CS200 - Computer Organization

Performance Metrics - Part 1

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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?

Metrics

- 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

    ...

Metrics

- 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?

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

- 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 ...

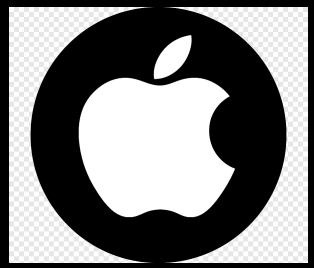
$\text{Performance}_X > \text{Performance}_Y$

$$\frac{1}{ExecutionTime_X} > \frac{1}{ExecutionTime_Y}$$

$$ExecutionTime_X < ExecutionTime_Y$$

... 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 $Time_B$/Execution $Time_A$ = 15s/10s = 1.5

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

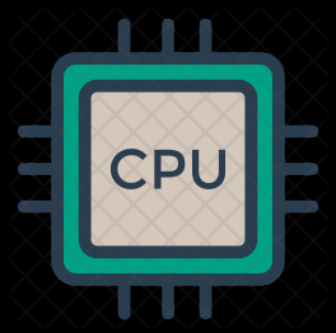
How do we compute Execution Time?

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

How do we compute Execution Time?

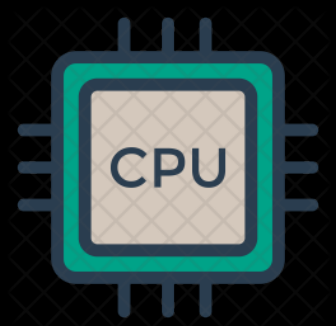
- CPU time
  - Time spent on processing a given job.
    - Discounts I/O time.
  - Comprises user CPU time and system CPU time.
  - Different programs are affected differently by CPU and system performance.

CPU Clocking



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

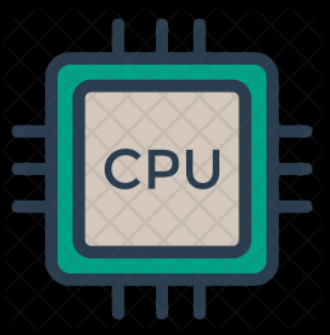
CPU Time



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

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

CPU Time



- 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)

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

$$= \frac{1.2 \times \text{Clock Cycles}_A}{6s}$$

Example-2 (contd)

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

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?

Reading Assignment

Section 1.6 in **PH**

Questions

- Feel free to ask your questions.
- I welcome you to stop by after class time to clarify any confusion related to class topics.
- Also please schedule my office hours so we can spend some time together.