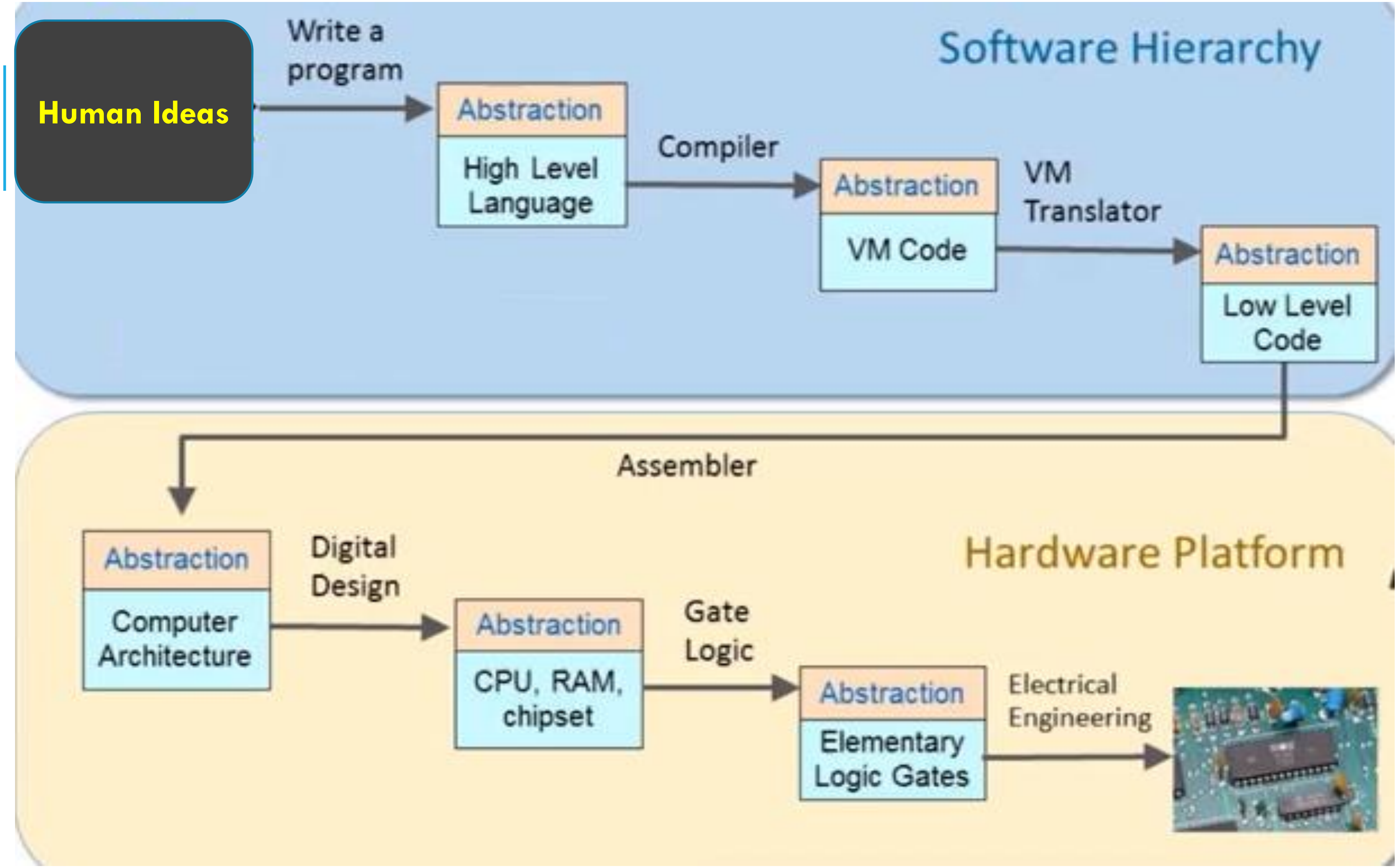
ABSTRACTION & PERFORMANCE 1

CS2400 Spring 2020


Human Ideas
Write a program
Software Hierarchy
Abstraction
High Level Language
Compiler
Abstraction
VM Code
VM Translator
Abstraction
Low Level Code
Assembler
Hardware Platform
Abstraction
Computer Architecture
Digital Design
Abstraction
CPU, RAM, chipset
Gate Logic
Abstraction
Elementary Logic Gates
Electrical Engineering

