

# Getting started with gem5

In this section, we will get familiar with  
the tutorial's codespace environment and run  
our first gem5 simulation



# Let's hit the ground running

This example will show:

1. How someone obtains gem5.
2. How you build it.
3. Running a very basic "Hello World" simulation.



- Getting and compiling gem5 is often the hardest part...
- There's a lot of complicated things happening behind the scenes. I will explain them later.

# Typical Downloading

DON'T  
DO THIS!

```
> git clone https://github.com/gem5/gem5
> cd gem5
```

**stable:** The default branch for gem5. Updated at stable releases. Currently v24.0.

**develop:** The branch in which new features, improvements, etc. are added regularly for the next release.

In this tutorial we're going to use codes paces with a repo which includes some example materials.  
Though all the gem5 code is v24.0

# Using CodeSpaces

- ▶ We will be using the “bootcamp environment” for ISCA 2024  
<https://github.com/gem5-ISCA24-tutorial/gem5-bootcamp-env>

**Step 1:** Go to <https://classroom.github.com/a/JF8G9CYc>

- ▶ You need to be in the github organization for free codespaces

# Using codespaces

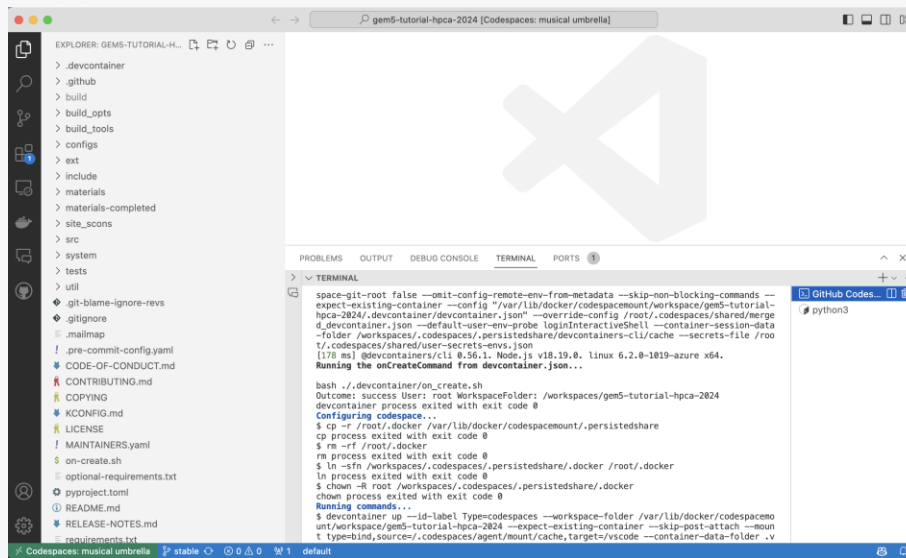
- ▶ AFTER joining the classroom...

<https://github.com/gem5-ISCA24-tutorial/gem5-bootcamp-env>

The screenshot shows the GitHub interface for the repository 'gem5-bootcamp-env'. The 'Code' button is highlighted with a red arrow and the text 'Click here'. The 'Codespaces' dropdown menu is open, showing a 'No codespaces' message and a 'Create codespace on main' button, which is also highlighted with a red arrow and the text 'and here'. The repository page includes a file list on the left, a search bar, and various repository statistics on the right.

# Using CodeSpaces

**Step 3:** Wait for your environment to load. Then you're done



```
space-git-root false --omit-config-remote-env-from-metadata --skip-non-blocking-commands --
expect-existing-container --config /var/lib/docker/codespacemount/workspace/gem5-tutorial-
hpca-2024/.devcontainer/devcontainer.json --override-config /root/.codespaces/shared/merge
d_devcontainer.json --default-user-env-probe loginInteractiveShell --container-session-data
-folder /workspaces/.codespaces/.persistedshare/devcontainers-cll/cache --secrets-file /roo
t/.codespaces/shared/user-secrets-envs.json
[178 ms] @devcontainers/cli 0.56.1, Node.js v18.19.0, Linux 6.2.0-1019-azure x64.
Running the onCreateCommand from devcontainer.json...

bash /devcontainer/on_create.sh
Outcome: success User: root WorkspaceFolder: /workspaces/gem5-tutorial-hpca-2024
devcontainer process exited with exit code 0
Configuring codespace...
$ cp -r /root/.docker /var/lib/docker/codespacemount/.persistedshare
cp process exited with exit code 0
$ rm -rf /root/.docker
rm process exited with exit code 0
$ ln -sf /workspaces/.codespaces/.persistedshare/.docker /root/.docker
ln process exited with exit code 0
$ chown -R root /workspaces/.codespaces/.persistedshare/.docker
chown process exited with exit code 0
Running commands...
$ devcontainer up --id-label Type=codespaces --workspace-folder /var/lib/docker/codespacem
ount/workspace/gem5-tutorial-hpca-2024 --expect-existing-container --skip-post-attach --non
$ typesetting/sources/.codespaces/agent/noun/cache/targets/vscode --container-data-folder v
```



## Building gem5



DON'T  
DO THIS!

```
> scons build/ALL/gem5.opt -j`nproc`
```

- ▶ This takes a while (10-15 minutes with 16 cores, ~1hr on 1 core)
- ▶ The codespace has pre-built gem5 binaries!

