Project 1 Report

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1. Introduction

This project use gem5 to simulate a basic computer system and run some complex executables. Also we will use gem5 outputs to analysis the performance of difference computers and executables.

2. Experiment Setup

2.1 Environment

- **gem5 Version:** download from https://github.com/ChaseLab-PKU/archlab-gem5
- **Host System:** Ubuntu 22.04 from WSL2
- **Hardware configuration:** CPU: i7-13700HX, GPU: 4060 Laptop, DRAM: 16GB DDR4
- **Simulator Mode:** syscall emulation (SE) mode

2.2 System Configuration

- **CPU Model:** Simple CPU / Minor CPU / O3CPU
- **Memory:** 2GB DDR3 / 2GB DDR4 / 2GB DDR5
- **Other Parameters:** clock frequency: 2GHz

2.3 Benchmarks/Programs

- **Tested Programs:**
  - `binary_search`
  - `gemm`
  - `shell_sort`
  - `spfa`

2.4 Simulation Commands

- Command to run a benchmark:

```
/build/X86/gem5.opt -d destdir configs/example/simple.py tests/labexe/gemm --cpu minor --mem DDR3
```

- use a max_insts_any_thread of 5e+8

3. Results

```
marcus@ASUS:~$ sudo docker start -ia lab1.correct
Checking for C header file fenv.h... (cached) yes
Checking for C header file png.h... (cached) yes
Checking for clock_nanosleep(0,0,NULL,NULL) in C library None... (cached) yes
Checking for C header file valgrind/valgrind.h... (cached) no
Checking for pkg-config package hdf5-serial... (cached) yes
Checking for H5Fcreate("", 0, 0, 0) in C library hdf5... (cached) yes
Checking for H5::H5File("", 0) in C++ library hdf5_cpp... (cached) yes
Checking whether __i386__ is declared... (cached) no
Checking whether __x86_64__ is declared... (cached) yes
Checking for compiler -Wno-self-assign-overloaded support... (cached) yes
Checking for linker -Wno-free-nonheap-object support... (cached) yes
scons: done reading SConscript files.
scons: Building targets ...
 [VER TAGS]  -> ARM/sim/tags.cc
 [MAKE INC] src/mem/ruby/slicc_interface/RubyRequest.hh -> ARM/mem/ruby/protocol/RubyRequest.hh
 [    LINK]  -> ARM/gem5.opt
scons: done building targets.
```