EIGHT GREAT IDEAS

Design for ***Moore's Law***

Use ***abstraction*** to simplify design

Make the ***common case fast***

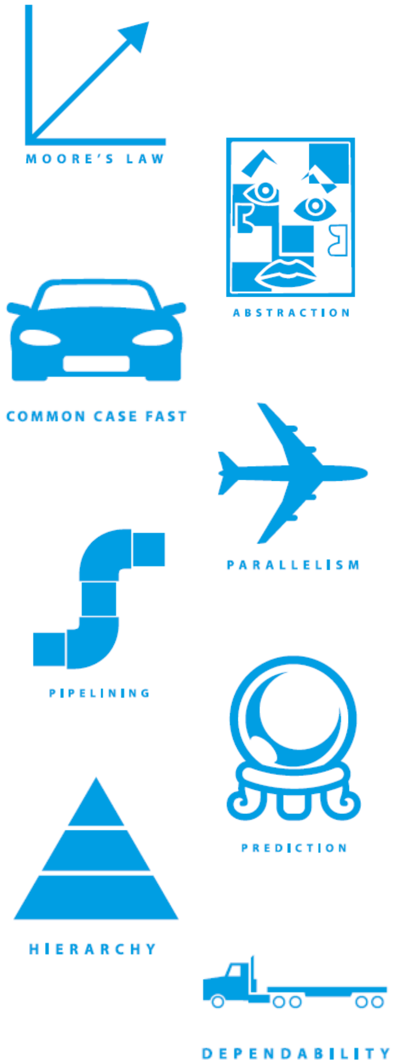
Performance *via* ***parallelism***

Performance *via* ***pipelining***

Performance *via* ***prediction***

Hierarchy of memories

Dependability *via* redundancy



