



به نام خدا



دانشگاه تهران

پردیس دانشکده‌های فنی

دانشکده مهندسی برق و کامپیوتر

سیستم‌های نهفته مبتنی بر هسته

تکلیف کامپیوتری ۱

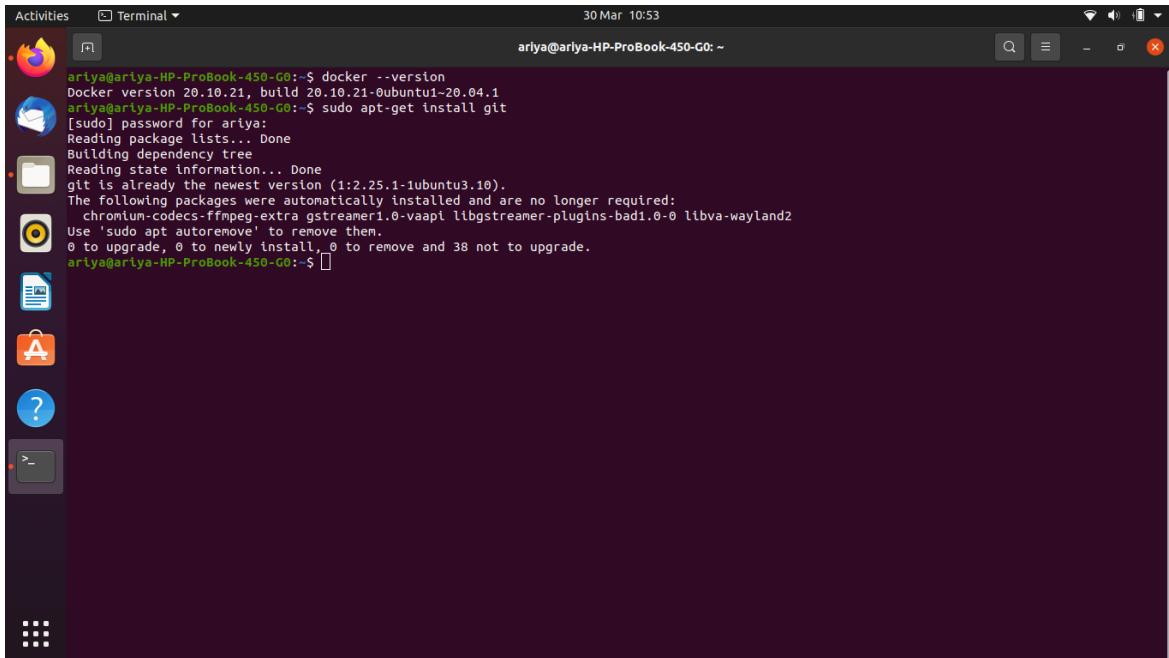
محمد تقی زاده گیوری

۸۱۰۱۹۸۳۷۳

۱۴۰۲ بهار

گام اول

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```
artya@artya-HP-ProBook-450-G0:~$ docker --version
Docker version 20.10.21, build 20.10.21-0ubuntu1-20.04.1
artya@artya-HP-ProBook-450-G0:~$ sudo apt-get install git
[sudo] password for artya:
Reading package lists... Done
Building dependency tree
Reading state information... Done
git is already the newest version (1:2.25.1-1ubuntu3.10).
The following packages were automatically installed and are no longer required:
chromium-codecs-ffmpeg-extra gstreamer1.0-vaapi libgstreamer-plugins-bad1.0-0 libva-wayland2
Use 'sudo apt autoremove' to remove them.
0 to upgrade, 0 to newly install, 0 to remove and 38 not to upgrade.
artya@artya-HP-ProBook-450-G0:~$
```

مطابق با تصویر فوق، git به درستی بر روی سیستم، نصب شده است.

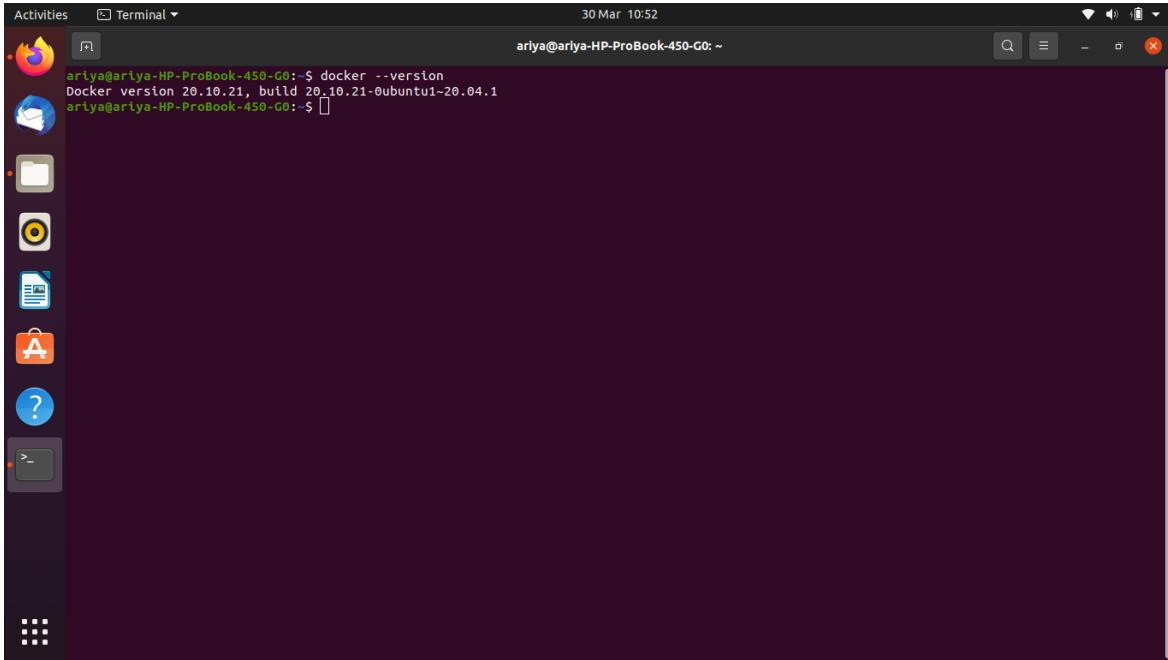
.۲

```
artya@artya-HP-ProBook-450-G0:~$ sudo git clone https://gem5.googlesource.com/public/gem5
fatal: destination path 'gem5' already exists and is not an empty directory.
```

مطابق با تصویر فوق، ابزار GEM5، از قبل کلون شده، که نشان از درستی

کلون شدن ابزار GEM5، بر روی سیستم می باشد.

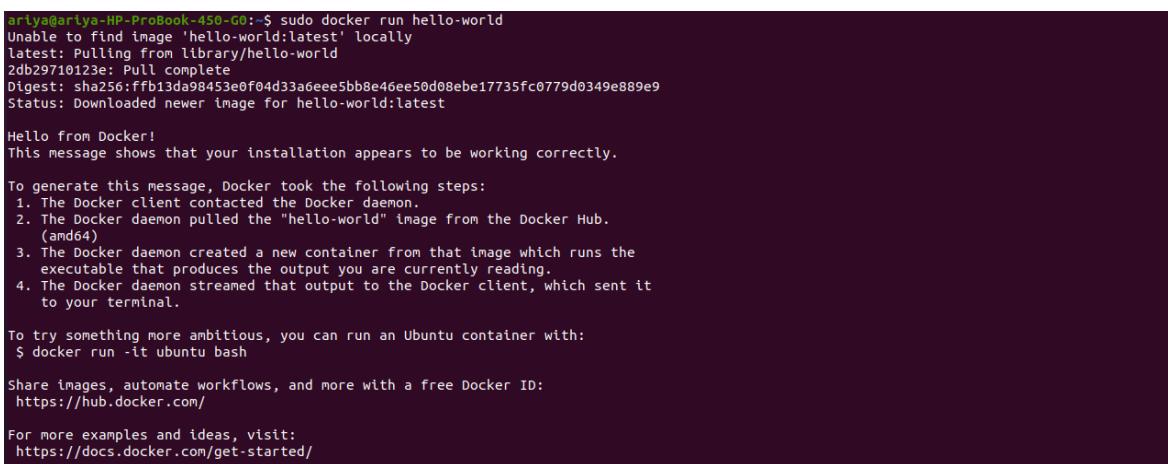
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```
ariya@ariya-HP-ProBook-450-G0:~$ docker --version
Docker version 20.10.21, build 20.10.21-0ubuntu1-20.04.1
ariya@ariya-HP-ProBook-450-G0:~$
```

مطابق با تصویر فوق، ورژن داکر، نشان داده شده، که نشان از درستی نصب داکر بر روی سیستم می باشد.

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```
ariya@ariya-HP-ProBook-450-G0:~$ sudo docker run hello-world
Unable to find image 'hello-world:latest' locally
latest: Pulling from library/hello-world
2db29710123e: Pull complete
Digest: sha256:ffb13da98453e0f04d33a6eee5bb8e46ee50d08eb17735fc0779d0349e889e9
Status: Downloaded newer image for hello-world:latest

Hello from Docker!
This message shows that your installation appears to be working correctly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
    (amd64)
 3. The Docker daemon created a new container from that image which runs the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which sent it
    to your terminal.

