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Chapter 1:

Question 1: What, in general terms, is the distinction between computer organization and computer architecture?

Computer architecture: refers to the hardware and the visible to the programmer and what have direct impact on the logical execution of a program.

Computer orgnization: refers to the operational units and their interconnections that realize the architectural specification.

Question 2: What are the four main functions of a computer?

1- Input
2- output
3- Processing
4- Control

Question 3: List and briefly define the main structural components of a computer.

Central Processing unit CPU: Controls the operation of the computer and performs its data processing functions.

Main memory: Stores data.

I/O: Moves data between the computer and its external environment.

System interconnection: Some mechanism that provides for communication among CPU, main memory, I/O.

Question 4: List and briefly define the main structural components of a processor.

1- Control Unit: Controls the operation of the CPU & hence the computer
2- Arithmetic and logical unit ALU: Performs the computer's data processing functions.
3- Registers: Provides storage internal to the CPU.
4- CPU interconnections: Some mechanism that provides for communication among the control unit, ALU, and registers.

Question 5: Explain Moore's law.

: Moore's law states that the number of transistors on a microchip doubles about every two years, though the cost of computers is halved.

Question 6: List and explain the key characteristics of a computer family.

1- Similar or identical instruction set: the same set of machine instructions is supported on all members of the family, thus a program that executes on one machine will execute on any computer

2- Similar or identical operating system: the same basic operating system is available for all family members.

3- increasing speed: the rate of instruction execution increases in going from lower to higher family members.

4- Number of I/O Ports: in going from lower to higher family members

5- increasing memory size: in going from lower to higher family members

6- Increasing cost; in going from lower to higher family members

Question 7: While browsing at Billy Bob's computer store, you overhear a customer asking Billy Bob what the fastest computer in the store is that he can buy. Billy Bob replies, "You're looking at our Macintoshes. The fastest Mac we have runs at a clock speed of 1.2 GHz. If you really want the fastest machine, you should buy our 2.4-GHz Intel Pentium IV instead." Is Billy Bob correct? What would you say to help this customer?

No he is not correct, the work of the computer is not measurable by using clock speed only, other part of the system factor should be considered. Even though intel machine may have a faster clock speed at 2.4GHz it does not mean the system will perform faster. there are a lot of factors such as the system components and the instruction set that are need to be taken care of, A more accurate measure is to run both system on a benchmark. Benchmark program exist for certain task such as running office apps..... etc.

the system can be compared to each other on how long they take to complete these tasks. G4 is comparable or better that a high-clock speed Pentium on many benchmark.

Question 8: For each of the following examples, determine whether this is an embedded system, explaining why or why not.

a. Are programs that understand physics and/or hardware embedded? For example, one that uses finite element methods to predict fluid flow over airplane wings?

Not embedded System because they are not an integral component of a large System.

b. Is the internal microprocessor controlling a disk drive an example of an embedded system?

Yes, the disk drive's function is: the HDA hardware is controlled by Software within the disk drive which is Also hard real time

system?

c. I/O drivers control hardware, so does the presence of an I/O driver imply that the computer executing the driver is embedded?

No, because that computer may be a general purpose computer that's not part of a large System.

d. Is a PDA (Personal Digital Assistant) an embedded system?

yes, because they perform a specific number of tasks which are controlled by a built in computer System

e. Is the microprocessor controlling a cell phone an embedded system?

Yes, because the microprocessor has designed in only one way to control and is to make the efficient use of the Cell Phone

f. Are the computers in a big phased-array radar considered embedded? These

Yes, these computers were generally some of the most powerful computers available when the system was built, are located in a large computer room occupying almost one floor of a building and may be hundreds of meters away.

g. Is a traditional flight management system (FMS) built into an airplane cockpit considered embedded?

if the FMS is not connected to the avionics then it is not embedded.

considered embedded?

h. Are the computers in a hardware in the loop (HIL) simulator embedded?

yes, becaus they are being controlled on both sides.

i. Is the computer controlling a pacemaker in a person's chest an embedded computer?

yes, the System is the combination of the Pacemaker and the heart.

j. Is the computer controlling fuel injection in an automobile engine embedded?

yes, It is Part of a large System and directly monitoring through hardware

Question 1: List and briefly define some of the techniques used in contemporary processors to increase speed.

