CS60003: High Performance Computer Architecture

Class Test - 1 [Spring 2023-24]

Model Solutions

1) Let the fraction be x. Then, by Amdahl's Law:
(for ~~percentage~~ encryption)

$$\text{Speedup} = 2 = \frac{1}{(1-x) + \frac{x}{20}}$$

$$\Rightarrow 1 - \frac{19x}{20} = \frac{1}{2} \Rightarrow \frac{19x}{20} = \frac{1}{2} \Rightarrow x = \frac{10}{19} \therefore \text{\% of encryption} = \frac{10}{19} \times 100\% = \boxed{52.63\%}$$

Let "x" be the fraction from part (a).

Then, fraction of time spent on executing (speeded up) cryptographic operations = $\frac{\text{Crypto. exec. time}}{\text{Total exec. time}} \times 100\%$

$$= \frac{(x/20)}{(1-x) + \frac{x}{20}} * 100\% \Bigg|_{x = \frac{10}{19}} = \frac{\frac{10/19}{20}}{1 - \frac{10}{19} + \frac{10/19}{20}} * 100\%$$

$$= \boxed{5.26\%}$$

Here, $x|_{actual} = 0.5$; consider only the cryptographic operations, & suppose there are 2 hardware accelerators for cryptography.

Speedup$|_{\text{only crypto, with 2 crypto units}}$ (Amdahl's Law)

$$= \frac{1}{0.1 + \frac{0.9}{2}} * \text{Speedup}|_{\text{only crypto, with 1 crypto unit}}$$

$$= \frac{1}{0.1 + 0.45} * 20 = \underline{36.37}$$

$$\text{Speedup}|_{\text{overall}} = \frac{1}{(1-x) + \frac{x}{36.37}} = \frac{1}{(1-0.5) + \frac{0.5}{36.37}} = \boxed{1.95}$$

Let: f_1 = fraction of FP operations = 0.2
f_2 = " " data cache accesses = 0.1

$$\text{Speedup} = \frac{1}{(1-f_1-f_2) + \frac{f_1}{2} + \frac{f_2}{(2/3)}} = \frac{1}{(1-0.2-0.1) + \frac{0.2}{2} + \frac{0.1}{2/3}} = \boxed{1.05}$$

a) 64-byte cache, with 8B blocks $\Rightarrow \frac{64}{8} = 8$ blocks in cache.

Associativity = 2, $\therefore$ # of sets $= \frac{8}{2} = 4$, $\therefore$ set index $= \log_2(4) = 2$ bits.

Physical ~~address~~ memory: 16 kB = 2^{14} bytes $\therefore$ physical address is 14 bits long.

Eight-byte block $\Rightarrow$ 3 bit block offset; $\therefore$ # of tag bits = 14 − (# of set index bits − # of block offset bits)

= (14 - 3 - 2) bits = 9 bits

∴ total # of tag bits = 8 * 9 bits = 72 bits
(# of blocks; # of tag bits/block)

(b) # of physical pages (frames) = $\frac{\text{Phy. Mem. Size}}{\text{Page size}} = \frac{16\,kB}{64\,B} = \frac{2^{14}\text{ bytes}}{2^{6}\text{ bytes}}$

$= 2^8 = \underline{256}$

∴ physical page (frame identifier) = 8 bits each.

∴ Page Table Entry (PTE) length

$= (4\text{ bits} + 8\text{ bits}) \longrightarrow 2\text{ bytes}$ (∵ only integral # of bytes allowed per PTE)

(4 bits: # of protection bits)

Virtual memory space size = 2^{16} bytes (∵ V.A. is 16-bit long)

∴ Single-level page table size

= (# of virtual pages) * (PTE size)

$= \frac{\text{Virtual Memory Space Size}}{\text{Page Size}} * (\text{PTE Size})$

$= \frac{2^{16}\text{ bytes}}{2^{6}\text{ bytes}} * (2\text{ bytes}) = 2^{11}\text{ bytes} = \boxed{2\,kB}$

(c) Effective CPI = Fraction of non-load instr. * $CPI_{non\text{-}load}$
+ Fraction of load instr. * CPI_{load}

$= (1-0.05)*1 + 0.05 * CPI_{load}$ —— (1).

CPI_{load} = Hit rate * Hit latency + Miss rate * Miss latency

$= 0.95 * 1 + (1-0.95) * (\text{Miss latency})_{load}$

$= 0.95 + 0.05 * [(\text{Prob. of dirty block}) * 2 * 50 + (\text{Prob. of non-dirty block}) * 50]$ → because of WBWWA policy

$= 0.95 + 0.05 * [0.1*100 + 0.9*50] = 3.70.$

∴ Effective CPI = $0.95 + 0.05 * 3.70 = \boxed{1.135}$