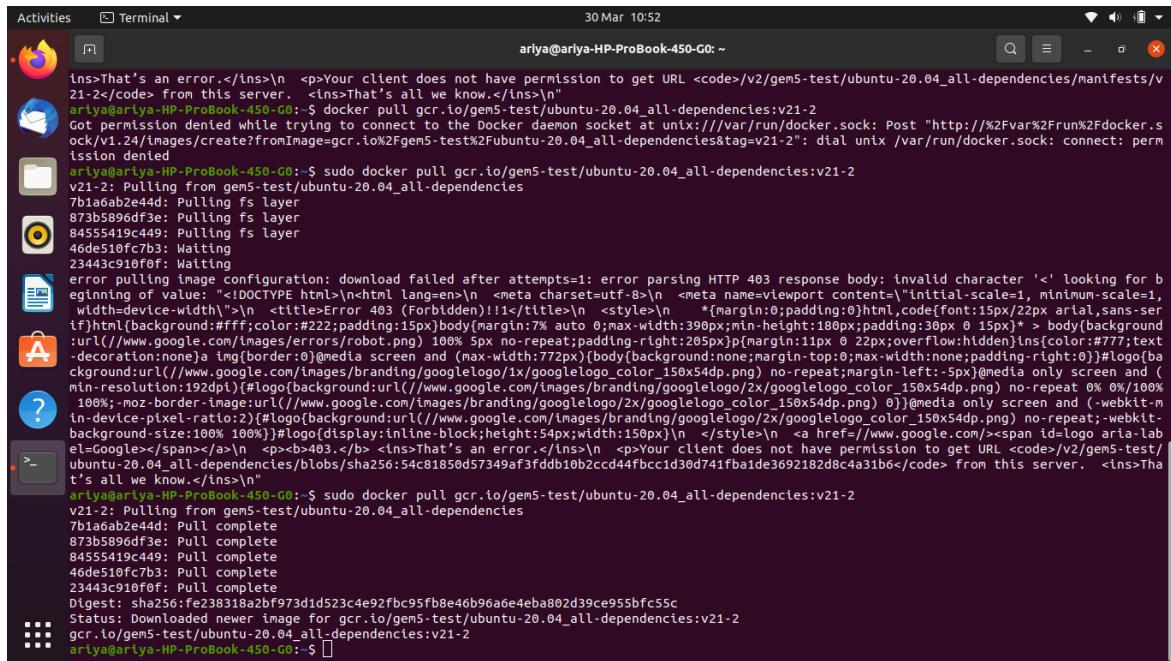
To try something more ambitious, you can run an Ubuntu container with:
 $ docker run -it ubuntu bash

Share images, automate workflows, and more with a free Docker ID:
 https://hub.docker.com/

For more examples and ideas, visit:
 https://docs.docker.com/get-started/
```

مطابق با تصویر فوق، برنامه پیش فرض *Hello World*، به درستی اجرا شده، که نشان از صحت نصب داکر می باشد.

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```
Activities Terminal 30 Mar 10:52
arya@ariya-HP-ProBook-450-G0: ~
ins>That's an error.</ins>\n <p>Your client does not have permission to get URL <code>/v2/gem5-test/ubuntu-20.04_all-dependencies/manifests/v21-2</code> from this server. <ins>That's all we know.</ins>\n"
arya@ariya-HP-ProBook-450-G0: $ docker pull gcr.io/gem5-test/ubuntu-20.04_all-dependencies:v21-2
Got permission denied while trying to connect to the Docker daemon socket at unix:///var/run/docker.sock. Post "http://%2Fvar%2Fr%2Fdocker.s
ock/v1.24/images/create?fromImage=gcr.io%2Fgem5-test%2Fubuntu-20.04_all-dependencies&tag=v21-2": dial unix /var/run/docker.sock: connect: perm
ission denied
arya@ariya-HP-ProBook-450-G0: $ sudo docker pull gcr.io/gem5-test/ubuntu-20.04_all-dependencies:v21-2
v21-2: Pulling from gem5-test/ubuntu-20.04_all-dependencies
7b1a6ab2e44d: Pulling fs layer
873b5896df3e: Pulling fs layer
84555419c449: Pulling fs layer
46de510fc7b3: Waiting
23443c910f0f: Waiting
error pulling image configuration: download failed after attempts=1: error parsing HTTP 403 response body: invalid character '<' looking for b
eginning of value: "<!DOCTYPE html><html lang=en>\n <meta charset=utf-8>\n <meta name=viewport content=\"initial-scale=1, mininum-scale=1,
width=device-width\"><title>Error 403 (Forbidden)!!1</title>\n <style>\n   *{margin:0;padding:0}html,code{font:15px/22px arial,sans-ser
if>html{background:#fff;color:#222;padding:15px}body{margin:7% auto 0;max-width:390px;min-height:180px;padding:30px 0 15px}*{> body[background
:url('https://www.google.com/images/errors/robot.png') 100% 5px no-repeat;padding-right:20px}{margin:11px 0 22px;overflow:hidden}ins{color:#777;text
-decoration:none}a img{border:none}@media screen and (max-width:772px){body[background:none;margin-top:0;max-width:none;padding-right:0]}#logo{ba
ckground:url('https://www.google.com/images/branding/googlelogo/1x/googlelogo_color_150x54dp.png') no-repeat;margin-left:-5px}@media only screen and (
min-resolution:192dpi){#logo[background:url('https://www.google.com/images/branding/googlelogo/2x/googlelogo_color_150x54dp.png') no-repeat 0% 0%/100%
100%;moz-border-image:url('https://www.google.com/images/branding/googlelogo/2x/googlelogo_color_150x54dp.png') 0)}@media only screen and (-webkit-m
in-device-pixel-ratio:2){#logo[background:url('https://www.google.com/images/branding/googlelogo/2x/googlelogo_color_150x54dp.png') no-repeat;webkit-
background-size:100% 100%}#logo{display:inline-block;height:54px;width:150px}\n </style>\n <a href='https://www.google.com/'>span id=logo aria-lab
el=Google</a></span></div>\n <p><b>403</b></p><ins>That's an error.</ins>\n <p>Your client does not have permission to get URL <code>/v2/gem5-test/
ubuntu-20.04_all-dependencies/blobs/sha256:54cb1850d57349af3fddbb10b2cc44fbcc1d30d741fb1ade3692182d8c4a31b6</code> from this server. <ins>Tha
t's all we know.</ins>\n"
arya@ariya-HP-ProBook-450-G0: $ sudo docker pull gcr.io/gem5-test/ubuntu-20.04_all-dependencies:v21-2
v21-2: Pulling from gem5-test/ubuntu-20.04_all-dependencies
7b1a6ab2e44d: Pull complete
873b5896df3e: Pull complete
84555419c449: Pull complete
46de510fc7b3: Pull complete
23443c910f0f: Pull complete
Digest: sha256:fe238318a2bf973d1d523c4e92fb95fb8e46b96a6e4eba802d39ce955bfc55c
Status: Downloaded newer image for gcr.io/gem5-test/ubuntu-20.04_all-dependencies:v21-2
gcr.io/gem5-test/ubuntu-20.04_all-dependencies:v21-2
arya@ariya-HP-ProBook-450-G0: $ 
```

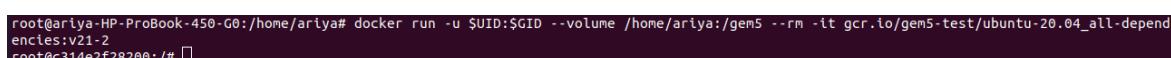
مطابق تصویر فوق، image docker با موفقیت دریافت شده است.



```
arya@ariya-HP-ProBook-450-G0: ~$ lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 20.04.6 LTS
Release:        20.04
Codename:       focal
arya@ariya-HP-ProBook-450-G0: ~$ 
```

در تصویر فوق، ورژن سیستم عامل Linux، نشان داده شده است.

