Homework 3 Solutions

3. Design an expanding opcode to allow all the following to be encoded in a 32-bit instruction:

15 instructions with two 12 bit addresses and one 4 bit register number

650 instructions with one 12 bit address and one 4 bit register number

80 instructions with no addresses or registers

Solution: For the first 15 instructions we can use first 4 bits as opcode (0000 to 1110).

For second instructions we can set first 4 bits as 1111. Opcode 1111 uses the first 12-bit address field to distinguish the 650 instructions. This will provide us 2^12= 4096 slots out of which we will use only 650.

For next 80 instructions with no address and no registers, the first 4 bits remain 1111. Then any one of the (4096-650) identifiers , that was not used for the second set of instructions will be used as an identifier for these 80 instructions.

6. Given the memory values below and a one address machine with an accumulator, what values do the following instructions load into the accumulator?

Word 20 contains 40

Word 30 contains 50

Word 40 contains 60

Word 50 contains 70

a. **LOAD IMMEDIATE 20**
b. **LOAD DIRECT 20**
c. **LOAD INDIRECT 20**
d. **LOAD IMMEDIATE 30**
e. **LOAD DIRECT 30**
f. **LOAD INDIRECT 30**

Solution:

LOAD IMMEDIATE 20	20
LOAD DIRECT 20	40
LOAD INDIRECT 20	60
LOAD IMMEDIATE 30	30
LOAD DIRECT 30	50
LOAD INDIRECT 30	70

10. Convert the following formulas from infix to reverse Polish notation

a. **A + B + C + D - E**
b. **(A - B) * (C + D) + E**
c. **(A * B) + (C * D) + E**
d. **(A - B) * (((C – D * E) / F) / G) * H**

Solution:

A + B + C + D - E	AB + C + D + E-
(A - B) * (C + D) + E	AB - CD +* E +
(A * B) + (C * D) + E	AB * CD *+ E +
(A - B) * (((C – D * E) / F) / G) * H	AB – CDE * - F / G / * H *

12. Convert the following reverse Polish notation formulas to infix.

a. **A B – C + D ***
b. **AB / CD / +**
c. **ABCDE +**/**
d. **ABCDE * F /+ G – H / *+**

Solution:

A B – C + D *	(A – B + C)*D
AB / CD / +	(A / B) + (C / D)
ABCDE +**/	A / (B*C*(D + E))
ABCDE * F /+ G – H / *+	A + (B * (((C + ((D * E) / F)) – G) / H))

14. Convert the following Boolean formulas from infix to reverse Polish notation

a. **(A AND B) OR C**
b. **(A OR B) AND (A OR C)**
c. **(A AND B) OR (C AND D)**

Solution:

(A AND B) OR C	AB AND C OR
(A OR B) AND (A OR C)	AB OR AC OR AND
(A AND B) OR (C AND D)	AB AND CD AND OR

18. It is common in programming for a program to need to determine where a variable X is with respect to the interval A to B. If a three address instruction were available with operands A, B, and X, how many condition code bits would have to be set by this instruction?

Solution:

There are five possible results: X < A, X = A, A < X < B, X = B, and X > B. To record all the possibilities, 3 bits are needed. Of the eight combinations, only five would be used.

23. For the 16 bit binary number 1001 0101 1100 0011, show the effect of

a. **A right shift of 4 bits with zero fill.**
b. **A right shift of 4 bits with sign extension.**
c. **A left shift of 4 bits.**
d. **A left rotate of 4 bits.**
e. **A right rotate of 4 bits.**

Solution:

a. Right shift 4 bit	0000 1001 0101 1100
b. Right shift 4 bit with sign	1111 1001 0101 1100
c. Left 4	0101 1100 0011 0000
d. Left rotate 4	0101 1100 0011 1001
e. Right rotate 4	0011 1001 0101 1100

25. Compute the Boolean expression (A AND B) OR C for

A = 1101 0000 1010 0011

B = 1111 1111 0000 1111

C = 0000 0000 0010 0000

Solution:

A AND B	1101 0000 0000 0011
(A AND B) OR C	1101 0000 0010 0011

30. Assume that the monks in Hanoi can move 1 disk per minute (they are in no hurry to finish the job because employment opportunities for people with this particular skill are limited in Hanoi). How long will it take them to solve the entire 64 disk problem? Express your results in years.

Solution:

Let, H_n = number of operation to move n disks.

So $H_n = 2H_{n-1} + 1$

Solving this recurrence gives $2^n - 1$

For 64 disks, we need $2^{64} - 1$ minutes = $3.5 * 10^{13}$ years.

32. A computer uses DMA to read from its disk. The disk has 64 512 byte sectors per track. The disk rotation time is 16 msec. The bus is 16 bits wide, and bus transfers take 500 nsec each. The average CPU instruction requires two bus cycles. How much is the CPU slowed down by DMA?

Solution:

Bus width = 16 bits = 2 bytes.

Bus transfer rate = 500 nsec.

The disk rotation time is 16 msec. That means, to transfer entire data of a track, it requires 16 msec.

The amount of data in a track = 64 * 512 byte = 32,768 bytes.

The time spent to transfer 32,768 bytes of data from disk = $16 * 10^{-3}$ s.

So, time spent to transfer 2 bytes of data from disk = 976 nsec.

Therefore, time spent by the CPU for 2 bytes = (required time – bus transfer time) = (976-500) = 476 nsec

So the CPU takes= (476/976)*100 = 48.8%

Therefore due to DMA, the CPU is slowed down by (100 – 48.8) = 51.2%