History of Computers

COMP375 Computer Architecture and Organization

Goals

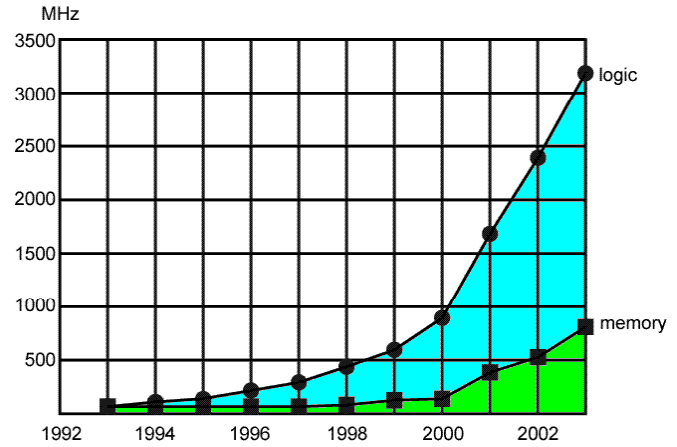
- Understand that the relative performance and cost of components has impacted computer design.
- Note the drop in the cost of computing
- Know Moore's Law
- Recognize that clock speed is not the major contributor to improved performance.

- *Look at some neat old computer stuff.*

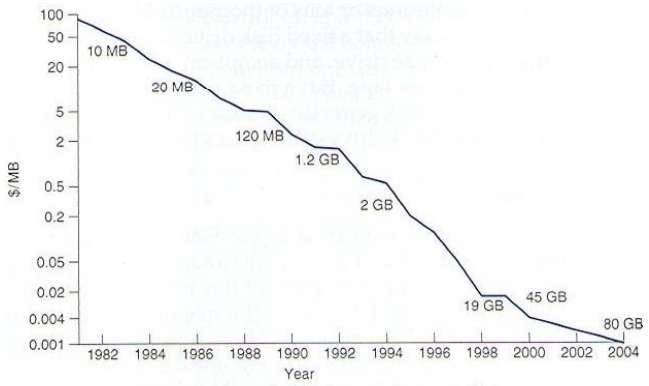
Relative Performance & Cost

- As computers evolved, the performance and cost of different components (such as memory, disk drives or digital logic) have improved at different rates.
- If a component is relatively expensive or slow, designs will usually minimize the component.

Logic and Memory Performance Gap



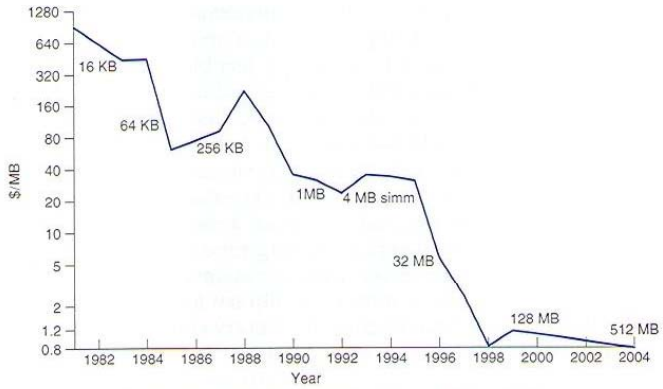
Continual Drop in Prices



Price per megabyte of magnetic hard disk

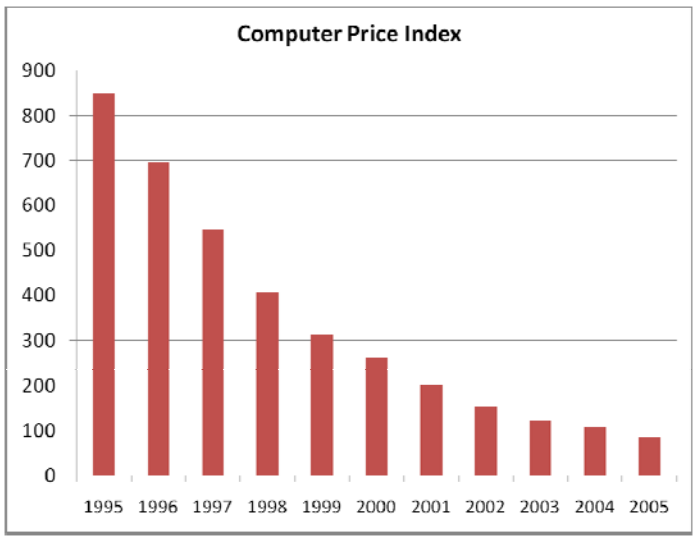
from Operating Systems Concepts, 7th ed by Silberschatz, Galvin and Gagne

