

# *CS200 - Computer Organization*

## Performance Metrics - Part 1

Aravind Mohan

Allegheny College

September 23, 2021



# Motivation to learn performance metrics



- When we say "Computer A" has better performance than "Computer B," what do we mean?
- What are the different way of measuring performance of computers?
- Is there any definitive way to state that one computer is better than another?



- Response time
  - How long does it take to complete a task?
- Throughput
  - How much work is completed per unit time?
    - e.g., tasks per hour, transactions per hour, etc

...



- 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!

# How do we compute Performance?



$$\text{Performance} = \frac{1}{\text{ExecutionTime}}$$

- To maximize performance, we should minimize execution time (same as response time).
- In general **Smaller response time** leads to **Larger throughput**

# Comparing Performance

Given two computers X and Y, if the performance of X is greater than the performance of Y, then ...

$$\text{Performance}_X > \text{Performance}_Y$$

$$\frac{1}{\text{ExecutionTime}_X} > \frac{1}{\text{ExecutionTime}_Y}$$

$$\text{ExecutionTime}_X < \text{ExecutionTime}_Y$$

... the execution time of X is less than the execution time of Y!

# Example-1



Let us suppose an Apple Mac Pro (A) runs program  $P_x$  in 10 seconds, and Dell Inspiron (B) runs the same program  $P_x$  in 15 seconds, how much faster is Mac over Dell?

Execution Time<sub>B</sub>/Execution Time<sub>A</sub> = 15s/10s = 1.5

So Mac (A) is 1.5 times faster than Dell (B)!

# How do we compute Execution Time?



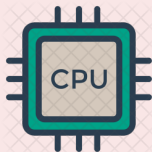
- Elapsed time
  - Total response time, including all aspects:
    - Processing, I/O, OS overhead, idle time.
  - Determines system performance.



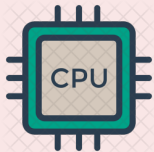
# How do we compute Execution Time?



- CPU time
  - Time spent on processing a given job.
    - Discounts I/O time.
  - Comprises user CPU time and system CPU time.
  - Different programs are affected differently by CPU and system performance.

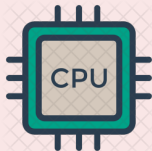


- Operation of digital hardware governed by a constant-rate clock
- Clock period: duration of a clock cycle
  - e.g.,  $250\text{ps} = 0.25\text{ns} = 250 \times 10^{-12}\text{s}$
- Clock frequency (rate): cycles per second
  - e.g.,  $4.0\text{GHz} = 4000\text{MHz} = 4.0 \times 10^9\text{Hz}$



CPU Time = CPU Clock Cycles  $\times$  Clock Cycle Time

$$= \frac{\text{CPU Clock Cycles}}{\text{Clock Rate}}$$



- Performance could be improved by:
  - Reducing number of clock cycles.
  - Increasing clock rate.
  - Hardware designer must often trade off clock rate against cycle count.

# Example-2

- Computer A has:
  - ① 2GHz clock rate
  - ② 10s CPU time
- Computer B:
  - ① 6s CPU time
  - ② Number of clock cycles is 1.2 times as much as the number of clock cycles of Computer A.
- So what is the clock rate of computer B??

## Example-2 (contd)

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

## Example-2 (contd)

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

## Example-2 (contd)

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

$$= 4\text{GHz}$$

So which machine is faster? Computer A or B?



# Exercise

- computer A has:
  - 1 4GHz clock rate
  - 2 8s CPU time
- computer B:
  - 1 6s CPU time
  - 2 Number of clock cycles is 1.4 times as much as the number of clock cycles of Computer A.
- computer C:
  - 1 4s CPU time
  - 2 Number of clock cycles is 1.8 times as much as the number of clock cycles of Computer B.
- So what is the clock rate of computer C?? and which among the three computers is faster?

# Exercise

- Upload your solution, either an image of hand-written solution file or typed down reflection file to your Week5 submission folder. Submission will be counted towards class participation credits.

# Reading Assignment

Section 1.6 in **PH**

# Questions

Do you have any questions from this class discussion?