

### Homework 3

(Due Feb. 25, 2020)

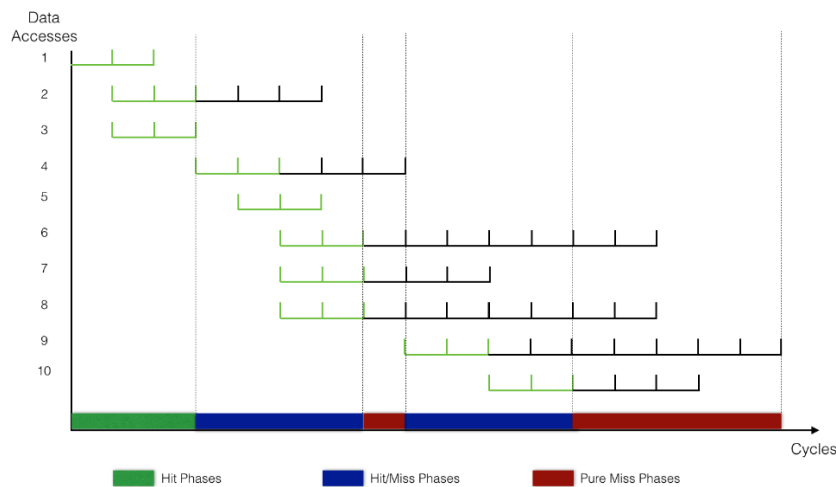
1. Read C-AMAT papers and other papers listed in lecture slides to get details of the model and its application. All the papers should be available online. For instance, the original C-AMAT paper can be found at the SCS website [http://www.cs.iit.edu/~scs/psfiles/SUN-ConcurrentAMAT\\_IEEE\\_May2014.pdf](http://www.cs.iit.edu/~scs/psfiles/SUN-ConcurrentAMAT_IEEE_May2014.pdf).
2. Derive the formula for calculating the average access time (AMAT) and the current average access time (C-AMAT) for a word in the first level cache of a system. Assume the following values for a theoretical system containing an L1 cache.

Location	Hit Time	Hit Concurrency	Miss Rate	Pure Miss Rate	Pure Miss Concurrency	Miss Penalty	Pure Miss Penalty
L1	5ns	3	10%	5%	5	800ns	1000ns

Determine the average access time (AMAT) and the current average access time (C-AMAT) for a memory word in the described system.

3. What is memory stall time? What is the advantage of the Layered Performance Matching method? Why LPM can improve memory performance (in terms of memory stall time) by more than one hundred times?
4. The following Figure 1 shows a cycle-accurate C-AMAT example. In this example, there are 10 data accesses in L1 cache. Among these data accesses, data access 1, 3, 5 are hit data accesses, others are miss data accesses. As Figure 1 shows, the green cycles are hit cycles and the black cycles are miss cycles. (hint: please be careful about what is the difference of miss data access and pure miss data access)

Cycle-accurate C-AMAT example



Access 1, 3, 5 are hit accesses, and the other accesses are miss accesses.

Figure 1. Cycle-accurate C-AMAT Example

Please calculate the AMAT and C-AMAT value of this example in this Figure 1.

5. In this following table, one set of AMAT and other parameters in L1 cache are given. Is it possible to use the given AMAT and other parameters to calculate C-AMAT in L1 cache? If it is possible, please calculate it and explain why?

Location	Hit Time	Hit Concurrency	Miss Concurrency	$\kappa$	AMAT
L1	3ns	1.5	2	0.3	50ns

7

6. Prove  $C-AMAT = 1/APC$

$$C-AMAT_1 = \frac{H_1}{C_{H_1}} + MR_1 \times \kappa_1 \times C-AMAT_2$$

7. Prove the C-AMAT recursive formula from the original formula  $C-AMAT = HitCycle/CH + pMR \times pAMP/CM$

8. Describe what is Pace Data Transfer, and explain why the new development of elastic computing architecture and FPGA are in favor of Pace Data Transfer?

### Challenging Homework (could be part of your term project)

**C-1.** Discuss how data access models can be used in remote data access and message passing? (hint: see slide 5 of Lecture 7)

**C-2.** What is your thought on the balance of memory locality and memory concurrency for performance optimization? How C-AMAT can help?