LAYERS OF ABSTRACTION

Application software

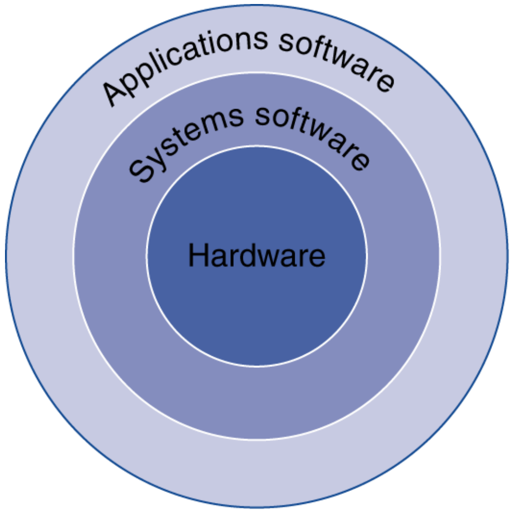
- Written in high-level language

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

High-level language

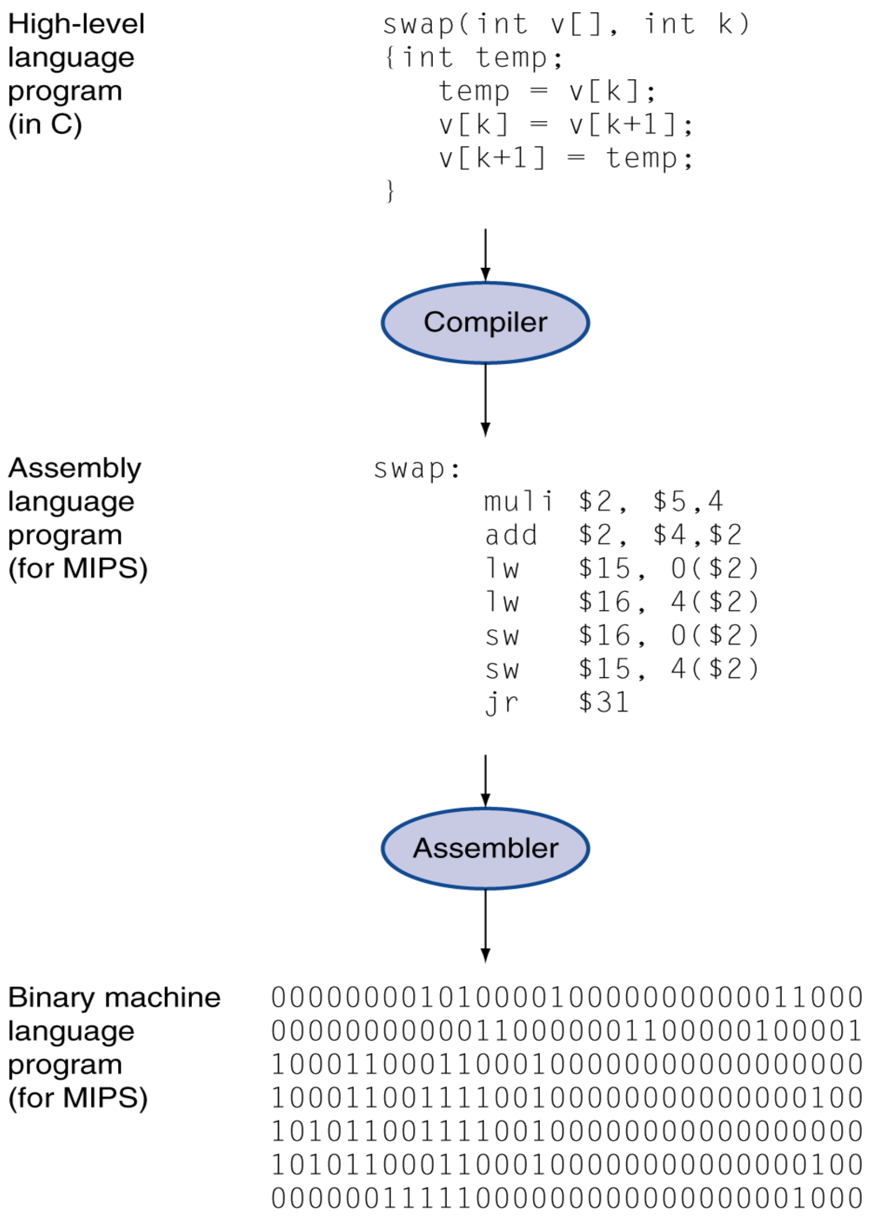
- Level of abstraction closer to problem domain
- Provides for productivity and portability

