CS311 Project 4: Cache Design

Due 11:59pm, December12nd
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1. Purpose

This project is intended to help you understand the principle of caching by implementing a data cache.

2. Overview

The main part of this project is to simulate a data cache from an input trace file. The cache should be configurable to adjust capacity, associativity, and block size with command-line options. You must support extra options to print out the content of the cache.

2.1 Standalone Data Cache Simulation

In this project, you must design a trace-based cache simulator. An input trace file contains a sequence of read or write operations with addresses. For each step, an entry of the trace is fed to the cache simulator, to simulate the internal operation of the cache. The write policy of the cache must be *write-allocate* and *write-back*. The replacement policy must be the perfect LRU.

2.2 Cache Parameters

The capacity, associativity, and block size of the cache must be configurable. The parameters are specified with "–c" option: -c <capacity>:<assoc>:<blocksize>
Configurable parameters:

- Capacity: 4B (one word) - 8KB
- Associativity: 1 – 16 way
- Block size: 4B – 32B

When you specify both capacity and block size, you should specify the number with byte granularity and power of two.
Ex) Capacity 4KB, Associativity 4way, Block size 32B → **4096:4:32**

3. Simulator Options and Output

3.1 Options

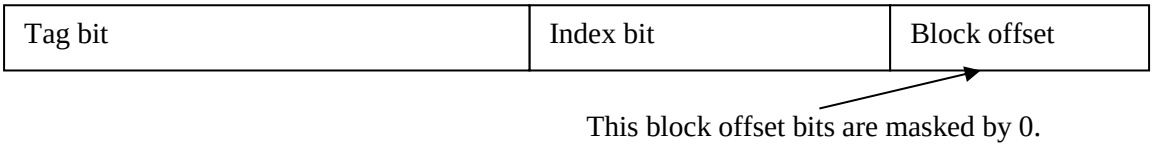
./cs311cache -c cap:assoc:block_size [-x] input_trace

- -c : cache configuration
- -x : dump the cache content at the end of simulation

Cache content is not data content but the address which is aligned with block size.
Ex) Block size 16B

When the address 0x10001234 is stored in cache, the content of the cache entry is 0x10001230.

The 4bits (block size bit) are masked by 0.



The TAs will provide skeleton code for displaying output format within “main.c”. You are free to change the parameters and corresponding parts of the code as long as it can print out the same format.

The example of output format with options ‘–c’ and ‘–x’ is attached as below.

```
Cache Configuration:
-------------------------------------
Capacity: 256B
Associativity: 4way
Block Size: 8B

Cache Stat:
-------------------------------------
Total reads: 0
Total writes: 0
Write-backs: 0
Read hits: 0
Write hits: 0
Read misses: 0
Write misses: 0

Cache Content:
-------------------------------------
          WAY[0]      WAY[1]      WAY[2]      WAY[3]
SET[0]:   0x00000000  0x00000000  0x00000000  0x00000000
SET[1]:   0x00000000  0x00000000  0x00000000  0x00000000
SET[2]:   0x00000000  0x00000000  0x00000000  0x00000000
SET[3]:   0x00000000  0x00000000  0x00000000  0x00000000
SET[4]:   0x00000000  0x00000000  0x00000000  0x00000000
SET[5]:   0x00000000  0x00000000  0x00000000  0x00000000
SET[6]:   0x00000000  0x00000000  0x00000000  0x00000000
SET[7]:   0x00000000  0x00000000  0x00000000  0x00000000
```

3.2 Input

The input trace contains a sequence of read or write operations with addresses as we mentioned.

Ex)
R 0x10000000
W 0x10003231
R 0x12341245
R 0x10003231
W 0x10023414
…

The TAs will provide several input traces which are both real world traces and the traces which we generate in order to check the cache operations.

3.3 Output

Your output must contain the following statistics:

- the number of total reads
- the number of total writes
- the number of write-backs
- the number of read hits
- the number of write hits
- the number of read misses
- the number of write misses

The order of output results is Cache Configuration (if –c option is on) → Cache Statistics → Cache Content (if –x option is on).The example of output format are attached as below.

3.4 Sample binary

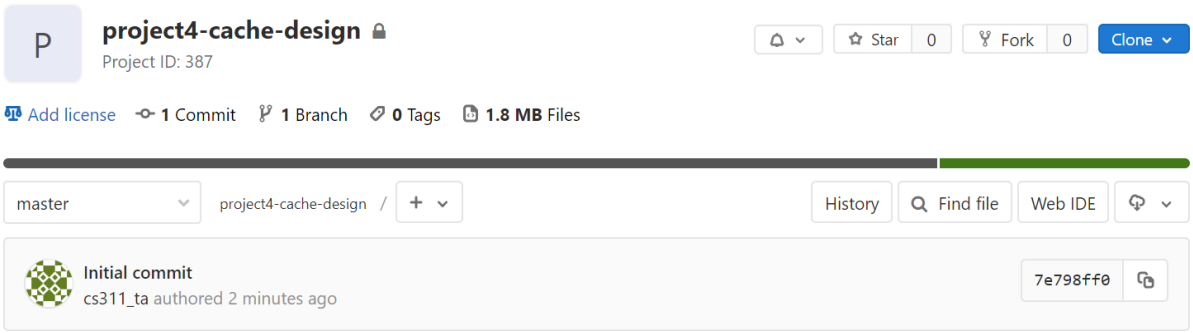
Sample binary file(cs311_ref_cache) is provided. You can execute it like below command.