Continual (but not steady) Drop in Prices



Price per megabyte of DRAM, from 1981 to 2004.

from Operating Systems Concepts, 7th ed by Silberschatz, Galvin and Gagne



data from the U.S. Bureau of Labor Statistics

Underlying Technologies

- Some technologies are not feasible unless underlying technologies are sufficiently capable.
  - Windows Vista will not run on my 8086 PC with only 640K of RAM and a 4.77 MHz clock.
  - Disk Drives in the 1970's were the size of washing machines. *Not very useful for laptops or iPods.*
  - Voice processing takes a lot of CPU power.

Historical Progression

- People have worked to build "thinking" devices for a long time.
- Improvements usually build on earlier work

- *Before the 1940's "Computer" was a job title, not a machine.*

Ancient Computing

Antikythera mechanism designed to calculate astronomical positions around 150 – 100 BC.

Date	Who	What
~1000 BC	?	Abacus
1621	William Oughtred	Slide Rule
1642	Blaise Pascal	Adding machine

Punch Cards

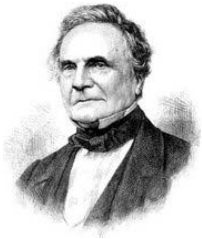
- In 1804-05 Joseph-Marie Jacquard invented a loom that used punch cards to specify the pattern.

Tabulating Equipment

- In 1882 Herman Hollerith created a punch card tabulating machine. It was used to calculate the 1890 census.
- Punched cards were used through the late 1970s.

Charles Babbage

Charles Babbage built a mechanical computer starting in 1822. He never completed the machine.



Ada Lovelace

Augusta Ada, Countess of Lovelace, was the daughter of Lord Byron and friend of Charles Babbage. She is considered the first computer programmer.

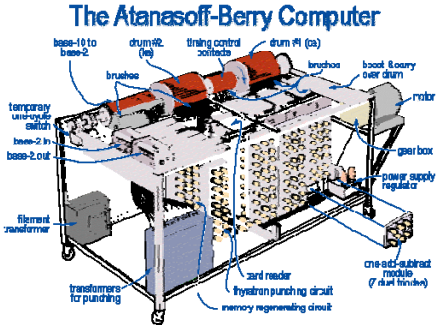
Alan Turing

- In 1936 Alan Turing invented the theoretical Turing Machine.
- With Alonzo Church developed the Turing-Church thesis.

  "Every function which would naturally be regarded as computable, can be computed by a Turing machine"
- He broke the code of the German Enigma machine in WWII.

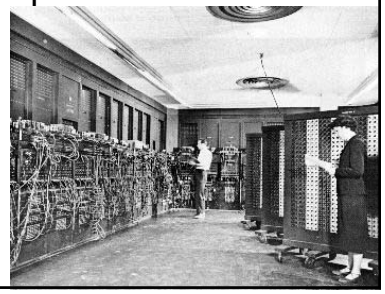
ABC machine

- John Atanasoff and Clifford Berry built the Atanasoff-Berry Computer (ABC) in 1939.



