BRADLEY University

CS 220 Computer Architecture

HW 08 - Performance Evaluation

Fall 2023

DEPARTMENT OF COMPUTER SCIENCE AND INFORMATION SYSTEMS

Part 0: Reading Instructional Videos

- Reading: Chapter 02 - Performance Concepts

Part 1: Questions on Performance Issues

Question 1

List and briefly define 5 major techniques used in contemporary processors to increase speed. **[15 PTS]**

Technique	Description
Pipelining	Enables a processor to work simultaneously on multiple instructions by performing a different phase for each of the multiple instructions at the same time.
Branch Prediction	Processor looks ahead in memory to determine which instruction is likely to be processed next. If the processor guesses right, it can help keep the execution engine busy
Superscalar Execution	This is the ability to issue more than one instruction in every processor clock cycle. In effect, multiple parallel pipelines are used
Data Flow Analysis	Using branch prediction and data flow analysis, some processors speculatively execute instructions ahead of their actual appearance in the program execution, holding the results in temporary places. This allows the execution engines to remain busy as the do the most important operations first
Speculative execution	Using branch prediction and data flow analysis, some

	processors speculatively execute instructions ahead of their actual appearance in the program execution, holding the results in temporary locations keeping execution engines as busy as possible

Question 2

Describe the concept of performance balance. **[10 PTS]**

The ability for a computer to process information consists of multiple parts. If any of these parts are slower than another part, it can create bottlenecks where the system cannot process a task efficiently. Machine balance is the idea that to run as efficiently as possible, there must be a balance between all the processors that can help speed up the computer's ability to process information.

Question 3

Compare and contrast multi-core systems, MICs, and GPGPUs. **[10 PTS]**

Multi-core system uses multiple cores to help speed up processing power without increasing the clock rate. Two cores compared to one almost doubles the processing power. The sort of evolution to this is the many integrated cores (MIC), which requires at least 50 general processing cores. Multi-core systems can have any amount of cores, but with over 50 the MICs can perform tasks extremely fast. The graphics processing units (GPUs) that use multi-cores, but are not general cores. These cores are specialized in rendering 2D and 3D graphics on a card. However; the GPUs are being used for more general purposes, and thus the term general-purpose computing on GPUs was born as the GPU is used for more repetitive computations.

QUESTION 4

Describe Amdahl's law and Little's law. **[10 PTS]**

Amdahl's law is used to improve system performance. The law states that *Speedup = time to execute program on a single processor / Time to execute program on N parallel processors*. The speedup comes from using parallel processors. If you had one single processor and two parallel processors, the speedup would be around two, as the parallel processors could do a task in 2 seconds compared to the four seconds required by the single processor.

Little's law states that *Average number of items (L) in a queuing system equals the average rate at which items arrive (λ) multiplied by the time an item spends in the system (W), so L = λ * W*. This relationship describes the average flow in and out of a system. The L is the amount of memory in a processor to process information. The λ is the flow of memory into the processor, and the W is the time to process the information. This equation helps calculate the flow of information through a processor.

QUESTION 5

Define MIPS and FLOPS. **[10 PTS]**

MIPS stands *for millions of instructions per second*. This is a unit of measurement to test how fast a processor can execute in a second. This is a standard unit when it comes to day to day operations.

FLOPS stands for *floating point operations done per second*. Floating point operations are similar to instructions, but since they work with larger bits, they tend to work at a different rate than MIPS.

QUESTION 6

Compare and contrast the following performance evaluation metrics for computer systems. **[10 PTS]**

Metric	Description
Base	A standard metric that is required for all reported results. The reported results have strict guidelines for compilation. These guidelines act as a default for metrics
Peak	Enables users to optimize their system performance by optimizing their compiler output
Speed	A measurement of the time it takes to execute a compiled benchmark. Mostly used for single tasks
Rate	The measurement of how many tasks a computer can accomplish in a certain amount of time. This allows for the system to test multiple processors.

QUESTION 7

Describe the SPEC benchmarks. **[10 PTS]**

SPEC stands for *Standard Performance Evaluation Corporation*. The SPEC created a benchmark to test a wide variety of hardware across the industry. This helps set a benchmark not for a single company, but for almost all companies in the world to see which hardware is the fastest.

QUESTION 8

List the **four** desirable characteristics of a benchmark program. **[10 PTS]**

1. It is written in a high level language, making it portable across different machines
2. It is representative of a particular kind of programming domain or paradigm, such as systems programming, numerical programming, or commercial programming
3. It can be measured easily
4. It has wide distribution

QUESTION 9

List and **define** the **three** methods for calculating a **mean** value of a set of data values. **Compute** the mean value for each method, given data set. **[15 PTS]**

S = {1, 2, 3, 3, 3, 10, 100}

x(n) equals the sum of values, and the n equals the number of values

1. Arithmetic mean - an appropriate measure if the sum of all the measurements is a meaningful and interesting value. Good for comparing the execution time performance of several systems

$$AM = \frac{x_1 + \cdots + x_n}{n} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

(1+2+3+3+3+10+100) / 7 = ~17.43 (or 122 / 7)

2. Geometric mean - Gives equal weight to all values in a data set. Where Arithmetic mean would be dominated by larger values, this gives credence to smaller values, so the distribution is more equal.

$$GM = \sqrt[n]{x_1 \times \cdots \times x_n} = \left(\prod_{i=1}^{n} x_i \right)^{1/n} = e^{\left(\frac{1}{n} \sum_{i=1}^{n} \ln(x_i) \right)}$$

7sqrt(1+2+3+3+3+10+100) = ~1.986 (or 7sqrt(1+2+3+3+3+10+100)

3. Harmonic mean - Calculates the mean to be inversely proportional to execution time. This results in a more useful measurement for the value of the system

$$HM = \frac{n}{\left(\frac{1}{x_1}\right) + \cdots + \left(\frac{1}{x_n}\right)} = \frac{n}{\sum_{i=1}^{n} \left(\frac{1}{x_i}\right)} \qquad x_i > 0$$

7 / ((1 / 1)... (1/100)) = ~2.682 (or 700/261)