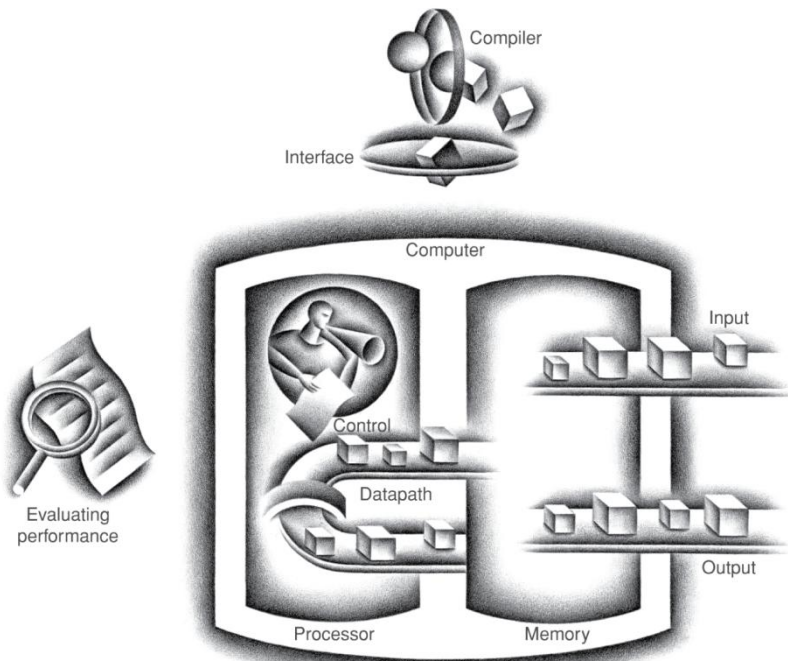# Lecture 2

Chapter 1: Computer Abstractions and Technology

These slides are based on Patterson and Hennessy's original slides
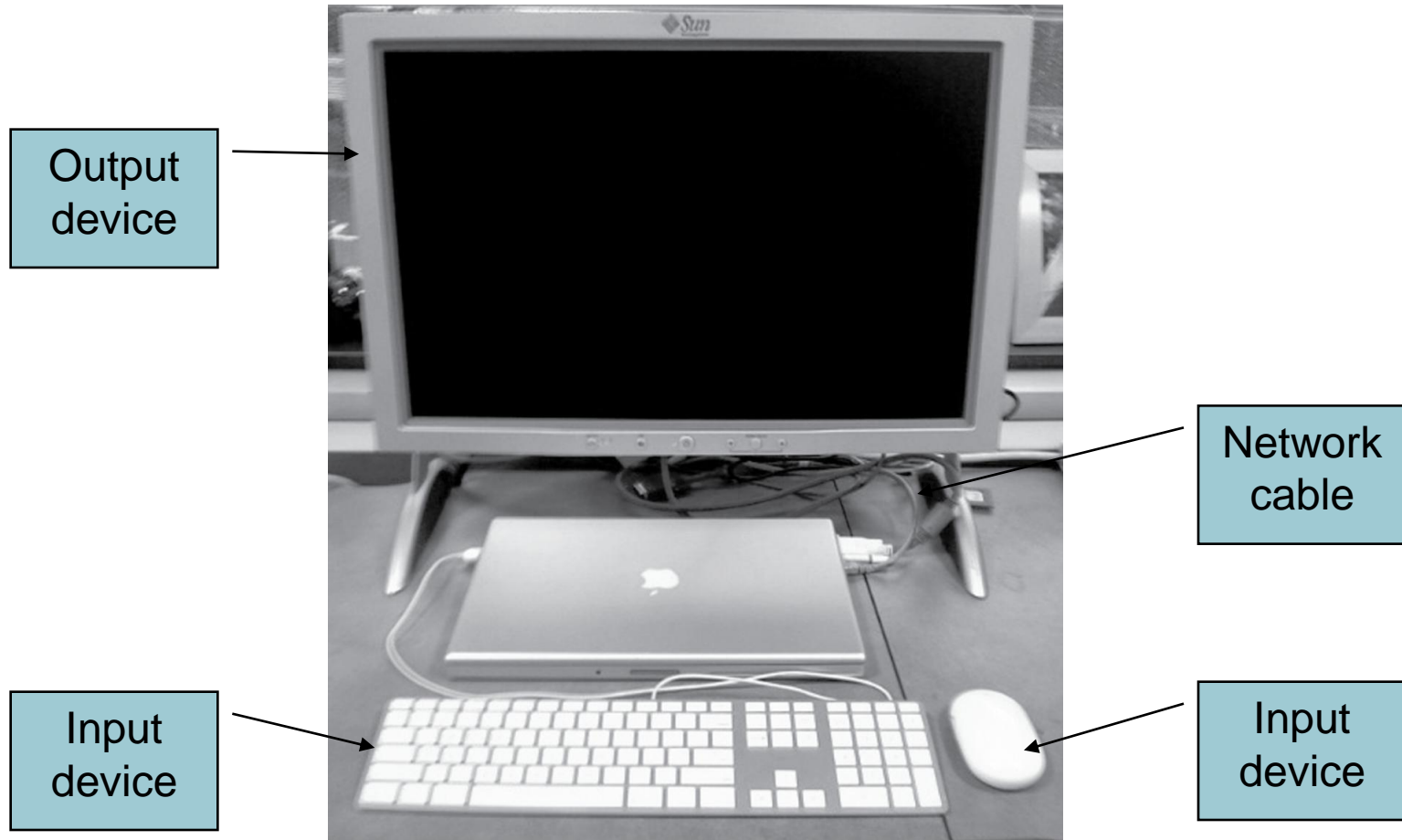
Components of a Computer

