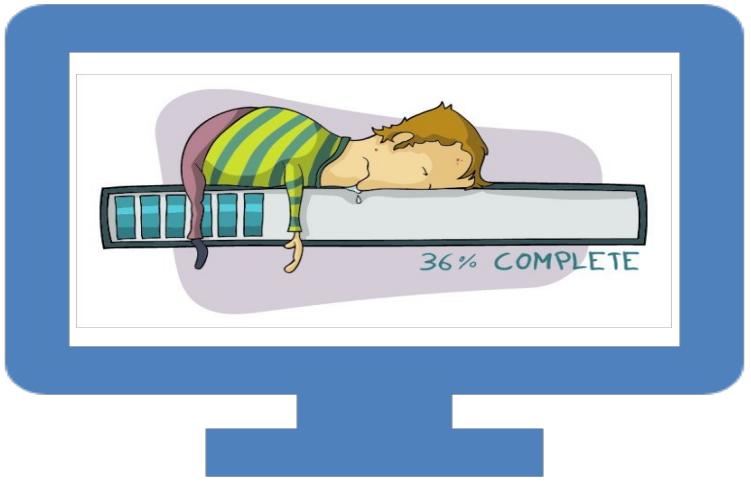


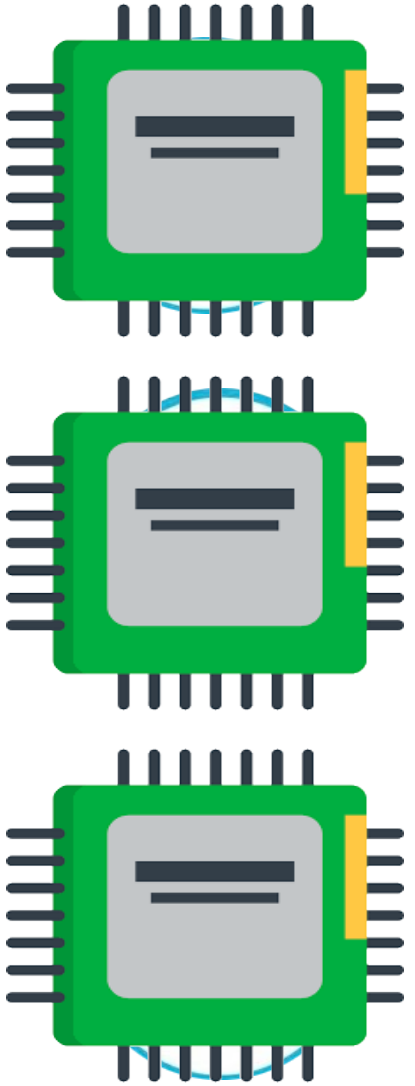
Sections 1.6 - 1.9

Computer Performance

Key Performance Metrics

- **When we say computer A is better than Computer B?**
- ***Response time***
  - Also referred to as ***execution time***
  - How long does it take to complete a task?
- ***Throughput***
  - Total work done per unit time
    - e.g., tasks/transactions/… per hour
  - *relevant to servers*

Discussion



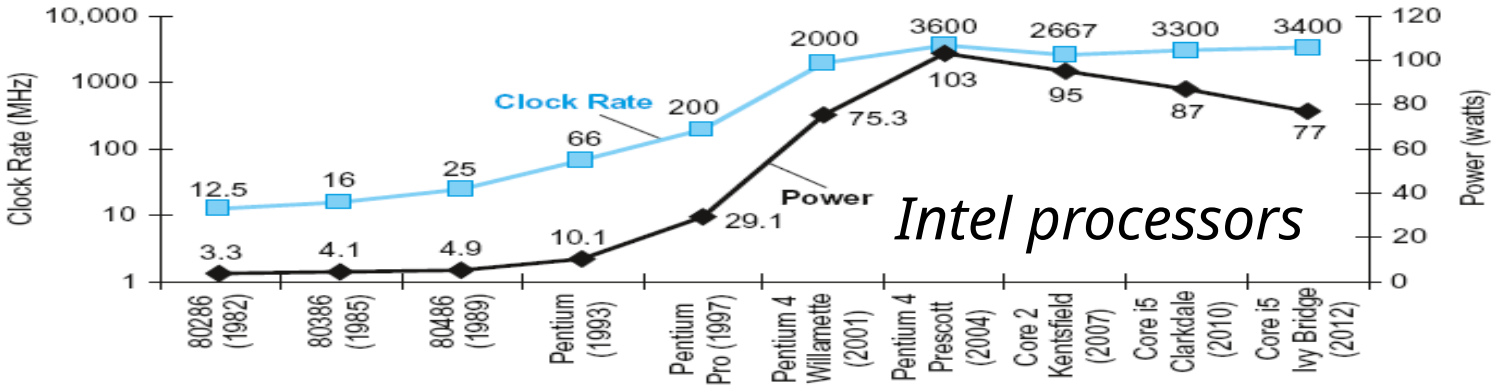
Queuing Theory

Discussion

- How are response time and throughput affected by
  1. Replacing the processor with a faster version?

