Cache Performance

Question 1

a) Block Offset – $\log_2 64 = 6$
Cache set = 256000/(64*4) =1000
Index bits = $\log_2 1000 \sim 10$
Tag bits = 32 – (10+6) + 16

b) CP I = CP I $_{execution}$ + StallCyclesPerInstruction
CP I = 1
For non-zero miss rate, let us compute StallCyclesP erInstruction
StallCyclesPerInstruction = (Memory accesses per instruction) * miss rate * miss penalty
Memory accesses per instruction = 1 + 0.5 (1 instruction access + 0.5 data access)
StallCyclesPerInstruction = 1.5 * 0.02 * 25 = 0.75
CP I = 1.75
The computer with no cache misses is 1.75 times faster

Question 2

Miss rate = 0.05 (5%)

Block size = 2 words (8 bytes)

Frequency of memory operations = 10^9

Frequency of writes from processor = $0.25 * 10^9$

So:

Fraction of read hits = $0.75 * 0.95 = 0.7125$

Fraction of read misses = $0.75 * 0.05 = 0.0375$

Fraction of write hits = $0.25 * 0.95 = 0.2375$

Fraction of write misses = $0.25 * 0.05 = 0.0125$

a) Write through Cache

Then:

No Memory access on read Hit

2 words sent to cache on read miss

A word sent to Memory on write hit

2 words sent to cache on write miss, one word sent to memory

Therefore;

Average words transferred = $0.7125 * 0 + 0.0375 * 2 + 0.2375 * 1 + 0.0125 * 3 = 0.35$

Average bandwidth used = $0.35 * 10^9$

$Fractionofbandwidthused = \frac{0.35*10^9}{10^9} = 0.35$

b) Writeback cache

No memory access on Read

On a read miss:

1. If replaced line is modified then cache must send two words to memory, and then memory must send two words to the cache

2. If replaced line is clean then memory must send two words to the cache

No memory access on write hit

On a write miss:

1. If replaced line is modified then cache must send two words to memory, and then memory must send two words to the cache

2. If replaced line is clean then memory must send two words to the cache

Thus:

Average words transferred = $0.7125 * 0 + 0.0375 * (0.7 * 2 + 0.3 * 4) + 0.2375 * 0 + 0.0125 * (0.7 * 2 + 0.3 * 4) = 0.13$

Average bandwidth used = $0.13 * 10^9$

$Fractionofbandwidthused = \frac{0.13*10^9}{10^9} = 0.13$

Question 3

CPU performance: CPU Time = IC * CP I * Clock Time

CP I = $CPI_{execution}$ + StallCyclesPerInstruction

Then:

$CPI_{execution} = 0.26 * 1 + 0.09 * 2 + 0.65 * 1 = 1.09$

Write through

StallCyclesPerInstruction = MRI *ss 50 + MRD * $(0.26 * 50 + 0.09 * 50) = 0.425$

so:

CP I = 1.09 + 0.425 = 1.515

Write back

StallCyclesPerInstruction = MRI $*$ 50 + MRD $*$ (0.26 $*$ (0.5 $*$ 50 + 0.5 $*$ 100) + 0.09 $*$ (0.5 $*$ 50 + 0.5 $*$ 100)) = 0.5125

so:

CP I = 1.09 + 0.5125 = 1.6025