The BIG Picture

- Same components for all kinds of computer
  - Desktop, server, embedded
- Input/output includes
  - User-interface devices
    - Display, keyboard, mouse
  - Storage devices
    - Hard disk, CD/DVD, flash
  - Network adapters
    - For communicating with other computers

Anatomy of a Computer

Output device

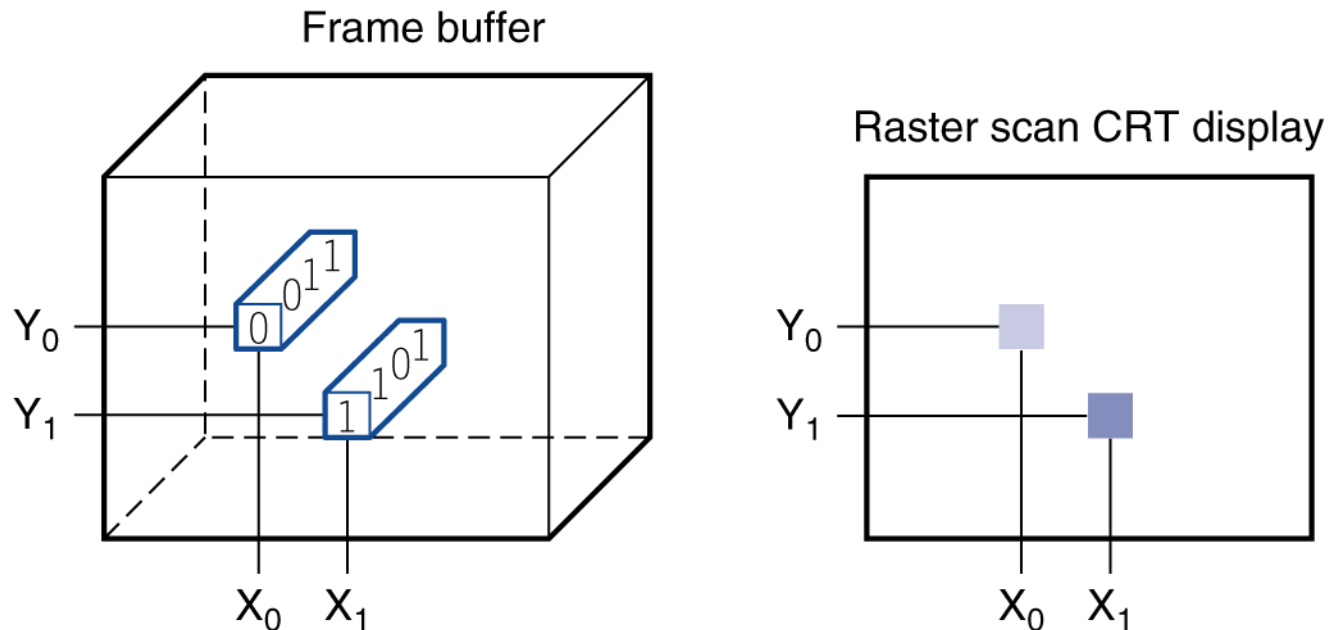Network cable

