

# EE/CE/CS 6304 Computer Architecture Gem5

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# Overview

- Gem5 resources
  1. Gem5 introduction
  2. login to CE6304 Server system
  3. Download the Benchmarks
  4. Run the experiment for 429.mcf benchmark

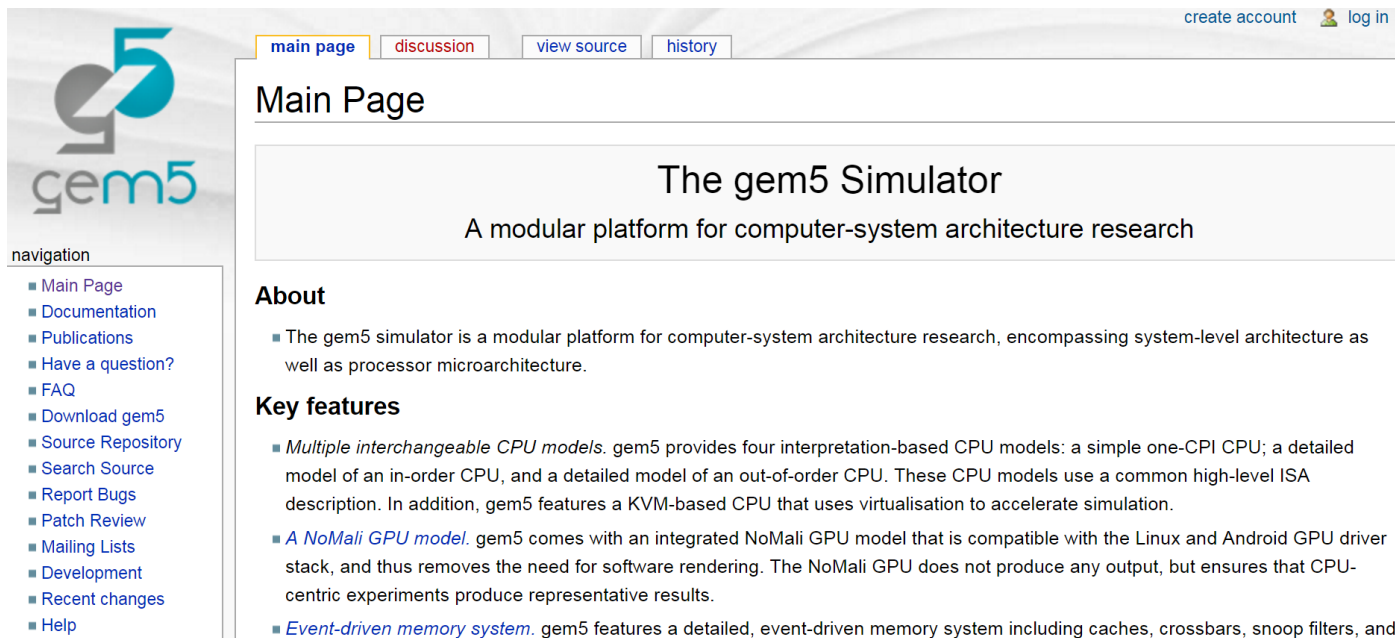


# Learning about gem5

- <http://learning.gem5.org/>
- [https://github.com/powerjg/learning\\_gem5](https://github.com/powerjg/learning_gem5)
- Google.com



- Ref : [http://gem5.org/Main\\_Page](http://gem5.org/Main_Page)



The screenshot shows the main page of the gem5 website. At the top, there is a navigation bar with links for 'main page', 'discussion', 'view source', and 'history'. To the right of these links are links for 'create account' and 'log in'. The main heading is 'Main Page', followed by 'The gem5 Simulator' and the subtitle 'A modular platform for computer-system architecture research'. Below this, there is an 'About' section and a 'Key features' section. The 'About' section states that gem5 is a modular platform for computer-system architecture research, encompassing system-level architecture as well as processor microarchitecture. The 'Key features' section lists several features: multiple interchangeable CPU models, a NoMali GPU model, and an event-driven memory system. On the left side of the page, there is a 'navigation' menu with links to 'Main Page', 'Documentation', 'Publications', 'Have a question?', 'FAQ', 'Download gem5', 'Source Repository', 'Search Source', 'Report Bugs', 'Patch Review', 'Mailing Lists', 'Development', 'Recent changes', and 'Help'.

gem5

create account log in

main page discussion view source history

## Main Page

### The gem5 Simulator

A modular platform for computer-system architecture research

#### About

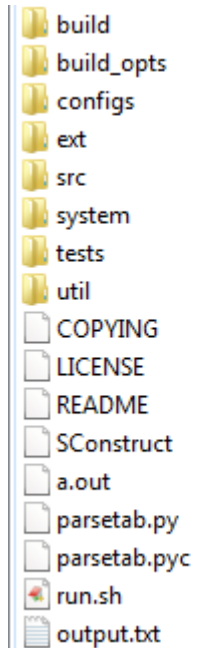
- The gem5 simulator is a modular platform for computer-system architecture research, encompassing system-level architecture as well as processor microarchitecture.

#### Key features

- *Multiple interchangeable CPU models.* gem5 provides four interpretation-based CPU models: a simple one-CPI CPU; a detailed model of an in-order CPU, and a detailed model of an out-of-order CPU. These CPU models use a common high-level ISA description. In addition, gem5 features a KVM-based CPU that uses virtualisation to accelerate simulation.
- *A NoMali GPU model.* gem5 comes with an integrated NoMali GPU model that is compatible with the Linux and Android GPU driver stack, and thus removes the need for software rendering. The NoMali GPU does not produce any output, but ensures that CPU-centric experiments produce representative results.
- *Event-driven memory system.* gem5 features a detailed, event-driven memory system including caches, crossbars, snoop filters, and

navigation

- Main Page
- Documentation
- Publications
- Have a question?
- FAQ
- Download gem5
- Source Repository
- Search Source
- Report Bugs
- Patch Review
- Mailing Lists
- Development
- Recent changes
- Help



A file tree diagram showing the directory structure of the gem5 project. The root directory contains several subdirectories and files: 'build', 'build\_opts', 'configs', 'ext', 'src', 'system', 'tests', 'util', 'COPYING', 'LICENSE', 'README', 'SConstruct', 'a.out', 'parsetab.py', 'parsetab.pyc', 'run.sh', and 'output.txt'.