Assembly language

- Textual representation of instructions

Hardware representation

- Binary digits (bits)
- Encoded instructions and data

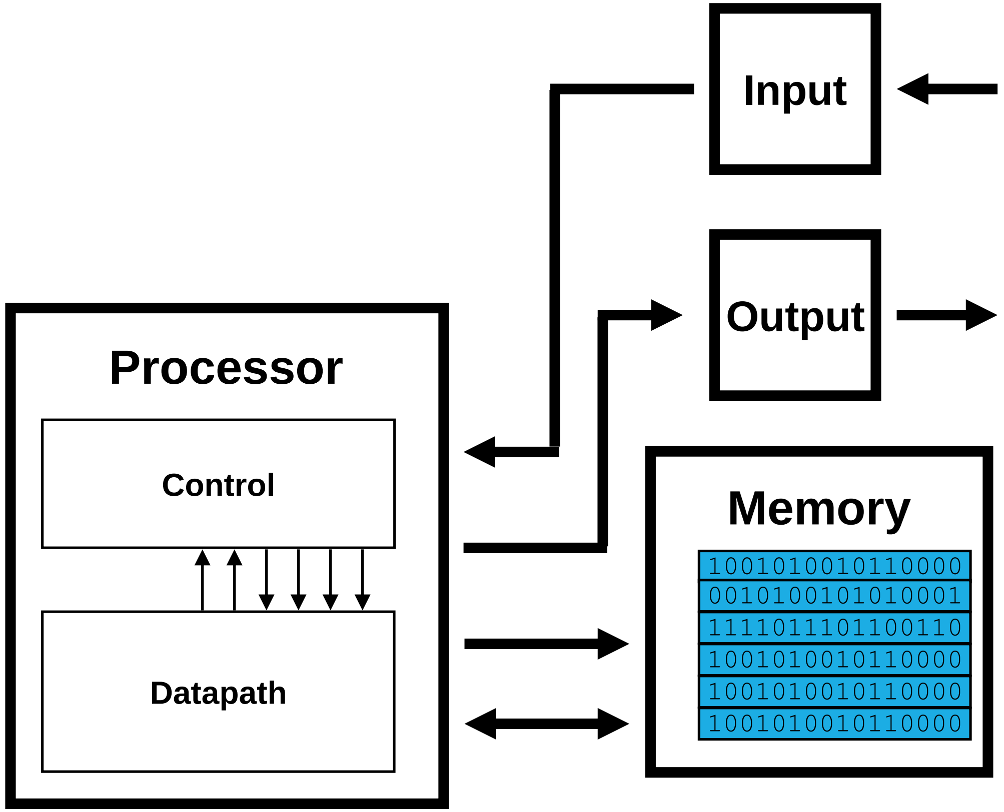


COMPONENTS OF A COMPUTER

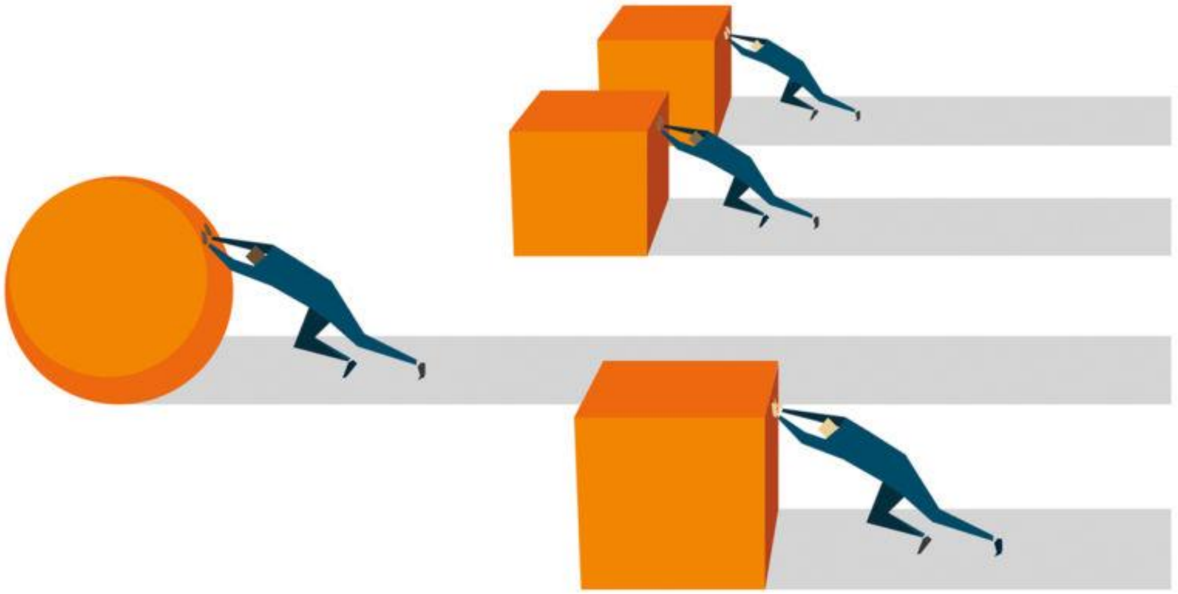
The Five Classic Components of a Computer

1. Input (mouse, keyboard, …)
2. Output (display, printer, …)
3. Memory
   - main (DRAM), cache (SRAM)
   - secondary (disk, CD, DVD, …)
4. Datapath
5. Control

$\left.\begin{array}{l}\text{4. Datapath}\\ \text{5. Control}\end{array}\right\}$ Processor (CPU)