Input device

Input device

Anatomy of a Mouse

- Optical mouse
  - LED illuminates desktop
  - Small low-res camera
  - Basic image processor
    - Looks for x, y movement
  - Buttons & wheel
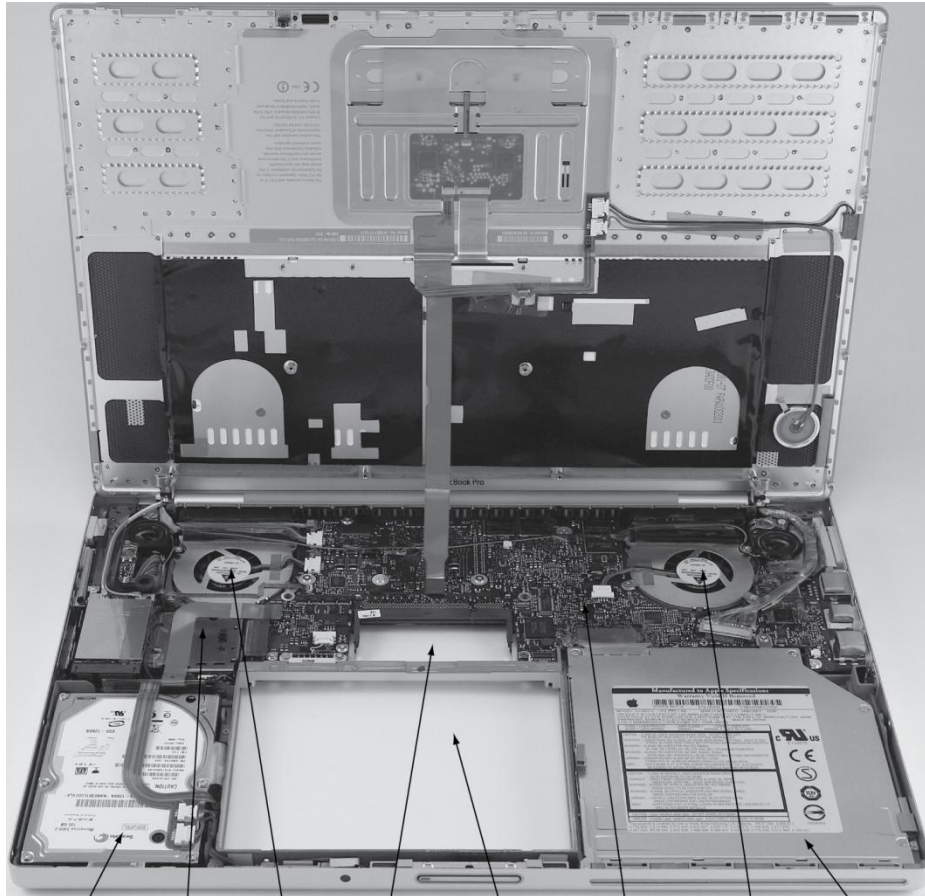- Supersedes roller-ball mechanical mouse
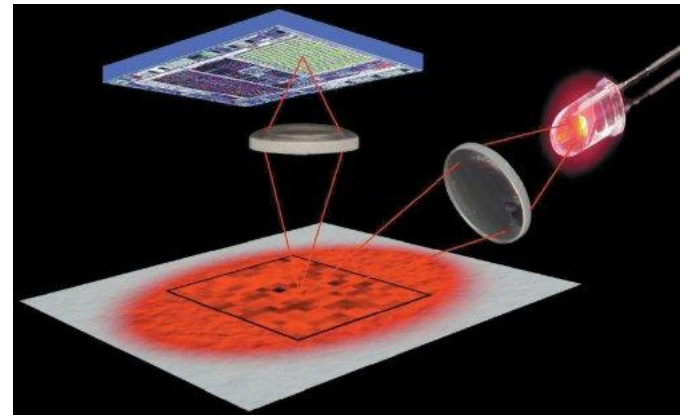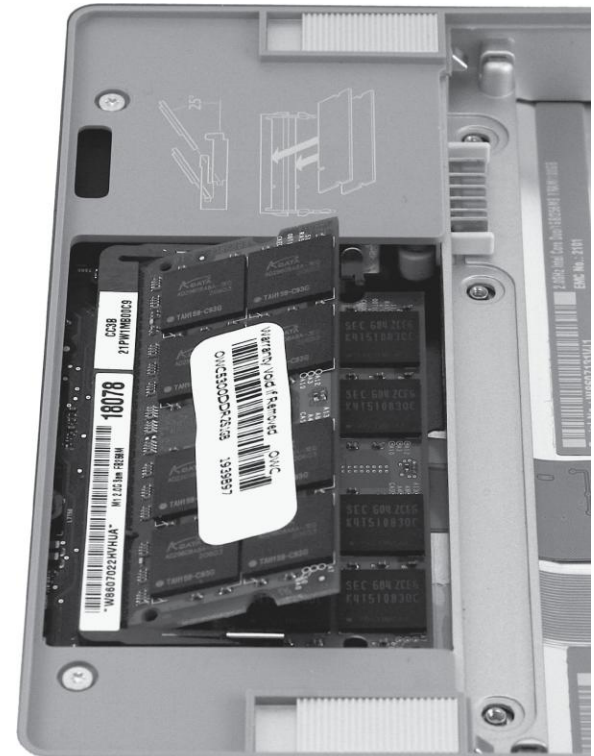
Through the Looking Glass