- build
- build\_opts
- configs
- ext
- src
- system
- tests
- util
- COPYING
- LICENSE
- README
- SConstruct
- a.out
- parsetab.py
- parsetab.pyc
- run.sh
- output.txt

# 1. gem5

- Modular platform for computer-system architecture research, encompassing system-level architecture as well as processor microarchitecture
- Four CPU models
  - Simple (one CPI) CPU
  - Detailed in-order CPU
  - Detailed out-of-order CPI
  - In order pipelined model
- All CPU models use a common high-level ISA



# 1. gem5

- gem5 is written primarily in C++ and python
- It can simulate a complete system:
  - With devices and an operating system in **full system mode (FS mode)**
  - User space only programs where system services are provided directly by the simulator in **syscall emulation mode (SE mode)**.
- There are varying levels of support for executing Alpha, ARM, MIPS, Power, SPARC, and 64-bit x86 binaries on any of the 4 CPU models



# Download and Install

```
%git clone https://gem5.googlesource.com/public/gem5
```

```
%cd gem5
```

```
%scons build/X86/gem5.opt -j5
```

Git= Online repository . Can be downloaded directly from Linux terminal

cd = change directory

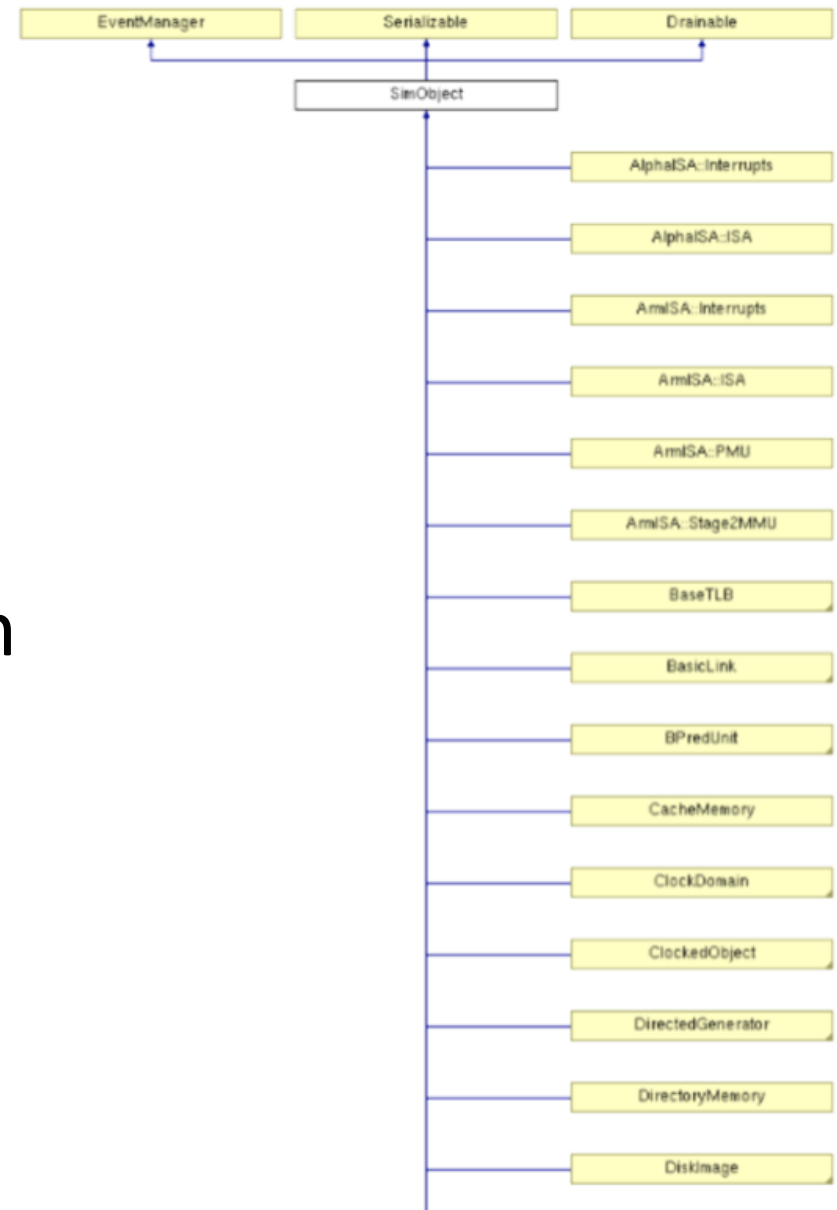
Scons = Builds the system (similar to make) – See <http://scons.org>

build/X86/gem5.opt = Parameter passed to scons



# Gem5 Architecture

- gem5 consists of “**SimObjects**” Most C++ objects in gem5 inherit
- from **class SimObject**
- Represent physical system components

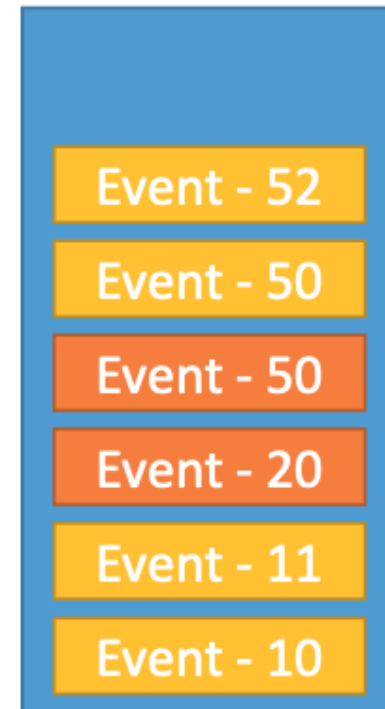




# Gem5 Simulator

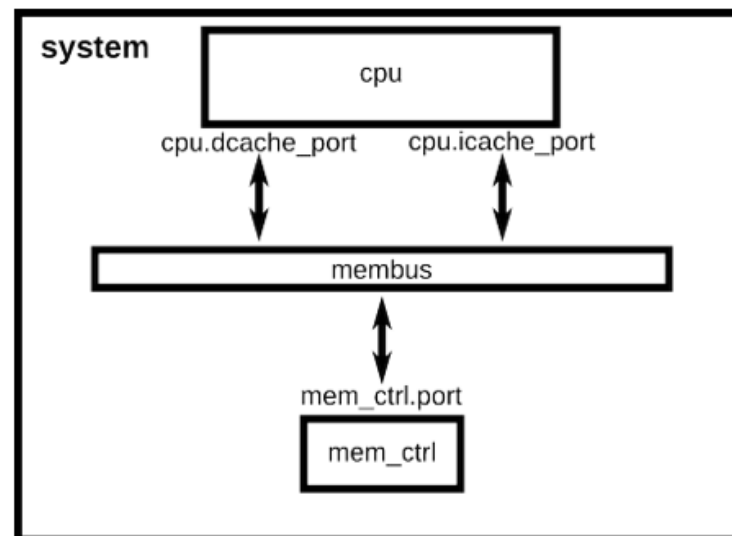
- Gem5 is a discrete event simulator
  1. Event is added to queue
  2. Event is dequeued
  3. Event is executed

