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ECE 581 Computer Architecture Fall 2020

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Homework 4

Due Date: 14th December 2020 – 23:59

ANSWERS

FACTORIAL

- **Command1** : `./build/X86/gem5.opt configs/example/se.py -c /home/ubuntu/Downloads/gem5/configs/tutorial/a.bin`
Output1 : `stats_for_factorial_1.txt`

```
root@ubuntu:/home/ubuntu/Downloads/gem5# build/X86/gem5.opt ./configs/example/se.py -c /home/ubuntu/Downloads/gem5/configs/tutorial/a.bin
gem5 Simulator System. http://gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 20.1.0.2
gem5 compiled Dec  9 2020 15:36:38
gem5 started Dec 10 2020 10:39:32
gem5 executing on ubuntu, pid 25158
command line: build/X86/gem5.opt ./configs/example/se.py -c /home/ubuntu/Downloads/gem5/configs/tutorial/a.bin

warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
Global frequency set at 100000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 Mbytes)
0: system.remote_gdb: listening for remote gdb on port 7000
**** REAL SIMULATION ****
info: Entering event queue @ 0. Starting simulation...
warn: ignoring syscall access(...)
info: Increasing stack size by one page.
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
Enter any Number: Factorial of 0 is: 1
Exiting @ tick 2252831500 because exiting with last active thread context
```

Picture1 : Factorial Command1

- **Command2** : `./build/X86/gem5.opt --debug-flags=O3PipeView --debug-file=trace.out configs/example/se.py --cpu-type=DerivO3CPU --caches -c /home/ubuntu/a.bin`
 - Used O3PipeView to see the pipelining and changed the cpu-type from AtomicSimpleCPU to DerivO3CPU.
 - Installed Konata(<https://github.com/shioyadan/Konata>) for pipeline visualizing.

Outputs2 : stats_for_factorial_2.txt and trace.out(trace.out is too big for attachment)

```
gem5 version 20.1.0.2
gem5 compiled Dec 11 2020 15:36:12
gem5 started Dec 11 2020 16:59:45
gem5 executing on ubuntu, pid 19842
command line: ./build/X86/gem5.opt --debug-flags=O3PipeView --debug-file=trace.out configs/example/se.py --cpu-type=DerivO3CPU --caches -c /home/ubuntu/a.bin

warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
Global frequency set at 100000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 Mbytes)
0: system.remote_gdb: listening for remote gdb on port 7000
**** REAL SIMULATION ****
info: Entering event queue @ 0. Starting simulation...
warn: x86 cpuid family 0x0000: unimplemented function 13
warn: ignoring syscall access(...)
info: Increasing stack size by one page.
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
Enter any Number: Factorial of 0 is: 1
Exiting @ tick 1402866500 because exiting with last active thread context
root@ubuntu:/home/ubuntu/gem5#
```

Picture2 : Factorial Command2

Inst	Op	Op2	Op3	Op4	Op5	Op6	Op7
0: s1 (t0: r0): 0x7fff1	F	Dc	Rn	1	Is	Cm	1
1: s2 (t0: r1): 0x7fff1	F	Dc	Rn	1	Is	Cm	1
2: s3 (t0: r2): 0x7fff1	F	Dc	Rn	1	Is	Cm	1
3: s4 (t0: r3): 0x7fff1	F	Dc	Rn	1	Ds	Is	Cm 1
4: s5 (t0: r4): 0x7fff1	F	Dc	Rn	1	Is	Cm	1 2
5: s6 (t0: r5): 0x7fff1	F	Dc	Rn	1	Ds	Is	Cm 1
6: s7 (t0: r6): 0x7fff1							
7: s8 (t0: r7): 0x7fff1							
8: s9 (t0: r8): 0x7fff1							
9: s10 (t0: r9): 0x7fff1							
10: s11 (t0: r10): 0x7fff1							
11: s12 (t0: r11): 0x7fff1							
12: s13 (t0: r12): 0x7fff1							
13: s14 (t0: r13): 0x7fff1							
14: s15 (t0: r14): 0x7fff1							
15: s16 (t0: r15): 0x7fff1							
16: s17 (t0: r6): 0x7fff1							
17: s18 (t0: r7): 0x7fff1							
18: s19 (t0: r8): 0x7fff1							
19: s20 (t0: r9): 0x7fff1							
20: s21 (t0: r10): 0x7fff1							
21: s22 (t0: r11): 0x7fff1							

Picture3 : PipelineView from trace.out (Used Konata)

1. From stats_for_factorial_1.txt

sim_insts	2174259	# Number of instructions simulate
------------------	----------------	--

2. From stats_for_factorial_1.txt

system.cpu.committedInsts	2174259	# Number of instructions committed
system.cpu.committedOps	3798181	# Number of ops (including micro ops)
		committed
Microinst. Comitted	3798181 - 2174259 = 1623922	

3. From stats_for_factorial_2.txt

system.cpu.rename.fullRegistersEvents	504	# Number of times there has been no free registers
system.cpu.numCycles	4505664	# number of cpu cycles simulated

Average Busy Register Per Cycle : $504 / 4505664 = 0,0001$ (Calculating got from https://www.gem5.org/documentation/general_docs/statistics/)

4. There is also physical register file.

Rename

Renames instructions using a physical register file with a free list. Will stall if there are not enough registers to rename to, or if back-end resources have filled up. Also handles any serializing instructions at this point by stalling them in rename until the back-end drains.

