

gem5 tutorial

References:

- <https://github.com/gem5bootcamp>



Environment

The steps outlined in this slide deck have been tested on a computer located in Delta 219. These computers are equipped with:

- CPU: 13th Gen Intel(R) Core(TM) i5-13500
- RAM: 16 GB
- SSD: 954 GB

On these computers, Docker Desktop is installed:

- <https://docs.docker.com/>

Open Docker Desktop on Windows

For Windows users:

1. Left-click on the **Start button** (or press the `Windows key`).
2. Select **Docker Desktop** (or type `Docker Desktop` and press `Enter`).
3. Expected outcome: Docker Desktop will open.

Open a terminal emulator on Windows

For Windows users:

1. Right-click on the **Start button** (or press the `Windows key` + `X`).
2. Select **Windows PowerShell** (or press `I`).
3. Expected outcome: A terminal emulator will open.

```
Windows PowerShell
```

```
Copyright (C) Microsoft Corporation. 著作權所有，並保留一切權利。
```

```
請嘗試新的跨平台 PowerShell https://aka.ms/pscore6
```

```
PS C:\Users\user>
```

Run a container in PowerShell

For PowerShell users, run this command:

```
docker container run `
--rm --interactive --tty `
--volume C:/workspaces/:/workspaces/ `
--workdir /workspaces/2024/ `
--hostname codespaces-ae14be `
ghcr.io/gem5/devcontainer:bootcamp-2024
```

Expected outcome: The Bash prompt will appear as:

```
root@codespaces-ae14be:/workspaces/2024#
```

Alternative outcome: An image will be downloaded.

```
PS C:\Users\user> docker container run `
>> --rm --interactive --tty `
>> --volume C:/workspaces/:/workspaces/ `
>> --workdir /workspaces/2024/ `
>> --hostname codespaces-ae14be `
>> ghcr.io/gem5/devcontainer:bootcamp-2024
Unable to find image 'ghcr.io/gem5/devcontainer:bootcamp-2024' locally
bootcamp-2024: Pulling from gem5/devcontainer
00d679a470c4: Pull complete
c782a11a41b6: Pull complete
4f6b9996da3d: Pull complete
bb60cbcef558: Pull complete
92c0abbbf0ee: Pull complete
865d1839a002: Pull complete
2ceb23f2c7bb: Pull complete
31825ae2d134: Pull complete
Digest: sha256:dc299b8bf11b324cbd89aab82bdbe31bf9ce71a33386f2a2153a590a803d2c71
Status: Downloaded newer image for ghcr.io/gem5/devcontainer:bootcamp-2024
root@codespaces-ae14be:/workspaces/2024#
```

Get the source code of gem5

Run this command:

```
time git clone --recurse-submodules \  
https://gitlab.larc-nthu.net/ee6455/public-gem5bootcamp-2024 \  
/workspaces/2024/
```

Expected outcome: A repository will be cloned, including its submodules.

```
root@codespaces-ae14be:/workspaces/2024# time git clone --recurse-submodules \  
> https://gitlab.larc-nthu.net/ee6455/public-gem5bootcamp-2024 \  
> /workspaces/2024/  
Cloning into '/workspaces/2024'...  
warning: redirecting to https://gitlab.larc-nthu.net/ee6455/public-gem5bootcamp-2024.git/  
remote: Enumerating objects: 10982, done.  
remote: Counting objects: 100% (6/6), done.  
remote: Compressing objects: 100% (6/6), done.  
remote: Total 10982 (delta 0), reused 0 (delta 0), pack-reused 10976  
Receiving objects: 100% (10982/10982), 378.29 MiB | 28.30 MiB/s, done.  
Resolving deltas: 100% (7432/7432), done.  
Updating files: 100% (952/952), done.  
Submodule 'gem5' (https://github.com/gem5/gem5) registered for path 'gem5'  
Submodule 'gem5-resources' (https://github.com/gem5/gem5-resources) registered for path 'gem5-resources'  
Cloning into '/workspaces/2024/gem5'...  
remote: Enumerating objects: 284540, done.  
remote: Counting objects: 100% (1403/1403), done.  
remote: Compressing objects: 100% (741/741), done.  
remote: Total 284540 (delta 909), reused 963 (delta 641), pack-reused 283137 (from 1)  
Receiving objects: 100% (284540/284540), 263.01 MiB | 22.75 MiB/s, done.  
Resolving deltas: 100% (163364/163364), done.  
Cloning into '/workspaces/2024/gem5-resources'...  
remote: Enumerating objects: 24775, done.  
remote: Counting objects: 100% (617/617), done.  
remote: Compressing objects: 100% (248/248), done.  
remote: Total 24775 (delta 469), reused 369 (delta 369), pack-reused 24158 (from 1)  
Receiving objects: 100% (24775/24775), 48.15 MiB | 14.22 MiB/s, done.  
Resolving deltas: 100% (10877/10877), done.  
Submodule path 'gem5': checked out 'bb418d41eb6d87c0a0591869097005c16420c6aa'  
Submodule path 'gem5-resources': checked out '6734bb4940dd90f3b7c0349eedeefcf3ee405938'  
  
real    3m39.695s  
user    0m32.154s  
sys     0m14.243s  
root@codespaces-ae14be:/workspaces/2024#
```