## Event Queue



# Gem5 configuration scripts

- [http://learning.gem5.org/book/part1/simple\\_config.html](http://learning.gem5.org/book/part1/simple_config.html)  
[http://learning.gem5.org/book/part1/cache\\_config.html](http://learning.gem5.org/book/part1/cache_config.html)
- **gem5 binary takes, as a parameter, a python script**
  - Sets up and executes the simulation
  - Creates all of the components of the system
  - Specifies all of the parameters for the system components



[http://learning.gem5.org/book/part1/simple\\_config.html](http://learning.gem5.org/book/part1/simple_config.html)

# Running gem5

%build/X86/gem5.opt configs/tutorial/simple.py

Output:

```
gem5 Simulator System.  http://gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 compiled Mar 16 2018 10:24:24
gem5 started Mar 16 2018 15:53:27
gem5 executing on amarillo, pid 41697
command line: build/X86/gem5.opt configs/tutorial/simple.py

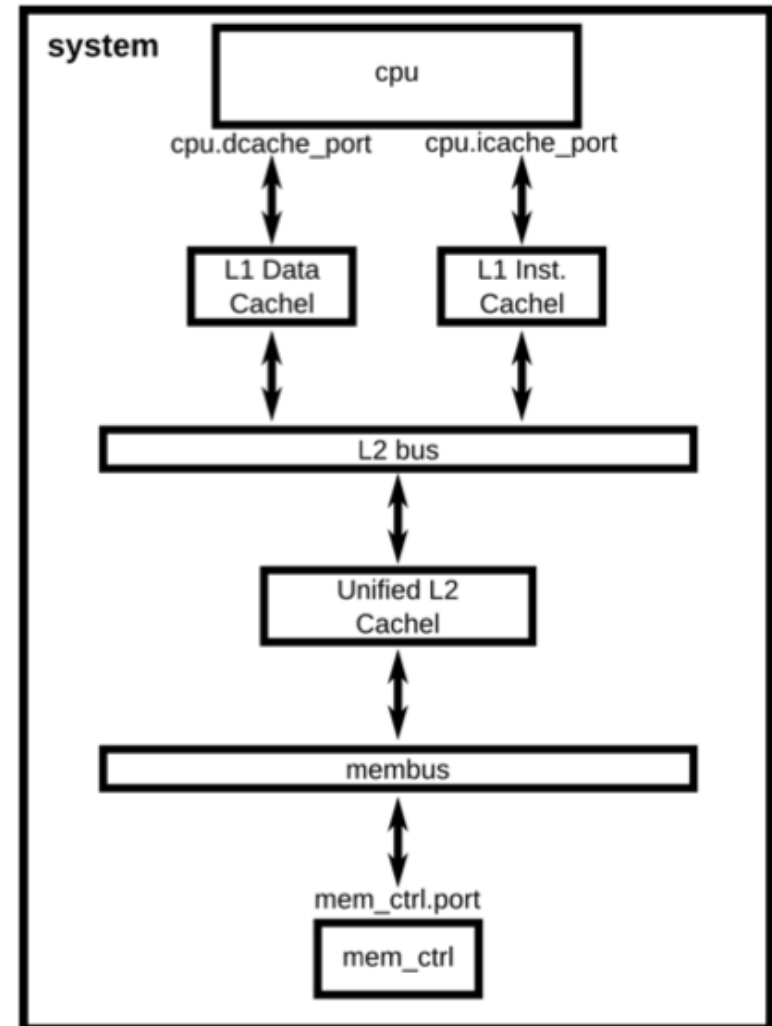
Global frequency set at 1000000000000 ticks per second
warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 Mbytes)
0: system.remote_gdb: listening for remote gdb on port 7000
Beginning simulation!
info: Entering event queue @ 0.  Starting simulation...
Hello world!
Exiting @ tick 507841000 because exiting with last active thread context
```

Results change if configuration parameters are modified,  
e.g., type of CPU or type of DDR controller



# Caches in gem5

- [http://learning.gem5.org/book/part1/cache\\_config.html](http://learning.gem5.org/book/part1/cache_config.html)
- Extending SimObjects in Python
- Object-oriented



# Gem5 Output

[http://learning.gem5.org/book/part1/gem5\\_stats.html](http://learning.gem5.org/book/part1/gem5_stats.html)  
%ls m5out

Filename	Description
Config.ini	Dumps all of the parameters Simobjects Shows exactly what you simulated
Config.json	Same as config.ini, but in json format (JavaScript Object Notation)
Stats.txt	Detailed statistic output. Each SimObject defines and updates statistics. They are printed here at the end of simulation



# gem5 - Usage

- The gem5 command line has four parts,
  1. the gem5 binary
  2. options for the binary
  3. a python simulation script
  4. Options for the script
- The options that are passed to the gem5 binary and those passed to the script are handled separately, so be sure any options you use are being passed to the right component.

% <gem5 binary> [gem5 options] <simulation script> [script options]



# gem5 - Usage –con't

command line: build/ALPHA/gem5.opt configs/example/se.py -h

Usage: se.py [options]

Options:

-h, --help show this help message and exit

-c CMD, --cmd=CMD The binary to run in syscall emulation mode.

-o OPTIONS, --options=OPTIONS ,

The options to pass to the binary, use " " around the entire string

-i INPUT, --input=INPUT Read stdin from a file.

--output=OUTPUT Redirect stdout to a file.

--errout=ERROUT Redirect stderr to a file.