## Let's start by writing a simulation configuration

```
from gem5.prebuilt.demo.x86_demo_board import X86DemoBoard
from gem5.resources.resource import obtain_resource
from gem5.simulate.simulator import Simulator
```

Open “materials/01-basic.py”. You’ll see the above already prepared for you. Do your work here.



# Let's be lazy and use a prebuild board

The X86DemoBoard has the following properties:

- Single Channel DDR3, 2GB Memory.
- A 4 core 3GHz processor (using gem5's 'timing' model).
- A MESI Two Level Cache Hierarchy, with 32kB data and instruction cache and a 1MB L2 Cache.
- Will be run as a Full-System simulation.

```
board = X86DemoBoard()
```

Source:

```
"src/python/gem5/prebuilt/demo/x86_demo_board.py"
```

# Let's load some software!

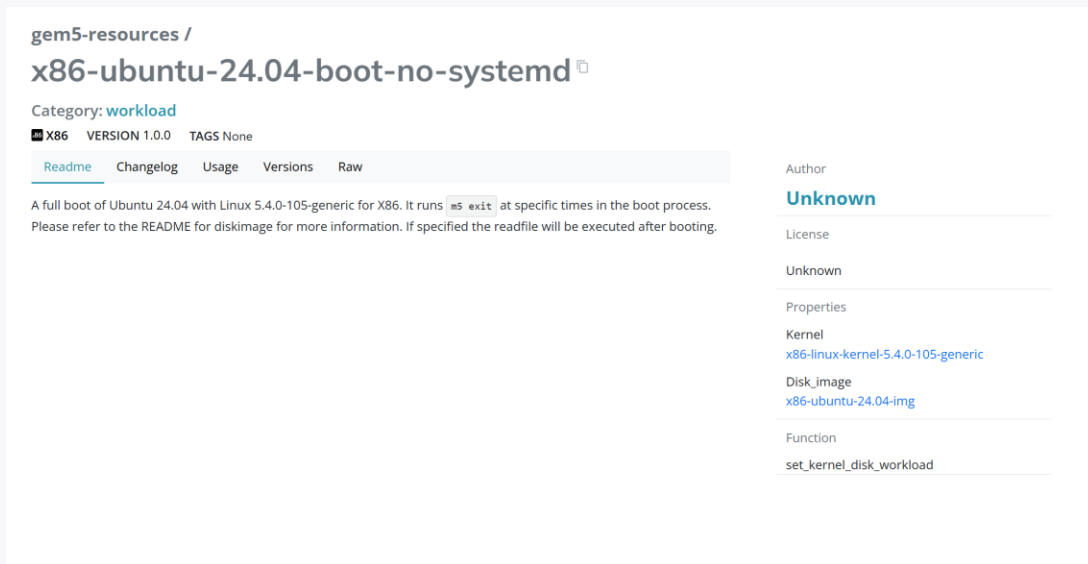
```
board.set_workload(observe_resource("x86-ubuntu-24.04-boot-no-systemd"))
```

- ▶ `observe_resource` downloads the files needed to run workload
  - ▶ Boots Ubuntu without systemd then exits the simulation
  - ▶ Downloads disk image, kernel, and sets default parameters

<https://resources.gem5.org/resources/x86-ubuntu-24.04-boot-no-systemd?version=1.0.0>

# gem5 resources web portal

<https://resources.gem5.org/resources/x86-ubuntu-24.04-boot-no-systemd?version=1.0.0>



gem5-resources /  
**x86-ubuntu-24.04-boot-no-systemd** 📄

Category: [workload](#)

🖥️ X86 VERSION 1.0.0 TAGS None

[Readme](#) [Changelog](#) [Usage](#) [Versions](#) [Raw](#)

A full boot of Ubuntu 24.04 with Linux 5.4.0-105-generic for X86. It runs `ms_exit` at specific times in the boot process. Please refer to the README for diskimage for more information. If specified the readfile will be executed after booting.

Author  
**Unknown**

License

Unknown

Properties

Kernel  
[x86-linux-kernel-5.4.0-105-generic](#)

Disk\_image  
[x86-ubuntu-24.04-img](#)

Function  
`set_kernel_disk_workload`

Now, let's run the simulation

```
simulator = Simulator(board=board)
simulator.run(20_000_000_000) # 20 ms
```

# That's it!

```
from gem5.prebuilt.demo.x86_demo_board import X86DemoBoard
from gem5.resources.resource import obtain_resource
from gem5.simulate.simulator import Simulator

board = X86DemoBoard()
board.set_workload(obtain_resource("x86-ubuntu-24.04-boot-no-systemd"))

simulator = Simulator(board=board)
simulator.run(20_000_000_000) # 20 ms
```

```
> gem5-mesi materials/01-basic.py
```

