Fall 2013 CENG 355

Assignment 3 <u>Due October 17, 12:59pm</u>

NOTE: Late submissions will **NOT** be accepted. Please put your solutions in the CENG 355 **drop-box** (ELW, second floor) – they will be collected at **13:00**.

1. [10 points] Assume a computer has <u>256-byte main memory</u> and <u>64-byte cache</u> with <u>eight blocks</u>, where each block has <u>two 32-bit words</u>. While executing some program, the CPU reads 32-bit words from the following sequence of addresses:

88 84 AO AC 08 04 80 8C A8 A4 00 0C

Show the <u>cache contents</u> (e.g., **[00]** = address **00**'s contents) at the end of this sequence (12 addresses) and calculate the corresponding <u>miss rate</u> given that:

- (a) Cache is direct-mapped.
- (b) Cache is <u>4-way set-associative</u> (4 blocks per set) and LRU replacement.
- (c) Cache is <u>fully-associative</u> with LRU replacement.
- **2.** [10 points] Assume a computer has <u>256-byte main memory</u> and <u>64-byte cache</u> with <u>four blocks</u>, where each block has <u>four 32-bit words</u>. While executing some program, the CPU reads 32-bit words from the following sequence of addresses:

24 8C 10 48 20 24 28 88 1C 40

Show the <u>cache contents</u> (e.g., **[00]** = address **00**'s contents) at the end of this sequence (10 addresses) and calculate the corresponding <u>miss rate</u> given that:

- (a) Cache is direct-mapped.
- (b) Cache is 2-way set-associative (2 blocks per set) with LRU replacement.
- (c) Cache is fully-associative with LRU replacement.
- 3. [5 points] Assume a computer uses L1 and L2 caches for both instructions and data. The L1 access time is $C_1 = 1\tau$ (L1 hit), the L2 access time is $C_2 = 8\tau$ (L1 miss, L2 hit), and the main memory access time is $M = 32\tau$ (L2 miss). Assume that for some given application the L1 hit rate is $h_1 = 80\%$ (for both instructions and data). What is the minimum possible value of the average access time T_{ave} under these assumptions? What is the L2 hit rate h_2 (for both instructions and data) such that $T_{ave} = 4\tau$?