ENIAC - background

- Electronic Numerical Integrator And Computer
- Eckert and 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 consumption
- 5,000 additions per second
von Neumann/Turing

- 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
- Princeton Institute for Advanced Studies — IAS
- Completed 1952
Structure of von Neumann machine

Main Memory (M) → Central Processing Unit (CPU) → Arithmetic-Logic Unit (CA) → Program Control Unit (CC) → I/O Equipment (I, O)
IAS - details

• 1000 x 40 bit words
  — Binary number
  — 2 x 20 bit instructions

• Set of registers (storage in CPU)
  — Memory Buffer Register
  — Memory Address Register
  — Instruction Register
  — Instruction Buffer Register
  — Program Counter
  — Accumulator
  — Multiplier Quotient
Structure of IAS – detail
Commercial Computers

• 1947 - Eckert-Mauchly Computer Corporation
• UNIVAC I (Universal Automatic Computer)
• US Bureau of Census 1950 calculations
• Became part of Sperry-Rand Corporation
• Late 1950s - UNIVAC II
  — Faster
  — More memory
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
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.
Transistor Based Computers

• Second generation machines
• NCR & RCA produced small transistor machines
• IBM 7000
• DEC - 1957
  —Produced PDP-1
Microelectronics

- Literally - “small electronics”
- A computer is made up of gates, memory cells and interconnections
- These can be manufactured on a semiconductor
- E.g. silicon wafer
Generations of Computer

- Vacuum tube - 1946-1957
- Transistor - 1958-1964
- Small scale integration - 1965 on
  - Up to 100 devices on a chip
- Medium scale integration - to 1971
  - 100-3,000 devices on a chip
- Large scale integration - 1971-1977
  - 3,000 - 100,000 devices on a chip
- Very large scale integration - 1978 to date
  - 100,000 - 100,000,000 devices on a chip
- Ultra large scale integration
  - Over 100,000,000 devices on a chip
Moore’s Law

- Increased density of components on chip
- Gordon Moore - cofounder of Intel
- Number of transistors on a chip will double every year
  — Number of transistors doubles every 18 months
- Since 1970’s development has slowed a little
- Cost of a chip has remained almost unchanged
- Higher packing density means shorter electrical paths, giving higher performance
- Smaller size gives increased flexibility
- Reduced power and cooling requirements
- Fewer interconnections increases reliability
Growth in CPU Transistor Count
IBM 360 series

- 1964
- Replaced (& not compatible with) 7000 series
- First planned “family” of computers
  - Similar or identical instruction sets
  - Similar or identical O/S
  - Increasing speed
  - Increasing number of I/O ports (i.e. more terminals)
  - Increased memory size
  - Increased cost
- Multiplexed switch structure
DEC PDP-8

• 1964
• First minicomputer (after miniskirt!)
• Did not need air conditioned room
• Small enough to sit on a lab bench
• $16,000
  —$100k+ for IBM 360
• Embedded applications & OEM
• BUS STRUCTURE
DEC - PDP-8 Bus Structure

Console Controller → OMNIBUS → CPU → OMNIBUS → Main Memory → OMNIBUS → I/O Module → OMNIBUS → I/O Module
Semiconductor Memory

- 1970
- Fairchild
- Size of a single core
  - i.e. 1 bit of magnetic core storage
- Holds 256 bits
- Non-destructive read
- Much faster than core
- Capacity approximately doubles each year
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

• 1974 - 8080
  — Intel’s first general purpose microprocessor
Speeding it up

- Pipelining
- On board cache
- On board L1 & L2 cache
- Branch prediction
- Data flow analysis
- Speculative execution
Performance Mismatch

- Processor speed increased
- Memory capacity increased
- Memory speed lags behind processor speed
DRAM and Processor Characteristics
Trends in DRAM use
Solutions

• Increase number of bits retrieved at one time
  — Make DRAM “wider” rather than “deeper”

• Change DRAM interface
  — Cache

• Reduce frequency of memory access
  — More complex cache and cache on chip

• Increase interconnection bandwidth
  — High speed buses
  — Hierarchy of buses
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 maths 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
  - Note Arabic rather than Roman numerals
  - Further floating point and multimedia enhancements

- Itanium
  - 64 bit
  - see chapter 15

- See Intel web pages for detailed information on processors
Internet Resources

- http://www.intel.com/
  - Search for the Intel Museum
- http://www.ibm.com
- http://www.dec.com
- Charles Babbage Institute
- PowerPC
- Intel Developer Home