# Standard output

```
root@codespaces-77cc1d:/workspaces/gem5-bootcamp-env/materials/isca24# gem5-default 01-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 Jun 25 2024 17:52:33
gem5 started Jun 25 2024 21:34:39
gem5 executing on codespaces-77cc1d, pid 1808
command line: gem5-default 01-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
```

```
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 statistics::Group. Legacy stat is deprecated.
```

```
0: board.pc.south_bridge.cmos.rtc: Real-time clock set to Sun Jan 1 00:00:00 2012
```

```
board.pc.com_1.device: Listening for connections on port 3456
```

```
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 statistics::Group. Legacy stat is deprecated.
```

```
src/dev/intel_8254_timer.cc:128: warn: Reading current count from inactive timer.
```

```
board.remote gdb: Listening for connections on port 7000
```

# Results/outputs

- ▶ m5out/
  - ▶ board.pc.com\_1.device
    - ▶ Terminal output

```
[ 0.000000] Linux version 5.4.0-105-generic (buildd@ubuntu) (gcc versi
[ 0.000000] Command line: earlyprintk=ttyS0 console=ttyS0 lpj=7999923
[ 0.000000] KERNEL supported cpus:
[ 0.000000]   Intel GenuineIntel
[ 0.000000]   AMD AuthenticAMD
[ 0.000000]   Hygon HygonGenuine
[ 0.000000]   Centaur CentaurHauls
[ 0.000000]   zhaoxin   Shanghai
[ 0.000000] x86/fpu: x87 FPU will use FXSAVE
[ 0.000000] BIOS-provided physical RAM map:
[ 0.000000] BIOS-e820: [mem 0x0000000000000000-0x000000000009fbff] usa
[ 0.000000] BIOS-e820: [mem 0x000000000009fc00-0x00000000000ffffff] res
[ 0.000000] BIOS-e820: [mem 0x0000000000100000-0x00000000007fffffff] usa
[ 0.000000] BIOS-e820: [mem 0x00000000ffffff0000-0x000000000xffffffff] res
[ 0.000000] printk: bootconsole [earlyser0] enabled
[ 0.000000] NX (Execute Disable) protection: active
[ 0.000000] SMBIOS 2.5 present.
[ 0.000000] DMI:   , BIOS 06/08/2008
[ 0.000000] tsc: Fast TSC calibration using PIT
[ 0.000000] tsc: Detected 3002.930 MHz processor
[ 0.000048] last_pfn = 0x80000 max_arch_pfn = 0x400000000
[ 0.000114] Disabled
[ 0.000125] x86/PAT: MTRRs disabled, skipping PAT initialization too.
[ 0.000150] CPU MTRRs all blank - virtualized system.
[ 0.000170] x86/PAT: Configuration [0 7]: WB, WT, UC, UC, WB, WT, UC
```

# Results/output

## ▶ m5out/

- ▶ board.pc.com\_1.device
- ▶ config.{ini/json}
  - ▶ A record of the simulated system

```
[board]
type=System
children=cache_hierarchy c]
auto_unlink_shared_backstor
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 32:
memories=board.memory.mem_c
mmap_using_noreserve=false
multi_thread=false
num_work_ids=16
readfile=
redirect_paths=
shadow_rom_ranges=
shared_backstore=
symbolfile=
thermal_components=
thermal_model=NULL
work_begin_ckpt_count=0
work_begin_cpu_id_exit=-1
work_begin_exit_count=0
work_cpus_ckpt_count=0
```

```
{
  "type": "Root",
  "cxx_class": "gem5::Root",
  "name": null,
  "path": "root",
  "eventq_index": 0,
  "full_system": true,
  "sim_quantum": 0,
  "time_sync_enable": false,
  "time_sync_period": 100000000000,
  "time_sync_spin_threshold": 100000000,
  "board": {
    "type": "System",
    "cxx_class": "gem5::System",
    "name": "board",
    "path": "board",
    "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",
      "32:2147483648",
      "32:2147483648"
    ]
  }
}
```



# Results/output

## ▶ m5out/

- ▶ board.pc.com\_1.device
- ▶ config.{ini/json}
- ▶ stats.txt
  - ▶ The detailed stats

```
----- Begin Simulation Statistics -----
simSeconds                0.020000
simTicks                  20000000000
finalTick                 20000000000
(Tick)
simFreq                   1000000000000
hostSeconds               31.09
hostTickRate              643331448
hostMemory                2753284
simInsts                  7479814
simOps                    34912342
hostInstRate              240599
hostOpRate                1123006
board.cache_hierarchy.ruby_system.delayHistogram::bucket_size    2
board.cache_hierarchy.ruby_system.delayHistogram::max_bucket     19
board.cache_hierarchy.ruby_system.delayHistogram::samples        735551
board.cache_hierarchy.ruby_system.delayHistogram::mean           1.036855
board.cache_hierarchy.ruby_system.delayHistogram::stdev          2.687016
board.cache_hierarchy.ruby_system.delayHistogram |                640220    87.0
0      0.00%    87.04% |                95329    12.96%    100.00% |
0      0.00%    100.00% |                1      0.00%    100.00% # delay his
```