-d, --detailed

-t, --timing

--inorder

-n NUM\_CPUS, --num-cpus=NUM\_CPUS

--caches

--l2cache

--fastmem

--clock=CLOCK

--num-dirs=NUM\_DIRS

--num-l2caches=NUM\_L2CACHES

--l1d\_size=L1D\_SIZE

--l2\_size=L2\_SIZE

--l1d\_assoc=L1D\_ASSOC

--l2\_assoc=L2\_ASSOC

...



# gem5 – Example

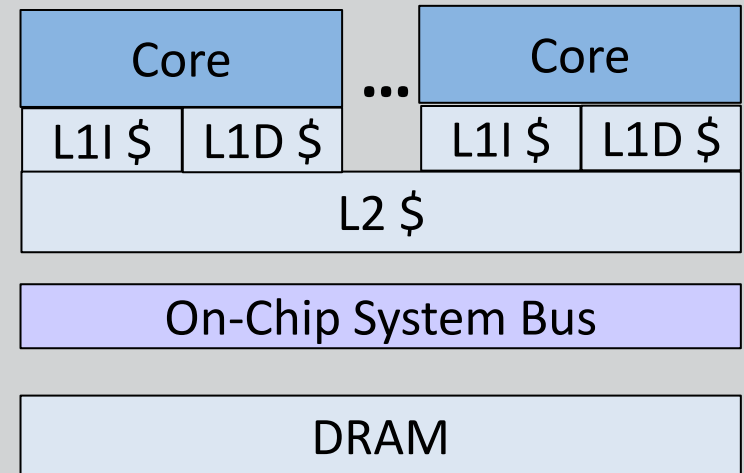
% <gem5 binary> [gem5 options] <simulation script> [script options]

```
3 export GEM5_DIR=/usr/local/gem5
4 export BENCHMARK=./src/benchmark
5 export ARGUMENT=./data/inp.in
6 time $GEM5_DIR/build/X86/gem5.opt
7 -d ~/m5out
8 $GEM5_DIR/configs/example/se.py --> System call emulation mode
9 -c $BENCHMARK } Binary file and its input
10 -o $ARGUMENT }
11 -I 100000000 -----> Simulation Instruction Number
12 --cpu-type=atomic -----> Atomic CPU
13 --caches
14 --l2cache
15 --l1d_size=128kB
16 --l1i_size=128kB
17 --l2_size=1MB
18 --l1d_assoc=2
19 --l1i_assoc=2
20 --l2_assoc=1
21 --cacheline_size=64
```

Cache Info

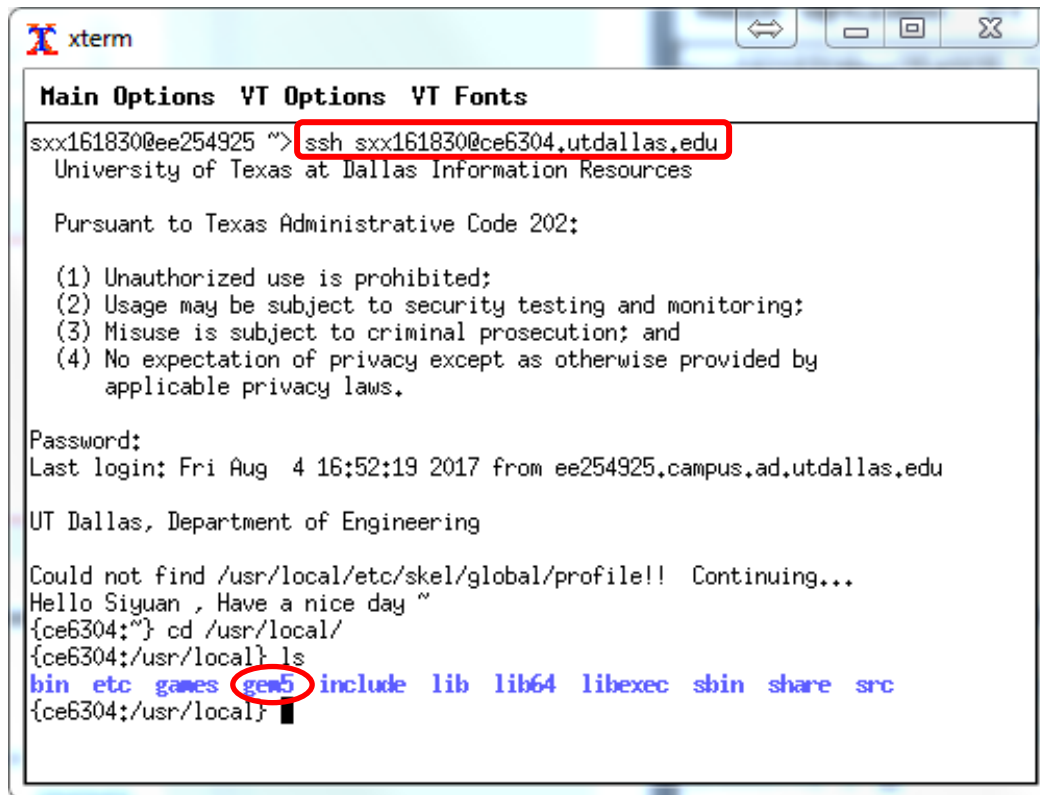
CPU

Atomic/Timing/Functional..





# 2. Login to Server system



```
xterm
Main Options  VT Options  VT Fonts
sxx161830@ee254925 ~> ssh sxx161830@ce6304.utdallas.edu
University of Texas at Dallas Information Resources

Pursuant to Texas Administrative Code 202:
(1) Unauthorized use is prohibited;
(2) Usage may be subject to security testing and monitoring;
(3) Misuse is subject to criminal prosecution; and
(4) No expectation of privacy except as otherwise provided by
    applicable privacy laws.

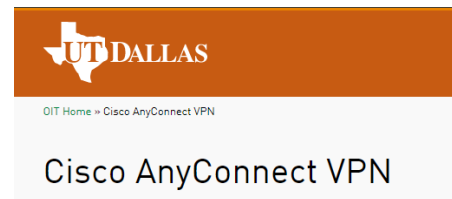
Password:
Last login: Fri Aug  4 16:52:19 2017 from ee254925.campus.ad.utdallas.edu
UT Dallas, Department of Engineering

Could not find /usr/local/etc/skel/global/profile!! Continuing...
Hello Siyuan , Have a nice day ~
{ce6304:~} cd /usr/local/
{ce6304:/usr/local} ls
bin etc games gem5 include lib lib64 libexec shin share src
{ce6304:/usr/local} █
```

