Modeling and Simulation with SST and OCCAM

Exercise 2 – Making a change in the SST code

Be on the lookout for this fellow: The call-outs are ACTIONs for you to do!

When you see the check mark, compare your work to the marked element
Exercise 2: Learning Objectives

- How to make a change to SST within OCCAM
- Explore variable spaces using ranges of values
Exercise 2: Overview of Steps

1. Modifying an OCCAM object
   - Permutation-based page interleaving
   - Modifying DRAMSim2
   - Instantiate a modified SST simulator

2. Compare page interleaving schemes
   - Defining variable ranges
   - Configure experiment

3. Plotting the results
Modifying an OCCAM object

Estimated time: 10 minutes
Permutation-based page interleaving scheme
1 Modifying an OCCAM object

Introduction

- We want to reproduce the work in

Modifying an OCCAM object

**Introduction**

- **Bit representation of memory addresses**
  - Seen by cache
    
    | TAG | SET INDEX | BLOCK OFFSET |
    |-----|-----------|--------------|
  - Seen by memory with conventional page interleaving
    
    | PAGE INDEX | BANK INDEX | PAGE OFFSET |
    |------------|------------|-------------|

Modifying an OCCAM object

Introduction

- Exploits data locality
- Severe row buffer conflicts

If TAG is not in the set a new page will be open in the same bank

HIGH LATENCY

Modifying an OCCAM object

Introduction

- Proposed solution
  - Permutation-based page interleaving

Modifying DRAMSim2
① Modifying an OCCAM object

Modifying DRAMSim2

- First we will edit a file in DRAMSim2

(a) Follow the instructions in the handout on terminal access

(b) Navigate to DRAMsim2 folder

(c) Edit the AddressMapping.cpp file
Modifying an OCCAM object

Modifying DRAMSim2

- DRAMSim2 was installed when we issued the “occam install” command
  - The modification was pre-inserted on the file

(a) Remove the comments in the code

Line #344
1. Modifying an OCCAM object

Modifying DRAMSim2

- Check that your code matches this example

Does your code look like this?

Save and exit
Modifying an OCCAM object

Modifying DRAMSim2

- DRAMSim2 is a git repository
  - We will now commit the changes

*Copy-paste:
git commit -am "Modified DRAMSim2 to support bank permutation"
1. Modifying an OCCAM object

Import changes into OCCAM

- Now that we modified DRAMSim2 we must import the new version into OCCAM

(a) Go back one directory

(b) Commit changes to occam
1. Modifying an OCCAM object

**Building SST**

- We need to build the new imported SST

Building takes a long time, therefore, we have built it for you in advance. If you want to use the pre-built version, please skip the next slide.

If you have the time to build, you can continue to the next slide.
We need to build the new imported SST

(a) Build SST

```bash
csil6user@ubuntu ~/tutorial/simulator-sst-scl6 (master*) $ occam build
Building Object
* Building a local version of this object.
* Installing file resource to /home/sci6user2/.occam/builds/fd/c4/fdc4c322-4ab1-11e6-a0b5-8b1c0893c32e/218d125ef9c7321f900e45d5dad55b5efb3ff29bbaa/openmpi-1.8.tar.gz
* Installing file resource to /home/sci6user2/.occam/builds/fd/c4/fdc4c322-4ab1-11e6-a0b5-8b1c0893c32e/218d125ef9c7321f900e45d5dad55b5efb3ff29bbaa/boost_1_56_0.tar.gz
* Installing file resource to /home/sci6user2/.occam/builds/fd/c4/fdc4c322-4ab1-11e6-a0b5-8b1c0893c32e/218d125ef9c7321f900e45d5dad55b5efb3ff29bbaa/sst-core
* Installing git resource to /home/sci6user2/.occam/builds/fd/c4/fdc4c322-4ab1-11e6-a0b5-8b1c0893c32e/218d125ef9c7321f900e45d5dad55b5efb3ff29bbaa/sst-elements
* Installing git resource to /home/sci6user2/.occam/builds/fd/c4/fdc4c322-4ab1-11e6-a0b5-8b1c0893c32e/218d125ef9c7321f900e45d5dad55b5efb3ff29bbaa/dramsim2
* Installing git resource to /home/sci6user2/.occam/builds/fd/c4/fdc4c322-4ab1-11e6-a0b5-8b1c0893c32e/218d125ef9c7321f900e45d5dad55b5efb3ff29bbaa/pyenv
* Using backend 'ubuntu:14.04' (non-native)
* Using backend 'ubuntu:14.04' (non-native)
* Using backend 'docker'
```
Instantiate a modified SST simulator
Define & Run in OCCAM