PERFORMANCE

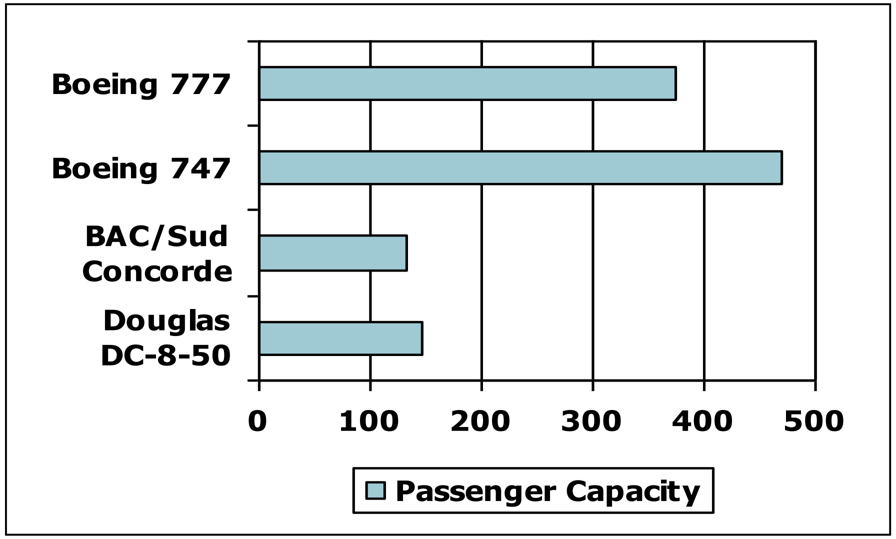


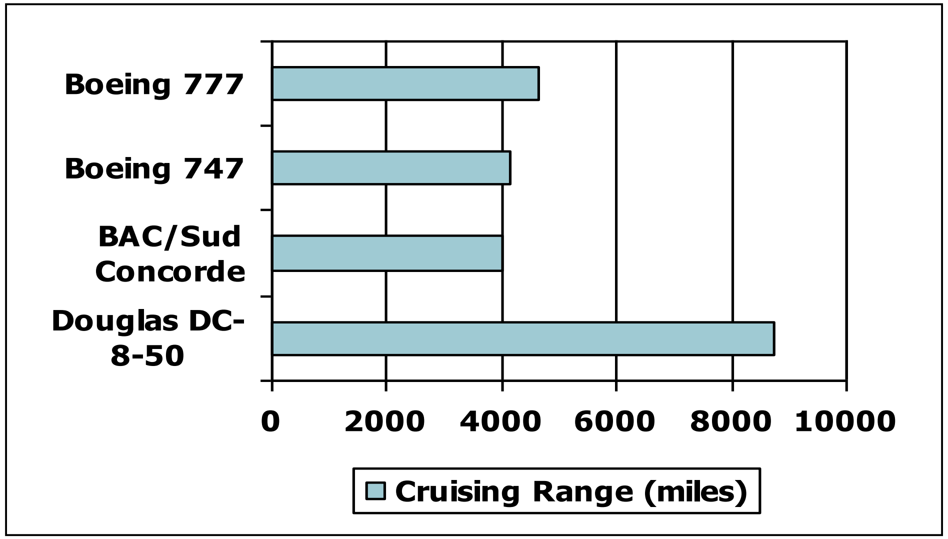
AIRPLANE DATA ,

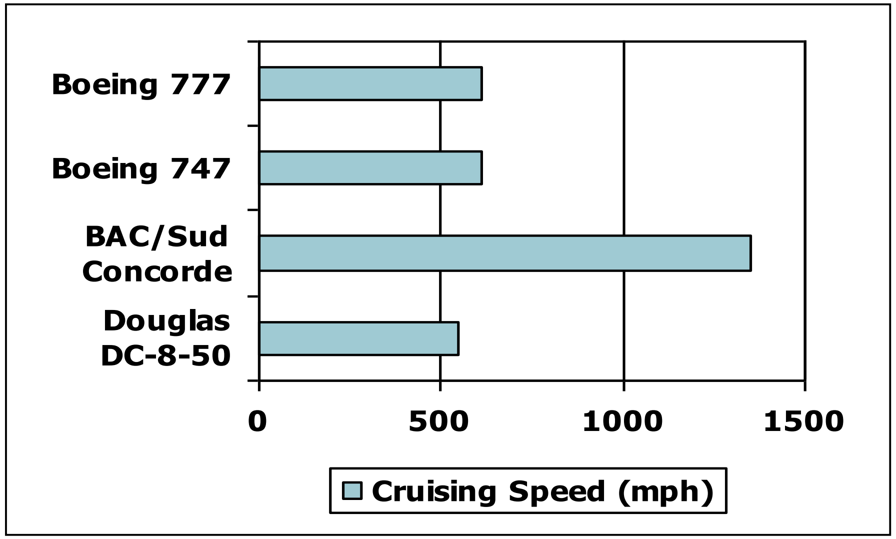
Which shows best performance ?