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```
root@ariya-HP-ProBook-450-G0:/home/ariya# docker run -u $UID:$GID --volume /home/ariya:/gem5 --rm -it gcr.io/gem5-test/ubuntu-20.04_all-depend
encies:v21-2
root@c314e2f28200:/# 
```

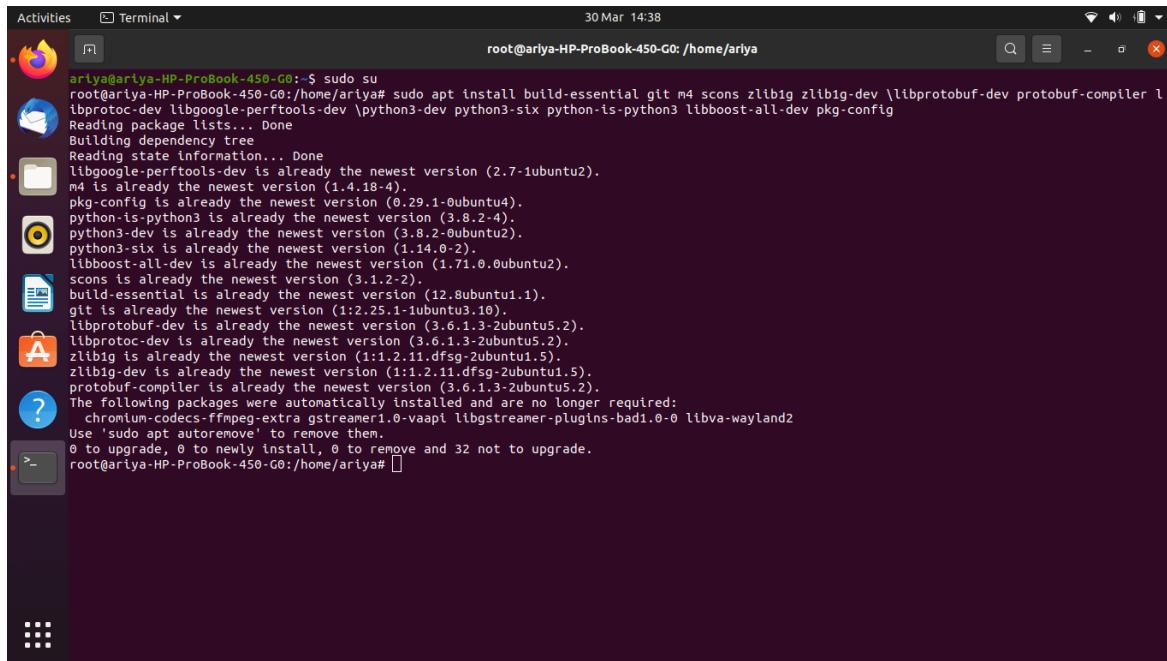
مطابق با تصویر فوق، image run دریافت شده، به درستی run شده است.

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```
Activities Terminal 30 Mar 14:37 arlya@arya-HP-ProBook-450-G0: ~
dev libgoogle-perf-tools-dev \python3-dev python3-six python-is-python3 libboost-all-dev pkg-config
Reading package lists... Done
Building dependency tree
Reading state information... Done
pkg-config is already the newest version (0.29.1-0ubuntu4).
pkg-config set to manually installed.
python3-six is already the newest version (1.14.0-2).
python3-six set to manually installed.
git is already the newest version (1:2.25.1-1ubuntu3.10).
zlibig is already the newest version (1:1.2.11.dfsg-2ubuntu1.5).
zlibig set to manually installed.
The following packages were automatically installed and are no longer required:
  chromium-codecs-ffmpeg-extra gstreamer1.0-vaapi libgstreamer-plugins-bad1.0-0 libva-wayland
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  autoconf automake autoparts-dev binutils binutils-common binutils-x86_64-linux-gnu cpp-8 dpkg-dev fakeroot g++ g++-9 gcc gcc-8-base
  gcc-9-gfortran gfortran-8 gfortran-9 libverbs-providers icu-devtools libalgorithm-diff-perl libalgorithm-diff-xs-perl
  libalgorithm-merge-perl libasan5 libbinutils libboost-atomic-dev libboost-atomic1.71-dev libboost-atomic1.71.0 libboostchrono-dev
  libboost-chrono1.71-dev libboost-chrono1.71.0 libboost-container-dev libboost-container1.71-dev libboost-container1.71.0
  libboost-context-dev libboost-context1.71-dev libboost-context1.71.0 libboost-coroutine-dev libboost-coroutine1.71-dev
  libboost-coroutine1.71.0 libboost-date-time-dev libboost-date-time1.71-dev libboost-dev libboost-exception-dev libboost-exception1.71-dev
  libboost-fiber-dev libboost-fiber1.71-dev libboost-fiber1.71.0 libboostfilesystem-dev libboostfilesystem1.71-dev libboostgraph-dev
  libboost-graph-dev libboost-graph-parallel1.71-dev libboost-graph-parallel1.71.0 libboostgraph1.71-dev libboostgraph1.71.0
  libboost-iostreams-dev libboost-iostreams1.71-dev libboost-local-dev libboost-locale1.71-dev libboostlog-dev libboostlog1.71-dev
  libboost-log1.71.0 libboost-math-dev libboost-math1.71-dev libboost-math1.71.0 libboost-mpi-dev libboost-mpi-dev libboost-mpi-python-dev
  libboost-mpi-python1.71-dev libboost-mpi1.71.0 libboost-mpl1.71-dev libboost-mpl1.71.0 libboost-numpy-dev libboost-numpy1.71-dev
  libboost-numpy1.71.0 libboost-program-options-dev libboost-program-options1.71-dev libboost-program-options1.71.0 libboost-python-dev
  libboost-python1.71-dev libboost-python1.71.0 libboost-random-dev libboost-random1.71-dev libboost-random1.71.0 libboost-regex-dev
  libboost-regex1.71-dev libboost-regex1.71.0 libboost-serialization-dev libboost-serialization1.71-dev libboost-serialization1.71.0
  libboost-stacktrace-dev libboost-stacktrace1.71-dev libboost-stacktrace1.71.0 libboost-system-dev libboost-system1.71-dev
  libboost-system1.71.0 libboost-test-dev libboost-test1.71-dev libboost-test1.71.0 libboost-thread-dev libboost-thread1.71-dev
  libboost-timer-dev libboost-timer1.71-dev libboost-tools-dev libboost-type-erasure-dev libboost-type-erasure1.71-dev
  libboost-type-erasure1.71.0 libboost-wave-dev libboost-wave1.71-dev libboost-wave1.71.0 libboost1.71-dev libboost1.71-dev tools-dev
  libc-dev-bin libc6-dev libcaf-openmp1.3 libcoarrays-dev libcoarrays-openmp1-dev libcrypt-dev libctf-nobfd0 libctf0 libdevcore-2.1-7
  libevent-dev libevent-extra-2.1-7 libevent-openssl2-2.1-7 libevent-pthreads2-2.1-7 libexpat1-dev libfabric1 libfakeroot libgcc-8-dev
  libgcc-9-dev libgfortran-8-dev libgfortran9-dev libgfortran5 libgoogle-perf-tools4 libhwloc-dev libhwloc-plugins libhwloc15 libhbverbs-dev
  libopenblas1 libicu-dev libitm1 libasan0 libitm1-dev libitmza-dev libmpx3 libm3-dev libnl-route-3-dev libnuma-dev libopenmp1-dev
  libopenmp13 libpmx2 libprotobuf-lite7 libprotoc17 libpsm2 libpython3.8 libpython3.8-dev
```

```
Activities Terminal 30 Mar 14:36
arya@arya-HP-ProBook-450-G0: ~
Setting up libboost-log1.71-dev (1.71.0-6ubuntu6) ...
Setting up libboost-coroutine1.71-dev:amd64 (1.71.0-6ubuntu6) ...
Setting up libboost-coroutine-dev:amd64 (1.71.0-6ubuntu2) ...
Setting up libopenmpi-dev:amd64 (4.0.3-0ubuntu1) ...
update-alternatives: using /usr/lib/x86_64-linux-gnu/openmpi/include to provide /usr/include/x86_64-linux-gnu/mpi (mpi-x86_64-linux-gnu) in auto mode
Setting up libboost-log-dev (1.71.0-6ubuntu2) ...
Setting up libboost-timer-dev:amd64 (1.71.0-6ubuntu2) ...
Setting up libboost-thread-dev:amd64 (1.71.0-6ubuntu2) ...
Setting up libboost-fiber-dev:amd64 (1.71.0-6ubuntu2) ...
Setting up libboost-mpi-python1.71.0 (1.71.0-6ubuntu6) ...
Setting up libboost-locale1.71-dev:amd64 (1.71.0-6ubuntu6) ...
Setting up libboost-locale-dev:amd64 (1.71.0-6ubuntu2) ...
Setting up gfortran (4:9.3.0-1ubuntu2) ...
update-alternatives: using /usr/bin/gfortran to provide /usr/bin/f95 (f95) in auto mode
update-alternatives: using /usr/bin/gfortran to provide /usr/bin/f77 (f77) in auto mode
Setting up libboost-type-erasure-dev:amd64 (1.71.0-6ubuntu2) ...
Setting up python3-dev (3.8.2-0ubuntu2) ...
Setting up libboost-graph-parallel-dev (1.71.0-6ubuntu2) ...
Setting up mpi-default-dev (1.13) ...
Setting up libboost-mpi1.71-dev (1.71.0-6ubuntu6) ...
Setting up libcoarrays-dev:amd64 (2.8.0-1) ...
Setting up libboost-python1.71-dev (1.71.0-6ubuntu6) ...
Setting up libboost-mpi-python1.71-dev (1.71.0-6ubuntu6) ...
Setting up libcoarrays-openmpi-dev:amd64 (2.8.0-1) ...
Setting up libboost-python-dev (1.71.0-6ubuntu2) ...
Setting up libboost-mpi-python-dev (1.71.0-6ubuntu2) ...
Setting up libboost-mpi-dev (1.71.0-6ubuntu2) ...
Setting up libboost-all-dev (1.71.0-6ubuntu2) ...
Processing triggers for desktop-file-utils (0.24-1ubuntu3) ...
Processing triggers for mime-support (3.64ubuntu1) ...
Processing triggers for gnome-menus (3.36.0-1ubuntu1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.9) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for install-info (6.7.0.dfsg.2-5) ...
arya@arya-HP-ProBook-450-G0: ~
```

مطابق با تصاویر فوق، *GEM5*، به درستی کامپایل شده است.



```

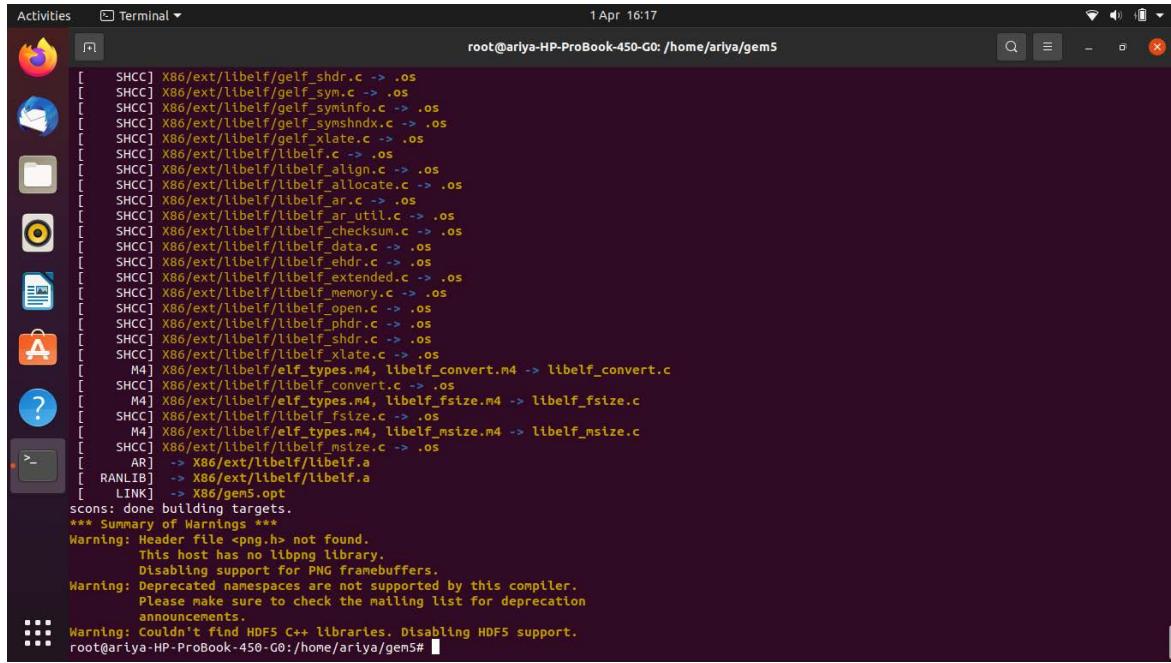
Activities Terminal ▾ 30 Mar 14:38
ariya@ariya-HP-ProBook-450-G0: ~
root@ariya-HP-ProBook-450-G0:/home/ariya# sudo apt update
[sudo] password for root:
Get:1 http://archive.ubuntu.com/ubuntu focal InRelease [242 kB]
Get:2 http://archive.ubuntu.com/ubuntu focal-updates InRelease [242 kB]
Get:3 http://archive.ubuntu.com/ubuntu focal-backports InRelease [242 kB]
Get:4 http://security.ubuntu.com/ubuntu focal-security InRelease [242 kB]
Fetched 972 kB in 1s (829 kB/s)
Reading package lists...
Building dependency tree
Reading state information...
m4 is already the newest version (1.4.18-4).
pkg-config is already the newest version (0.29.1-0ubuntu4).
python-is-python3 is already the newest version (3.8.2-4).
python3-dev is already the newest version (3.8.2-0ubuntu2).
python3-six is already the newest version (2.7-1ubuntu2).
libboost-all-dev is already the newest version (1.71.0.0ubuntu2).
scs is already the newest version (3.1.2-2).
build-essential is already the newest version (12.8ubuntu1.1).
git is already the newest version (1:2.25.1-1ubuntu3.10).
libprotobuf-dev is already the newest version (3.6.1.3-2ubuntu5.2).
libprotoc-dev is already the newest version (3.6.1.3-2ubuntu5.2).
zlib1g is already the newest version (1:1.2.11.dfsg-2ubuntu1.5).
zlib1g-dev is already the newest version (1:1.2.11.dfsg-2ubuntu1.5).
The following packages were automatically installed and are no longer required:
  chromium-codecs-ffmpeg-extra gstreamer1.0-vaapi libgstreamer-plugins-bad1.0-0 libva-wayland2
Use 'sudo apt autoremove' to remove them.
0 to upgrade, 0 to newly install, 0 to remove and 32 not to upgrade.
root@ariya-HP-ProBook-450-G0:/home/ariya#

```

مطابق با تصویر فوق، *GEM5*، به درستی در مد *superuser* کامپایل شده است.