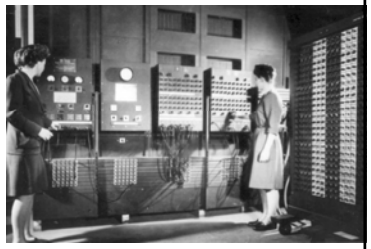
ENIAC

- Electronic Numerical Integrator And Computer
- John Eckert and J. Presper Mauchly
- University of Pennsylvania
- Trajectory tables for weapons
- Started 1943
- Finished 1946
  - Too late for war effort
- Used until 1955



ENIAC - details

- Decimal (not binary)
- 20 accumulators of 10 digits
- Programmed manually by switches
- 18,000 vacuum tubes
- 30 tons
- 15,000 square feet
- 140 kW power
- 5,000 additions/sec

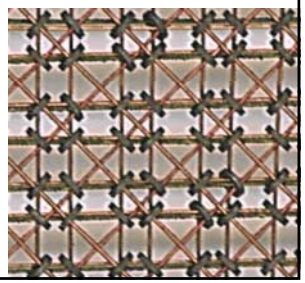


von Neumann Architecture

- Stored Program concept
- Main memory storing programs and data
- ALU operating on binary data
- Control unit interpreting instructions from memory and executing
- Input and output equipment operated by control unit
- Completed 1952

Core Memory

- Invented by An Wang and Way-Dong Woo in 1949
- A bit is stored by magnetizing a ring of iron.
- Cycle times of about 6µs
- Non-volatile storage



Transistors

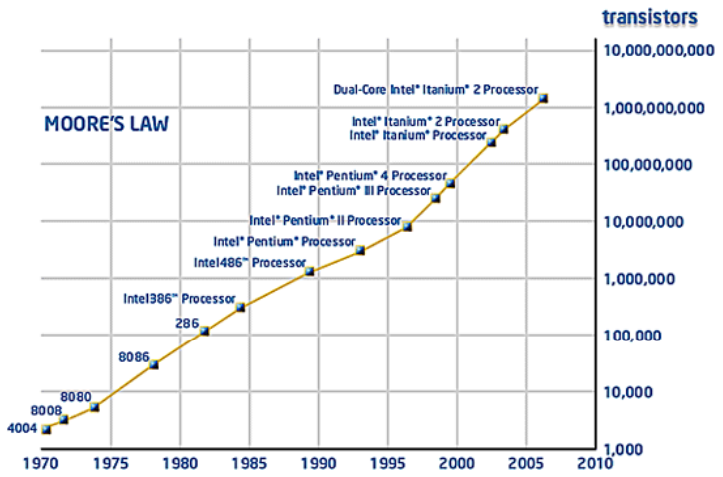
- Replaced vacuum tubes
- Smaller
- Cheaper
- Less heat dissipation
- Solid State device
- Made from silicon *(sand)*
- Invented 1947 at Bell Labs
- William Shockley et al.