Accessing OCCAM

Use your laptop’s web browser to access your OCCAM instance for exercise 2

- Follow instructions in the handout on exercise 2 access.

Click login
Then input your username & password
① Modifying an OCCAM object

Create a new workset

- Create a new workset named “Ex 2 workset”
  - Used to create and maintain OCCAM objects

(a) click here to access all worksets

(b) give new workset a name

(c) click to make workset!
1. **Modifying an OCCAM object**

   *Instantiate a modified simulator*

   - **Workflow: Steps to do an experiment**
     - Use workflow to instantiate simulator in OCCAM
     - We first add a new workflow object

   ![Diagram of workflow process](image)

   - (a) go to bottom of workset page
   - (b) give workflow a good descriptive name
   - (c) click to add the workflow
Modifying an OCCAM object

**Instantiate a modified simulator**

- Add the SST block
  - This block instantiates SST simulators

(a) Select the empty block

(b) And then click on the top section of the box
1. Modifying an OCCAM object

*Instantiate a modified simulator*

- Add the SST block
  - This block instantiates SST simulators

(a) Type "simulator-instantiator"

(b) Select the “simulator-instantiator” option
1. Modifying an OCCAM object

* Instantiate a modified simulator*

- Add the SST block
  - This block instantiates SST simulators

(a) Add SST as the framework on the middle section

(b) Click Attach
Modifying an OCCAM object

Instantiate a modified simulator

- Add a block to the simulator
  - Block specifies configuration to instantiate simulator

Click plus sign to add a new block then select in top section “configuration”
① Modifying an OCCAM object

*Instantiate a modified simulator*

- Add the SST configuration block
  - We’ll use the same configuration as in the previous exercise (Prospero+DRAMSim2)

(a) Click middle section and search for “SST Tutorial Configuration”

(b) Click attach (hidden)
1 Modifying an OCCAM object

*Instantiate a modified simulator*

It may seem the same as before, but the version number on the SST object will be different.
1 Modifying an OCCAM object

Instantiate a modified simulator

- Let’s name the instantiated simulator

(a) Click the SST configuration tab
   Careful: check that you are using the “General Options” subtab

(b) Name simulator: “Simulator Modified DRAMSim2”

(c) Click Update (scroll down)
1 Modifying an OCCAM object

Instantiate a modified simulator

- And select the configuration file
  - Configures SST for prospero + DRAMSim2

(a) Click the SST Tutorial configuration tab

(b) Select `config_ProsperoDRAMSIM2.py`

(c) Click Update (Scroll down)
Modifying an OCCAM object

Instantiate a modified simulator

- Instantiate simulator by executing workflow
  - Extracts specifications & objects for OCCAM
  - Associates SST simulator with the named object

(a) Select the Run tab

(b) Click Run
1. **Modifying an OCCAM object**

   *Instantiate a modified simulator*

   - Instantiate simulator by executing workflow

   ![Workflow Execution Diagram](image)

   - Wait until the run finishes
① Modifying an OCCAM object

Check your work!

- Verify that we have generated the simulator

(a) Refresh web page (not shown)

(b) Click Output tab

(c) Check for new simulator
② Interleaving schemes

Estimated time: 10 minutes
2 Interleaving schemes

Create new experiment

- We will now create an experiment that executes the simulator on the same traces as before, but this time, we will compare the results with and without the modification.

