307403

國立臺灣科技大學
九十一學年度碩士班招生考試試題

系所組別： 電機工程系丙一組
科　目： 計算機組織

1. (10 points) A certain processor has a microinstruction format containing 10 separate control fields C_0:C_9. Each C can activate any one of n distinct control lines, where n is specified as follows:

$i=$	0	1	2	3	4	5	6	7	8	9
$n_i=$	4	3	3	11	9	16	7	1	10	22

   A. (5 points) What is the minimum number of control bits needed to represent the 10 control fields?

   B. (5 points) What is the maximum number of control bits needed if a purely horizontal format is used for all the control information?

2. (20 points) The CORDIC (Coordinate Rotation Digital Computer) technique due to James E. Volder has been widely used in scientific calculators for computing trigonometric functions. It is relatively fast and can be implemented by very simple circuits. In the CORDIC system, a number Z is treated as a vector represented by its Cartesian coordinates (X, Y), and the required functions of Z are calculated by operations that are analogous to vector rotation. Suppose that the vector Z is rotated through an angle θ. The resulting vector $Z'=(X', Y')$ is defined by the equations:

$$\begin{aligned} X' &= X\cos\theta \pm Y\sin\theta \\ Y' &= Y\cos\theta \,\mu\, X\sin\theta \end{aligned} \qquad (2.1)$$

Where the upper and lower signs correspond to clockwise and counterclockwise rotation, respectively. These equations imply that

$$\begin{aligned} X'' &= \frac{X'}{\cos\theta} = X \pm Y\tan\theta \\ Y'' &= \frac{Y'}{\cos\theta} = Y \,\mu\, X\tan\theta \end{aligned} \qquad (2.2)$$

$Z''=(X'', Y'')$ can be interpreted as the original vector Z after rotation through an angle θ and a magnitude increase by the factor $K=1/\cos\theta$. If $\tan\theta$ is a power of 2, then the multiplication by $\tan\theta$ required in (2.2) can be realized by shifting. The essence of CORDIC is to implement the rotation described by (2.2) as a sequence of $n+1$ rotations through angles α_i such that

$$\theta = \alpha_0 \pm \alpha_1 \pm \alpha_2 \pm \Lambda \pm \alpha_n \qquad (2.3)$$

$$\text{and } \alpha_i = \tan^{-1}(2^{-i}) \qquad (2.4)$$

Then if we set $Z=(X_0, Y_0)$, each rotation through angle α_i is defined by (2.2) and (2.4) and has the form

$$\begin{aligned} X_{i+1} &= X_i \pm Y_i 2^{-i} \\ Y_{i+1} &= Y_i \,\mu\, X_i 2^{-i} \end{aligned} \qquad (2.5)$$

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The resulting vector Z_n has magnitude $Z_n = K_n|Z_0|$, where $K_n = \Pi_{i=0}^{n}(\cos\alpha_i)^{-1}$. K_n is a constant depending on n and it converges toward 1.6468. Note that the only operations required in (2.5) are addition, subtraction, and shifting.

The signs appearing in (2.3) depend on the given angle θ, these signs must be computed in order to determine the operations (addition or subtraction) needed in evaluating (2.5). The sign computation is carried out by storing the constants $\{\alpha_i\}$ in a table as follows:

$i = 0$	1	2	3	4	5	6	7	Λ
$\alpha_i = 0.7854$	0.4636	0.2450	0.1244	0.0624	0.0312	0.0156	0.0078	Λ

Notice that α_i closes to 2^{-i} when i increases. In each iteration it is determined which of $+\alpha_i$ and $-\alpha_i$ causes $|\theta + (\pm\alpha_0 \pm \alpha_1 \cdots \pm \alpha_i)|$ to converge toward zero. If $+\alpha_i$ $(-\alpha_i)$ is selected then the upper (lower) signs in (2.5) are used which correspond to a clockwise (counterclockwise) rotation through the angle α_i. Note that each iteration increases the accuracy of (X_i, Y_i) by approximately one bit.

The CORDIC method can be used to calculated $\sin\theta$, $\cos\theta$, $\tan\theta$ as follows. Let $X_0 = K_n^{-1} \fallingdotseq 0.6073$ and $Y_0=0.0$, where n has been chosen to achieve the desired accuracy. Compute (X_n, Y_n) according to (2.5). From (2.1) and (2.2) we see that $X_n = K_n X_0 \cos\theta$ and $Y_n = -K_n X_0 \sin\theta$, hence X_n and Y_n are the required values of $\cos\theta$ and $\sin\theta$, respectively. $\tan\theta$ can now be computed by a single division since $\tan\theta = Y_n/X_n$. Please give in tabular form all the calculation required to compute cos70 to two decimal places using the CORDIC method.

3. (20 points) Assume that instructions are executed in an n-stage pipeline. The delay of each pipeline state is one unit. If an instruction depends on one or more of its predecessors, then all these predecessors must complete execution before the current instruction can begin execution. If such a predecessor is k instruction preceding the current instruction, then if $k \leqq n$, a delay of $(n-k)$ units is added to the total execution time. Let p_n be the probability of encountering a data dependency from the nth predecessor. Consider an integer $Q>n$. Let $p_n = 1/Q$ for $n = 1, 2, 3, \ldots$, Q and $p_n=0$ otherwise.

   A. (15 points) Find the expected value of the total time T to execute a block of N instructions.

   B. (5 points) Determine the performance P of the instruction pipeline, where

$$P = \lim_{N\to\infty} \frac{N}{T}$$

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4. (20 points) Describe the generations of computers and special features of each generation so far.

5. (20 points) A computer system contains a main memory of 32K 16-bit words. It also has a 4K-word cache divided into 4-slot sets with 64 words per slot. Assume that the cache is initially empty. The CPU fetches words from locations 10, 11, 12, ..., 4220 in that order. It then repeats this fetch sequence 5 more times. The cache is 5 times faster than main memory. Estimate the improvement resulting from the use of the cache. Assume a FIFO policy for block replacement.

6. (10 points) Assume the following transfer rates:

Disk drive	800 Kbytes/s
Magnetic tape drive	200 Kbytes/s
Line printer	6.6 Kbytes/s
Card reader	1.2 Kbytes/s
VDT	1 Kbytes/s

Suppose a 64-bit computer has two selector channels and one multiplexor channel. One selector channel supports 3 magnetic disk and one magnetic tape units. The other selector channel supports two magnetic tapes and two line printers. The multiplexor channel has two line printers, two card readers, and ten VDT terminals connected to it. Estimate the maximum aggregate I/O transfer rate in this computer system.