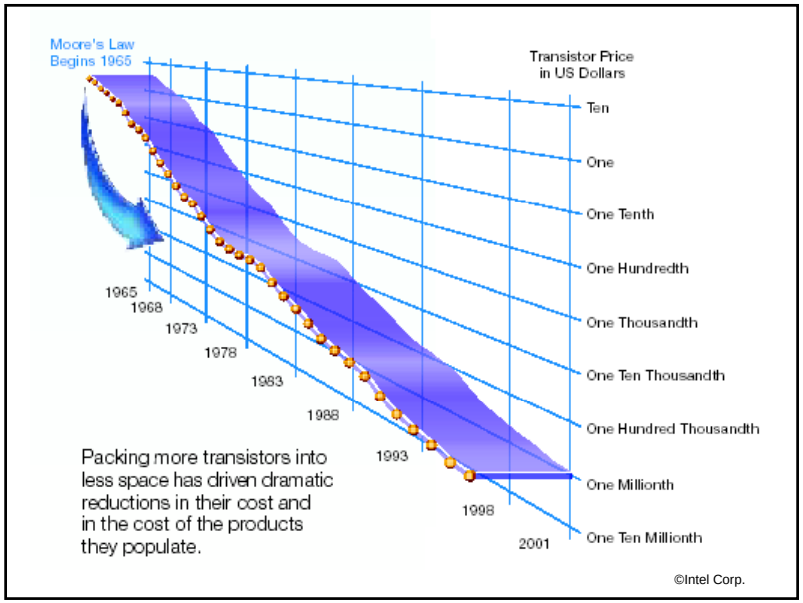
Semiconductor Memory

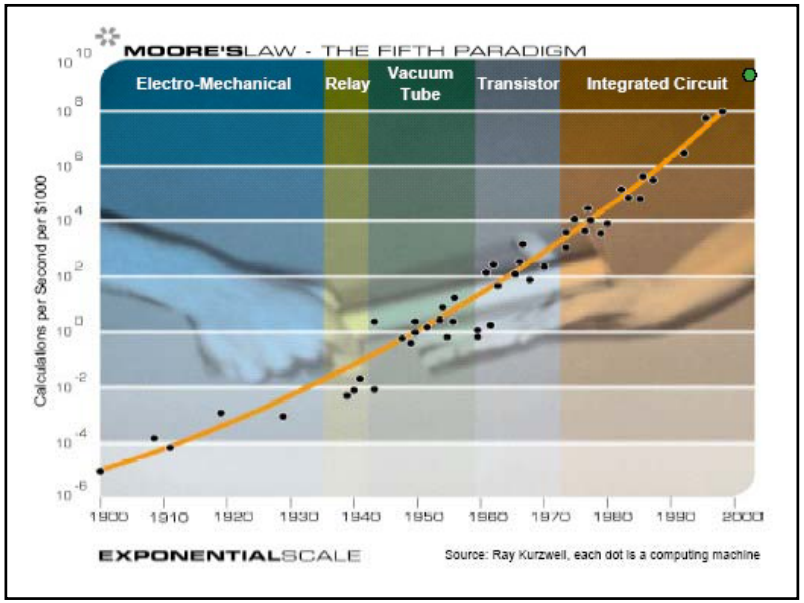
- Created in1970 at Fairchild corporation
- Size of a single core
  - i.e. 1 bit of magnetic core storage
- Non-destructive read
- Much faster than core
- Capacity approximately doubles each year

Moore's Law

- Increased density of components on chip
- Gordon Moore – co-founder of Intel
- Number of transistors on a chip will double every year
- Since 1970's development has slowed a little
  - **Number of transistors on a chip doubles every 18 months**
- Cost of a chip has remained almost unchanged
- Higher packing density means shorter electrical paths, giving higher performance
- Reduced power and cooling requirements
- Fewer interconnections increases reliability







Analog Computers

- An analog computer does not store information digitally.
- Values are stored as voltage levels.
- Analog computers are particularly useful solving nonlinear simultaneous differential equations.
- An electric circuit can be defined by an equation. An analog computer is programmed by creating a circuit that follows a desired equation.

IBM

- Punched-card processing equipment
- 1953 - the 701
  - IBM's first stored program computer
  - Scientific calculations
- 1955 - the 702
  - Business applications
- Lead to 700/7000 series

IBM 360 series

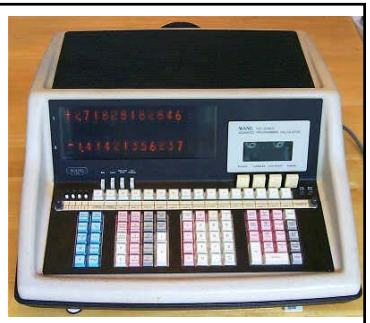
- Introduced in 1964.
- Replaced (& not compatible with) 7000 series
- Cost $133K to $5.5M ($33.7M in today's $)
- First planned "family" of computers
  - Similar or identical instruction sets
  - Similar or identical O/S
  - Increasing speed
  - Increasing I/O ports
  - Increased memory size
  - Increased cost
- Multiplexed switch structure

DEC PDP-8

- Introduced in 1964
- First minicomputer
- Did not need air conditioned room
- Small enough to sit on a lab bench
- $16,000 vs. $100k+ for IBM 360
- Used a bus structure

Calculators

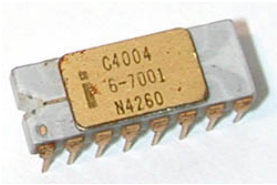
Wang 720 was a programmable calculator.



