UNIT I BASIC STRUCTURES OF COMPUTERS

Functional units – Basic operational concepts – Bus Structures – Performance – Memory locations and addresses – Memory operations – Instruction and Instruction sequencing — Addressing modes – Assembly language – Case study: RISC and CISC Architecture.

1. Explain the various components of computer System with neat diagram.
2. Discuss in detail the various measures of performance of a computer (16) or Explain the techniques used to measure the performance of a computer.
3. Illustrate the concepts of memory operations with example.
4. Explain in detail about bus structure with neat diagram
5. Elaborate the concept of Instruction and Instruction Sequencing.
6. Prove that how performance and execution are inverse to each other
7. Define Addressing mode and explain the basic addressing modes with an example for each.
8. Convert the C code to Assembly language. Assume that the variables f, g, h, i, and j are assigned to registers $s0, $s1, $s2, $s3, and $s4, respectively. Assume that the base address of the arrays A and B are in registers $s6 and $s7, respectively. C Code: f = g + A[B[4]-B[3]]; For the C statement above, what is the corresponding assembly code?

   Ans:

   ```
   lw $t0, 16($s7) // $t0 = B[4]
   lw $t1, 12($s7) // $t1 = B[3]
   sub $t0, $t0, $t1 // $t0 = B[4] – B[3]
   sll $t0, $t0, 2 // $t0 = $t0 * 4
   add $t0, $t0, $s6 // $t0 = &A[B[4] – B[3]]
   lw $t1, 0($t0) // $t1 = A[B[4] – B[3]]
   add $s0, $s1, $t1 // f = g + A[B[4] – B[3]
   ```
9. Consider three different processors, P1 P2 and P3, executing the same instruction set. P1 has a 3 GHz clock rate and a CPI of 1.5. P2 has a 2.5 GHz clock rate and a CPI of 1.0. P3 has a 4.0 GHz clock rate and a CPI of 2.2.

   1. Which processor has the highest performance expressed in instructions per second?

2. If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions.

3. We are trying to reduce the execution time by 30% but this leads to an increase of 20% in the CPI. What clock rate should we have to get this time reduction?

Solution:

1.

P1: 3GHz / 1.5 = 2 * 10^9 instructions per second

P2: 2.5GHz / 1.0 = 2.5 * 10^9 instructions per second

P3: 4GHz / 2.2 = 1.82 * 10^9 instructions per second

So P2 has the highest performance among the three processor.

2.

Cycles:

P1: 3GHz * 10 = 3 * 10^{10} cycles

P2: 2.5GHz * 10 = 2.5 * 10^{10} cycles

P3: 4GHz * 10 = 4 * 10^{10} cycles

Number of instructions:

P1: 3GHz * 10 / 1.5 = 2 * 10^{10} instructions

P2: 2.5GHz * 10 / 1.0 = 2.5 * 10^{10} instructions

P3: 4GHz * 10 / 2.2 = 1.82 * 10^{10} instructions

3.

Execution time = (Num of instructions * CPI) / (Clock rate)

So, if we want to reduce the execution time by 30%, and CPI increases by 20%, we have:

Execution time * 0.7 = (Num of instructions * CPI * 1.2) / (New Clock rate)

New Clock rate = Clock rate * 1.2 / 0.7 = 1.71 * Clock rate

New Clock rate for each processor:

P1: 3GHz * 1.71 = 5.13 GHz

P2: 2.5GHz * 1.71 = 4.27 GHz

P3: 4GHz * 1.71 = 6.84 GHz

10. Favorite program runs in 10 seconds on computer A, which has a 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?

Solution

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

CPU Clock Cycle $_A$ = 20 x 10^9 cycles

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

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

Clock Rate $_B$ = 4 GHz

To run the program in 6 seconds, B must have twice the clock rate of A

11. Have two implementations of the same instruction set architecture. Computer A has a clock cycle time of 250 ps and a CPI of 2.0 for some program, and computer B has a clock cycle time of 500 ps and a CPI of 1.2 for the same program. Which computer is faster for this program and by how much?

Solution

CPU clock cycles $_A$ = I x 2.0

CPU clock cycles $_B$ = I x 1.2

Compute the CPU time for each

CPU time $_A$ = CPU clock cycles $_A$ × Clock cycle time

CPU time $_A$ = 500 x I ps

CPU time $_B$ = 600 x I ps

$$\frac{\text{CPU performance}_A}{\text{CPU performance}_B} = \frac{\text{Execution time}_B}{\text{Execution time}_A} =$$ 600 x I ps / 500 x I ps

Computer A is 1.2 times as fast as computer B

12. A compiler designer is trying to decide between two code sequences for a particular computer. The hardware designers have supplied the following facts:

Class	A	B	C
CPI for class	1	2	3
IC in sequence 1	2	1	2
IC in sequence 2	4	1	1

Solution

Sequence 1:

IC = 5 (2+1+2)

Clock Cycles = 10 (2×1 + 1×2 + 2×3)

CPI = clock cycle / IC = 10/5 = 2.0

Sequence 2:

IC = 6 (4+1+1)

Clock Cycles = 9 (4×1 + 1×2 + 1×3)

CPI = 9/6 = 1.5

Since Sequence 2 takes fewer overall clock cycles but has more instructions it must have a lower CPI