

gem5 tutorial

References:

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



Environment

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

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

Docker Desktop is pre-installed.

Installation on Your Own PC

You may also install Docker on your own PC. Please prepare at least 10G of disk space.

For Windows/Mac, please download and install Docker Desktop:

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

For Windows, use Powershell as command line interface as in the following slides.

For Mac, please use Terminal App as command line shell to start the Docker image.

Install Docker Desktop on Windows

For users of Delta 219 computers:

- Docker Desktop is already installed on these computers. Reinstallation is unnecessary.

For other Windows users:

1. Download [the installer](#).
2. Double-click `Docker Desktop Installer.exe` to run the installer.
3. Follow the instructions in the installation wizard to authorize the installer and proceed with the installation.
4. Once the installation is complete, select **Close** to finish the process.



Install Docker Desktop on macOS

For macOS users:

1. Download [the installer](#).
2. Double-click `Docker.dmg` to open the installer, then drag the Docker icon to the **Applications** folder.
3. Double-click `Docker.app` in the **Applications** folder to start Docker.
4. The Docker menu will display the Docker Subscription Service Agreement. Select **Accept** to continue.
5. In the installation window, select **Use recommended settings (Requires password)**.
6. Select **Finish**.

Back up files from \$HOME\workspaces\ to a flash drive

Delta 219 computers are configured to automatically revert to a previously saved system state (a restore point) without prior notice.

- Your files may be permanently deleted without warning at any time (unannounced data loss).
- You cannot predict when these reverts will occur, nor can you prevent them from happening (limited user control).

Temporary data storage:

Your files are temporarily stored in the `$HOME\workspaces\` directory; however, these files are deleted during the automatic system revert process.

Protecting your data:

To avoid data loss, regularly back up your data using external USB drives or cloud storage services.

Reason for automatic system reverts:

This feature is designed to maintain a consistent simulation environment for all users.



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>
```


Open a terminal emulator on macOS

For macOS users:

1. Click the **Launchpad** icon in the Dock.
2. Type in the search field.
3. Click **Terminal**.

Expected outcome: A terminal emulator will open.

Run a container in PowerShell

For PowerShell users, run this command:

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

Expected outcome: An interactive TTY will indicate its readiness to accept commands.

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

Alternative outcome: A newer image will be downloaded before the interactive TTY prints the username, hostname, and working directory.

```
PS C:\Users\user> docker container run `
>> --rm --interactive --tty `
>> --volume $HOME\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#
```

Run a container on macOS

For macOS users, run this command:

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

Expected outcome: An interactive TTY will indicate its readiness to accept commands.

```
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'
```

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 a 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
src/mem/dram_interface.cc:690: warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (2048 Mbytes)
src/sim/kernel_workload.cc:46: info: kernel located at: /root/.cache/gem5/x86-linux-kernel-5.4.0-105-generic
```

Retrieve the simulation statistics on Windows

For Windows users, open `$HOME\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 `$HOME\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
```