Login to Server system:

- Your netid @ ce6304.utdallas.edu
- Your password( the same as galaxy)

Off-campus ,you need to setup the VPN, info:  
<http://www.utdallas.edu/oit/vpn/>

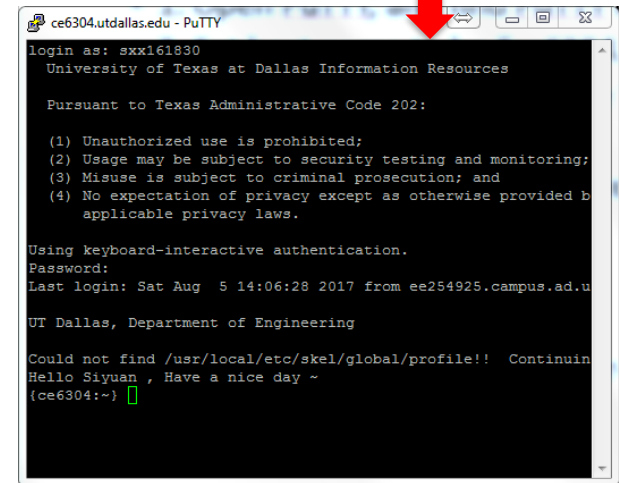
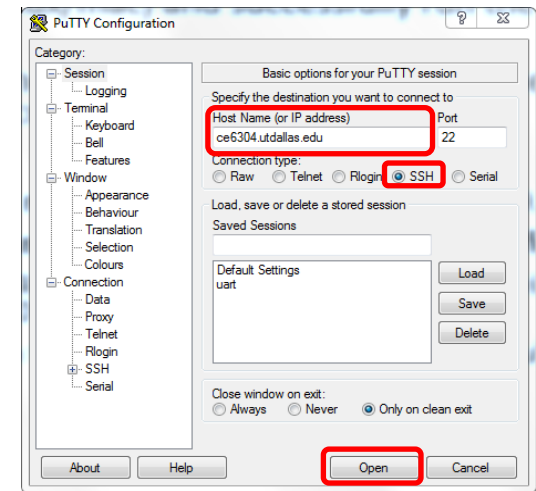


- Gem5 is installed in the `/usr/local/` folder
- **NOTE:** You **DO NOT** have write permissions on this folder → work on your home directory



# 2. Login to Server system -- Con't

- Log on server from **Windows**:
  - 1. Open PuTTY, and find PuTTY configuration window;
  - 2. Set host name to be “ce6304.utdallas.edu”;
  - 3. Select connection type to be “SSH”;
  - 4. Click on open;
  - 5. Fills in your NetID and password in coming windows.
- 
- Log on server from **Mac/Linux**:
  - 1. Open Terminal;
  - 2. Type in command  
“ssh <your-net-id>@ce6304.utdallas.edu”;
  - 3. Type in your password.



## 2. Login to Server system -- Con't

- If you are using your own Linux machine you can install the gem5 as you can modify it by yourself (download link):

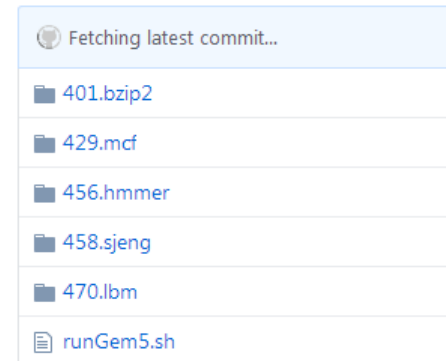
Steps to install gem5 are generally broken down into two steps:

- first, install all dependencies; second, install gem5 itself. Detailed steps can be found in following links.
- Install dependencies: <http://gem5.org/Dependencies>
- Install gem5 itself: [http://gem5.org/Build\\_System](http://gem5.org/Build_System)
- Particularly, if you choose to install gem5 on Ubuntu system, you have an easier way to install dependencies (sudo for access administrator access):
- `sudo apt-get install python-dev scons m4 build-essential g++ swig zlib-dev`



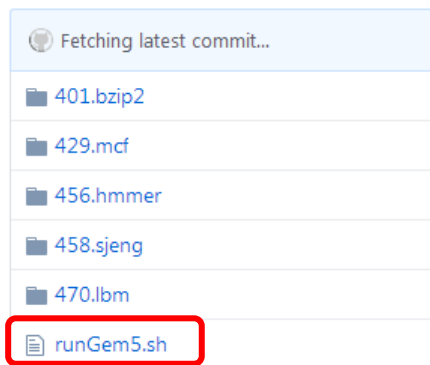
# 3. Download the Benchmarks

- We will use a set of CPU benchmarks to simulate your architectural design. You can download the benchmarks at the following link:
  - [https://github.com/timberjack/Project1\\_SPEC.git](https://github.com/timberjack/Project1_SPEC.git)
- Or you could download the zip file from the following link:
  - [https://github.com/timberjack/Project1\\_SPEC](https://github.com/timberjack/Project1_SPEC)