$ ./cs311_ref_cache -c cap:assoc:block_size [-x] input_trace

4. Forking and Cloning your Repository

4.1 Forking the TA's Repo

(1) Go to the following page: http://cs311.kaist.ac.kr:10080/cs311_projects/project4-cache-design.



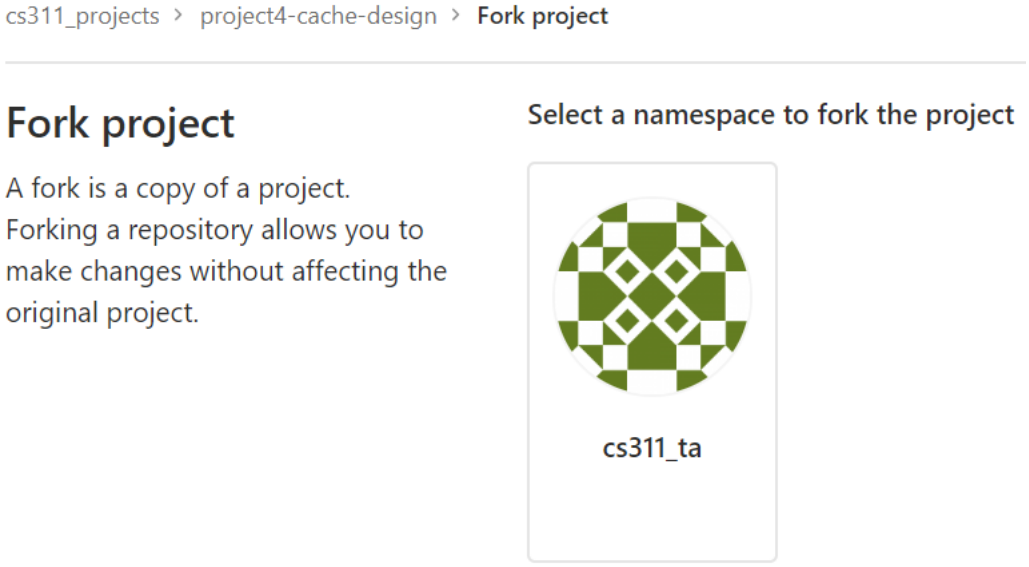
This page is the TA's repository!!!

Important!!!

***Don't make a branch in this repository (TA's repository). If you make your branch in this repository, then other students can see your code. We saw some students made their own branch in TA's repository during previous projects. So please don't make branches in the TA's**

repository.

(2) Click the fork button just like previous projects.
(3) Now select your username and the repo will be forked.



(4) Your own repo will have the following URL: http://cs311.kaist.ac.kr:10080/[Your student ID]/project4-cache-design

4.2 Cloning your own repository to your local machine

***We highly recommended to work on your allocated server throughout this class**

From the website of your team repo copy the SSH or HTTPS URL of the git repository
the SSH URL will look something like the following:
ssh://git@cs311.kaist.ac.kr:10022/[Your student ID]/project4-cache-design.git

Change directory to the location you want to clone your project and clone!
$ git clone ssh://git@cs311.kaist.ac.kr:10022/[Your student ID]/project4-cache-design.git

Be sure to read the README.md file for some useful information.

5. Grading Policy

Grades will be given based on the examples provided for this project provided in the `sample_input` directory. Your simulator should print the exactly same output as the files in the `sample_output` directory.

We will be automating the grading procedure by seeing if there are any difference between the files in the `sample_output` directory and the result of your simulator executions.
Please make sure that your outputs are identical to the files in the sample_output directory.

You are encouraged to use the `*diff*` command to compare your outputs to the provided outputs.

$ ./cs311cache -c 1024:8:8 -x sample_input/simple > my_output
$ diff -Naur my_output sample_output/simple

If there are any differences (including whitespaces) the diff program will print the different lines. If there are no differences, nothing will be printed.

Being "Correct" means that every digit and location is the same to the given output of the example. If a digit is not the same, you will receive **0 score** for the example.

Important!!!

***Before you use 'make test' command, type 'make clean' first to eliminate all other execution files.**

If you want to check all test cases, you can use 'make test' command as same as previous projects.

```
$ make clean
$ make test
```

6. Submission (Important!!)

6.1 Make sure your code works well on your allocated Linux server.

In fact, it is highly recommended to work on your allocated server throughout this class.
Your project will be graded on the same environment as your allocated Linux server.

6.2 Add the 'submit' tag to your final commit and push your work to the gitlab server.

The following commands are the flow you should take to submit your work.

```
$ git tag submit
$ git push
$ git push --tags
```

If there is no "submit" tag, your work will not be graded so please remember to submit your work with the tag.

If you do not `push` your work, we will not have the visibility to your work. Please make sure you push your work before the deadline.

7. Late Policy

You will lose **50%** of your score on the **first day** (Dec 13rd 0:00~23:59). We will **not accept** works that are submitted after then.

Be aware of plagiarism! Although it is encouraged to discuss with others and refer to extra materials, **copying other students or opened code is strictly banned.**

The TAs will compare your source code with open source codes and other student's code. If you are caught, you will receive a penalty for plagiarism.

If you have any requests or questions regarding administrative issues (such as late submission due to

an unfortunate accident, GitLab is not working) please send an e-mail to the TAs(cs311_ta@calab.kaist.ac.kr).

8. Updates/Announcements

If there are any updates to the project, including additional tools/inputs/outputs, or changes, we will post a notice on the Notice board of KLMS, and will send you an e-mail using the KLMS system. **Frequently check your KLMS linked e-mail account or the KLMS notice board for updates.**