CPSC440 Computer System Architecture II

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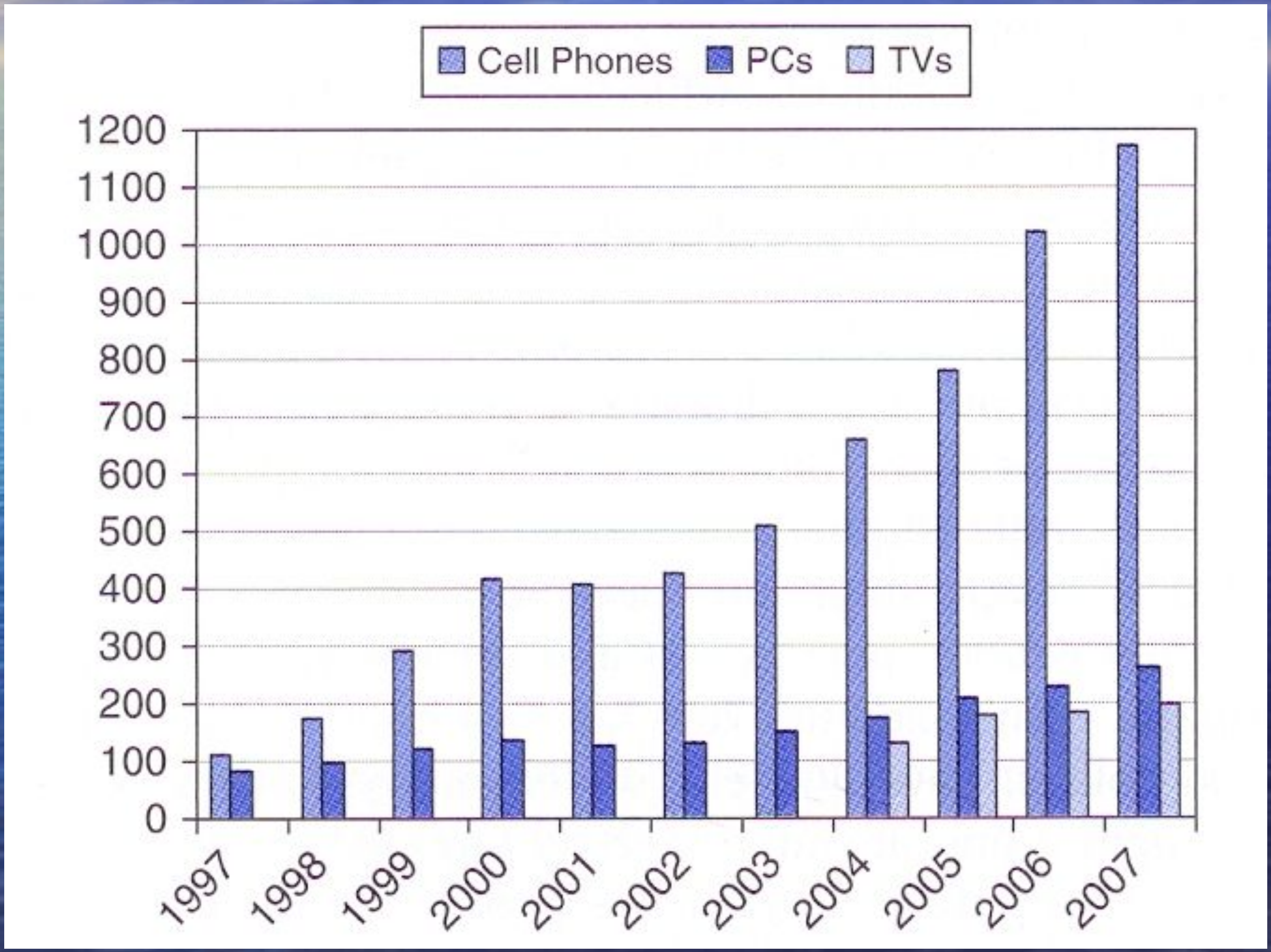
Chapter 1
Computer Abstractions and Technology