(Source https://www.gem5.org/documentation/general_docs/cpu_models/O3CPU)

5.

system.cpu.rename.runCycles	624129	# Number of cycles rename is running
system.cpu.rename.lookups	12606768	# Number of register rename lookups that rename has made

BZIP2

- **Command1** : `./build/X86/gem5.opt configs/example/se.py -c /home/ubuntu/Masaüstü/401.bzip2/exe/bzip2_base_compsys`
Output1 : `stats_for_bzip2_1.txt`

```
root@ubuntu:/home/ubuntu/gem5# ./build/X86/gem5.opt configs/example/se.py -c /home/ubuntu/Masaüstü/401.bzip2/exe/bzip2_base_compsys
gem5 Simulator System.  http://gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 20.1.0.2
gem5 compiled Dec 11 2020 15:36:12
gem5 started Dec 13 2020 11:25:01
gem5 executing on ubuntu, pid 73957
command line: ./build/X86/gem5.opt configs/example/se.py -c '/home/ubuntu/Masaüstü/401.bzip2/exe/bzip2_base_compsys'

warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
Global frequency set at 100000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 Mbytes)
0: system.remote_gdb: listening for remote gdb on port 7005
**** REAL SIMULATION ****
info: Entering event queue @ 0. Starting simulation...
warn: ignoring syscall access(...)
info: Increasing stack size by one page.
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
spec_init
Loading Input Data
Duplicating 13329296 bytes
warn: MOVNTDQ: Ignoring non-temporal hint, modeling as cacheable!
Input data 67108864 bytes in length
Compressing Input Data, level 5
info: Increasing stack size by one page.
info: Increasing stack size by one page.
^CExiting @ tick 15013759492000 because user interrupt received
```

Picture4: bzip2 Command1

- Outputs2 :** stats_for_bzip2_2.txt and trace.out (trace.out is too big for attachment and displaying)

```

root@ubuntu:/home/ubuntu/gen5# ./build/X86/gen5.opt --debug-flags=O3Plpeview --debug-file=trace.out configs/example/se.py --cpu-type=Deriv03CPU --caches -c /home/ubuntu/Masausto/401.bzip2/exe/bzip2_base
gen5 Simulator System. http://gen5.org
gen5 is copyrighted software; use the --copyright option for details.

gen5 version 20.1.0.2
gen5 compiled Dec 11 2020 15:36:12
gen5 started Dec 13 2020 15:39:08
gen5 executing on ubuntu, pid 78546
command line: ./build/X86/gen5.opt --debug-flags=O3Plpeview --debug-file=trace.out configs/example/se.py --cpu-type=Deriv03CPU --caches -c '/home/ubuntu/Masausto/401.bzip2/exe/bzip2_base.compys' -m 1000
000000

warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
warn: membus.slave is deprecated. 'slave' is now called 'cpu_side_ports'
warn: membus.master is deprecated. 'master' is now called 'mem_side_ports'
Global frequency set at 1000000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
warn: gnm device capacity (512 Mbytes) does not match the address range assigned (512 Mbytes)
0: system.remote gdb: listening for remote gdb on port 7002
**** REAL SIMULATION ****
[info: Entering event queue @ 0. Starting simulation...]
warn: aio cpu() family 0x0000: unimplemented function 13
warn: ignoring syscall access(...)
[info: Increasing stack size by one page.
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
warn: ignoring syscall mprotect(...)
spec init
Exiting @ tick 1000000000 because simulate() limit reached
root@ubuntu:/home/ubuntu/gen5#

```

Picture5: bzip2 Command2

1. From stats_for_bzip2_1.txt

sim_insts	15085543512	# Number of instructions simulate
------------------	--------------------	--

2. From stats_for_bzip2_1.txt

system.cpu.committedInsts	15085543512	# Number of instructions committed
system.cpu.committedOps	24880270595	# Number of ops (including micro ops)
		committed
Microinst. Comitted	24880270595 - 15085543512	= 9794727083

3. From stats_for_bzip2_2.txt

system.cpu.rename.fullRegistersEvents	NaN	# Number of times there has been no free registers
--	------------	---

4. There is also physical register file.

Rename

Renames instructions using a physical register file with a free list. Will stall if there are not enough registers to rename to, or if back-end resources have filled up. Also handles any serializing instructions at this point by stalling them in rename until the back-end drains.
(Source https://www.gem5.org/documentation/general_docs/cpu_models/O3CPU)

5.

system.cpu.rename.runCycles	197308	# Number of cycles rename is running
system.cpu.rename.lookups	2880358	# Number of register rename lookups that rename has made