گام دوم

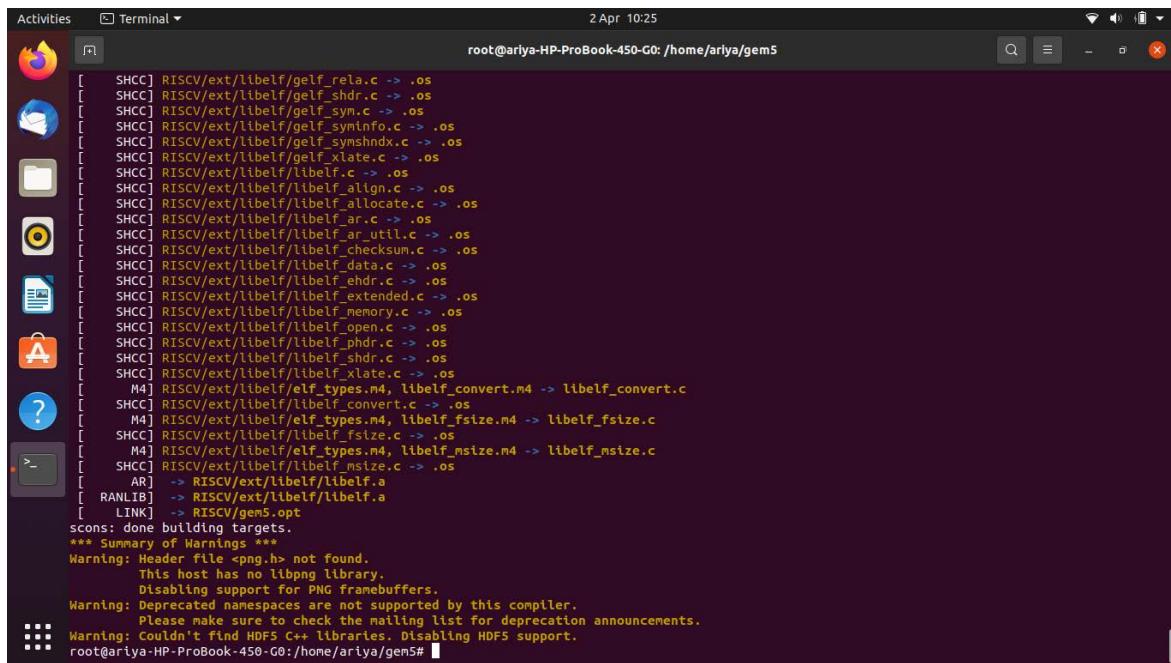
X86 شدن پردازنده build



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5
[ SHCC] X86/ext/libelf/gelf_shdr.c -> .os
[ SHCC] X86/ext/libelf/gelf_sym.c -> .os
[ SHCC] X86/ext/libelf/gelf_syminfo.c -> .os
[ SHCC] X86/ext/libelf/gelf_symsndx.c -> .os
[ SHCC] X86/ext/libelf/gelf_xlate.c -> .os
[ SHCC] X86/ext/libelf/libelf.c --> .os
[ SHCC] X86/ext/libelf/libelf_align.c -> .os
[ SHCC] X86/ext/libelf/libelf_allocate.c -> .os
[ SHCC] X86/ext/libelf/libelf_ar.c -> .os
[ SHCC] X86/ext/libelf/libelf_ar_util.c -> .os
[ SHCC] X86/ext/libelf/libelf_checksum.c -> .os
[ SHCC] X86/ext/libelf/libelf_data.c -> .os
[ SHCC] X86/ext/libelf/libelf_ehdr.c -> .os
[ SHCC] X86/ext/libelf/libelf_extended.c -> .os
[ SHCC] X86/ext/libelf/libelf_memory.c -> .os
[ SHCC] X86/ext/libelf/libelf_open.c -> .os
[ SHCC] X86/ext/libelf/libelf_phdr.c -> .os
[ SHCC] X86/ext/libelf/libelf_shdr.c -> .os
[ SHCC] X86/ext/libelf/libelf_xlate.c -> .os
[ M4] X86/ext/libelf/elf_types.m4, libelf_convert.m4 -> libelf_convert.c
[ SHCC] X86/ext/libelf/libelf_convert.c -> .os
[ M4] X86/ext/libelf/elf_types.m4, libelf_fsize.m4 -> libelf_fsize.c
[ SHCC] X86/ext/libelf/libelf_fsize.c -> .os
[ M4] X86/ext/libelf/elf_types.m4, libelf_msize.m4 -> libelf_msize.c
[ SHCC] X86/ext/libelf/libelf_msize.c -> .os
[ AR] -> X86/ext/libelf/libelf.a
[ RANLIB] -> X86/gen5.opt
[ LINK] -> X86/gen5
scons: done building targets.
*** Summary of Warnings ***
Warning: Header file <png.h> not found.
This host has no libpng library.
Disabling support for PNG framebuffers.
Warning: Deprecated namespaces are not supported by this compiler.
Please make sure to check the mailing list for deprecation
announcements.
Warning: Couldn't find HDF5 C++ libraries. Disabling HDF5 support.
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

مطابق با تصویر فوق، پردازنده X86 با موفقیت بر اساس build scons شده است.

:RISCV شدن پردازنده build

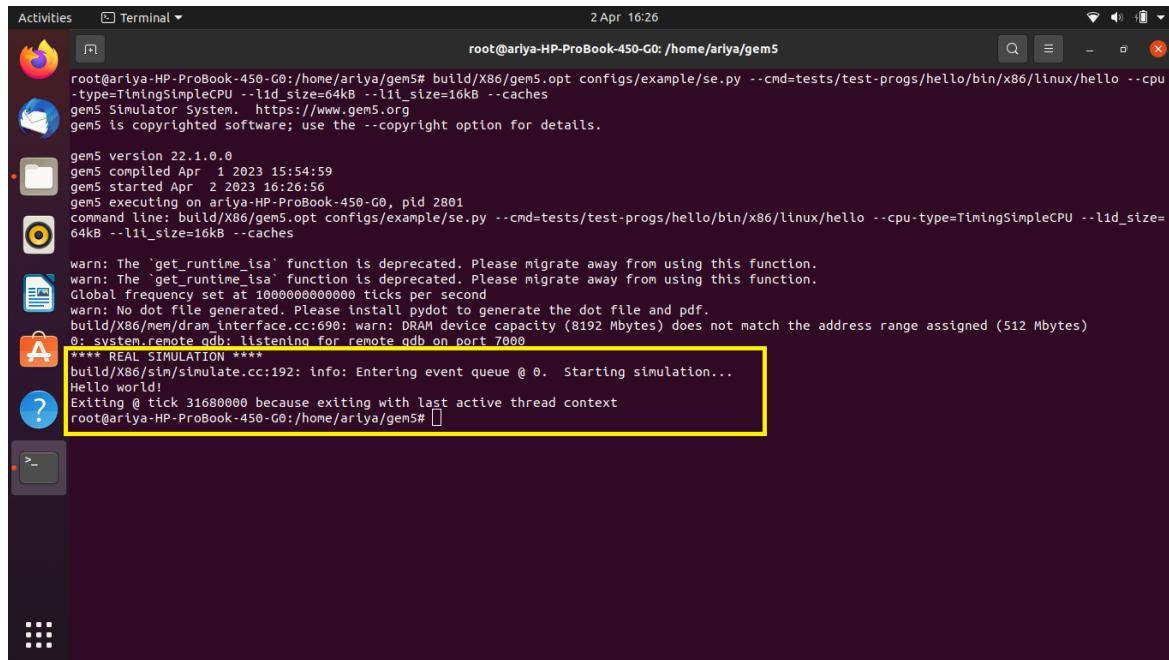


```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5
[ SHCC] RISCV/ext/libelf/gelf_rela.c -> .os
[ SHCC] RISCV/ext/libelf/gelf_shdr.c -> .os
[ SHCC] RISCV/ext/libelf/gelf_sym.c -> .os
[ SHCC] RISCV/ext/libelf/gelf_syminfo.c -> .os
[ SHCC] RISCV/ext/libelf/gelf_symsndx.c -> .os
[ SHCC] RISCV/ext/libelf/gelf_xlate.c -> .os
[ SHCC] RISCV/ext/libelf/libelf.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_align.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_allocate.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_ar.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_ar_util.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_checksum.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_data.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_ehdr.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_extended.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_memory.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_open.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_phdr.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_shdr.c -> .os
[ SHCC] RISCV/ext/libelf/libelf_xlate.c -> .os
[ M4] RISCV/ext/libelf/elf_types.m4, libelf_convert.m4 -> libelf_convert.c
[ SHCC] RISCV/ext/libelf/libelf_convert.c -> .os
[ M4] RISCV/ext/libelf/elf_types.m4, libelf_fsize.m4 -> libelf_fsize.c
[ SHCC] RISCV/ext/libelf/libelf_fsize.c -> .os
[ M4] RISCV/ext/libelf/elf_types.m4, libelf_msize.m4 -> libelf_msize.c
[ SHCC] RISCV/ext/libelf/libelf_msize.c -> .os
[ AR] -> RISCV/ext/libelf/libelf.a
[ RANLIB] -> RISCV/ext/libelf/libelf.a
[ LINK] -> RISCV/gen5.opt
scons: done building targets.
*** Summary of Warnings ***
Warning: Header file <png.h> not found.
This host has no libpng library.
Disabling support for PNG framebuffers.
Warning: Deprecated namespaces are not supported by this compiler.
Please make sure to check the mailing list for deprecation announcements.
Warning: Couldn't find HDF5 C++ libraries. Disabling HDF5 support.
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

مطابق با تصویر فوق، پردازنده RISCV با موفقیت بر اساس build scons شده است.

گام سوم

اجرا برنامه *Hello World* از نوع *cpu-type* با X86 بر روی پردازنده *TimingSimpleCPU*



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Hello/bin/x86/linux/Hello --cpu-type=TimingSimpleCPU --l1d_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

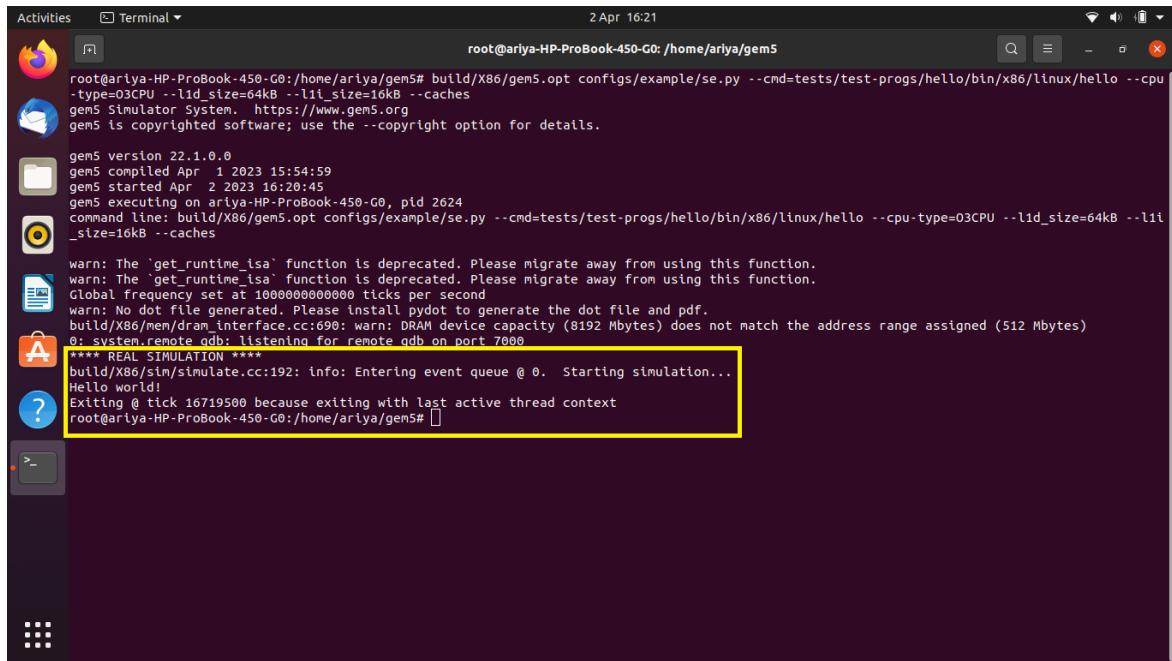
gem5 version 22.1.0
gem5 compiled Apr 1 2023 15:54:59
gem5 started Apr 2 2023 16:26:56
gem5 executing on ariya-HP-ProBook-450-G0, pid 2801
command line: build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Hello/bin/x86/linux/Hello --cpu-type=TimingSimpleCPU --l1d_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
Global frequency set at 1000000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/X86/mem/dram_interface.cc:690: 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
*** REAL SIMULATION ***
build/X86/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
Hello world!
Exiting @ tick 31680000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5#
```