1- Pipelining
2- on board Cache
3- on board L1 & L2 Cache
4- Branch Prediction
5- data flow analysis
6- Speculative execution

Question 2: Briefly characterize Amdahl's law.

: It States that when a Part of a System is improved the overall System improvement will be Proportional to how much that Part makes up of the System.

Question 3: Briefly characterize Little's law.

: It States that the long-term Average number Of Customers in a Stable System L is equal to the long-term average effective arrival rate λ, multiplied by the average time a Customer Spends in the System.

Question 4: Using Ahmdal's law, try to find the number of cores required to speed up the execution of program by a factor of 5 if 90% of the instructions are parallelizable?

Amdahl's law

$$S_{latency} = \frac{1}{(1-P+(\frac{P}{S}))}$$

$$S_{latency} = 5$$

$$\text{or, } \frac{1}{(1-P+(\frac{P}{S}))} = 5$$

$$\text{or, } \frac{1}{(1-0.9+(\frac{0.9}{S}))} = 5$$

$$\text{or, } 5-4.5+((\frac{0.9}{S})*5) = 1$$

$$\text{or, } (\frac{4.5}{S}) = 0.5 \quad \text{or, } S=9$$

hence, the number Of required Core is $\underline{\underline{9}}$

Question 5: Arithmetic instructions take 5 cycles, load / store instructions take 10 cycles, branch instructions take 4 cycles, while logic instructions take 1 cycle. Assume that there are 5 instructions of each type in a program. What are the average cycles per instruction for the program?

CPI for arthmetic instruction = 5 cycles

CPI for load Store instruction = 10 cycles

CPI for branch instruction = 4 cycles

CPI for logic instruction = 1 cycle

Assuming 5 instructions of each type in a Program

total = 5+5+5+5+5 = 20

$$\text{Average CPI} \Rightarrow \frac{5 * \text{CPI Arthimetic} + 5 * \text{CPI load Store} + 5 * \text{CPI Branch} + 5 * \text{CPI logic}}{\text{Total instruction}}$$

$$= \frac{5 \times 5 + 5 \times 10 + 5 \times 4 + 5 * 1}{20} = \frac{100}{20} = \boxed{5}$$

Question 6: A processor has a clock of 1 GHz. The **CPI** (Cycle Per Instruction) of the processor were calculated to be 6 cycles per instruction. What is the rate at which instructions are executed in **MIPS** (millions of instructions per second)?

Clock Speed = 1GH $= 10^9$ Hz

CPI = 6

$$\text{MIPS} = \frac{\text{Clock Speed}}{\text{CPI} \times 10^6}$$

$$\text{Put the Values MIPS} = \frac{10^9}{6 \times 10^6} \Rightarrow \text{MIPS} = 166.67$$

Question 7: While benchmarking three programs were run on two processors A and B. The execution times of the program are given below. Calculate the arithmetic mean value for each processor using C as the reference machine for the three processors and indicate which of them is faster.

	Processor A	Processor B	Processor C
Program 1	1.0	0.2	1.0
Program 2	1.5	0.5	1.3
Program 3	3.0	0.7	0.5

result: Processor B has less time and It's faster

$$\text{Processor A} \rightarrow \frac{(2.0+1.5+3.0)}{3} = 2.166$$

$$\text{Processor B} \rightarrow \frac{(3.0+2.0+1.0)}{3} = 2.0$$

$$A: (2.0 * 1.5 * 3.0) = \sqrt[3]{9} = 2.080$$

$$B: (3.0 * 2.0 * 1.0) = \sqrt[3]{6} = 1.817$$

$$A: \frac{3}{\frac{1}{2.0} + \frac{1}{1.5} + \frac{1}{3.0}} = 2$$

$$B: \frac{3}{\frac{1}{3.0} + \frac{1}{2.0} + \frac{1}{1.0}} = 1.6364$$

Question 8: A benchmark program is run on a 40 MHz processor. The executed program consists of 100,000 instruction executions, with the following instruction mix and clock cycle count:

