

Note: We have procured permission to post these problems from Computer Architecture: A Quantitative Approach from the publisher.

Problem #1 (20 Points): Page 136 in H&P5, Problem 2.8 parts a, b, and c.

- 2.8 [12/12/15] <2.2> The following questions investigate the impact of small and simple caches using CACTI and assume a 65 nm (0.065  $\mu\text{m}$ ) technology. (CACTI is available in an online form at <http://quid.hpl.hp.com:9081/cacti/>.)
- a. [12] <2.2> Compare the access times of 64 KB caches with 64 byte blocks and a single bank. What are the relative access times of two-way and four-way set associative caches in comparison to a direct mapped organization?
  - b. [12] <2.2> Compare the access times of four-way set associative caches with 64 byte blocks and a single bank. What are the relative access times of 32 KB and 64 KB caches in comparison to a 16 KB cache?
  - c. [15] <2.2> For a 64 KB cache, find the cache associativity between 1 and 8 with the lowest average memory access time given that misses per instruction for a certain workload suite is 0.00664 for direct mapped, 0.00366 for two-way set associative, 0.000987 for four-way set associative, and 0.000266 for eight-way set associative cache. Overall, there are 0.3 data references per instruction. Assume cache misses take 10 ns in all models. To calculate the hit time in cycles, assume the cycle time output using CACTI, which corresponds to the maximum frequency a cache can operate without any bubbles in the pipeline.

Problem #2 (10 Points): Page 138 in H&P5, Problem 2.11 parts a and b.

- 2.11 [12/15] <2.2> Consider the usage of critical word first and early restart on L2 cache misses. Assume a 1 MB L2 cache with 64 byte blocks and a refill path that is 16 bytes wide. Assume that the L2 can be written with 16 bytes every 4 processor cycles, the time to receive the first 16 byte block from the memory controller is 120 cycles, each additional 16 byte block from main memory requires 16 cycles, and data can be bypassed directly into the read port of the L2 cache. Ignore any cycles to transfer the miss request to the L2 cache and the requested data to the L1 cache.
- a. [12] <2.2> How many cycles would it take to service an L2 cache miss with and without critical word first and early restart?
  - b. [15] <2.2> Do you think critical word first and early restart would be more important for L1 caches or L2 caches, and what factors would contribute to their relative importance?