مطابق با تصویر فوق، برنامه *Hello World* پیش فرض *GEM5*، به درستی بر روی پردازنده X86 با

اجرا شده است.

اجرا برنامه *Hello World* بر روی پردازنده X86 با نوع *cpu-type O3CPU*



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/hello/bin/x86/linux/hello --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

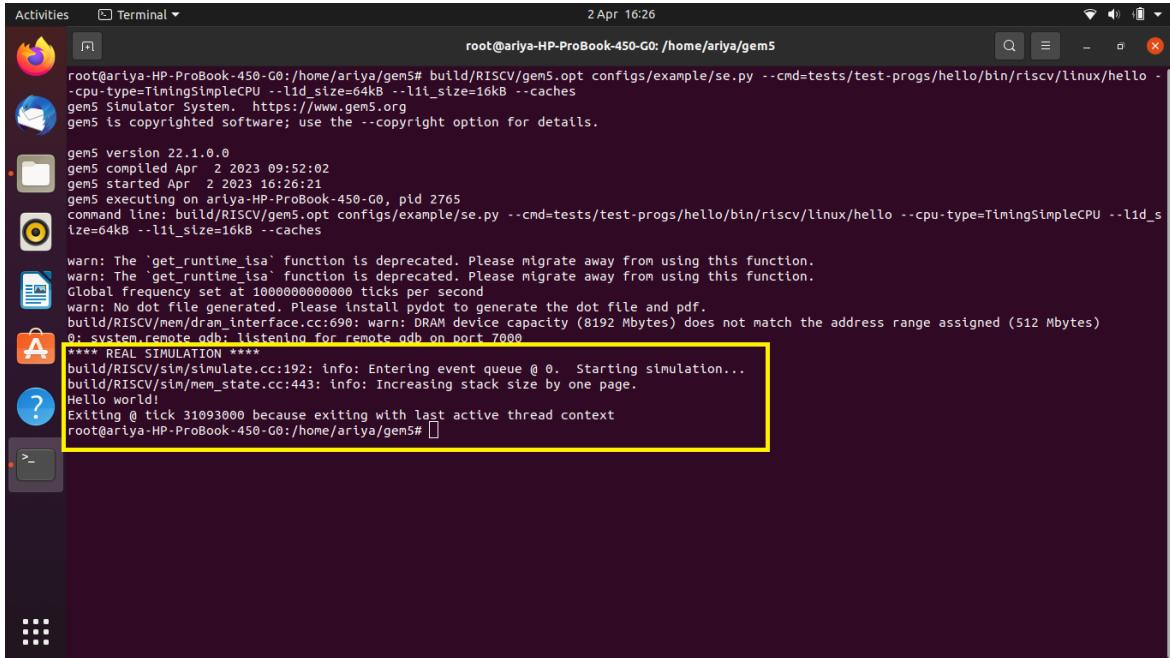
gem5 version 22.1.0.0
gem5 compiled Apr 1 2023 15:54:59
gem5 started Apr 2 2023 16:20:45
gem5 executing on ariya-HP-ProBook-450-G0, pid 2624
command line: build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/hello/bin/x86/linux/hello --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
Global frequency set at 1000000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/X86/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/X86/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
Hello world!
Exiting @ tick 16719500 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

مطابق با تصویر فوق، برنامه *Hello World* پیش فرض *GEM5*، به درستی بر روی پردازنده X86 با

اجرا شده است.

اجرا برنامه *Hello World* بر روی پردازنده RISCV با نوع *cpu-type* *TimingSimpleCPU*

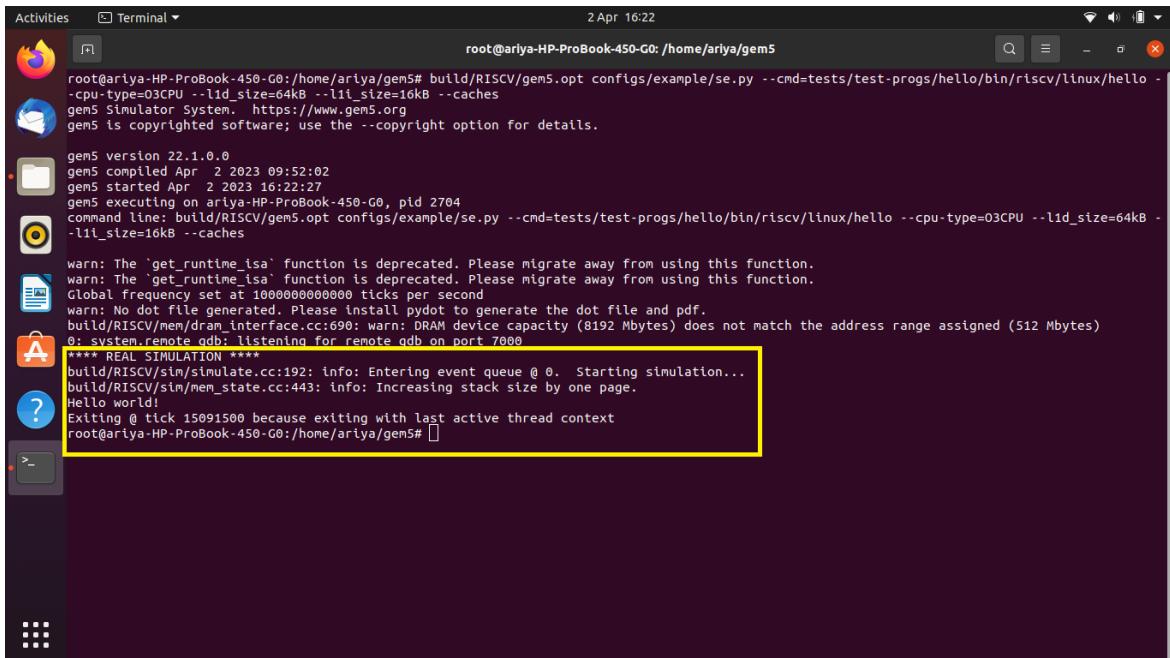


```
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5# build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Hello/bin/riscv/linux/Hello -cpu-type=TimingSimpleCPU -l1d_size=64kB -l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 2 2023 09:52:02
gem5 started Apr 2 2023 16:26:21
gem5 executing on ariya-HP-ProBook-450-G0, pid 2765
command line: build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Hello/bin/riscv/linux/Hello --cpu-type=TimingSimpleCPU --l1d_size=64kB -l1i_size=16kB --caches
warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
Global frequency set at 100000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/RISCV/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/RISCV/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/RISCV/sim/mem_state.cc:443: info: Increasing stack size by one page.
Hello world!
Exiting @ tick 31093000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

مطابق با تصویر فوق، برنامه *Hello World* پیش فرض *GEM5*، به درستی بر روی پردازنده RISCV اجرا شده است.

اجرا برنامه *Hello World* بر روی پردازنده RISCV با نوع *cpu-type* *O3CPU*



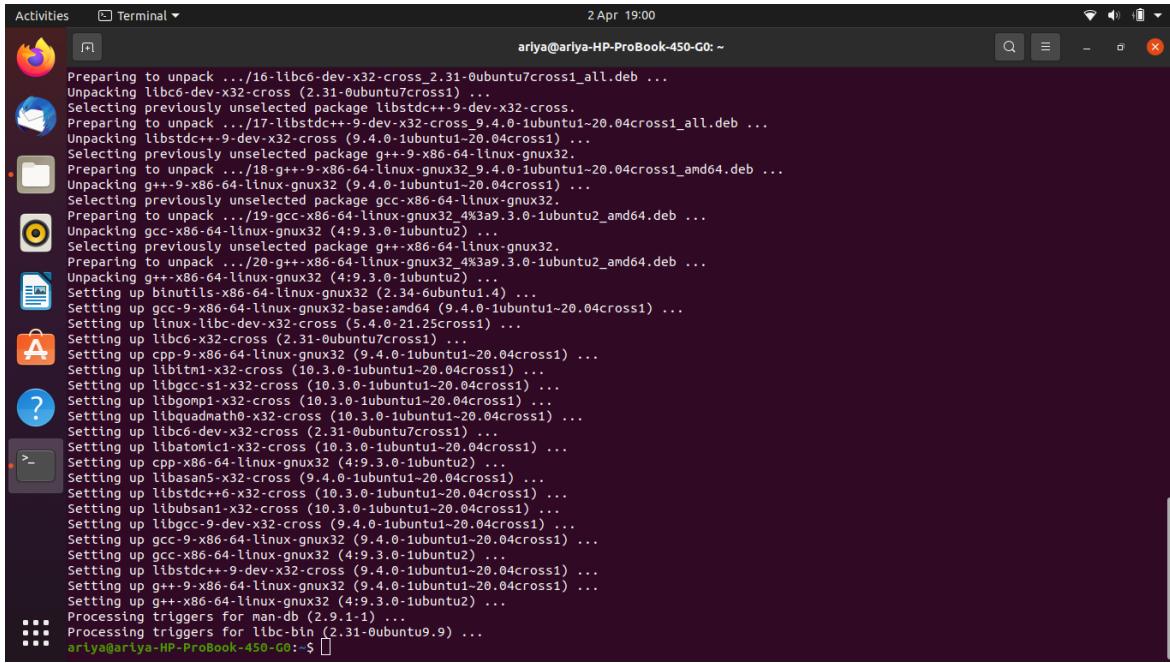
```
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5# build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Hello/bin/riscv/linux/Hello -cpu-type=O3CPU -l1d_size=64kB -l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 2 2023 09:52:02
gem5 started Apr 2 2023 16:22:27
gem5 executing on ariya-HP-ProBook-450-G0, pid 2704
command line: build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Hello/bin/riscv/linux/Hello --cpu-type=O3CPU --l1d_size=64kB -l1i_size=16kB --caches
warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
Global frequency set at 100000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/RISCV/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/RISCV/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/RISCV/sim/mem_state.cc:443: info: Increasing stack size by one page.
Hello world!
Exiting @ tick 15091500 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