## 4. Run the experiments for 429.mcf benchmark

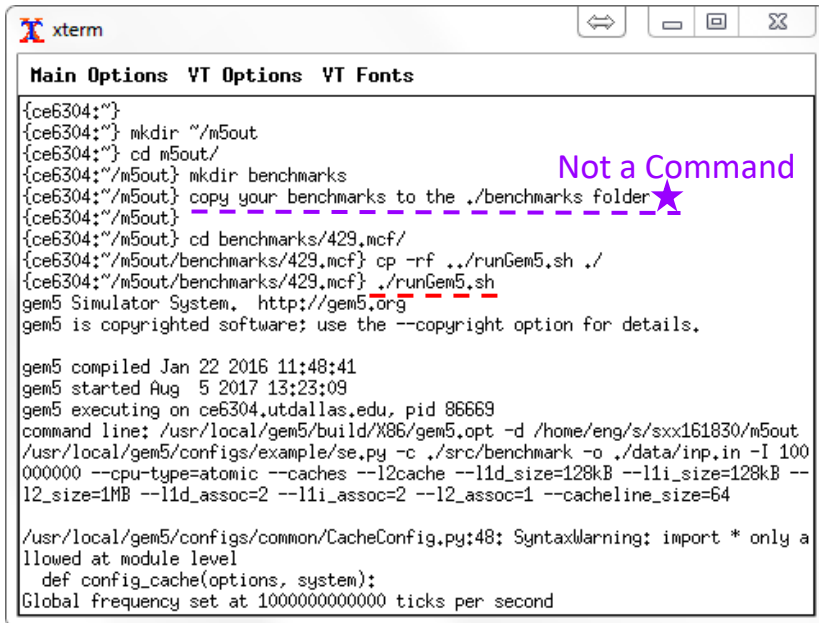
- Within “spec” folder, you can also find the script “**runGem5.sh**”. It is a sample script that runs gem5 on benchmark **429.mcf**. You can use this as an example how to specify the command line to run a benchmark program on gem5.



```
1 # -- an example to run SPEC 429.mcf on gem5,--
2 # -- put it under 429.mcf folder --
3 export GEM5_DIR=/usr/local/gem5
4 export BENCHMARK=./src/benchmark
5 export ARGUMENT=./data/inp.in
6 time $GEM5_DIR/build/X86/gem5.opt -d ~/m5out $GEM5_DIR/cc
```

# 4. Run the experiments for 429.mcf benchmark

1. Create the folder `~/m5out`
2. Go to that folder, then create the folder `./benchmarks`
3. Copy the spec(downloads) to the `./benchmarks` folder
4. To run SPEC 429.mcf on gem5, put `./runGem5.sh` under 429.mcf folder
5. Run the `./runGem5.sh`

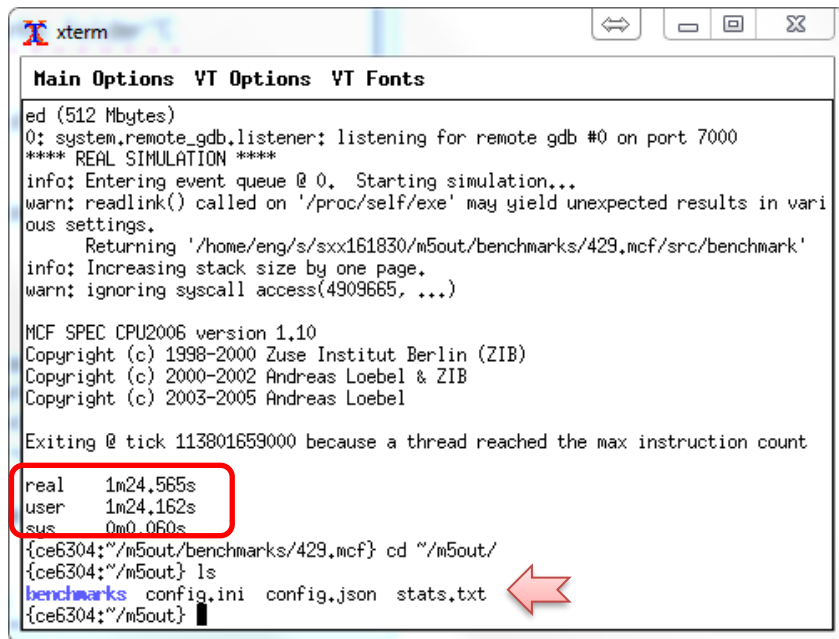


```
xterm
Main Options  VT Options  VT Fonts
{ce6304:~}
{ce6304:~} mkdir ~/m5out
{ce6304:~} cd m5out/
{ce6304:~/m5out} mkdir benchmarks
{ce6304:~/m5out} copy your benchmarks to the ./benchmarks folder ★
{ce6304:~/m5out} -----
{ce6304:~/m5out} cd benchmarks/429.mcf/
{ce6304:~/m5out/benchmarks/429.mcf} cp -rf ../runGem5.sh ./
{ce6304:~/m5out/benchmarks/429.mcf} ./runGem5.sh
gem5 Simulator System. http://gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 compiled Jan 22 2016 11:48:41
gem5 started Aug  5 2017 13:23:09
gem5 executing on ce6304.utdallas.edu. pid 86669
command line: /usr/local/gem5/build/X86/gem5.opt -d /home/eng/s/sxx161830/m5out
/usr/local/gem5/configs/example/se.py -c ./src/benchmark -o ./data/inp.in -I 100
000000 --cpu-type=atomic --caches --l2cache --l1d_size=128kB --l1i_size=128kB --
l2_size=1MB --l1d_assoc=2 --l1i_assoc=2 --l2_assoc=1 --cacheline_size=64

/usr/local/gem5/configs/common/CacheConfig.py:48: SyntaxWarning: import * only a
llowed at module level
def config_cache(options, system):
Global frequency set at 1000000000000 ticks per second
```

# 4. Run the experiments for 429.mcf benchmark



```
xterm
Main Options VT Options VT Fonts
ed (512 Mbytes)
0: system.remote_gdb.listener: listening for remote gdb #0 on port 7000
**** REAL SIMULATION ****
info: Entering event queue @ 0. Starting simulation...
warn: readlink() called on '/proc/self/exe' may yield unexpected results in various settings.
      Returning '/home/eng/s/sxx161830/m5out/benchmarks/429.mcf/src/benchmark'
info: Increasing stack size by one page.
warn: ignoring syscall access(4909665, ...)

MCF SPEC CPU2006 version 1.10
Copyright (c) 1998-2000 Zuse Institut Berlin (ZIB)
Copyright (c) 2000-2002 Andreas Loebel & ZIB
Copyright (c) 2003-2005 Andreas Loebel

Exiting @ tick 113801659000 because a thread reached the max instruction count

real    1m24.565s
user    1m24.162s
sys     0m0.060s
{ce6304:~/m5out/benchmarks/429.mcf} cd ~/m5out/
{ce6304:~/m5out} ls
benchmarks config.ini config.json stats.txt
{ce6304:~/m5out}
```

