

CDA 3103 Computer Organization Module 6 Assignment

Part I: Problems

1. [20 points] Suppose a computer has 2^{32} bytes of byte-addressable main memory and a cache size of 2^{15} bytes, and each cache block contains 64 bytes.
 - a) How many blocks of main memory are there? (2^{26} Blocks)
 - b) How many blocks of cache memory are there? (2^9 Blocks)
 - c) If this cache is direct-mapped, what is the format of a memory address as seen by the cache; that is, the size of the tag field 17, the size of block field 9, and the size of the offset field 6.
 - d) If this cache is fully associative, what is the format of a memory address as seen by the cache; that is, the size of the tag field 26, and the size of the offset field 6.
 - e) If this cache is 4-way set associative, what is the format of a memory address as seen by the cache; that is, the size of the tag field 19, the size of set field 7, and the size of the offset field 6.
2. [24 points] Suppose we have a memory and a direct-mapped cache with the following characteristics.
 - Memory is byte addressable
 - Memory addresses are 16 bits
 - The cache has 8 blocks
 - Each cache block holds 16 bytes of data
 - a) [6 points] In the spaces below, indicate how the 16 address bits are allocated to the offset, index, and tag parts of the address used to reference the cache: 4 offset bits 3 tag bits 9 index bits.
 - b) [12 points] Below is a sequence of four binary memory addresses in the order they are used to reference memory. Assume that the cache is initially empty. For each reference, write down the tag and index bits and circle either hit or miss to indicate whether that reference is a hit or a miss.

Memory address	Tag	Index	Hit / Miss (circle)
0010 1101 1011 0011	0010 1101 1	011	Miss
0000 0110 1111 1100	0000 0110 1	111	Miss
0010 1101 1011 1000	0010 1101 1	011	Hit
1010 1010 1010 1011	1010 1010 1	010	Miss

- c) [6 points] Suppose the cache access time is 15ns, main memory access time is 220ns,

and the cache hit rate is 95%. Assuming non-overlapped access, what is the average access time for the processor to access an item?

$$(.95)(15\text{ns}) + (.05)(220\text{ns} + 15\text{ns})$$

3. [20 points] Assuming a cache of 4096 blocks, a four-word block size, each word contains 4 bytes, and a 64-bits memory address. Memory is byte addressable, and random block replacement policy and write back policy are implemented. Find the total number of tag bits for caches that are

a) direct-mapped

Tag = 48 bit

b) 2-way set associative

Tag = 49 bit

c) 4-way set associative

Tag = 50 bit

d) Fully associative

Tag = 60 bit

4. [30 points] Suppose you have a byte-addressable virtual address memory system with 8 virtual pages of 64 bytes each, and 4 page frames. Assuming the following page table, answer the questions below:

Page #	Frame #	Valid Bit
0	1	1
1	3	1
2	-	0
3	0	1
4	2	1
5	-	0
6	-	0
7	-	0

- a) [2 points] How many bits are in a virtual address?

9 bits

- b) [2 points] How many bits are in a physical address?

8 bits

- c) [2 points] How many bits are virtual page number?

3 bits

- d) [2 points] How many bits are page frame number?

2 bits

- e) [2 points] How many bits are page offset?

6 bits

- f) [20 points] What physical address corresponds to the following virtual addresses (if the address causes a page fault, simply indicate this is the case)?

1) 0x00

01 00 0000, Hit

2) 0x44

11 00 0100, Hit

3) 0xC2

00 00 0010, Hit

4) 0x80

Page fault.

5. [6 points] Suppose we have 2^{10} bytes of virtual memory and 2^8 bytes of physical main memory. Suppose the page size is 2^4 bytes.

a) [2 points] How many pages are there in virtual memory?

2^6 pages

b) [2 points] How many page frames are there in main memory?

2^4 pages

c) [2 points] How many entries are in the page table for a process that uses all of virtual memory?

2^6

Part II: Submission Requirements

The following requirements are for electronic submission via Canvas.

- Your solutions must be in a single file with a file name yourname-module6-assignment.
- Upload the file by following the link where you download the homework description on Canvas.
- If scanned from hand-written copies, then the writing must be legible, or loss of credits may occur.
- Only submissions via the link on Canvas where this description is downloaded are graded. Submissions to any other locations on Canvas will be ignored.