مطابق با تصویر فوق، برنامه *Hello World* پیش فرض *GEM5*، به درستی بر روی پردازنده RISCV اجرا شده است.

گام چهارم

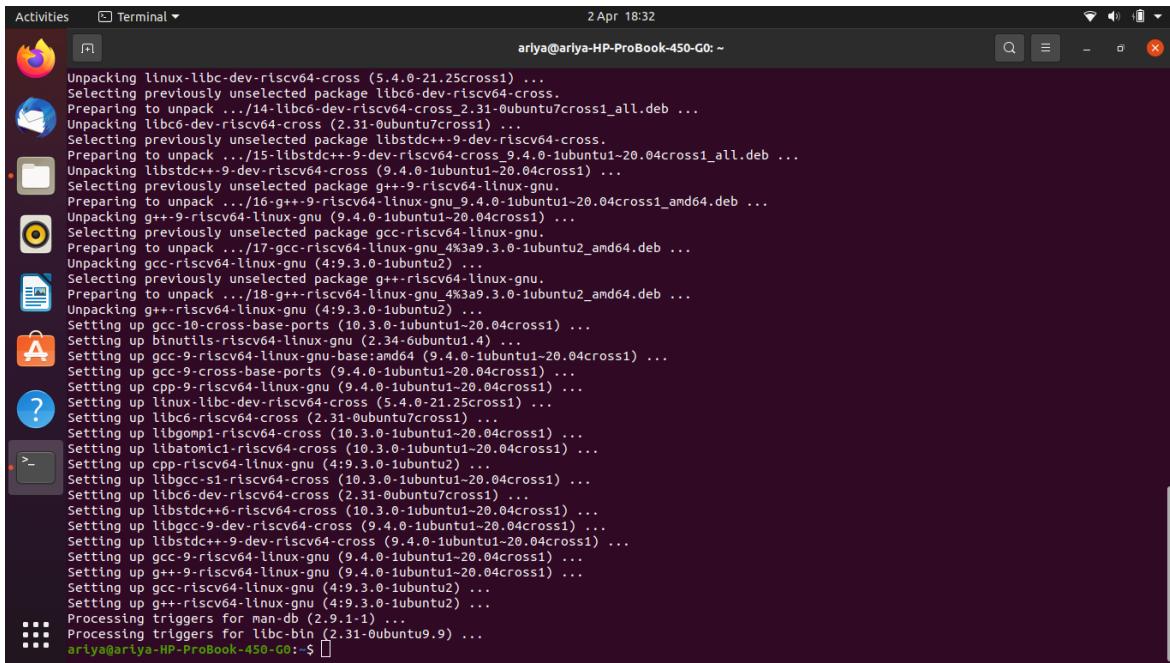
نصب شدن کامپایلر پردازنده X86



```
Preparing to unpack .../16-libc6-dev-x32-cross_2.31-0ubuntu7cross1_all.deb ...
Unpacking libc6-dev-x32-cross (2.31-0ubuntu7cross1) ...
Selecting previously unselected package libstdc++-9-dev-x32-cross.
Preparing to unpack .../17-libstdc++-9-dev-x32-cross_9.4.0-1ubuntu1~20.04cross1_all.deb ...
Unpacking libstdc++-9-dev-x32-cross (9.4.0-1ubuntu1~20.04cross1) ...
Selecting previously unselected package g++-9-x86-64-linux-gnu32.
Preparing to unpack .../18-g++-9-x86-64-linux-gnu32_9.4.0-1ubuntu1~20.04cross1_amd64.deb ...
Unpacking g++-9-x86-64-linux-gnu32 (9.4.0-1ubuntu1~20.04cross1) ...
Selecting previously unselected package gcc-x86-64-linux-gnu32.
Preparing to unpack .../19-gcc-x86-64-linux-gnu32_4%3a9.3.0-1ubuntu2_amd64.deb ...
Unpacking gcc-x86-64-linux-gnu32 (4:9.3.0-1ubuntu2) ...
Selecting previously unselected package g++-x86-64-linux-gnu32.
Preparing to unpack .../20-g++-x86-64-linux-gnu32_4%3a9.3.0-1ubuntu2_amd64.deb ...
Unpacking g++-x86-64-linux-gnu32 (4:9.3.0-1ubuntu2) ...
Setting up binutils-x86-64-linux-gnu32 (2.34-6ubuntu1.4) ...
Setting up gcc-9-x86-64-linux-gnu32-base:amd64 (9.4.0-1ubuntu1~20.04cross1) ...
Setting up linux-libc-dev-x32-cross (5.4.0-21.25cross1) ...
Setting up libc6-x32-cross (2.31-0ubuntu7cross1) ...
Setting up cpp-9-x86-64-linux-gnu32 (9.4.0-1ubuntu1~20.04cross1) ...
Setting up libitm1-x32-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libgcc-s1-x32-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libgomp1-x32-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libquadmath0-x32-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libc6-dev-x32-cross (2.31-0ubuntu7cross1) ...
Setting up libatomic1-x32-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up cpp-x86-64-linux-gnu32 (4:9.3.0-1ubuntu2) ...
Setting up libasan5-x32-cross (9.4.0-1ubuntu1~20.04cross1) ...
Setting up libstdc++-6-x32-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libubsan1-x32-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libgcc-9-dev-x32-cross (9.4.0-1ubuntu1~20.04cross1) ...
Setting up gcc-9-x86-64-linux-gnu32 (9.4.0-1ubuntu1~20.04cross1) ...
Setting up libstdc++-9-dev-x32-cross (9.4.0-1ubuntu1~20.04cross1) ...
Setting up g++-9-x86-64-linux-gnu32 (9.4.0-1ubuntu1~20.04cross1) ...
Setting up g++-x86-64-linux-gnu32 (4:9.3.0-1ubuntu2) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.9) ...
arlyya@arlyya-HP-ProBook-450-G0: ~
```

مطابق با تصویر فوق، کامپایلر پردازنده X86 با موفقیت نصب شده است.