Instruction Type	Instruction Count	Cycles per Instruction
Integer arithmetic	45,000	1
Data transfer	32,000	2
Floating point	15,000	2
Control transfer	8000	2

Determine the effective CPI, MIPS rate, and execution time for this program.

$$CPI = \frac{\text{Instruction Count} * \text{Cycle Per Instruction}}{\text{Sum of Instruction Count}}$$

$$= \frac{45000*1+32000*2+15000*2+8000*2}{100000} = 1.55$$

$$MIPS = \frac{40\,Hz}{1.55} = 25.08\ MIPS$$

Execution time: CPI * instruction Count * Clock

$$= \frac{CPI * \text{instruction Count}}{\text{frequency}}$$

$$1.55 * \frac{100000}{40} * 1000000 = 0.003875\ Sec$$

$$\approx 3.875\ ms$$

Question 9: Consider two different machines, with two different instruction sets, both of which have a clock rate of 200 MHz. The following measurements are recorded on the two machines running a given set of benchmark programs:

Instruction Type	Instruction Count (millions)	Cycles per Instruction
Machine A		
Arithmetic and logic	8	1
Load and store	4	3
Branch	2	4
Others	4	3
Machine B		
Arithmetic and logic	10	1
Load and store	8	2
Branch	2	4
Others	4	3

a. Determine the effective *CPI*, MIPS rate, and execution time for each machine.
b. Comment on the results.

A)

$$CPI_A = \frac{\Sigma CPI_i \times I_i}{I_i} = \frac{(8\times1+4\times3+2\times4+4\times3)\times10^6}{(8+4+2+4)\times10^6} \approx 2.22$$

$$MIPS_A = \frac{f}{CPI_A \times 10^6} = \frac{200\times10^6}{2.22\times10^6} = 90$$

$$CPU_A = \frac{I_c \times CPI_A}{f} = \frac{18\times10^6\times2.2}{200\times10^6} = 0.2\ S$$

$$CPI_B = \frac{\Sigma CPI_i \times I_i}{I_i} = \frac{(10\times1+8\times2+2\times4+4\times3)\times10^6}{(10+8+2+4)\times10^6} = 1.92$$

$$MIPS_B = \frac{f}{CPI_B\times10^6} = \frac{200\times10^6}{1.92\times10^6} = 104$$

$$CPU_B = \frac{I_c\times CPI_B}{f} = \frac{24\times10^6\times1.92}{200\times10^6} = 0.23\ S$$

B) even though machine B has higher MIPS than A, it needs a longer CPU time to execute the similar instructions.

Question 10: Early examples of CISC and RISC design are the VAX 11/780 and the IBM RS/6000, respectively. Using a typical benchmark program, the following machine characteristics result:

Processor	Clock Frequency (MHz)	Performance (MIPS)	CPU Time (secs)
VAX 11/780	5	1	12x
IBM RS/6000	25	18	x

The final column shows that the VAX required 12 times longer than the IBM measured in CPU time.

a. What does the relative size of the instruction count of the machine code for this benchmark program running on the two machines?

b. What are the CPI values for the two machines?

A) the MIPS rate could be computed as the following:

$$\left[\frac{(\text{MIPS rate})}{10^6}\right] = \frac{I_c}{T} \Rightarrow \frac{[x \times 18]}{[12x \times 1]} = \frac{18x}{12x} = 1.5$$

B) VAX 11/780 the $CPI = \frac{5MHz}{1MIPS} = 5$

IBM RS/6000, the $CPI \; \frac{(25MHz)}{18MIPS} = 1.4$