The execution of this command provides the output file “**stats.txt**” under folder “**m5out**” (default, or into your defined directory).

```
1
2 ----- Begin Simulation Statistics -----
3 sim_seconds                                0.113802
4 sim_ticks                                113801659000
5 final_tick                                113801659000
6 sim_freq                                  1000000000000
7 host_inst_rate                            1195793
8 host_op_rate                              2278462
9 host_tick_rate                            1360830753
10 host_mem_usage                           821056
11 host_seconds                             83.63
12 sim_insts                                100000000
13 sim_ops                                  190540015
14 system.voltage_domain.voltage            1
15 system.clk_domain.clock                  1000
16 system.mem_ctrls.bytes_read::cpu.inst    31168
17 system.mem_ctrls.bytes_read::cpu.data    5889856
18 system.mem_ctrls.bytes_read::total       5921024
```

# Project

- Using GEM5, in this project, we will study the effect of varying Branch Prediction parameters on different benchmarks.
- There are 3 kinds of Branch Predictors available in GEM5 (stable).
  1. 2bit\_local Predictor
  2. Bi\_mode Predictor
  3. Tournament Predictor
- Groups of 2
- 10min ppt report summarizing all the results
- Grading rubric attached at the end of pdf report





# Project : Branch Predictor

1. Set up the simulation environment
2. Adding Branch Predictor for TimingSimpleCPU
3. Adding extra resulting parameter in stats.txt file
4. Comparison among different branch predictors



## 2. Adding Branch Predictor

- By default, the Gem5 TimingSimple CPU does not have the Branch Predictor Support, thus, in the **\$gem5/src/cpu/simple/BaseSimpleCPU.py**

```
branchPred = Param.BranchPredictor(NULL, "Branch Predictor")
```

```
→ branchPred = Param.BranchPredictor(LocalBP(), "Branch Predictor")
```

```
→ branchPred = Param.BranchPredictor(TournamentBP(), "Branch Predictor")
```

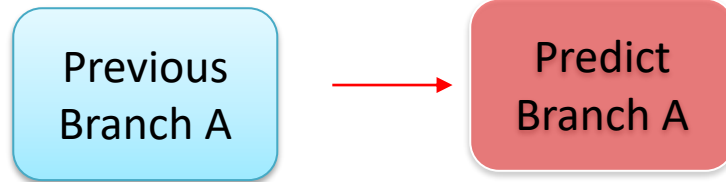
```
→ branchPred = Param.BranchPredictor(BiModeBP(), "Branch Predictor")
```

LocalBP	2bit Local Branch Predictor
BiModeBP	Global Behavioral Branch Predictor
Tournament	Combined/Hybrid Predictor



# 2. Adding Branch Predictor

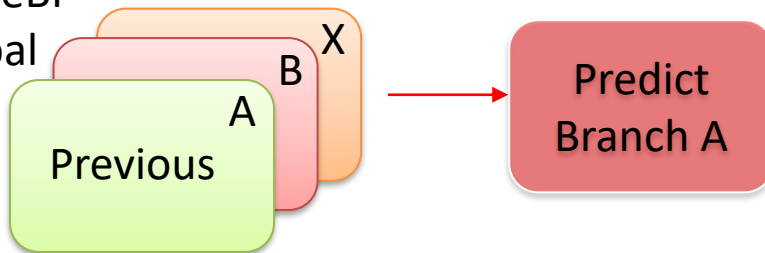
## LocalBP



```
class LocalBP(BranchPredictor):  
    type = 'LocalBP'  
    cxx_class = 'LocalBP'  
    cxx_header = "cpu/pred/2bit_local.hh"  
  
    localPredictorSize = Param.Unsigned(2048, "Size of local predictor")  
    localCtrBits = Param.Unsigned(2, "Bits per counter")
```

## BiModeBP

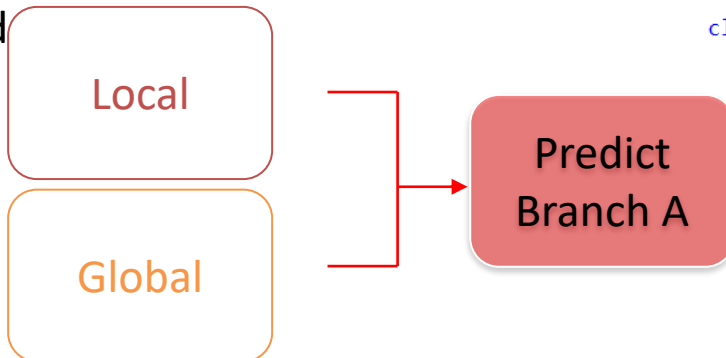
Global



```
class BiModeBP(BranchPredictor):  
    type = 'BiModeBP'  
    cxx_class = 'BiModeBP'  
    cxx_header = "cpu/pred/bi_mode.hh"  
  
    globalPredictorSize = Param.Unsigned(8192, "Size of global predictor")  
    globalCtrBits = Param.Unsigned(2, "Bits per counter")  
    choicePredictorSize = Param.Unsigned(8192, "Size of choice predictor")  
    choiceCtrBits = Param.Unsigned(2, "Bits of choice counters")
```

## Tournament

Hybrid



```
class TournamentBP(BranchPredictor):  
    type = 'TournamentBP'  
    cxx_class = 'TournamentBP'  
    cxx_header = "cpu/pred/tournament.hh"  
  
    localPredictorSize = Param.Unsigned(2048, "Size of local predictor")  
    localCtrBits = Param.Unsigned(2, "Bits per counter")  
    localHistoryTableSize = Param.Unsigned(2048, "size of local history table")  
    globalPredictorSize = Param.Unsigned(8192, "Size of global predictor")  
    globalCtrBits = Param.Unsigned(2, "Bits per counter")  
    choicePredictorSize = Param.Unsigned(8192, "Size of choice predictor")  
    choiceCtrBits = Param.Unsigned(2, "Bits of choice counters")
```



# 2. Adding Branch Predictor

LocalBP : 2bit Local Branch Predictor  
BiModeBP : Global Behavioral Branch Predictor  
Tournament : Combined/Hybrid Predictor

## ★ config.ini - Local

```
[system.cpu.branchPred]
type=LocalBP
BTBEntries=4096
BTBTagSize=16
RASSize=16
eventq_index=0
instShiftAmt=2
localCtrBits=2
localPredictorSize=2048
numThreads=1
```

## ★ config.ini - Bimode

```
[system.cpu.branchPred]
type=BiModeBP
BTBEntries=4096
BTBTagSize=16
RASSize=16
choiceCtrBits=2
choicePredictorSize=8192
eventq_index=0
globalCtrBits=2
globalPredictorSize=8192
instShiftAmt=2
numThreads=1
```