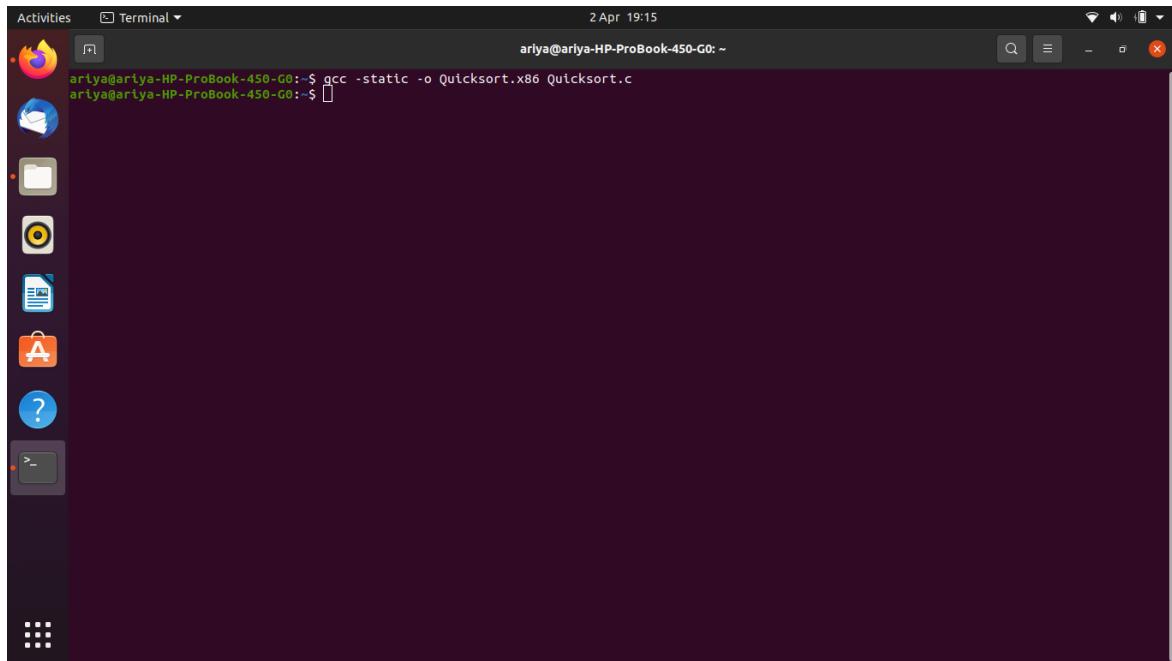
نصب شدن کامپایلر پردازنده RISCV



```
Unpacking linux-libc-dev-riscv64-cross (5.4.0-21.25cross1) ...
Selecting previously unselected package libc6-dev-riscv64-cross.
Preparing to unpack .../14-libc6-dev-riscv64-cross_2.31-0ubuntu7cross1_all.deb ...
Unpacking libc6-dev-riscv64-cross (2.31-0ubuntu7cross1) ...
Selecting previously unselected package libstdc++-9-dev-riscv64-cross.
Preparing to unpack .../15-libstdc++-9-dev-riscv64-cross_9.4.0-1ubuntu1~20.04cross1_all.deb ...
Unpacking libstdc++-9-dev-riscv64-cross (9.4.0-1ubuntu1~20.04cross1) ...
Selecting previously unselected package g++-9-riscv64-linux-gnu.
Preparing to unpack .../16-g++-9-riscv64-linux-gnu_9.4.0-1ubuntu1~20.04cross1_amd64.deb ...
Unpacking g++-9-riscv64-linux-gnu (9.4.0-1ubuntu1~20.04cross1) ...
Selecting previously unselected package gcc-riscv64-linux-gnu.
Preparing to unpack .../17-gcc-riscv64-linux-gnu_4%3a9.3.0-1ubuntu2_amd64.deb ...
Unpacking gcc-riscv64-linux-gnu (4:9.3.0-1ubuntu2) ...
Selecting previously unselected package g++-riscv64-linux-gnu.
Preparing to unpack .../18-g++-riscv64-linux-gnu_4%3a9.3.0-1ubuntu2_amd64.deb ...
Unpacking g++-riscv64-linux-gnu (4:9.3.0-1ubuntu2) ...
Setting up gcc-10-cross-base-ports (10.3.0-1ubuntu1~20.04cross1) ...
Setting up binutils-riscv64-linux-gnu (2.34-6ubuntu1.4) ...
Setting up libgcc-riscv64-linux-gnu-base:amd64 (9.4.0-1ubuntu1~20.04cross1) ...
Setting up gcc-9-cross-base-ports (9.4.0-1ubuntu1~20.04cross1) ...
Setting up cpp-9-riscv64-linux-gnu (9.4.0-1ubuntu1~20.04cross1) ...
Setting up riscv64-base:amd64 (5.4.0-21.25cross1) ...
Selecting previously unselected package g++-riscv64-linux-gnu.
Preparing to unpack .../18-g++-riscv64-linux-gnu_4%3a9.3.0-1ubuntu2_amd64.deb ...
Unpacking g++-riscv64-linux-gnu (4:9.3.0-1ubuntu2) ...
Setting up libgcc-10-riscv64-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libatomic1-riscv64-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libgcc-9-riscv64-cross (4:9.3.0-1ubuntu2) ...
Setting up libgcc-s1-riscv64-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libc6-dev-riscv64-cross (2.31-0ubuntu7cross1) ...
Setting up libstdc++-6-riscv64-cross (10.3.0-1ubuntu1~20.04cross1) ...
Setting up libgcc-9-dev-riscv64-cross (9.4.0-1ubuntu1~20.04cross1) ...
Setting up libstdc++-9-dev-riscv64-cross (9.4.0-1ubuntu1~20.04cross1) ...
Setting up gcc-9-riscv64-linux-gnu (9.4.0-1ubuntu1~20.04cross1) ...
Setting up g++-9-riscv64-linux-gnu (9.4.0-1ubuntu1~20.04cross1) ...
Setting up gcc-riscv64-linux-gnu (4:9.3.0-1ubuntu2) ...
Setting up g++-riscv64-linux-gnu (4:9.3.0-1ubuntu2) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.9) ...
arlyya@arlyya-HP-ProBook-450-G0: ~
```

مطابق با تصویر فوق، کامپایلر پردازنده RISCV با موفقیت نصب شده است.

کامپایل شدن برنامه محک Quicksort.c در پردازنده X86

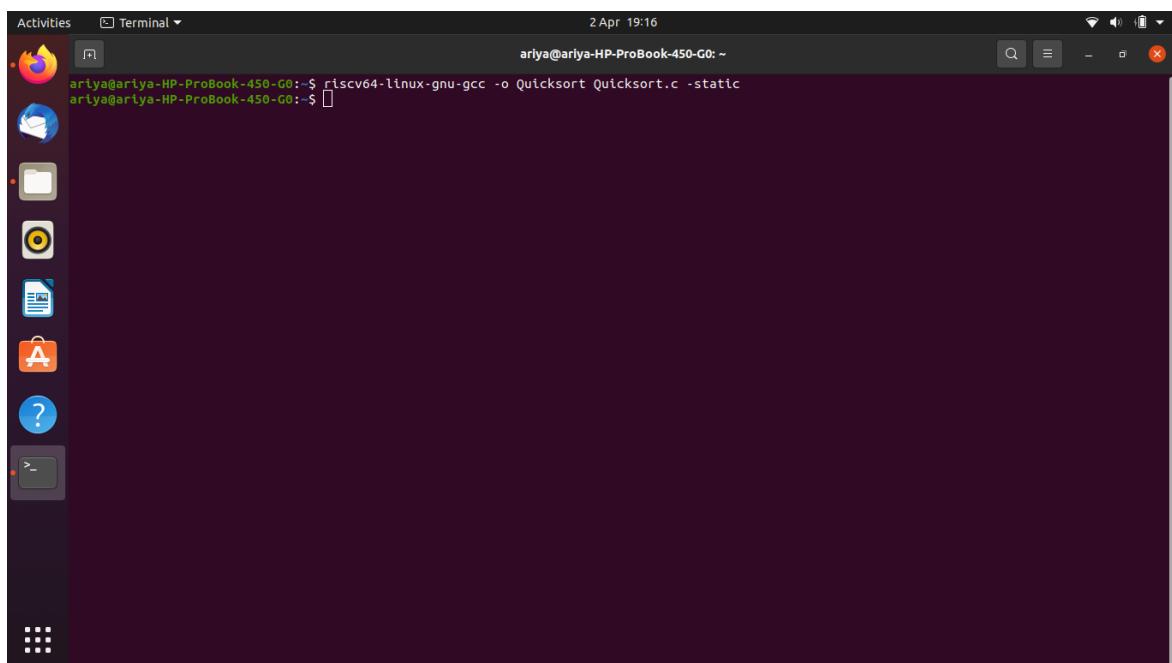


```
Activities Terminal 2 Apr 19:15
ariya@ariya-HP-ProBook-450-G0:~$ gcc -static -o Quicksort.x86 Quicksort.c
ariya@ariya-HP-ProBook-450-G0:~$
```

A screenshot of a Linux desktop environment showing a terminal window. The terminal window title is "Terminal" and the date and time are "2 Apr 19:15". The terminal content shows the command "gcc -static -o Quicksort.x86 Quicksort.c" being run by user "ariya" at host "ariya-HP-ProBook-450-G0". The terminal window has a dark background with light-colored text. The desktop interface includes a vertical dock on the left with icons for various applications like a browser, file manager, and system settings.

مطابق با تصویر فوق، برنامه محک Quicksort.c با موفقیت بر روی پردازنده X86 کامپایل شده است.

کامپایل شدن برنامه محک Quicksort.c در پردازنده RISCV



```
Activities Terminal 2 Apr 19:16
ariya@ariya-HP-ProBook-450-G0:~$ riscv64-linux-gnu-gcc -o Quicksort Quicksort.c -static
ariya@ariya-HP-ProBook-450-G0:~$
```