- LCD screen: picture elements (pixels)
  - Mirrors content of frame buffer memory

Frame buffer

Raster scan CRT display

Opening the Box

Hard drive   Processor   Fan with cover   Spot for memory DIMMs   Spot for battery   Motherboard   Fan with cover   DVD drive
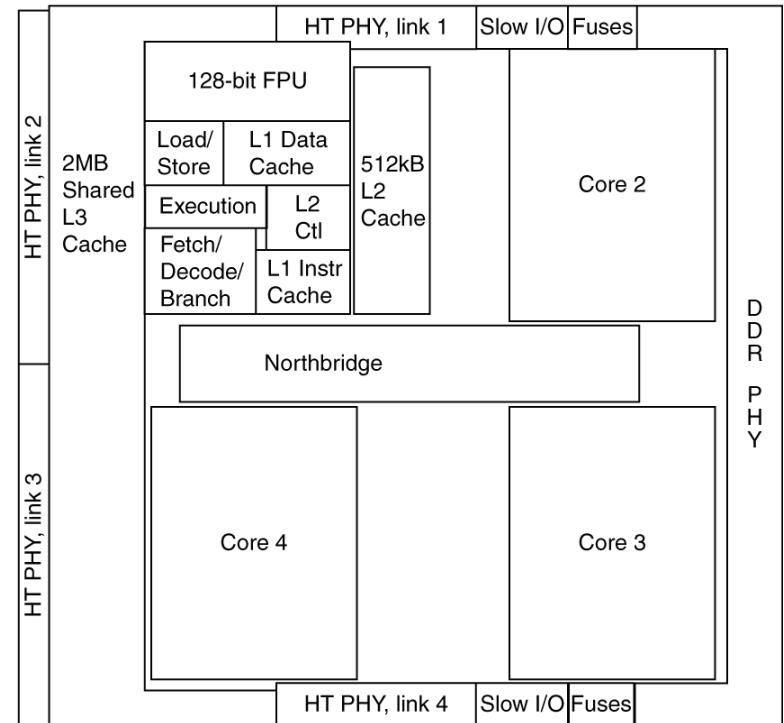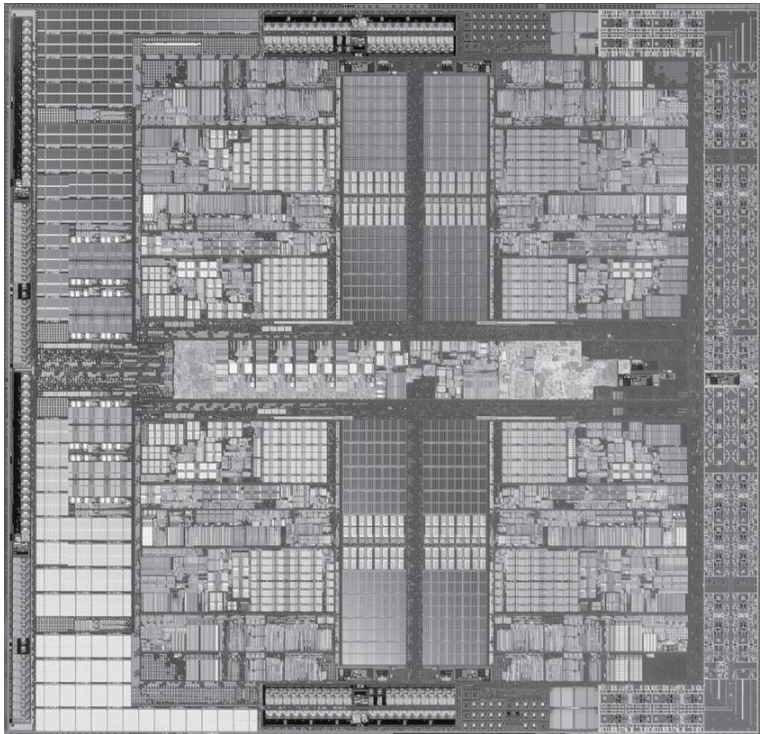
Inside the Processor (CPU)

