

Engineering 9859  
CoE Fundamentals — Computer Architecture  
Review

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## PS3, Question 2

A computer operating at a 1 GHz clock speed uses three levels of mixed cache memories which produce miss rates of 1%, 10%, and 25%, respectively. CPI for a perfect first level cache is 2 clock cycles, and the hit times for the second and third levels of cache are 5 and 15 clock cycles, respectively. If the average number of memory references per instruction is 1.30, compute the average CPU time. If a given program takes 1 millisecond to execute in this system, what is the size of this code? Assume that the penalty for main memory access is 30 clock cycles.

## Q2 Solution

$H$  = Hit time,  $R$  = Miss rate,  $P$  = Miss penalty

- 1 GHZ  $\Rightarrow \tau = 1$  ns
- $R_{L1} = 0.01$ ,  $R_{L2} = 0.10$ ,  $R_{L3} = 0.25$ .
- $\text{CPI}_{\text{execution}} = 2$
- Memory accesses per instruction,  $\text{API} = 1.30$

$$\begin{aligned} \text{CPI} &= \text{CPI}_{\text{execution}} + \text{API} * R_{L1} * P_{L1} \\ &= 2 + 1.30 * 0.01 * P_{L1} = 2.09425 \end{aligned}$$

$$\begin{aligned} P_{L1} &= H_{L2} + R_{L2} * P_{L2} \\ &= 5 + 0.10 * P_{L2} = 7.25 \end{aligned}$$

$$\begin{aligned} P_{L2} &= H_{L3} + R_{L3} * P_{L3} \\ &= 15 + 0.25 * P_{L3} = 22.5 \end{aligned}$$

$$P_{L3} = \text{main memory access} = 30\tau$$

## Q2 Solution (cont'd)

$$\begin{aligned}T_{\text{CPU}} &= \text{IC} * \text{CPI} * \tau \\ \text{IC} &= \frac{T_{\text{CPU}}}{\text{CPI} * \tau} \\ &= \frac{10^{-3}}{2.09425 * 10^{-9}} = 477\,498\end{aligned}$$