COMPUTER ORGANIZATION (IS F242)

LECT 20: PERFORMANCE

Response Time and Throughput

- Response time / Execution time
  - How long does it take for *my* job to run?
  - How long does it take to execute (start to finish) *my* job?
- Throughput / Bandwidth
  - how *many* jobs can the machine run at once?
  - what is the *average* execution rate?
  - how *much* work is getting done?
- How are response time and throughput affected by
  - Replacing the processor with a faster version?
  - Adding more processors?

Execution Time

- *Elapsed Time*
  - counts everything (disk and memory accesses, waiting for I/O, running other programs etc.) from start to finish
  - a useful number, but often not good for comparison purposes

    elapsed time = CPU time + wait time (I/O, other programs, etc.)
  - Determines system performance
- *CPU time*
  - doesn't count waiting for I/O or time spent running other programs
  - can be divided into user CPU time and system CPU time (OS calls)

    CPU time = user CPU time + system CPU time

    $\Rightarrow$ elapsed time = user CPU time + system CPU time + wait time
- Our focus: *user CPU time* (*CPU execution time* or, simply, *execution time*)
  - time spent executing the lines of code that are in our program

Dependability

- Module reliability
  - Mean time to failure (MTTF)
  - Mean time to repair (MTTR)
  - Mean time between failures (MTBF) = MTTF + MTTR
  - Availability = MTTF / MTBF

Relative Performance

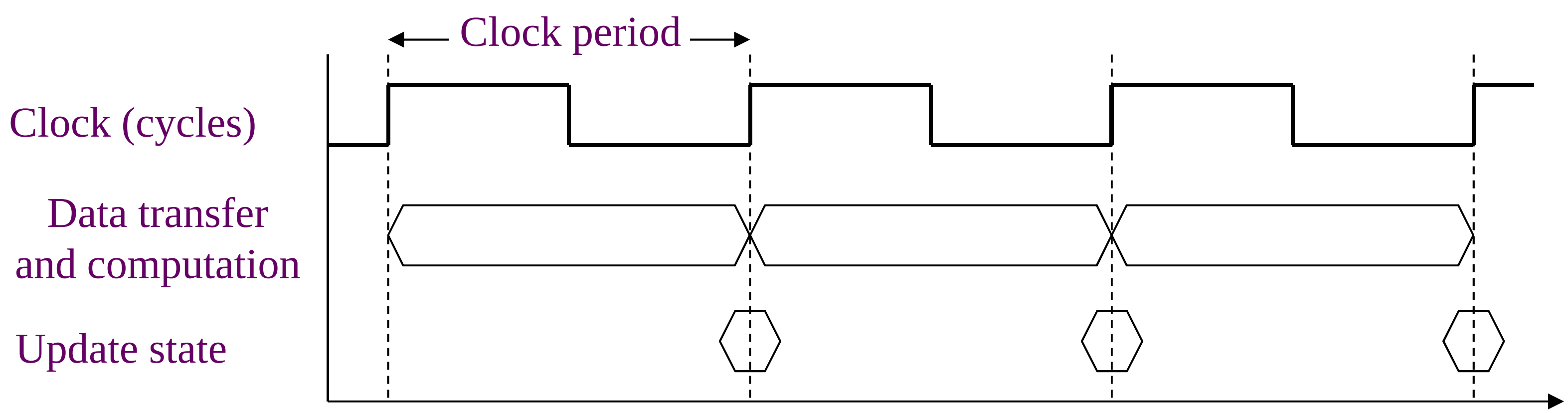
- Define Performance = 1/Execution Time
- "X is n time faster than Y"

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

- 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

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

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

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

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

CPU Time Example

- Computer A: 2GHz clock, 10s CPU time
- Designing Computer B
  - Aim for 6s CPU time
  - Can do faster clock, but causes 1.2 × clock cycles
- How fast must Computer B clock be?

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

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

$$= 10\text{s} \times 2\text{GHz} = 20 \times 10^9$$

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