In The Name of God

Computer Architecture Homework 1

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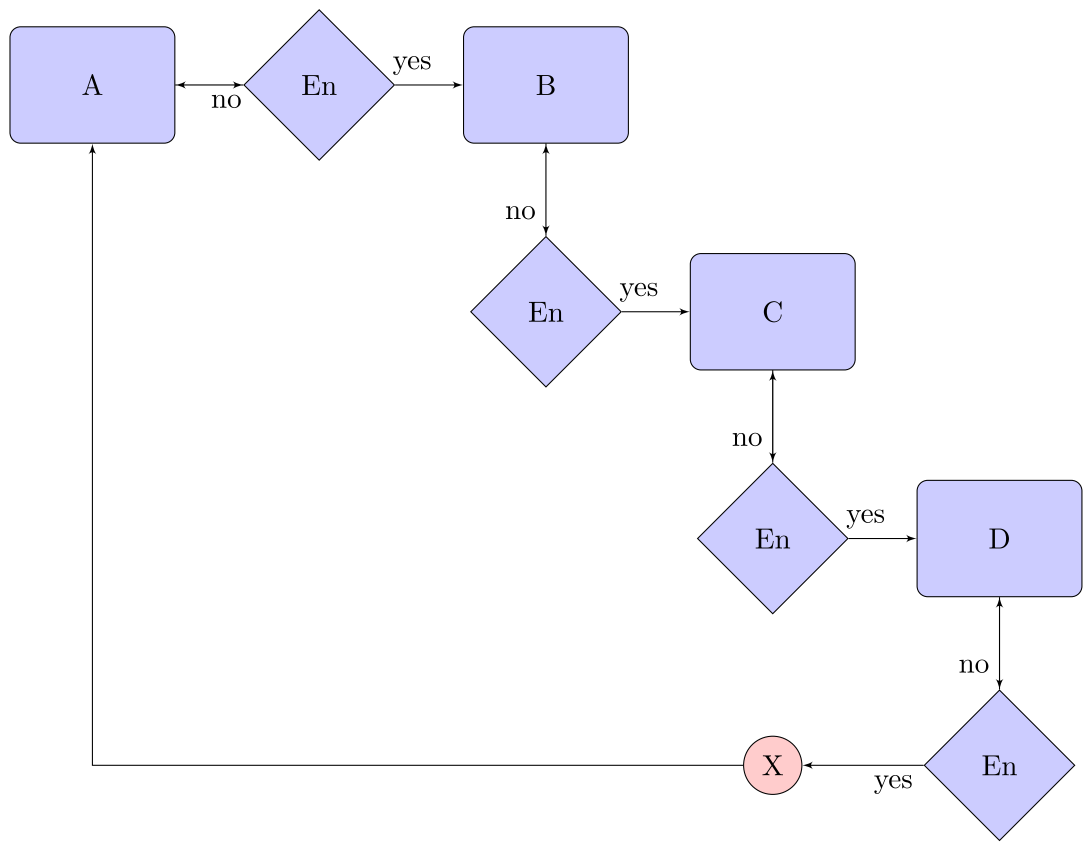
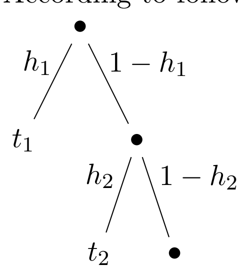
1 Problem 1



2 Problem 2

1 We are using memory hierarchy in order to reduce average memory access time and decrease cost per byte.

2 According to following diagram :



- Average Memory Access Time, the exact formula

$$t_1 + (1 - h_1) * [t_2 + (1 - h_2) * [\ldots]] \tag{1}$$

- Average Memory Access Time, an approximate formula

$$h_1 * t_1 + (1 - h_1)[h_2 * t_2 + (1 - h_2) * [\ldots]] \tag{2}$$

3

- Average Memory Access Time, the exact formula

$$t_1+(1-h_1)*t_2+(1-h_1)*(1-h_2)*t_3+(1-h_1)*(1-h_2)*(1-h_3)*t_4 \tag{3}$$

- Average Memory Access Time, an approximate formula

$$h_1*t_1+(1-h_1)*h_2*t_2+(1-h_1)*(1-h_2)*h_3*t_3+(1-h_1)*(1-h_2)*(1-h_3)*h_4*t_4 \tag{4}$$

