University of Colombo School of Computing

SCS 1305 - Computer Systems

Tutorial - CPU Organization

1. Machine A has a clock cycle time of 10 ns and CPI = 2.0.
   Machine B has a clock cycle time of 30 ns and CPI = 0.5.
   Both machines run the same program with 1 million instructions.
   (a) Which machine is faster?
   (b) By what factor?

2. A benchmark program executes 200 instructions:
   50 are type A (2 cycles each)
   100 are type B (1 cycle each)
   50 are type C (10 cycles each)
   What is the overall CPI?

3.
```
for i = 1 to 100 do
     for j = 1 to 100 do
          for k = 1 to 100 do
               10 instructions
          endfor
     endfor
endfor
```

   If each loop adds 2 extra instructions (for increment + exit check), calculate the
   dynamic instruction count.

4. A CPU runs at 2.5 GHz.
   (a) What is its clock cycle time?
   (b) How many cycles are executed in 1 millisecond?

5. Two compilers generate code for the same program:
   Compiler 1: 1 million instructions, CPI = 2.5
   Compiler 2: 1.5 million instructions, CPI = 1.8
   CPU clock rate = 2 GHz
   Which compiler produces faster code?

6. A memory system has 12-bit addresses and is word-addressable with a word size of

16 bits.
(a) What is the maximum number of addresses?
(b) What is the maximum memory size in bytes?
(c) What is the address range?

7. Given the following 16-bit instruction word layouts:

   (a) Opcode (4 bits) — Register 1 (4 bits) — Register 2 (4 bits) — Register 3 (4 bits)

   (b) Opcode (4 bits) — Register (4 bits) — Immediate Value (8 bits)

   (c) Opcode (4 bits) — Register (4 bits) — Memory Address (8 bits)

   (d) Opcode (4 bits) — Unused (4 bits) — Register (4 bits) — Register (16 bits)

   Identify which layout corresponds to which type of instruction, and give an example instruction for each.

8. Assume a 32-bit Immediate instruction format:
   Opcode (6) — Register (5) — Immediate (21)
   Given the binary instruction:

   $$100010\ 01001\ 0000000000010101101$$

   Write the corresponding assembly instruction.

9. Given the instruction: SUBI R12, 45
   Format: 32-bit instruction = Opcode (6) — Register (5) — Immediate (21)
   Opcode for SUBI = 100101
   Write the corresponding binary instruction.

10. 2021 Past Paper - Q4 (Cache Memory)