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.

gem5

Typical Downloading


```
> 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

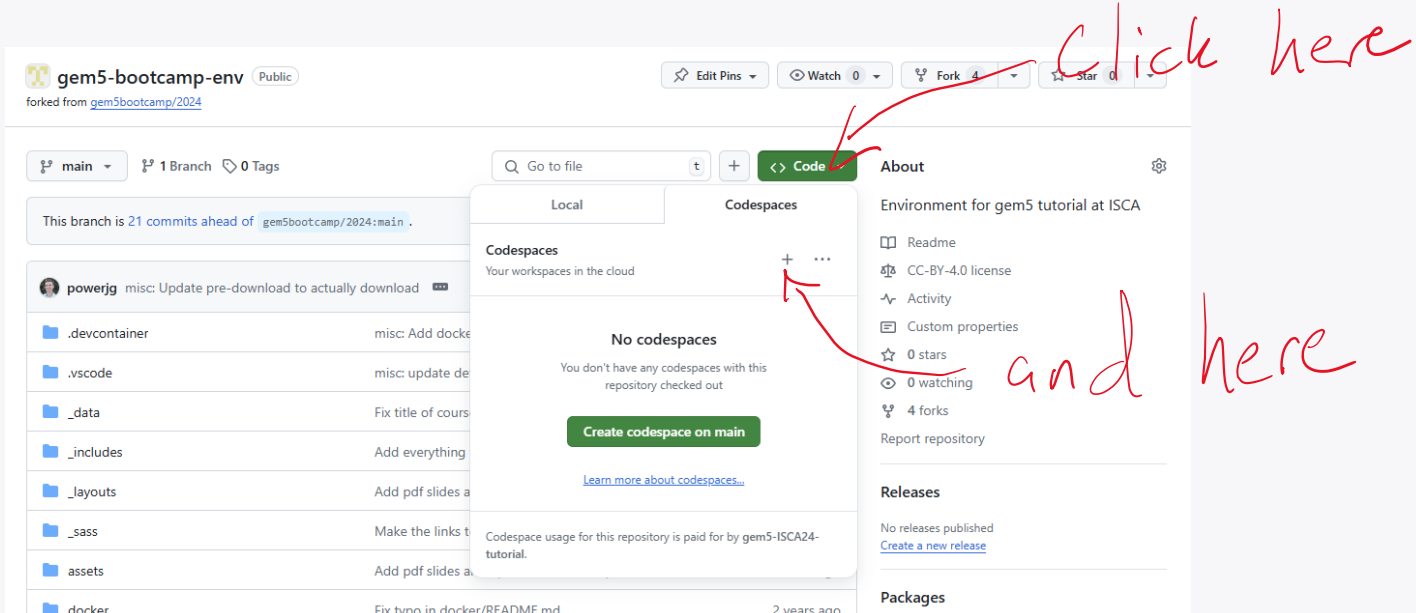
Step 1: Go to https://classroom.github.com/a/JF8G9CYc

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

Using codespaces

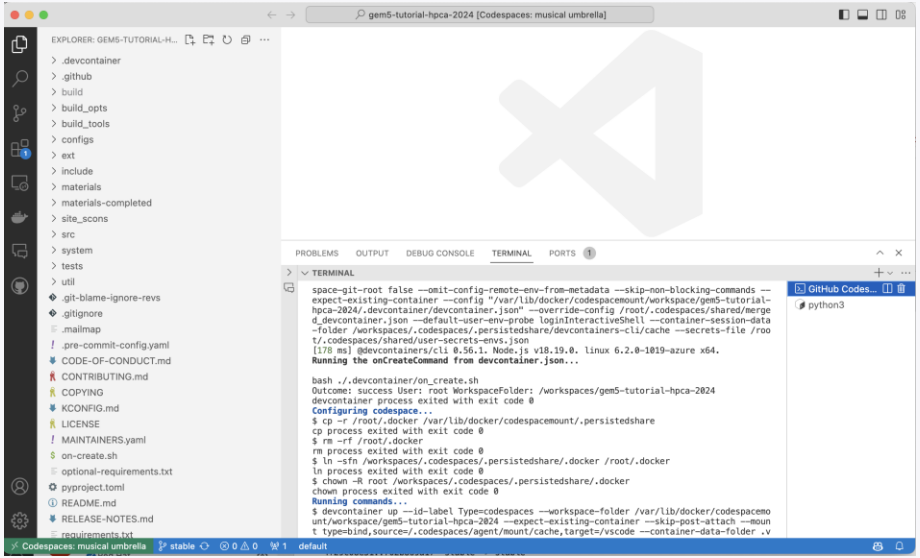
- AFTER joining the classroom…

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



Using CodeSpaces

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



6

Building gem5


```
> 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.

8

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 case 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!

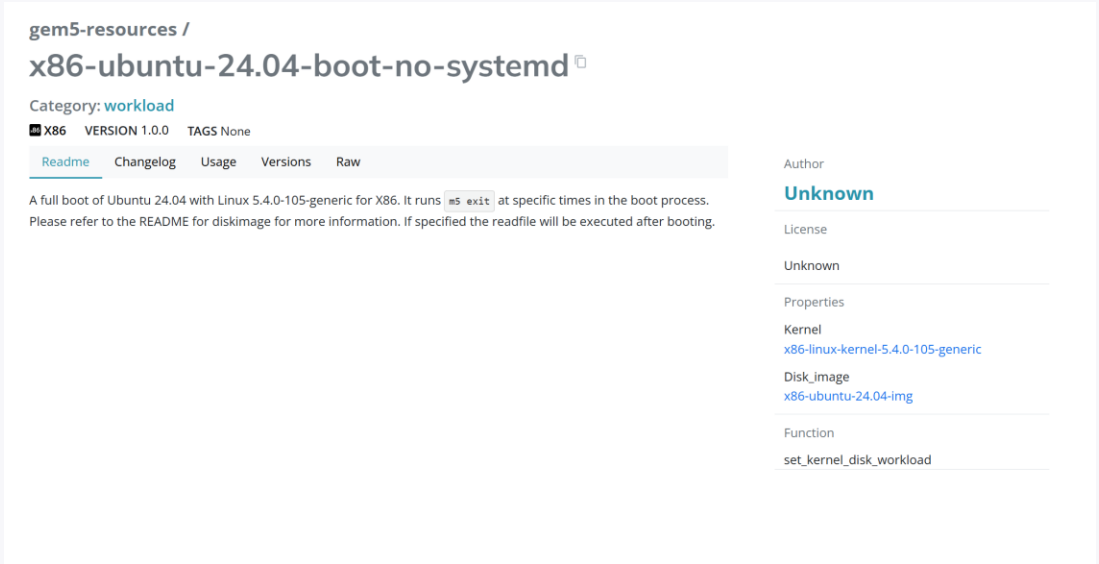
```
board.set_workload(obtain_resource("x86-ubuntu-24.04-boot-no-systemd"))
```

- `obtain_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



Now, let's run the simulation

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

That's it!

```python
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 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 depre
cated.
      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 depre
cated.
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 0x000000000009fc00-0x000000000000ffff] res
[    0.000000] BIOS-e820: [mem 0x0000000000100000-0x000000007fffffff] usa
[    0.000000] BIOS-e820: [mem 0x00000000ffff0000-0x00000000ffffffff] 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.
```

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 322
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",
```

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
```