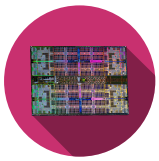


Performance

Exercises Computer Architecture

1 Processor Benchmark & Performance

1.1 Which of the following statements are correct?

- ☐ The wall clock time is the total elapsed time , including I/O, Operating system overhead etc.
- ☐ Multi-threading improves the throughput of a process
- ☐ The Central-Processing-Unit (CPU) time does not include the I/O time
- ☐ Multi-threading improves the execution time of a process

per/benchmark-01

1.2 What is the throughput?

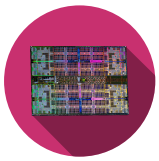
- ☐ performance per Watt (the number of FLOPS per Watt)
- ☐ rate of processing work (n jobs/second)
- ☐ the time between start and completion of event/task/program (n seconds)
- ☐ the percentage of time a system is up and running

per/benchmark-02

1.3 What is the SPEC?

- ☐ is a benchmark suit developed to measure performance based on the latest Java application feature
- ☐ is a benchmark that evaluates the power and performance characteristics of volume server class computers
- ☐ is the wordwide standard for measuring graphics performance based on professional applications
- ☐ is a bechmark suit designed to provide performance measurements that can be used to compare computer-intensive workloads on different computer systems

per/benchmark-03



1.4 What is the goal of the EEMBC Benchmark?

- ☐ to evaluate performance of embedded microprocessors
- ☐ to evaluate integer computation performance
- ☐ to measure the energy efficiency of different computer systems
- ☐ to evaluate floating point performance

per/benchmark-04

1.5 Which of the following is an energy efficiency metric?

- ☐ flops
- ☐ Microprocessor without Interlocked Pipelined Stages (MIPS)
- ☐ Performance per watt
- ☐ Power consumption

per/benchmark-05

1.6 Both power consumption and performance per watt matters for an embedded system.

- ☐ True
- ☐ False

per/benchmark-06

1.7 Processor performance

A program consists of 5′000 floating point instructions and 25′000 integer instructions. Processor A has a clock rate of 2.0GHz. Floating point instructions take 7 cycles and integer instructions take 1 cycle.

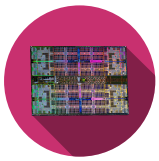
a) How long does it take for this processor to run the program?
b) What is the average Cycles per Instruction (CPI) for this processor for the given program?
c) Processor A runs program 2 consisting of 100′000 floating point instructions and 50′000 integer instructions. What is the average CPI for this program?
d) Processor B has an average CPI for program 2 of 3.5. It's clock rate is 1.8GHz. How much time does it take to execute the program?
e) Which processor is faster and by how much?

Processor _____ is _____ times faster than processor _____.

per/performance-01

1.8 Processor performance

Consider the following two machine designs with their respective CPI's for various instruction types. Computer A and Computer B have the same instruction set:



Instruction Type	CPI_A	CPI_B	Compiler 1 Mix
Data Manipulation	1.5	1.0	25%
Arithmetic	1.0	1.5	30%
Shifting	1.0	1.2	10%
Branching	4.0	2.0	25%
Multiply	20	12	10%

a) What is the average CPI for each of the computers using this program?
b) Computer A has a clock cycle time of 0.5ns. Computer B is running at 1.8GHz. Write a quantitative statement comparing the two computers.
c) What would the clock rate of the slower computer have to be to equal performaner of the faster computer?

per/performance-02

1.9 Processor performance

A CPU run on a base frequency of 2GHz. It executes a program with 5 million instructions with the given instruction mix. newline What is the execution time of the program?

Instruction	Frequency	CPI_{instr}
ALU	50%	3
Load	20%	5
Store	10%	4
Branch	20%	3

per/performance-03

1.10 Processor performance

A CPU is designed for an optimal performance on a given program with the following characteristics. 25% of all instructions are floating point instructions with an average CPI of 4.0, in addition the program contains 2% Floating Point Square Root (FPSQR) instructions with an average CPI of 20. All other instructions have an average CPI or 1.33.

There are two design alternatives:
1. Decrease CPI of FPSQR instructions to 2.0
2. Decrease the average CPI of all floating point instructions to 2.5

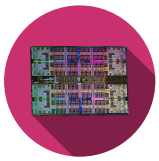
Which choice is best?

per/performance-04

1.11 Processor performance

We want to buy a new computer. It will mostly run programs P_1 and P_2.

What weigth w_1 and w_2 need the programs to have so that:



a) CPU A the best buy?
b) CPU B the best buy?
c) CPU C the best buy?

Program	CPU_A	CPU_B	CPU_C
Program P_1 (sec)	1	10	100
Program P_2 (sec)	100	10	1

per/performance-05

1.12 Processor performance

Given the following performance of two programs on three CPU's, user the geometric mean to calculate which computer is the fastest:

a) CPU A is the fastest?
b) CPU B is the fastest?
c) CPU C is the fastest?

Program	CPU_A	CPU_B	CPU_C
P_1 (sec)	40	15	20
P_2 (sec)	40	1000	150

per/performance-06

1.13 Processor performance

Calculate the average CPI and the execution time for 5million instructions of the following instruction frequencies:

Instruction	Frequency	CPI_{instr}
ALU	40%	4
Load	30%	6
Store	5%	5
Branch	25%	4

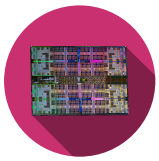
The clock frequency of the CPU is 2 GHz

per/performance-07

1.14 What is the best metric for comparinc performance?

- ☐ arithmetic mean
- ☐ geometric mean
- ☐ median
- ☐ maximum performance
- ☐ harmonic mean

per/performance-08



1.15 Processor performance

Calculate the execution time in ms, supposing to have CPU with the following instruction frequencies:

Instruction	Frequency	CPI_{instr}
ALU	45%	5
Load	25%	6
Store	10%	5
Branch	20%	3

For 2 Million instructions and a CPU frequency of 3GHz.

per/performance-09

1.16 Amdahl's Law

An improvement of the floating point execution unit resulted in 2x faster floating point instructions. In average 10% of all instructions are floating point instruction for this processor.

What will be the overall speedup?

per/amdahls-law-01

1.17 Amdahl's Law

We want an overall speedup of 2 and can accelerate the floating point instructions by 4 times.

What should be the fraction of floating point instructions?

per/amdahls-law-02

1.18 Amdahl's Law

A program consists of 2 different elements. Part A has a duration of 15 and part B a duration of 5 time units. There are two optimization variants:

1. optimization of the A part by two times
2. optimization of the B part by five times

Which optimization is more advantageous? What are the implications?

per/amdahls-law-03