  2. Adding more processors?

Why speeding processor is challenging?



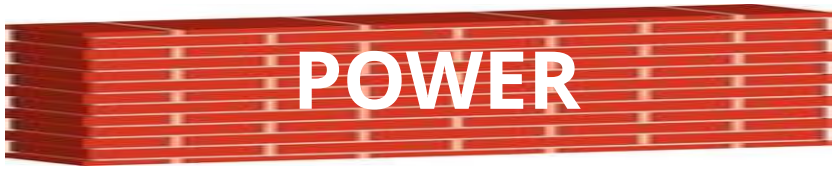
- In CMOS IC technology
  - Complementary Metal Oxide Semiconductor (CMOS)

$$\text{Power} = \text{Capacitive load} \times \text{Voltage}^2 \times \text{Frequency}$$

×30

5V → 1V

×1000



Power wall refers to challenge that accompany increasing the CPU frequency without reducing the voltage level due to the high leakage current. Expensive cooling systems are needed to compensate for temperature increase.

Is multi-core processor useful for a single process?

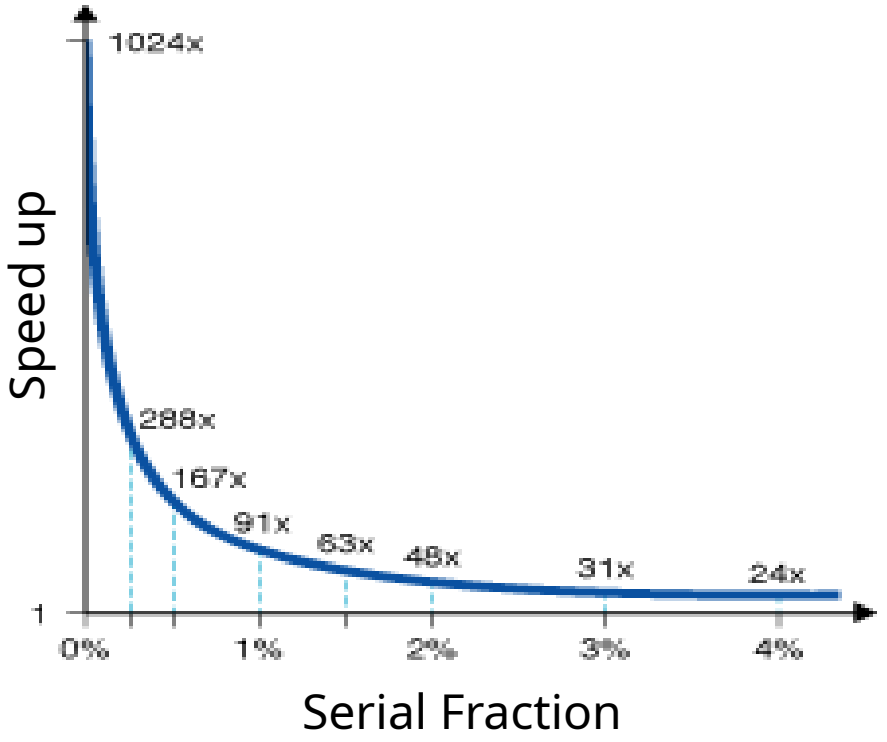
- It is difficult because it needes
- Partitioning the work into parallel pieces
- Scheduling (Balancing the load evenly between the workers)
- Synchronization
- Minimize overhead communications

Amdahl's Law

Speed-up = 1 / [(1 - α) + α/n]

N: number of cores

α: percentage of parallelized code



Parallel Processing Program

- Consider a program with 100 tasks can be parallelized and 10 tasks are serial
  - ***With 10 processors***
    - execution time = 10 + 100/10
      = 20 time units
    - Speed up = 110t / 20t = 5.5

With 40 processors
Execution time = 10 + 100/40
= 12.5 time units
Speed up = 110 /12.5 = 8.8

- ***Increasing the size of the parallelizable jobs increases the speed up*** [Check 100 tasks → 400 tasks]
- ***Unbalanced*** processor load reduces the speed-up factor.
  - One processor gets 20% parallelizable jobs → exec. time = 10 + max(0.2*100 /1, 0.8*100/9)= 30 time units → speedup = 110 / 30 = 3.67

Processor Performance

- Speeding the clock improves ***both*** response time and throughput
- Speeding the clock cycle is challenged by the power wall.

- Multicore processor improves the throughput, but does not impact the response time.
- Multi-core processor is only useful for a single process if its instructions can be executed in parallel.