19)</td>
<td>Take next instruction from left half of M(X)</td>
</tr>
<tr>
<td></td>
<td>00001110</td>
<td>JUMP M(X,20:39)</td>
<td>Take next instruction from right half of M(X)</td>
</tr>
<tr>
<td>Conditional branch</td>
<td>00001111</td>
<td>JUMP+ M(X,0:19)</td>
<td>If number in the accumulator is nonnegative, take next instruction from left half of M(X)</td>
</tr>
<tr>
<td></td>
<td>00010000</td>
<td>JUMP+ M(X,20:39)</td>
<td>If number in the accumulator is nonnegative, take next instruction from right half of M(X)</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>00000101</td>
<td>ADD M(X)</td>
<td>Add M(X) to AC; put the result in AC</td>
</tr>
<tr>
<td></td>
<td>00000111</td>
<td>ADD</td>
<td>M(X)</td>
</tr>
<tr>
<td></td>
<td>00000110</td>
<td>SUB M(X)</td>
<td>Subtract M(X) from AC; put the result in AC</td>
</tr>
<tr>
<td></td>
<td>00001000</td>
<td>SUB</td>
<td>M(X)</td>
</tr>
<tr>
<td></td>
<td>00001011</td>
<td>MUL M(X)</td>
<td>Multiply M(X) by MQ; put most significant bits of result in AC, put least significant bits in MQ</td>
</tr>
<tr>
<td></td>
<td>00001100</td>
<td>DIV M(X)</td>
<td>Divide AC by M(X); put the quotient in MQ and the remainder in AC</td>
</tr>
<tr>
<td></td>
<td>00010100</td>
<td>LSH</td>
<td>Divide accumulator by 2, i.e., shift left one bit position</td>
</tr>
<tr>
<td></td>
<td>00010101</td>
<td>RSH</td>
<td>Divide accumulator by 2, i.e., shift right one position</td>
</tr>
<tr>
<td>Address modify</td>
<td>00010010</td>
<td>STOR M(X,8:19)</td>
<td>Replace left address field at M(X) by 12 rightmost bits of AC</td>
</tr>
<tr>
<td></td>
<td>00010011</td>
<td>STOR M(X,28:39)</td>
<td>Replace right address field at M(X) by 12 rightmost bits of AC</td>
</tr>
</tbody>
</table>
Harvard architecture

Data memory

Address

Data

Instructions

Instruction memory

Address

CPU
The UNIVAC

- **UNIVersal Automatic Computer**
  - First commercial computer, released in 1951
- Based upon the von Neumann architecture
- Product of the Eckert-Mauchly Computer Corporation
- Many generations of the UNIVAC
  - around for thirty years or so
The Second Generation (1959-1965)

- The Transistor
  - smaller, faster, cheaper and more reliable than the vacuum tube

- Magnetic Core Memory
  - instant access to items in memory
Transistors

- Invented in 1947 by Bardeen, Brattain and Shockley
- Solid State (no moving parts)
- Silicon
- Low heat dissipation
- Just a switch...
Figure 3-1. (a) A transistor inverter. (b) A NAND gate. (c) A NOR gate.
Magnetic Core Memory

- Used tiny, doughnut shaped devices
  - one per bit
- Always available
  - i.e. instant access to data
- No moving parts
The Third Generation (1965-1971)

- Integrated Circuits
  - solid pieces of silicon containing multiple components
  - much smaller, faster cheaper and more reliable than printed circuit boards
Silicon Wafer
IC Memory

- Memory moved from cores to ICs as well
  - replace a single core (1 bit) with 256 bit IC
- Non-destructive read
  - unlike core memory
- Much faster
- Still volatile
  - i.e. goes away when the power is turned off
Moore’s Law

- 1965 - Gordon Moore
  - Co-founder of Intel
- Predicted that the number of circuits that could be placed on a single IC would double each year
  - or 18 months... or 10 months, or every few years
- Chip cost has stayed the same
- Tighter packing means shorter interconnects
  - faster
  - more reliable
  - reduced power and cooling requirements
Moore’s Law