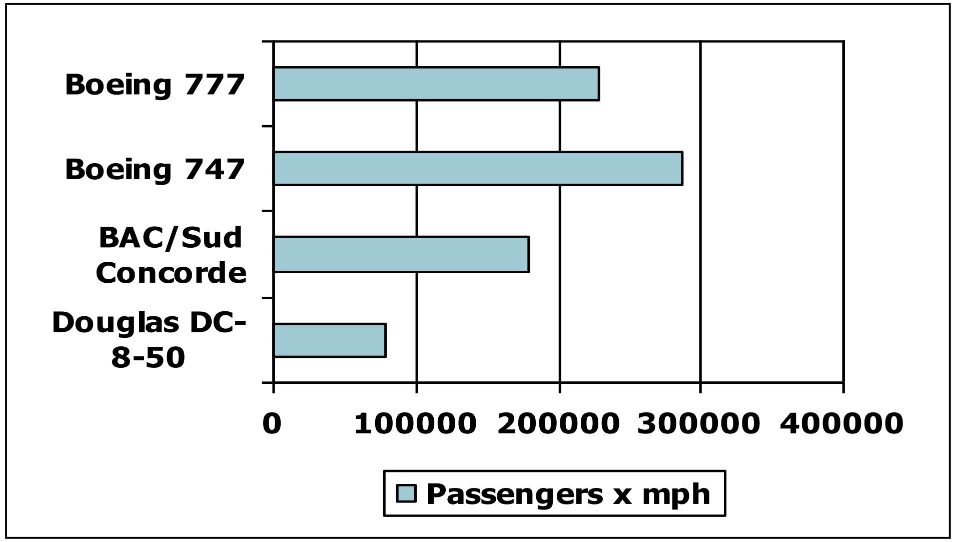
Airplane	Passenger capacity	Cruising range (miles)	Cruising speed (m.p.h.)	Passenger throughput (passengers x m.p.h.)
Boeing 777	375	4630	610	228,750
Boeing 747	470	4150	610	286,700
BAC/Sud Concorde	132	4000	1350	178,200
Douglas DC-8-50	146	8720	544	79,424

Which airplane has the best performance?

