Homework 10: Memory

CS 200 • 10 Points Total
Due Wednesday, April 26, 2017

Assignment

Read chapter 6 of Computer Organization and Architecture and work the following problems (5 pts. each).

1. Suppose a computer using direct mapped cache has 2^{36} words of main memory and a cache of 256 blocks, where each cache block contains 128 words.
    a. How many blocks of main memory are there?
        $2^{36}/128 = 2^{36}/2^7 = 2^{36-7} = 2^{29}$ blocks
    b. What is the format of a memory address as seen by the cache, that is, what are the sizes of the tag, block, and word fields?
        The Word field must be 7 bits (128 words is 2^7), the Block field must be 8 bits (256 blocks is 2^8), and so the Tag field is (36 – 8) – 7 = 21 bits.
        TTTTTTTTTTTTTTTTTTTTBBBBBBBBWWWWWWW
    c. To which cache block will the memory reference $0000063FA_{16}$ map?
    00000000000000000000110001111111010 in binary
        11000111 = C7 = 307

2. A 2-way set associative cache consists of four sets. Main memory contains 2K blocks of eight words each.
    a. Show the main memory address format that allows us to map addresses from main memory to cache. Be sure to include the fields as well as their sizes.
        2K * 8 = 2^{14}. 8 words is 2^3. 4 sets is 2^2. The rest is tag.
        TTTTTTTTTSSWWW
    b. Compute the hit ratio for a program that loops 3 times from location 8_{10} to 51_{10} in main memory. You may leave the hit ratio in terms of a fraction.
        First iteration of the loop: Address 8 is a miss, then entire block brought into Set 1. 9-15 are then hits. 16 is a miss, entire block brought into Set 2, 17-23 are hits. 24 is a miss, entire block brought into Set 3, 25-31 are hits. 32 is a miss, entire block brought into Set 0, 33-39 are then hits. 40 is a miss, entire block brought into Set 1 (note we do NOT have to throw out the block with address 8 as this is 2-way set associative), 41-47 are hits. 48 is a miss, entire block brought into Set 2, 49-51 are hits. For the first iteration of the loop, we have 6 misses, and 5*7 + 3 hits, or 38 hits. On the remaining iterations, we have 5*8+4 hits, or 44 hits each, for 88 more hits. Therefore, we have 6 misses and 126 hits, for a hit ratio of 126/132, or 95.45%.