Market for different computers



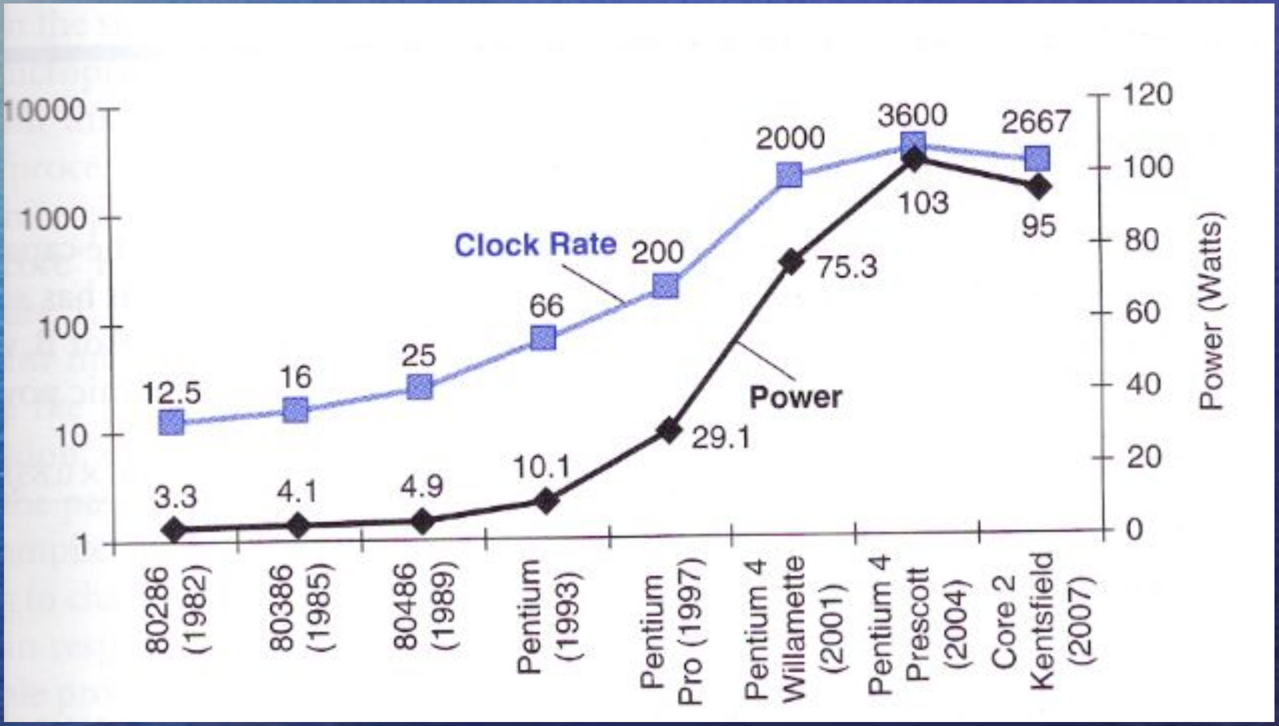
Measuring Performance

- CPU execution time for a program =

  (CPU clock cycles for a program) x (Clock cycle time)

  = (CPU clock cycles for a program)/(Clock rate)

Power consumption of CPU



Power equation

- Power = Capacitive load X Voltage^2 X Frequency switched

Example (page 34)

- Our favorite program runs in 10 seconds on computer A, which has 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?