## ★ config.ini - Tournament

```
[system.cpu.branchPred]
type=TournamentBP
BTBEntries=4096
BTBTagSize=16
RASSize=16
choiceCtrBits=2
choicePredictorSize=8192
eventq_index=0
globalCtrBits=2
globalPredictorSize=8192
instShiftAmt=2
localCtrBits=2
localHistoryTableSize=2048
localPredictorSize=2048
numThreads=1
```



## 2. Result with **Tournament** for hello Bench

```
siyuan@gimli1:~/proj2_t/results/hello_PredStd/TournamentBP_hello3_PredStd
File Edit View Search Terminal Help
[siyuan@gimli1 TournamentBP_hello3_PredStd]$
[siyuan@gimli1 TournamentBP_hello3_PredStd]$ grep -ri tournament ./
./config.ini:type=TournamentBP
./config.ini:cwd=/home/siyuan/proj2_t/gem5_ TournamentBP_PredStd
./config.json:      "cwd": "/home/siyuan/proj2_t/gem5_ TournamentBP_PredStd",
./config.json:      "cxx_class": "TournamentBP",
./config.json:      "type": "TournamentBP",
[siyuan@gimli1 TournamentBP_hello3_PredStd]$
[siyuan@gimli1 TournamentBP_hello3_PredStd]$
[siyuan@gimli1 TournamentBP_hello3_PredStd]$ grep -ri branch ./
./stats.txt:system.cpu.branchPred.lookups      1317      # Number of BP lookups
./stats.txt:system.cpu.branchPred.condPredicted  1317      # Number of conditional branches predicted
./stats.txt:system.cpu.branchPred.condIncorrect  477       # Number of conditional branches incorrect
./stats.txt:system.cpu.branchPred.BTBLookups     998       # Number of BTB lookups
./stats.txt:system.cpu.branchPred.BTBHits       367       # Number of BTB hits
./stats.txt:system.cpu.branchPred.BTBCorrect     0         # Number of correct BTB predictions (this stat may not work properly.
./stats.txt:system.cpu.branchPred.BTBHitPct     36.773547 # BTB Hit Percentage
./stats.txt:system.cpu.branchPred.BTBMissPct    63.226453 # BTB Miss Percentage
./stats.txt:system.cpu.branchPred.usedRAS       105       # Number of times the RAS was used to get a target.
./stats.txt:system.cpu.branchPred.RASInCorrect   75        # Number of incorrect RAS predictions.
./stats.txt:system.cpu.Branches                1317      # Number of branches fetched
./stats.txt:system.cpu.predictedBranches        472       # Number of branches predicted as taken
./stats.txt:system.cpu.BranchMispred            477       # Number of branch mispredictions
./stats.txt:system.cpu.BranchMispredPercent     36.218679 # Percent of Branch Mispredict
./config.ini:children=apic_clk_domain branchPred dtb interrupts isa itb tracer workload
./config.ini:branchPred=system.cpu.branchPred
./config.ini:[system.cpu.branchPred]
./config.json:      "branchPred": {
./config.json:        "name": "branchPred",
./config.json:        "path": "system.cpu.branchPred",
[siyuan@gimli1 TournamentBP_hello3_PredStd]$
[siyuan@gimli1 TournamentBP_hello3_PredStd]$
```

# 3.Adding BTB Miss Percentage

★ \$Gem5/src/cpu/pred/**bpred\_unit.cc**

```
void
BPredUnit::regStats()
{
    .....
    .....

    /*----- Siyuan Xu ----- */
    BTBMissPct
        .name(name() + ".BTBMissPct")
        .desc("BTB Miss Percentage")
        .precision(6);
    BTBMissPct = (1 - (BTBHits/BTBLookups)) * 100;
    /*----- Siyuan Xu ----- */

    .....
    .....
}
```

★ \$Gem5/src/cpu/pred/**bpred\_unit.hh**

```
/*----- Siyuan Xu ----- */
/** Stat for percent times an entry in BTB not found. */
Stats::Formula BTBMissPct;
/*----- Siyuan Xu ----- */
```



# 3. Adding extra resulting Parameters

★ \$Gem5/src/cpu/simple/**base.cc**

```
void
BaseSimpleCPU::regStats()
{
    using namespace Stats;

    BaseCPU::regStats();

    for (ThreadID tid = 0; tid < numThreads; tid++) {

        .....
        .....

        /*----- Siyuan Xu ----- */
        t_info.BranchMispredPercent =
            (t_info.numBranchMispred / t_info.numBranches) * 100;
        t_info.BranchMispredPercent
            .name(thread_str + ".BranchMispredPercent")
            .desc("Percent of Branch Mispredict")
            .prereq(t_info.BranchMispredPercent);
        /*----- Siyuan Xu ----- */
    }
}
```

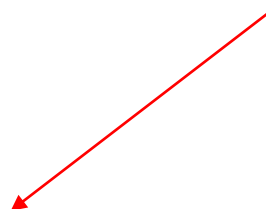
★ \$Gem5/src/cpu/simple/**exec\_context.hh**

```
class SimpleExecContext : public ExecContext {

    .....
public:

    /*----- Siyuan Xu ----- */
    // Percent of Branch Mispredict
    Stats::Formula BranchMispredPercent;
    /*----- Siyuan Xu ----- */

    ..... }
```



# 4. Branch Prediction Exploration

- BTBEntries : 4096 -> 2048
- LocalBP localPredictorSize : 2048 -> 1024
- BiModeBP globalPredictorSize : 8192 -> 2048
- BiModeBP choicePredictorSize : 8192 -> 2048
- TournamentBP localPredictorSize : 2048 -> 1024
- TournamentBP globalPredictorSize: 8192 -> 4096
- TournamentBP choicePredictorSize 8192 -> 4096





**Technical deliverables (70%) marking scheme:**

Feature	Max marks	Marks	Comments
Part 1: Problem discussion	10		
Part 2: Result of config.ini	15		
Part 3: Modification of source code (clarity and correctness)	25		
Part 4: BP exploration	60		
<b>TOTAL</b>	<b>100</b>		

**Presentation Marking Scheme (30%):**

Feature	Max marks	Marks	Comments
Quality of PowerPoint slides and clarity of results shown	100		
<b>TOTAL</b>	<b>100</b>		