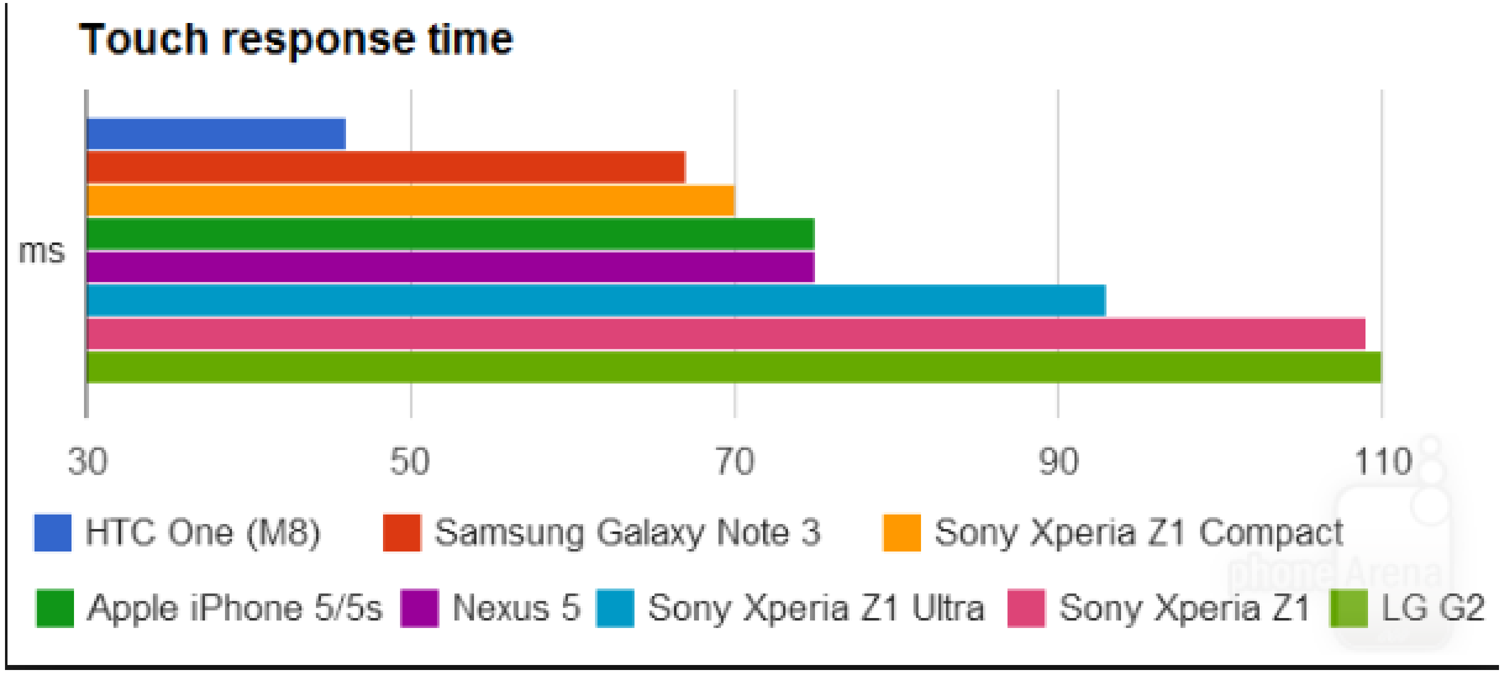








RESPONSE TIME



Smallest
is the Best

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

Q 1

Execution Time

Throughput

Execution time

1 min

10 Cars / min

Improves

Improves

Q2

1.Replacing a processor in a computer with a faster processor has what effect,

- Decrease Response time ?
- Increase Throughput ?
- Both

2.Adding additional processors to a system that uses multiple processors for separate tasks -- for example, searching the web -- has what effect? Assume that before adding processors, tasks do not wait to execute (tasks do not "queue up").

- Decrease Response time ?
- Increase Throughput ?
- Both ?

PERFORMANCE

$$\text{Performance} = 1/\text{Execution Time}$$

$$\text{Performance}_X / \text{Performance}_Y = \text{Execution time}_Y / \text{Execution time}_X = n$$

- Q11: If computer A runs a program in 10 seconds and computer B runs the same program in 15 seconds, how much faster is A than B?

ANS

- Example: time taken to run a program
  - 10s on A,   15s on B
  - Execution Time_B / Execution Time_A = 15s / 10s = 1.5
  - So A is 1.5 times faster than B

Q 12

Computer C's performance is 4 times as fast as the performance of computer B, which runs a given application in 28 seconds. How long will computer C take to run that application?

$$Performance_X / Performance_Y \quad = \quad Executiontime_Y / Executiontime_X = n$$

Q 13

1. A
2. B
3. 0.1
4. 0.2
5. 2
6. Perf C/ Perf D

TIME

Time is the measure of computer performance

- ***Wall clock time ,Response time ,Elapsed time***
- ***CPU Time***

MEASURING EXECUTION TIME

Elapsed time

- Total response time, including all aspects
  - Processing, I/O, OS overhead, idle time
- Determines system performance

CPU time

- Time spent processing a given job
  - Excludes I/O time, other jobs shares
- Comprises user CPU time and system CPU time
- Different programs are affected differently by CPU and system performance

Q 14

A task runs alone on a CPU. The task starts by running for 5 ms. The task then waits for 4 ms while the operating system runs some instructions to access disk. The CPU is then idle for 2 ms while waiting for data from disk. Finally, the task runs another 10 ms and completes.

The elapsed time = 5 + 4 + 2 + 10 = 21. Elapsed time is the total time, also known as wall clock time or response time.

The user CPU time = 5 + 10 = 15. User CPU time is just the time that the task runs on the CPU.