Answer

Let's first find the number of clock cycles required for the program on A:

ANSWER

$$\text{CPU time}_A = \frac{\text{CPU clock cycles}_A}{\text{Clock rate}_A}$$

$$10 \text{ seconds} = \frac{\text{CPU clock cycles}_A}{2 \times 10^9 \frac{\text{cycles}}{\text{second}}}$$

$$\text{CPU clock cycles}_A = 10 \text{ seconds} \times 2 \times 10^9 \frac{\text{cycles}}{\text{second}} = 20 \times 10^9 \text{ cycles}$$

CPU time for B can be found using this equation:

$$\text{CPU time}_B = \frac{1.2 \times \text{CPU clock cycles}_A}{\text{Clock rate}_B}$$

$$6 \text{ seconds} = \frac{1.2 \times 20 \times 10^9 \text{ cycles}}{\text{Clock rate}_B}$$

$$\text{Clock rate}_B = \frac{1.2 \times 20 \times 10^9 \text{ cycles}}{6 \text{ seconds}} = \frac{0.2 \times 20 \times 10^9 \text{ cycles}}{\text{second}} = \frac{4 \times 10^9 \text{ cycles}}{\text{second}} = 4 \text{ GHz}$$

Fallacies and Pitfalls

- Commonly held misconceptions – Fallacies
- Easily made mistakes - pitfalls

Pitfall

- Expecting the improvement of one aspect of a computer to increase overall performance by an amount proportional to the size of the improvement.

Pitfall example

- Suppose a program runs in 100 seconds on a computer, with multiply operations responsible for 80 seconds of this time. How much do I have to improve the speed of multiplication if I want my program to run five times faster?

Approach

the following simple equation known as **Amdahl's law**:

$$\text{Execution time after improvement} = \frac{\text{Execution time affected by improvement}}{\text{Amount of improvement}} + \text{Execution time unaffected}$$

For this problem:

$$\text{Execution time after improvement} = \frac{80 \text{ seconds}}{n} + (100 - 80 \text{ seconds})$$

Since we want the performance to be five times faster, the new execution time should be 20 seconds, giving

$$20 \text{ seconds} = \frac{80 \text{ seconds}}{n} + 20 \text{ seconds}$$

$$0 = \frac{80 \text{ seconds}}{n}$$

Amdahl's law A rule stating that the performance enhancement possible with a given improvement is limited by the amount that the improved feature is used. It is a quantitative version of the law of diminishing returns.

Fallacy example

- Computers at low utilization use little power.

Pitfall example (another)

- Using a subset of the performance equation as a performance metric.

MIPS

- **MIPS**, for ***M*icroprocessor without *i*nterlocked *p*ipeline *s*tages**, is a RISC, is a RISC microprocessor architecture developed by MIPS Computer Systems Inc.

(**From Wikipedia, the free encyclopedia ■**)

MIPS (Million Instructions Per Second)

- MIPS= (Instruction count)/(Execution time x 10^6)
- CPI = Clock Cycles Per Instruction

Measurement	Computer A	Computer B
Instruction Counts	10 billion	8 billion
Clock Rate	4 GHz	4 GHz
CPI (averaged)	1.0	1.1

Which computer has the higher MIPS rating?

Approach

- Computer A can run 4 G clock cycles per second. Since CPI=1, that means this computer can run 4G instructions per second (which is 4000 Million Instructions Per Second, thus, 4000 MIPS)

Approach

- Computer B can run 4 G clock cycles per second. Since B's CPI=1.1, that means in one second, B executes 4G/1.1 = 3.64 x 10^9 instructions = 3640 Million Instruction Per Second = 3640 MIPS.

Which computer is faster?

Approach

- How many clock cycles needed for computer A to finish the program: 10 B x CPI = 10 x 10^9 x 1 = 10^{10} cycles
- How many seconds needed for computer A to finish the job? (10^{10} cycles/4G cycles =10 x 10^9 / 4 x 10^9 = 2.5 seconds

Approach

- How many clock cycles needed for computer B to finish the program: 8 B x CPI = $8 \times 10^9 \times 1.1 = 8.8 \times 10^9$ cycles
- How many seconds needed for computer B to finish the job?
- 8.8×10^9 cycles /4G cycles $=8.8 \times 10^9 / 4 \times 10^9 = 2.2$ seconds