Study Guide

What are the 8 great Architectural Idea's

1. Design for Moore's Law
2. Use Abstraction to simplify design
3. Make Common Case Fast
4. Performance via Parallelism
5. Performance via Pipelining
6. Performance via Prediction
7. Hierarchy of memories
8. Dependability via redundancy

Explain Measuring Performance - CPU Time, Clock Rates, Instruction Time, CPI

Discussing performance mandates that we understand **Latency (response Time)**, the time between the start and the completion of an event, and **Throughput (bandwidth)**, the total amount of work done in a given period of time.

Performance has an inverse relationship with execution time, aka the less execution time the better the performance and vice versa. This means that we can use the following formula to determine the performance.

$$Performance = \frac{1}{ExecutionTime}$$

Therefore we can also use this formula to determine the difference in performance (also used to determine which is greater). This comparison can be done using the following formula. We can use this to our advantage to be able to gauge **Relative Performance**. This will allow us to declare statements such as *Program A is N times faster than Program B*. To understand this we use the following formula:

$$\frac{Performance_x}{Performance_y} = \frac{Execution_x}{Execution_y}$$

There are several ways in which we can measure the execution time on a machine.

- **Elapsed Time**: Total wall clock time needed to perform a task
- **CPU Time**: Time CPU spends on the task, not including I/O

- **User CPU Time**: Time CPU spend in the program
- **System CPU Time**: Time CPU spent in the OS doing actions on behalf of the program

It may be useful to look at performance through other metrics than time, such as how fast a computer can perform some basic operations. Here are some more terms we use for these.

- **Clock Cycle**: The basic discrete intervals of a processor clock, constant rate
- **Clock Period**: the length of each clock cycle
- **Clock Rate**: inverse of the clock period

In order to determine the effect of a change on performance we must apply the following:

$$CPUExecutionTime = CPUClockCycles * ClockPeriod$$

This can alternatively be expressed as,

$$CPUExecutionTime = \frac{CPUClockCycles}{ClockRate}$$

From this we can see that we can reduce the execution time by either reducing the number of clock cycles required or the length of each clock cycle.

Another useful formula is for the CPU clock cycles. This can be calculated by finding the number of instructions for a program and multiplying it by the Average Clock Cycles per instruction. This can be seen below, as well as the formula for the **CPI**.

$$CPUClockCycles = InstructionsForAProgram * AvgClockCyclesPerInstruction*$$

$$CPI = \frac{CPUClockCycles}{InstructionCount}$$

The **CPI** is the clock cycles per instruction.

Now rewriting the basic equation in terms of the instruction count, CPI, and clock cycle time we achieve.

$$CPUTime = InstructionCount * CPI * ClockPeriod$$

Or Alternatively,

$$CPUTime = \frac{InstructionCount * CPI}{ClockRate}$$

What is AMDAHL'S Law?

Amdahl's Law states that the performance improvement that is gained from using a faster mode of execution is limited by the fraction of the time the new faster mode can use.

This means that Amdahl's law is dependent on two factors

- The fraction of time the enhancement can be exploited
- The improvement gained by the enhancement while it is exploited

$$ImprovedExeTime = \frac{AffectedExeTime}{AmountImproved} + UnaffectedExeTime$$

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