

Laboratory Exercise 12

Cache Memory

Goals

After this laboratory exercise, you should understand the basic principles of cache memories and how different parameters of a cache memory affect the efficiency of a computer system.

Literature

■ Patterson and Hennessy: Chapter 7.1–7.3

Preparation

Read the literature and this laboratory exercise in detail and solve the home assignments.

Assignments at Home and at Lab

Home Assignment 1

Looking for and research information about Cache in CPU.

Home Assignment 2

Try to use Data Cache Simulation Tool in MARS.

Understand terms and change parameters.

The screenshot displays the 'Data Cache Simulation Tool, Version 1.2' window. The 'Cache Organization' section shows 'Direct Mapping' for Placement Policy, 'LRU' for Block Replacement Policy, 8 Number of blocks, 1 Cache block size (words), and 32 Cache size (bytes). The 'Cache Performance' section shows Memory Access Count: 73, Cache Hit Count: 34, Cache Miss Count: 39, and Cache Hit Rate: 47%. A 'Cache Block Table' shows 8 blocks, with block 6 highlighted in green. The 'Runtime Log' shows 'trying block 6 tag 0x00800800 -- HIT (73) address: 0x1001001b (tag 0x00800800) block range: 6-6' and 'trying block 6 tag 0x00800800 -- HIT'. The 'Tool Control' section has buttons for 'Disconnect from MIPS', 'Reset', and 'Close'.

Function of a Cache Memory

A cache memory is a memory that is smaller but faster than the main memory. Due to the locality of memory references, the use of a cache memory can have the effect on the computer system that the apparent speed of the memory is that of the cache memory, while the size is that of the main memory.

Assignment 1

Create a project, type in the program of Laboratory 7, Home Assignment 4, build it and upload it to the cache simulator.

Assignment 2

Run the program in the cache simulator and study how the instruction cache works. Then give *full* answers to the following questions.

- How is the full 32-bit address used in the cache memory?
- What happens when there is a cache miss?
- What happens when there is a cache hit?
- What is the block size?
- What is the function of the tag?

Assignment 3

The parameters of the cache memory can be changed to test the effects of different cases. Investigate the effects of different parameter settings.

- Explain the following: cache size, block size, number of sets, write policy and replacement policy.
- If a cache is large enough that all the code within a loop fits in the cache, how many cache misses will there be during the execution of the loop? Is this good or bad?
- What should the code look like that would benefit the most from a large block size?

Cache Efficiency

The actual efficiency gained by using a cache memory varies depending on cache size, block size and other cache parameters, but it also depends on the program and data.

Conclusions

Before you pass the laboratory exercise, think about the questions below:

- What is the general idea with cache memory?
- What is a block?
- How does block size affect the efficiency of a cache?
- How fast is a cache memory? How fast is a DRAM?
- Do the optimal cache parameters depend on the program code?
- How can one select good cache parameters?
- Is it possible to change cache size on a PC? On a Mac?