Run a simulation using gem5

Run this command:

```
time gem5-mesi --outdir=/workspaces/m5out/ \
/workspaces/2024/materials/01-Introduction/02-getting-started/completed/basic.py
```

Expected outcome: The `X86DemoBoard` will be simulated using `x86-ubuntu-24.04-img` as the workload.

```
root@codespaces-ae14be:/workspaces/2024# time gem5-mesi --outdir=/workspaces/m5out/ \
> /workspaces/2024/materials/01-Introduction/02-getting-started/completed/basic.py
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 24.0.0.0
gem5 compiled Jul 25 2024 18:47:27
gem5 started Sep  8 2024 12:45:46
gem5 executing on codespaces-ae14be, pid 13
command line: gem5-mesi --outdir=/workspaces/m5out/ /workspaces/2024/materials/01-Introduction/02-getting-started/completed/basic.py

warn: The X86DemoBoard is solely for demonstration purposes. This board is not known to be representative of any real-world system. Use with caution.
info: Using default config
Resource 'x86-linux-kernel-5.4.0-105-generic' was not found locally. Downloading to '/root/.cache/gem5/x86-linux-kernel-5.4.0-105-generic'...
Finished downloading resource 'x86-linux-kernel-5.4.0-105-generic'.
Resource 'x86-ubuntu-24.04-img' was not found locally. Downloading to '/root/.cache/gem5/x86-ubuntu-24.04-img.gz'...
Finished downloading resource 'x86-ubuntu-24.04-img'.
Decompressing resource 'x86-ubuntu-24.04-img' ('/root/.cache/gem5/x86-ubuntu-24.04-img.gz')...
Finished decompressing resource 'x86-ubuntu-24.04-img'.
warn: Max ticks has already been set prior to setting it through the run call. In these cases the max ticks set through the `run` function is used
Global frequency set at 1000000000000 ticks per second
```

Retrieve the simulation statistics on Windows

For Windows users, open `C:/workspaces/m5out/stats.txt` using a text editor.

Expected outcome: The first few lines will resemble this:

```
----- Begin Simulation Statistics -----
simSeconds          0.020000          # Number of seconds simulated (Second)
simTicks            20000000000        # Number of ticks simulated (Tick)
finalTick           20000000000        # Number of ticks from beginning of simulation (restored from checkpoints and never reset) (Tick)
simFreq             1000000000000       # The number of ticks per simulated second ((Tick/Second))
hostSeconds         18.88              # Real time elapsed on the host (Second)
hostTickRate        1059100397         # The number of ticks simulated per host second (ticks/s) ((Tick/Second))
hostMemory          2770924            # Number of bytes of host memory used (Byte)
simInsts            7479814            # Number of instructions simulated (Count)
simOps              34912342           # Number of ops (including micro ops) simulated (Count)
hostInstRate        396059             # Simulator instruction rate (inst/s) ((Count/Second))
hostOpRate          1848597            # Simulator op (including micro ops) rate (op/s) ((Count/Second))
board.cache_hierarchy.ruby_system.delayHistogram:bucket_size 2          # delay histogram for all message (Unspecified)
board.cache_hierarchy.ruby_system.delayHistogram:max_bucket 19          # delay histogram for all message (Unspecified)
board.cache_hierarchy.ruby_system.delayHistogram:samples 735551         # delay histogram for all message (Unspecified)
board.cache_hierarchy.ruby_system.delayHistogram:mean 1.036855          # delay histogram for all message (Unspecified)
board.cache_hierarchy.ruby_system.delayHistogram:stdev 2.687016         # delay histogram for all message (Unspecified)
```


Retrieve the simulation configuration on Windows

For Windows users, open `C:/workspaces/m5out/config.ini` using a text editor.

Expected outcome: The first few lines will resemble this:

```
[board]
type=System
children=cache_hierarchy clk_domain dvfs_handler iobus memory pc processor workload
auto_unlink_shared_backstore=false
cache_line_size=64
eventq_index=0
exit_on_work_items=true
init_param=0
m5ops_base=4294901760
mem_mode=timing
mem_ranges=0:2147483648 3221225472:3222274048
memories=board.memory.mem_ctrl.dram
mmap_using_noreserve=false
multi_thread=false
```