4 If we have following conditions in our memory hierarchy, this memory hierarchy would reduce our average memory access time:

- $t_1 < t_2 < t_3 < \ldots < t_n$
- $h_1 < h_2 < h_3 < \ldots < h_n$

Condition 2 is valid only if we consider searching time.

5 Substituting $2ns$ for t_1, 0.25 for h_1, $2ns$ for t_2, 0.36 for h_2, $4ns$ for t_3, 0.54 for h_3,$5ns$ for t_4, 0.76 for h_3, in (4) gives us:

$$\begin{aligned}
\bar{T} &= 0.25 * 2 + (1 - 0.25) * 0.36 * 2 + (1 - 0.25) * (1 - 0.36) * 0.54 * 4 + \\
&\qquad (1 - 0.25) * (1 - 0.36) * (1 - 0.54) * 0.76 * 5 \\
&= 0.5 + 0.75 * 0.36 * 2 + 0.75 * 0.64 * 0.54 * 4 + 0.75 * 0.64 * 0.46 * 0.76 * 5 \\
&= 0.50 + 0.54 + 1.00 + 0.80 \\
&= 2.84ns
\end{aligned}$$

3 Problem 3

The following is the avrage memory access time equlation for memory with 3 level:

$$\bar{T} = h_1 * t_1 + (1 - h_1) * h_2 * t_2 + (1 - h_1) * (1 - h_2) * h_3 * t_3 \qquad (5)$$

Substituting $1ns$ for t_1, 0.9 for h_1, $10ns$ for t_2, 0.5 for h_2, $1000ns$ for t_3 and 1 for h_3 in (5) gives us:

$$\begin{aligned}
\bar{T} &= 0.9 * 1 + (1 - 0.9) * 0.5 * 10 + (1 - 0.9) * (1 - 0.5) * 1000 \\
&= 0.9 + 0.1 * 0.5 * 10 + 0.1 * 0.5 * 1000 \\
&= 0.9 + 0.5 * 10 + 0.5 * 1000 \\
&= 0.9 + 5 + 500.00 \\
&= 505.9ns
\end{aligned}$$

4 Problem 4

Substituting $1ns$ for t_1, 0.9 for h_1, $10ns$ for t_2, 0.5 for h_2, $8ns$ for t_3, 0.63 for h_3,$1000ns$ for t_4, 1 for h_3, in (4) gives us:

$$\begin{aligned}
\bar{T} &= 0.9 * 1 + (1 - 0.9) * 0.5 * 10 + (1 - 0.9) * (1 - 0.5) * 0.63 * 8 + \\
&\qquad (1 - 0.9) * (1 - 0.5) * (1 - 0.63) * 1000 \\
&= 0.9 * 1 + 0.1 * 0.5 * 10 + 0.1 * 0.5 * 0.63 * 8 + 0.1 * 0.5 * 0.37 * 1000 \\
&= 0.90 + 0.50 * 10 + 0.31 * 8 + 0.18 * 1000 \\
&= 0.90 + 5.00 + 2.48 + 180.00 \\
&= 188.38ns
\end{aligned}$$

5 Problem 5

1 Adrress bits = 14 bits, Length = 2 bytes, Width = 2^{14} words, The smallest unit available = 16 bits.

2 Adrress bits = 15 bits, Length = 2 bytes, Width = 2^{15} words, The smallest unit available = 16 bits.

3 Adrress bits = 15 bits, Length = 1 bytes, Width = 2^{15} words, The smallest unit available = 8 bits.

4 Adrress bits = 13 bits, Length = 4 bytes, Width = 2^{13} words, The smallest unit available = 32 bits.