Unit-1

Problems

Problem: 1

- A computer uses a memory unit with 256K words of 32 bits each. A binary instruction code is stored in one word of memory. The instruction has 4 parts an indirect bit, an operation code, a register code part to specify one of 64 registers, and address part.
- How many bits are there in the operation code, the register code part and address part?
- Draw the instruction word format and indicate the number of bits in each part.
- How many bits are there in the data and address inputs of the memory

Solution: 1

Memory Size =256 K
No. of bits to encode memory address = $2^8 \times 2^{10} = 2^{18}$
Number of Registers = 64
No. of bits to encode register no = 2^6
Size of the memory word =32 bits

a)
Address	- 18 bits
Register code	- 6 bits
Indirect	- 1 bit
	25 bits

32-25 = 7 bits for opcode

b)

1	7	6	18
I	Opcode	Register	Address

=32 bits

c) Data =32 bits; address =18 bits

Problem:2

- A Program Counter contains a number 825 and the address part of the instruction contains the number 24. The effective address in the relative addressing mode when the instruction is read from the memory is ___

A.849

B.850

C.801

D.802

Solution :2

- Suppose PC = 825. Address part has 24.
  - The instruction at the location 825 is read from memory during fetch and PC is incremented by 1 to 826. 826 + 24 = 850.
- MIPS: Suppose PC = 825. Address part has 24.
  - The instruction at the location 825 is read from memory during fetch and PC is incremented by 1 to 826. 826 + (24*4) = 922.

Problem :3

- A processor has 40 distinct instructions and 24 general purpose registers. A 32-bit instruction word has an opcode, two register operands and an immediate operand. The number of bits available for the immediate operand field is 16.
- SOLN: 16

problem #4 : Performance

uppose we have two computers A and B.

mputer A has a clock cycle of 1 ns and performs 2 instructions per cycle.
mputer B, instead, has a clock cycle of 600 ps and performs 1.25 instructio
 cycle.

uming a program requires the execution of the same number of instructio
oth computers:

Vhich computer is faster for this program?

problem #4 : Performance

- Computer A performs = $\frac{2 \text{ instructions}}{1 \text{ cycle}} \times \frac{1 \text{ cycle}}{10 ^{-9} \text{ seconds}}$

$$= 2 \times 10^{9} \frac{\text{instructions}}{\text{second}}$$

Computer B performs = $\frac{1.25 \text{ instructions}}{1 \text{ cycle}} \times \frac{1 \text{ cycle}}{600 \times 10 ^{-12} \text{ seconds}}$

$$= 2.08 \times 10 ^{9} \frac{\text{instructions}}{\text{second}}$$

Computer B performs more instructions per second, thus it is the fastest for this program

problem 5 : CPI Example

- Computer A: 2GHz clock, 10s CPU time
- Designing Computer B
  - Aim for 6s CPU time
  - Can do faster clock, but causes 1.2 × clock cycles
- How fast must Computer B clock be?

$$\text{Clock Rate}_B = \frac{\text{Clock Cycles}_B}{\text{CPU Time}_B} = \frac{1.2 \times \text{Clock Cycles}_A}{6s}$$

$$\text{Clock Cycles}_A = \text{CPU Time}_A \times \text{Clock Rate}_A$$

$$= 10s \times 2\text{GHz} = 20 \times 10^9$$

$$\text{Clock Rate}_B = \frac{1.2 \times 20 \times 10^9}{6s} = \frac{24 \times 10^9}{6s} = 4\text{GHz}$$

Problem#6 : CPI Example

- Computer A: Cycle Time = 250ps, CPI = 2.0
- Computer B: Cycle Time = 500ps, CPI = 1.2
- Same ISA
- Which is faster, and by how much?

$$\text{CPU Time}_A = \text{Instruction Count} \times \text{CPI}_A \times \text{Cycle Time}_A$$
$$= I \times 2.0 \times 250\text{ps} = I \times 500\text{ps}$$

A is faster…

$$\text{CPU Time}_B = \text{Instruction Count} \times \text{CPI}_B \times \text{Cycle Time}_B$$
$$= I \times 1.2 \times 500\text{ps} = I \times 600\text{ps}$$

$$\frac{\text{CPU Time}_B}{\text{CPU Time}_A} = \frac{I \times 600\text{ps}}{I \times 500\text{ps}} = 1.2$$

…by this much

problem #7 : Performance

- Assume a new web-server with a CPU being 10 times faster on computation than the previous web-server. I/O performance is not improved compared to the old machine. The web-server spends 40% of its time in computation and 60% in I/O. How much faster is the new machine overall?

problem #7 : Performance

- Fraction $_{enh}$ $=$40%
- Speedup $_{enh}$ =10

$$\text{Speedup}_{\text{overall}} = \frac{\text{Ex Time}_{\text{old}}}{\text{Ex Time}_{\text{new}}} = \frac{1}{(1 - \text{Fraction}_{\text{enhanced}}) + \dfrac{\text{Fraction}_{\text{enhanced}}}{\text{Speedup}_{\text{enhanced}}}}$$

problem #7 : Performance

- $\text{Speedup}_{\text{overall}} = \dfrac{1}{(1-0.4) + \dfrac{.4}{10}}$

$= 1/0.64$

$= 1.56$

problem #8 : Performance

- :ample: Consider a graphics card
- 0% of its total execution time is spent in floating point operations
- 0% of its total execution time is spent in floating point square t operations (FPSQR).
- otion 1: improve the FPSQR operation by a factor of 10.
- otion 2: improve all floating point operations by a factor of 1.6
- hich design is better?

problem #8 : Performance

$$Speedup_{overall} = \frac{Time_{org}}{Time_{enh}} = \frac{1}{(1 - Fraction_{enh}) + \frac{Fraction_{enh}}{Speedup_{enh}}}$$

problem #8 : Performance

$$Speedup_{FPSQR} = \frac{1}{(1-0.2)+(\frac{0.2}{10})} = \frac{1}{0.82} = 1.22$$

$$Speedup_{FP} = \frac{1}{(1-0.5)+(\frac{0.5}{1.6})} = \frac{1}{0.8125} = 1.23 \rightarrow \text{Option 2 slightly faster}$$