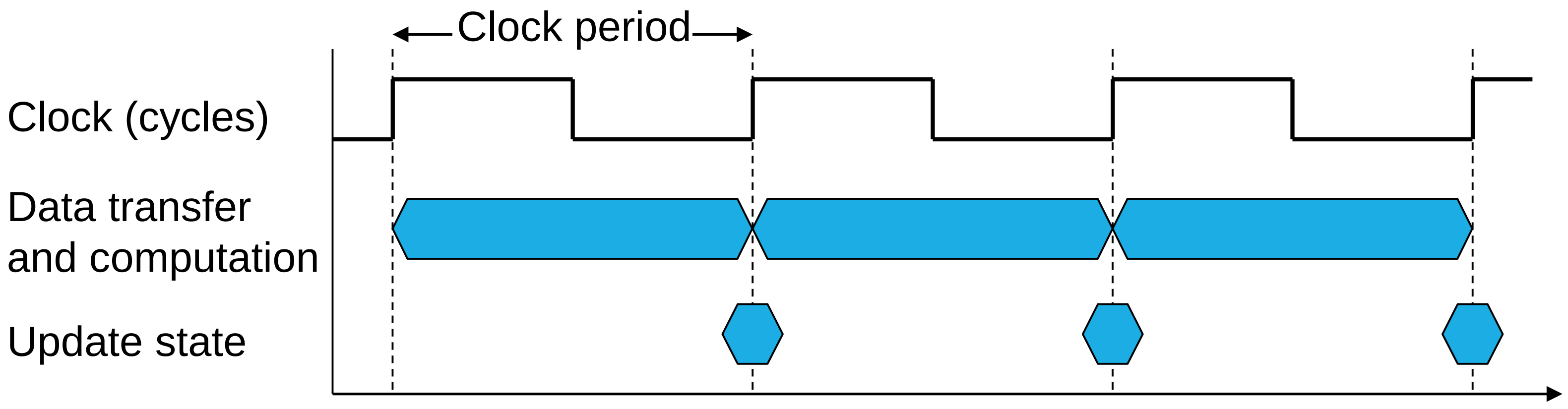
The System CPU time =5 + 4 + 10 = 19 ms. CPU time is the total time the CPU spends running instructions either of this task or of the operating system for this task.

System performance is the elapsed time, so 5 + 4 + 2 + 10 = 21.

The CPU performance is just the user CPU time, so 5 + 10 = 15.

CPU CLOCKING

Operation of digital hardware governed by a constant-rate clock.



- Clock period: duration of a clock cycle.
- Clock frequency (rate): cycles per second

CPU TIME

$$\text{CPU Time} = \text{CPU Clock Cycles} \times \text{Clock Cycle Time}$$
$$= \frac{\text{CPU Clock Cycles}}{\text{Clock Rate}}$$

Performance improved by

- Reducing number of clock cycles
- Increasing clock rate

CPU TIME EXAMPLE

Our favourite program runs in 10 seconds on computer A, which has a 2 GHz clock. We are trying to help a computer designer build a computer, B, which will run this program in 6 seconds. The designer has determined that a substantial increase in the clock rate is possible, but this increase will affect the rest of the CPU design, causing computer B to require 1.2 times as many clock cycles as computer A for this program. What clock rate should we tell the designer to target?

CPU TIME EXAMPLE

Computer A: 2GHz clock, 10s CPU time

Designing Computer B

- Aim for 6s CPU time
- Restriction : Can do faster clock, but 1.2 × clock cycles

How fast must Computer B clock be?

CPU TIME EXAMPLE

Computer A: 2GHz clock, 10s CPU time

Computer B: ? clock, 6s CPU time.

$$\text{Clock Rate}_B = \frac{\text{Clock Cycles}_B}{\text{CPU Time}_B} = \frac{1.2 \times \text{Clock Cycles}_A}{6\text{s}}$$

$$\text{Clock Cycles}_A = \text{CPU Time}_A \times \text{Clock Rate}_A$$
$$= 10\text{s} \times 2\text{GHz} = 20 \times 10^9$$

$$\text{Clock Rate}_B = \frac{1.2 \times 20 \times 10^9}{6\text{s}} = \frac{24 \times 10^9}{6\text{s}} = 4\text{GHz}$$