- Datapath: performs operations on data
- Control: sequences datapath, memory, ...
- Cache memory
    - Small fast SRAM memory for immediate access to data

Inside the Processor

- AMD Barcelona: 4 processor cores

Abstractions

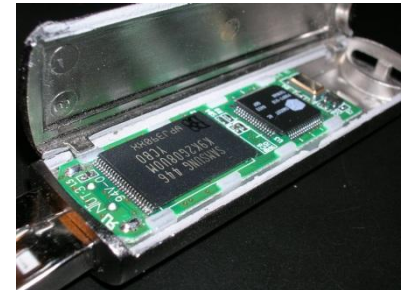**The BIG Picture**

- Why abstraction?

Abstractions

The BIG Picture

- Abstraction helps us deal with complexity
  - Hide lower-level detail
- Instruction set architecture (ISA)
  - The hardware/software interface
- Application binary interface
  - The ISA plus system software interface
- Implementation
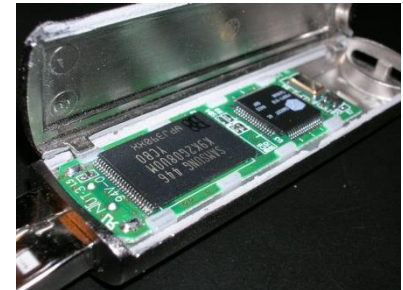 - The details underlying and interface
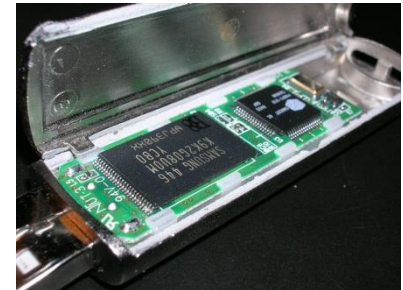
A Safe Place for Data

- Types of memory?

A Safe Place for Data

- Volatile main memory
- Non-volatile secondary memory

A Safe Place for Data

- Volatile main memory
  - Loses instructions and data when power off
- Non-volatile secondary memory
  - Magnetic disk
  - Flash memory
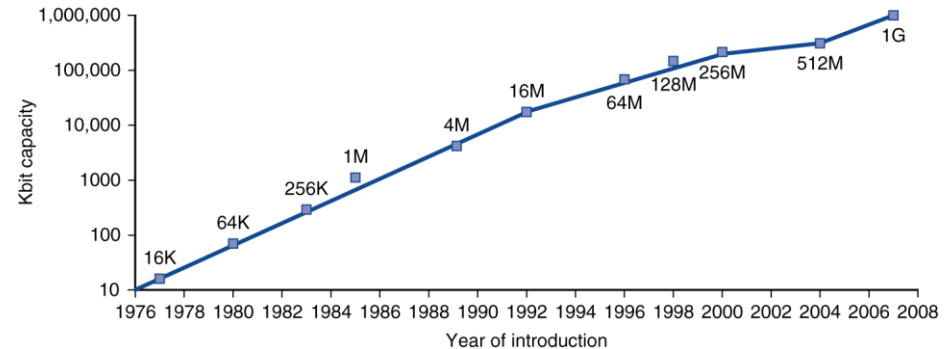 - Optical disk (CDROM, DVD)