Go back to “Ex 2 workset”
Click on the link on the top left of the page
2 Interleaving schemes

Create new experiment

We just created this experiment to instantiate simulator.
2. Interleaving schemes

Create new experiment

- Now we create a new experiment
  - Compare interleaving schemes with/without permutation

(a) Add an experiment object

(b) Give experiment a name

(c) Add the experiment
2 Interleaving schemes

Add simulator to workflow

- Use the simulator that you just created

(a) Select empty block and select “simulator” in top section (not shown)

(b) Click middle section and search for “Simulator Modified DRAMSim2” (the name we gave the instantiated sim)

(c) Click attach (hidden)
Interleaving schemes

Add traces for simulator

- We’ll use the same trace as before

Click plus to add an input (trace) to the instantiated simulator
Interleaving schemes

Add traces for simulator

- Insert trace object as the simulator’s input

  (a) Type “trace” in top section

  (b) Click middle section and search for “Prospero Traces”

  (c) Click Attach to add a trace object into the workflow (hidden)
2 Interleaving schemes

Add traces for simulator

- Check your work – does it match?

(a) Is your workflow the same?

(b) Select the bottom plus
2 Interleaving schemes

Add configuration for DRAMSim2

- Add a DRAMsim2 configuration to the workflow

(a) Type “configuration” in top section

(b) Select “new configuration” in the middle section

(c) Click Attach (not shown)
2 Interleaving schemes

Add configuration for DRAMSim2

- Add a DRAMSim2 configuration to the workflow

(a) Does your workflow look like this?

(b) Select the bottom plus
2. **Interleaving schemes**

*Add configuration for DRAMSim2*

- Add the DRAMSim2 configuration generator

(a) Type “configuration-generator” in the top section

(b) Select “DRAMSIM2-config-generator” in the middle section

(c) Click Attach (hidden)
② Interleaving schemes

Check your workflow

(a) Does your workflow look like this?
2 Interleaving schemes

Setup the traces in workflow

- Specify the traces to run with simulator

(a) Click “Prospero Traces” tab

(b) Select all traces to add each one for a separate simulation run

(c) Click Update to save parameters for the trace object
2. Interleaving schemes

Setup the DRAMSim2 configuration

(a) Click “DRAMSim2-config-generator” tab

(b) Select System Configuration
2) Interleaving schemes

Setup the DRAMSim2 configuration

(a) Change the Permutate banks with cache to the range 0…1

(note the three dots!)

(b) Click Update
Side note: Defining variable ranges
OCCAM allows to define ranges of values
  ◦ Easier to define multiple executions of an experiment

Three methods are supported:
  ◦ Lists:
    • 1,2,4,8,16  ◦ Ranges
    • 1…16  ◦ Functions:
      • 1…16:x*2
        (generates 1,2,4,8,16)

Multiple variables can be defined simultaneously
  ◦ All permutations will execute
2 Interleaving schemes

Defining variable ranges

• Namely

This option will automatically execute our experiment twice:
  o One with this option set to 0 (no permutation)
  o The other with this option set to 1 (with permutation)
Interleaving schemes

Run the experiment

(a) Click “Run” tab

(b) Click “Run” to dispatch workflow. You should see it executing.
2 Interleaving schemes

Run the experiment

Example of output from the running experiment

Wait until the run finishes
③ Create a report
Estimated time: 10 minutes
3 Create a report

Try it yourself now

Challenge: Try to create the plots comparing the results with and without the permutation for both trace files.
Note: If you don’t know what to do follow the remaining slides! They have the instructions.