HP-35 introduced in 1973 for $399

$1,750 in today's dollars

Intel



- 1971 - 4004
  - First microprocessor
  - All CPU components on a single chip
  - 4 bit
- Followed in 1972 by 8008
  - 8 bit
  - Both designed for specific applications

Pentium Evolution (1)

- 8080
  - first general purpose microprocessor
  - 8 bit data path
  - Used in first personal computer – Altair
- 8086
  - much more powerful
  - 16 bit
  - instruction cache, prefetch few instructions
  - 8088 (8 bit external bus) used in first IBM PC
- 80286
  - 16 Mbyte memory addressable
  - up from 1Mb
- 80386
  - 32 bit
  - Support for multitasking

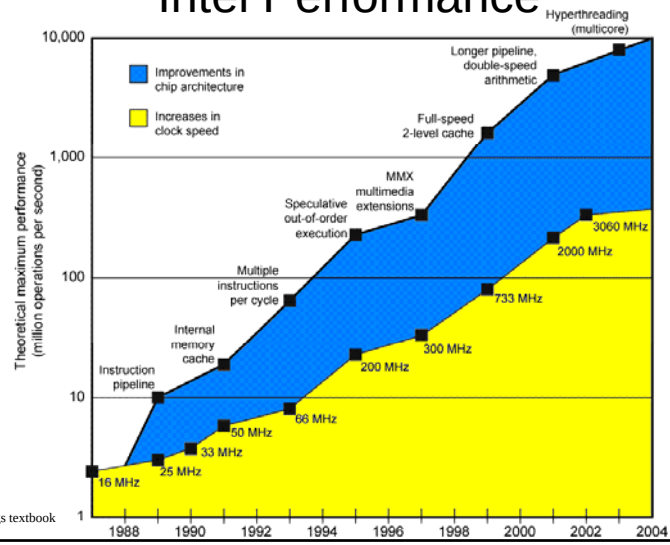
Pentium Evolution (2)

- 80486
  - sophisticated powerful cache and instruction pipelining
  - built in math co-processor
- Pentium
  - Superscalar
  - Multiple instructions executed in parallel
- Pentium Pro
  - Increased superscalar organization
  - Aggressive register renaming
  - branch prediction
  - data flow analysis
  - speculative execution

Pentium Evolution (3)

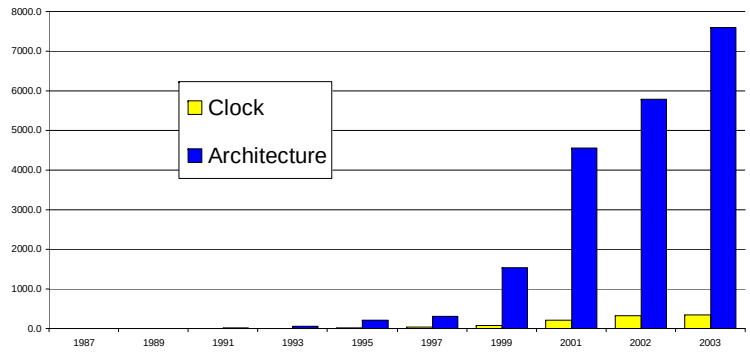
- Pentium II
  - MMX technology
  - graphics, video & audio processing
- Pentium III
  - Additional floating point instructions for 3D graphics
- Pentium 4
  - Further floating point and multimedia enhancements
- Itanium
  - 64 bit RISC processor
- Itanium 2
  - Hardware enhancements to increase speed

Intel Performance



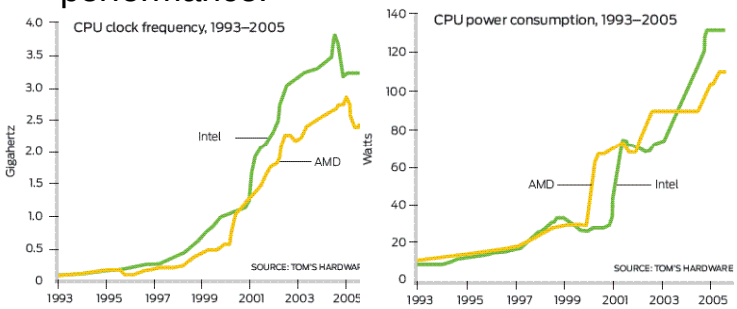
source:
Stallings textbook

Intel Performance



Incentive for Dual Core

- Intel reports that underclocking a single core by 20 percent saves half the power while sacrificing just 13 percent of the performance.



Source: IEEE Spectrum April, 2008