Networks

- Communication and resource sharing
- Local area network (LAN): Ethernet
  - Within a building
- Wide area network (WAN): the Internet
- Wireless network: WiFi, Bluetooth
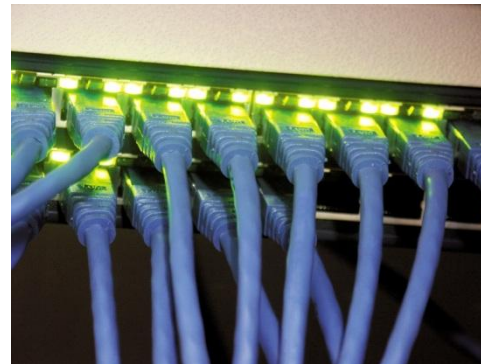
Technology Trends (MOORE)

- Electronics technology continues to evolve

  - Increased capacity and performance

  - Reduced cost

DRAM capacity

| Year	Technology	Relative performance/cost
1951	Vacuum tube	1
1965	Transistor	35
1975	Integrated circuit (IC)	900
1995	Very large scale IC (VLSI)	2,400,000
2005	Ultra large scale IC	6,200,000,000

Understanding Performance

- What impacts performance?

Understanding Performance

- Algorithm
  - Determines number of operations executed
- Programming language, compiler, architecture
  - Determine number of machine instructions executed per operation
- Processor and memory system
  - Determine how fast instructions are executed
- I/O system (including OS)
  - Determines how fast I/O operations are executed

Below Your Program
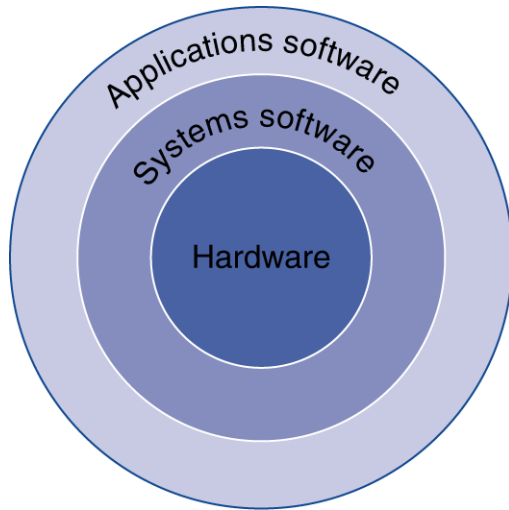
- ## Application software
  - Written in high-level language
- ## System software
  - Compiler: translates HLL code to machine code
  - Operating System: service code
    - Handling input/output
    - Managing memory and storage
    - Scheduling tasks & sharing resources
- ## Hardware
 - Processor, memory, I/O controllers

Levels of Program Code

- An example of high level language?

Levels of Program Code

- **High-level language**
  - Level of abstraction closer to problem domain
  - Provides for productivity and portability
- **Assembly language**
  - Textual representation of instructions
- **Hardware representation**
  - Binary digits (bits)
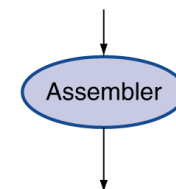 - Encoded instructions and data

High-level language program (in C)

```
swap(int v[], int k)
{int temp;
    temp = v[k];
    v[k] = v[k+1];
    v[k+1] = temp;
}
```

Compiler
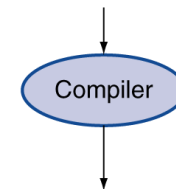
Assembly language program (for MIPS)

```
swap:
    muli $2, $5,4
    add  $2, $4,$2
    lw   $15, 0($2)
    lw   $16, 4($2)
    sw   $16, 0($2)
    sw   $15, 4($2)
    jr   $31
```

Assembler

Binary machine language program (for MIPS)

```
00000000101000010000000000011000
00000000000110000000011000100001
10001100011000100000000000000000
10001100111100100000000000000100
10101100111100100000000000000000
10101100011000100000000000000100
00000011111000000000000000001000
```