Impact of permutation-based page interweaving

Each bar set corresponding to one of the trace files. Purple and blue bars corresponding to experiments with and without permutation.
Create a report

Create a report with plot

(a) Go back to the Ex 2 Workset (not shown)

(b) Add a new object of type "paper"

(c) Name it "Permutation Report"

(d) Click Add
Create a report

Create a report with plot

- A page is used to hold content in the report
- We’ll add the plot to a page

(a) Add a Page

(b) Give the page the name “Permutation”

(c) Click Add
3 Create a report

Create a report with a plot

- A widget is a script on a Page (in this case, to plot results)

(a) Select the Permutation page from the report

(b) Click the Plus

(c) Select widget

(d) Click Add for a widget
③ Create a report

Create a report with a plot

- We have an “unloaded widget”
- Need to specify a widget for plotting

(a) Hover the mouse on this spot to show the configuration button

(b) Click configuration button
Create a report

Create a report with a plot

- The widget is a *filter* that operates on results

(a) Search for “plotly.js”

(b) click Attach
Create a report

Add results to the plot

- Plot results from running without permutation
  - Navigate the drop down options and open the dataset without permutation

(a) Select Datasets tab
(b) Navigate dropdowns from Open From Workset
(c) Click on output without permutation
③ Create a report

Add results to the plot

- Select the data from results to plot

(a) Click on the tab

(b) Search for prospero0.trace (Note: not “prospero1.trace”)

(c) Collapse “inputs”
③ Create a report

*Add results to the plot*

- Select the data from results to plot

(a) Select the results:
   - Memory \(\rightarrow\) cycles\_attempted\_issue\_but\_rejected \(\rightarrow\) SimTime

(b) Select “Groups”
   (create a new data group for the plot)

(c) Click Append
Create a report

Add results to the plot

- Select the data from results to plot

(a) Search for prospero1.trace

(b) Collapse “inputs”
Select the data from results to plot

(a) Select the results:
Memory ➔ cycles_attempted_issue_but_rejected ➔ SimTime

(b) Select “Groups[0]”
(add data to the previously created group)

(c) Click Append
3. Create a report

Set how to plot the results

- Resize the plot area

(a) Drag this down to reveal the plot
Create a report

Set how to plot the results

- We’ll use a bar chart

(a) Click on Data tab

(b) Change Type to Bar

(c) Change Name to “Without Permutation”
Create a report

Add results to the plot

- Plot results from running with permutation
  - Navigate the drop down options and open the dataset with permutation

(a) Select Datasets tab

(b) Navigate dropdowns from Open From Workset

(c) Click on output with permutation
3. Create a report

Add results to the plot

- Select the data from results to plot

  (a) Click on the tab

  (b) Search for prospero0.trace (Note: not “prospero1.trace”)

  (c) Collapse “inputs”
3 Create a report

Add results to the plot

- Select the data from results to plot

  (a) Select the results:
  Memory → cycles_attempted_issue_but_rejected → SimTime

  (b) Select “Groups”
  (create a new data group for the plot)

  (c) Click Append
③ Create a report

Add results to the plot

- Select the data from results to plot

(a) Search for prospero1.trace

(b) Collapse the inputs
Create a report

Add results to the plot

- Select the data from results to plot

(a) Select the results:

- Memory → cycles_attempted_issue_but_rejected → SimTime

(b) Select “Groups[1]”

(add data to the newly created group)

(c) Click Append
3) Create a report

Set how to plot the results

(a) Click on the data tab

(b) Click on group
③ Create a report

Set how to plot the results

- We’ll use a bar chart

(a) Change Type to Bar

(b) Change Name to “With Permutation”
3 Create a report

Set how to plot the results

(a) Click on Layout tab

(b) Change Title to “Impact of permutation-based page interleaving”

(c) Change X Axis name to “Trace file”
3. **Create a report**

*Set how to plot the results*

(a) Click Y Axis

(b) Change Y Axis name to “nanoseconds”
Create a report

The Final Result!

You may need to refresh

Impact of permutation-based page interweaving

Each bar set corresponding to one of the trace files. Purple and blue bars corresponding to without and with permutation.
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