COMP4300 Fall 2022
Homework 2

1. Suppose you are designing a cache for a machine with 28-bit addresses. The cache is 8MB in size. Cache blocks are 8192 bytes.

a. How many blocks can be held in the cache

1 MB = 2^20 bytes

8 MB = 2^23 bytes

8192 bytes = 2^13 bytes

2^23/2^13 = 2^10 = 1024 blocks

b. How many bits of the address are devoted to the offset?

8192 = 2^13

So 13 bits of the address are devoted to the offset

c. If the cache is direct-mapped, how many bits are devoted to the tag and index?

Index = cache size / block size

Index = 2^23 / 2^13 = 2^10 = 10 bits to the index

Tag = machine address – offset – index

Tag = 28 – 13 – 10 = 5 bit to the tag

d. If the cache is 8-way set associative, how many bits are devoted to the tag and index? How many sets are there?

Sets = blocks / 8 = 1024 / 8 = 128 = 2^7 sets

7 bits for the index

Tag = 28 – 13 – 7 = 8 bits for the tag

e. If the cache is fully associative, how many bits are devoted to the tag and index?

Index is 0 in fully associative mapping

Tag = machine address – offset = 28 – 13 = 15 bits for the tag

So 15 bits for the tag

0 bits for the index

13 bits for the offset

2. Suppose you have a machine with separate I- and D- caches. The miss rate on the I-cache is 1.2%, and on the D-cache 3.4%. On an I-cache hit, the value can be read in the same cycle the data is requested. On a D-cache hit, one additional cycle is required to read the value. The miss penalty is 90 cycles for data cache, 100 for I-cache. 22% of the instructions on this RISC machine are LW or SW instructions, the only instructions that access data memory. A cycle is 0.5ns. What is the average memory access time?

miss rate of I-cache = 1.2% = 0.012

miss rate of D-cache = 3.4% = 0.034

Access time for I-cache = 1 cycle = 0.5ns

Access time for D-cache = 2 cycles = 1ns

Miss penalty for D-cache = 90 cycles

Miss penalty for I-cache = 100 cycles

Branch instructions = 22%

Non-branch instruction = 78%

Average access time = access time + miss rate * miss penalty

Average access time for I-cache = 0.5 + 0.012 * 100 = 1.7 ns

Average access time for D-cache = 1 + 0.034 * 90 = 4.06 ns

Average memory access time = 0.22 * 4.06 + 0.78 * 1.7 = 2.2192 ns