Defining Performance

- Which airplane has the best performance?
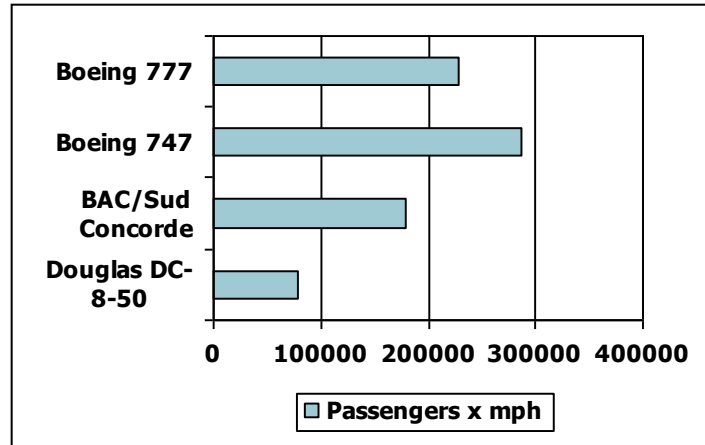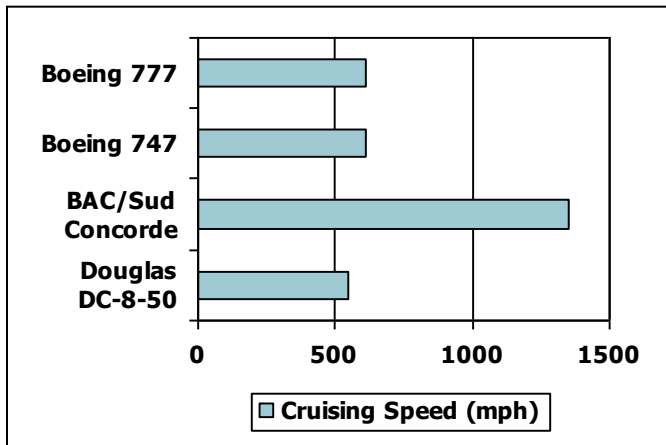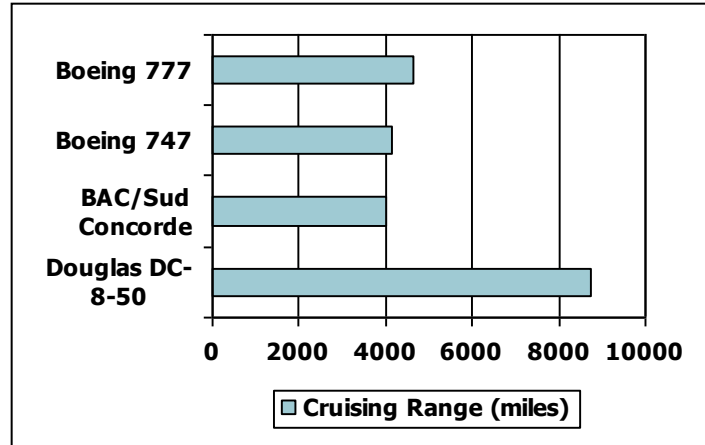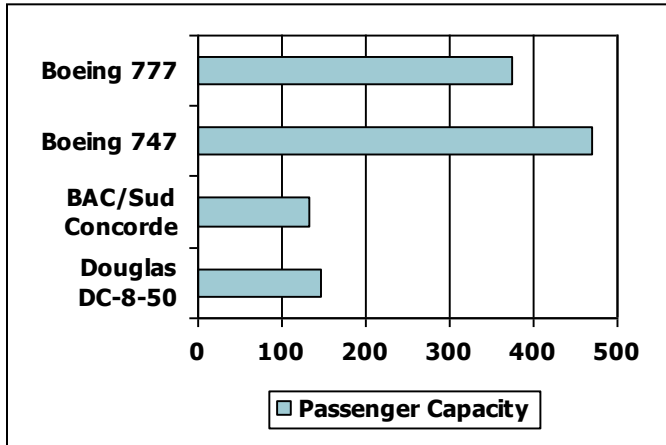
Response Time and Throughput

- Response time
    - How long it takes to do a task
- Throughput
    - Total work done per unit time
        - e.g., tasks/transactions/… per hour
- How are response time and throughput affected by
    - Replacing the processor with a faster version?
    - Adding more processors?
- We'll focus on response time for now…