- **Figure 1**

  gem5 compiled correctly in the environment

```
root@39e1679d876e:/gem5# build/ARM/gem5.opt configs/proj1/simple.py
gem5 Simulator System.  https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 24.0.0.1
gem5 compiled Sep 21 2025 14:09:14
gem5 started Sep 21 2025 15:43:36
gem5 executing on 39e1679d876e, pid 134
command line: build/ARM/gem5.opt configs/proj1/simple.py

Global frequency set at 1000000000000 ticks per second
src/mem/dram_interface.cc:690: warn: DRAM device capacity (16384 Mbytes) does not match the address range assigned (2048 Mbytes)
src/base/statistics.hh:279: warn: One of the stats is a legacy stat. Legacy stat is a stat that does not belong to any statistic
s::Group. Legacy stat is deprecated.
system.remote_gdb: Listening for connections on port 7000
src/sim/simulate.cc:199: info: Entering event queue @ 0.  Starting simulation...
src/sim/mem_state.cc:448: info: Increasing stack size by one page.
src/sim/syscall_emul.hh:1075: warn: readlink() called on '/proc/self/exe' may yield unexpected results in various settings.
     Returning '/gem5/tests/labexe/hello'
src/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)
Hello, World!
exiting with last active thread context (0) @ 518684250
root@39e1679d876e:/gem5#
```
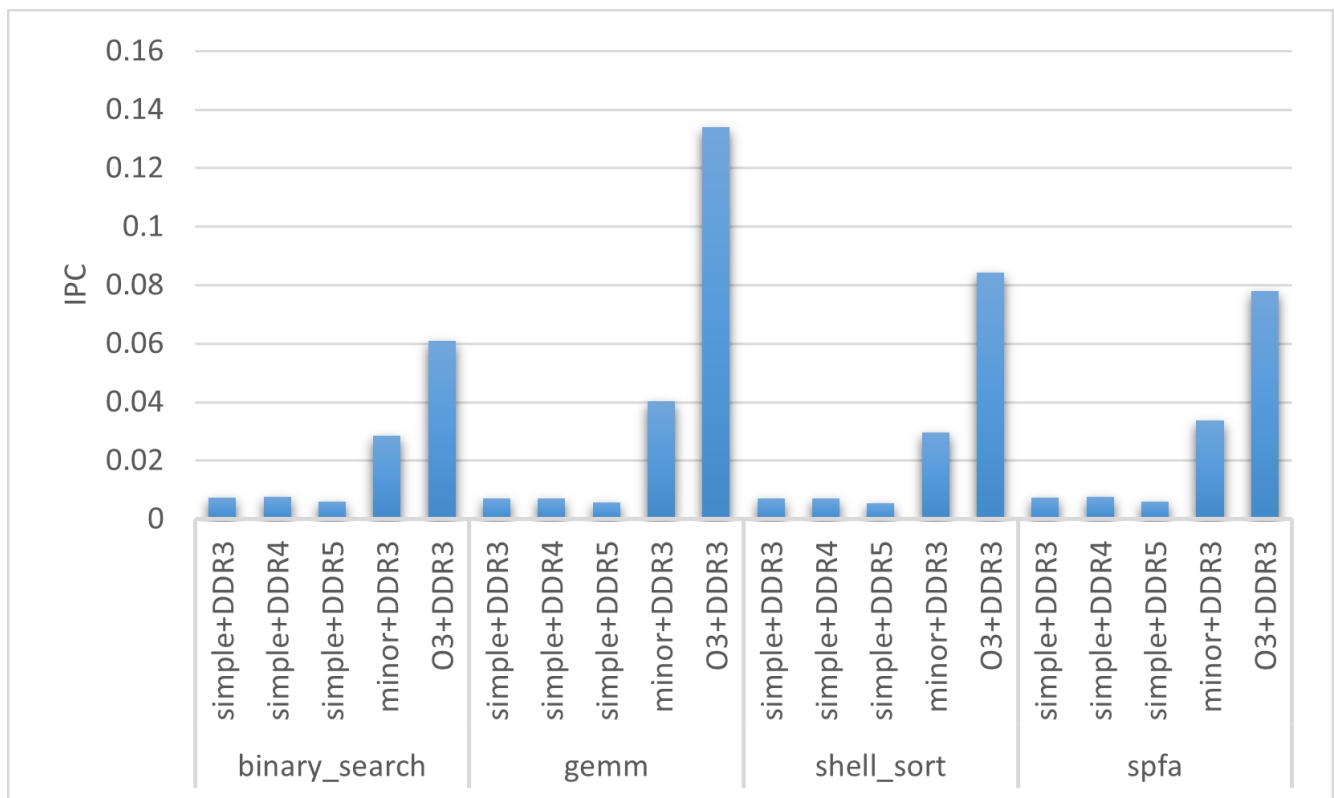
- **Figure 2**

  output of `hello` on stdout of my configuration script

	A	B	C	D	E
1	executable	config	simInsts	numCycles	IPC
2		simple+DDR3	5.00E+08	67275799184	0.007432
3		simple+DDR4	5.00E+08	65864999590	0.007591
4		simple+DDR5	5.00E+08	85742409634	0.005831
5		minor+DDR3	5.00E+08	17506189049	0.028561
6	binary_search	O3+DDR3	5.00E+08	8215769995	0.060859
7		simple+DDR3	5.00E+08	71150143497	0.007027
8		simple+DDR4	5.00E+08	69741514934	0.007169
9		simple+DDR5	5.00E+08	89933284403	0.00556
10		minor+DDR3	5.00E+08	12431057073	0.040222
11	gemm	O3+DDR3	5.00E+08	3730661950	0.134024
12		simple+DDR3	5.00E+08	72235207045	0.006922
13		simple+DDR4	5.00E+08	70783846423	0.007064
14		simple+DDR5	5.00E+08	91069540258	0.00549
15		minor+DDR3	5.00E+08	16824706556	0.029718
16	shell_sort	O3+DDR3	5.00E+08	5938508384	0.084196
17		simple+DDR3	5.00E+08	67361026906	0.007423
18		simple+DDR4	5.00E+08	65873082774	0.00759
19		simple+DDR5	5.00E+08	84962693440	0.005885
20		minor+DDR3	5.00E+08	14817974143	0.033743
21	spfa	O3+DDR3	5.00E+08	6455970572	0.077853

- **Figure 3**

  Table of performances of difference executables and CPU/mem types

- **Figure 4**

  Graph of performances of difference executables and CPU/mem types

4. Analysis

- **Performance Trends:** Different executables has different IPC, and advanced CPU/mem could improve the performance of executables. CPU has a bigger effect than memory.

5. Appendix

- **Codes and Raw Outputs:** Recources can be found at https://github.com/ZhouBC123/Autumn2025_PKUArchlab/lab1.