Moore’s Law - 2005

Transistors Per Die

1965 Data (Moore)
Memory
Microprocessor

Source: Intel
Moore’s Law

Moore’s law really is dead this time
The chip industry is no longer going to treat Gordon Moore’s law as the target to aim for.

by Peter Bright - Feb 10, 2016 8:22pm EST

http://arstechnica.com/information-technology/2016/02/moores-law-really-is-dead-this-time/#p3
Other Advancements

- 1960 - DEC developed the first **terminal**
  - keyboard and screen for direct interaction with computer
- 1962 - Stanford and Purdue open the first CS departments
- 1962 - The first computer game is created at MIT
- 1964 - Doug Englebart develops the mouse
- 1968 - The birth of **Arpanet**
Space War

- Developed by Steve Russell, MIT grad student
PDP 8

- The first of the *minicomputers*
The Fourth Generation (1971- ...)

- **Large Scale Integrated Circuits**
  - able to put a whole microcomputer on a single chip

- Brought about the PC revolution
  - chips were now small enough and cheap enough to create *personal computers*

- Innovations come fast and furious
Enter the Microprocessor...
## Ascendancy of Intel

<table>
<thead>
<tr>
<th>Model Number</th>
<th>First Delivery</th>
<th>Clock rate</th>
<th>Bus width</th>
<th>Addressable memory</th>
<th>Number of Transistors</th>
</tr>
</thead>
<tbody>
<tr>
<td>4004</td>
<td>11/15/71</td>
<td>740 kHz</td>
<td>4 bits</td>
<td>640 bytes</td>
<td>2,300</td>
</tr>
<tr>
<td>8008</td>
<td>4/1/72</td>
<td>0.5-0.8 MHz</td>
<td>8 bits</td>
<td>16 KB</td>
<td>3,500</td>
</tr>
<tr>
<td>8080</td>
<td>4/1/72</td>
<td>2 MHz</td>
<td>8 bits</td>
<td>16 KB</td>
<td>6,000</td>
</tr>
<tr>
<td>8086 / 8088</td>
<td>6/8/78</td>
<td>5-10 MHz</td>
<td>16 bits</td>
<td>1 MB</td>
<td>29,000</td>
</tr>
</tbody>
</table>
The first personal computer

- 1975 - The first PC, the Altair 8800 is released on the public
An innovation... that vanished

- 1973 - Xerox PARC develops the Alto
  - uses ethernet connection, a mouse and the first GUI
Birth of Apple

- 1977 - **Steve Jobs** and **Steve Wozniak** form Apple Computers
  - the Apple II is released from their garage
The IBM PC

- 1981 - Release of the first IBM Personal Computer
The GUI hits the mainstream

- 1984 - The Macintosh Computer says hello
Hitting the power wall

**FIGURE 1.15** Clock rate and Power for Intel x86 microprocessors over eight generations and 25 years. The Pentium 4 made a dramatic jump in clock rate and power but less so in performance. The Prescott thermal problems led to the abandonment of the Pentium 4 line. The Core 2 line reverts to a simpler pipeline with lower clock rates and multiple processors per chip. Copyright © 2009 Elsevier, Inc. All rights reserved.
FIGURE 1.16 Growth in processor performance since the mid-1980s. This chart plots performance relative to the VAX 11/780 as measured by the SPECint benchmarks (see Section 1.8). Prior to the mid-1980s, processor performance growth was largely technology-driven and averaged about 25% per year. The increase in growth to about 52% since then is attributable to more advanced architectural and organizational ideas. By 2002, this growth led to a difference in performance of about a factor of seven. Performance for floating-point-oriented calculations has increased even faster. Since 2002, the limits of power, available instruction-level parallelism, and long memory latency have slowed uniprocessor performance recently, to about 20% per year. Copyright © 2009 Elsevier, Inc. All rights reserved.
Multiprocessors...
GPGPU computing