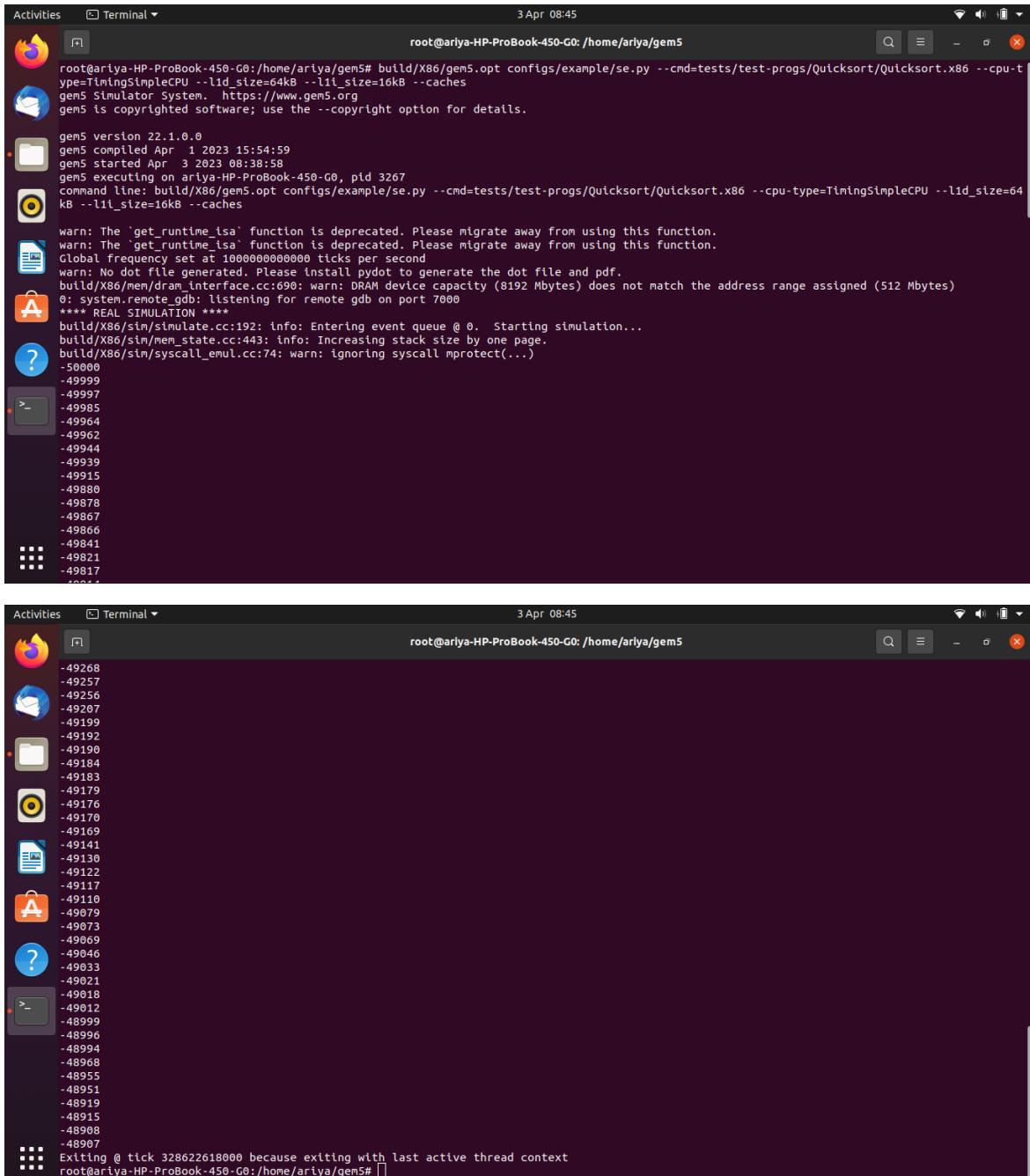
A screenshot of a Linux desktop environment showing a terminal window. The terminal window title is "Terminal" and the date and time are "2 Apr 19:16". The terminal content shows the command "riscv64-linux-gnu-gcc -o Quicksort Quicksort.c -static" being run by user "ariya" at host "ariya-HP-ProBook-450-G0". The terminal window has a dark background with light-colored text. The desktop interface includes a vertical dock on the left with icons for various applications like a browser, file manager, and system settings.

مطابق با تصویر فوق، برنامه محک Quicksort.c با موفقیت بر روی پردازنده RISCV کامپایل شده است.

گام پنجم

الف:

خروجی اجرا برنامه محک Quicksort.c بر روی پردازنده X86:



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=TimingSimpleCPU -l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 1 2023 15:54:59
gem5 started Apr 3 2023 08:38:58
gem5 executing on ariya-HP-ProBook-450-G0, pid 3267
command line: build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=TimingSimpleCPU -l1i_size=16kB --caches

warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
Global frequency set at 1000000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/X86/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/X86/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/X86/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/X86/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect...
-50000
-49999
-49997
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49817
-49816
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زمان اجرا برنامه محک Quicksort.c بر روی پردازنده X86

```

1
2 ----- Begin Simulation Statistics -----
3:iSeconds 0.328623 # Number of seconds simulated (Second)
4:iTicks 328622618000 # Number of ticks simulated (Tick)
5:iNalTick 328622618000 # Number of ticks from beginning of simulation (restored from
6:iFreq 1000000000000 # The number of ticks per simulated second ((Tick/Second))
7:iostSeconds 355.01 # Real time elapsed on the host (Second)
8:iostTickrate 925663425 # The number of ticks simulated per host second (ticks/s)
9:iostMemory 658856 # Number of bytes of host memory used (Byte)
10:iInsts 172916971 # Number of instructions simulated (Count)
11:iMops 263412208 # Number of ops (including micro ops) simulated (Count)
12:iostInstRate 487072 # Simulator instruction rate (inst/s) ((Count/Second))
13:iostOpRate 741979 # Simulator op (including micro ops) rate (ops/s) ((Count/Second))
14:ystem.clk_domain.clock 1000
15:ystem.cpu.numCycles 657245236
16:ystem.cpu.numWorkItemsStarted 0
17:ystem.cpu.numWorkItemsCompleted 0
18:ystem.cpu.dcache.demandHits::cpu.data 99052056
19:ystem.cpu.dcache.demandHits::total 99052056
20:ystem.cpu.dcache.overallHits::cpu.data 99052056
21:ystem.cpu.dcache.overallHits::total 99052056
22:ystem.cpu.dcache.demandMisses::cpu.data 870
23:ystem.cpu.dcache.demandMisses::total 870
24:ystem.cpu.dcache.overallMisses::cpu.data 870
25:ystem.cpu.dcache.overallMisses::total 870
26:ystem.cpu.dcache.demandMissLatency::cpu.data 52396500
27:ystem.cpu.dcache.demandMissLatency::total 52396500
28:ystem.cpu.dcache.overallMissLatency::cpu.data 52396500
29:ystem.cpu.dcache.overallMissLatency::total 52396500
30:ystem.cpu.dcache.demandAccesses::cpu.data 99052926
31:ystem.cpu.dcache.demandAccesses::total 99052926

```

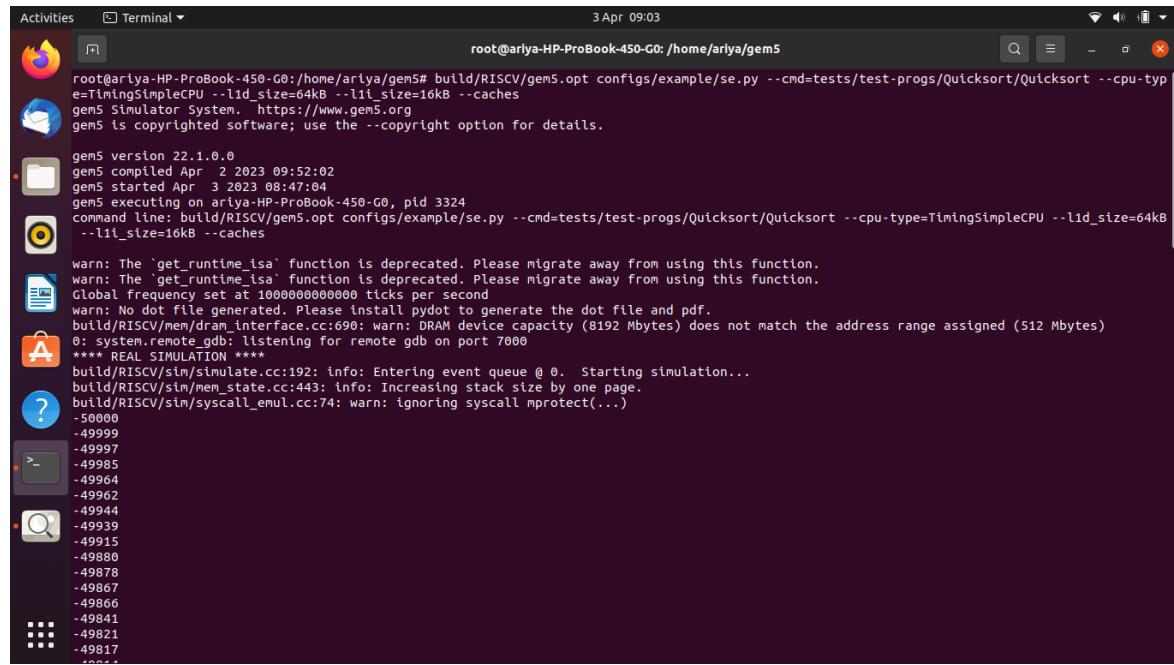
توان و انرژی مصرفی اجرا برنامه محک Quicksort.c بر روی پردازنده X86

```

604:ystem.nem_ctrls.dram.rank0.actEnergy 2556120
605:ystem.nem_ctrls.dram.rank0.preEnergy 1351020
606:ystem.nem_ctrls.dram.rank0.readEnergy 4969440
607:ystem.nem_ctrls.dram.rank0.writeEnergy 903060
608:ystem.nem_ctrls.dram.rank0.refreshEnergy 25940881200.000004
609:ystem.nem_ctrls.dram.rank0.actBackEnergy 5108147340
610:ystem.nem_ctrls.dram.rank0.preBackEnergy 121889487840
611:ystem.nem_ctrls.dram.rank0.actPowerDownEnergy 0
612:ystem.nem_ctrls.dram.rank0.prePowerDownEnergy 0
613:ystem.nem_ctrls.dram.rank0.selfRefreshEnergy 0
614:ystem.nem_ctrls.dram.rank0.totalEnergy 152948296020
615:ystem.nem_ctrls.dram.rank0.averagePower 465.422304
616:ystem.nem_ctrls.dram.rank0.totalIdleTime 0
617:ystem.nem_ctrls.dram.rank0.pwrStateTime::IDLE 316837946000
618:ystem.nem_ctrls.dram.rank0.pwrStateTime::REF 109733000000
619:ystem.nem_ctrls.dram.rank0.pwrStateTime::SREF 0
620:ystem.nem_ctrls.dram.rank0.pwrStateTime::PRE_PDN 0
621:ystem.nem_ctrls.dram.rank0.pwrStateTime::ACT 811372000
622:ystem.nem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 0
623:ystem.nem_ctrls.dram.rank1.actEnergy 1556520
624:ystem.nem_ctrls.dram.rank1.preEnergy 804540
625:ystem.nem_ctrls.dram.rank1.readEnergy 4512480
626:ystem.nem_ctrls.dram.rank1.writeEnergy 709920
627:ystem.nem_ctrls.dram.rank1.refreshEnergy 25940881200.000004
628:ystem.nem_ctrls.dram.rank1.actBackEnergy 4876342590
629:ystem.nem_ctrls.dram.rank1.preBackEnergy 122084691840
630:ystem.nem_ctrls.dram.rank1.actPowerDownEnergy 0
631:ystem.nem_ctrls.dram.rank1.prePowerDownEnergy 0
632:ystem.nem_ctrls.dram.rank1.selfRefreshEnergy 0
633:ystem.nem_ctrls.dram.rank1.totalEnergy 152909499090
634:ystem.nem_ctrls.dram.rank1.averagePower 465.384245
635:ystem.nem_ctrls.dram.rank1.totalIdleTime 0
636:ystem.nem_ctrls.dram.rank1.pwrStateTime::IDLE 317347925250
637:ystem.nem_ctrls.dram.rank1.pwrStateTime::REF 109733000000

```

خروجی اجرا برنامه محک Quicksort.c بر روی پردازنده RISCV

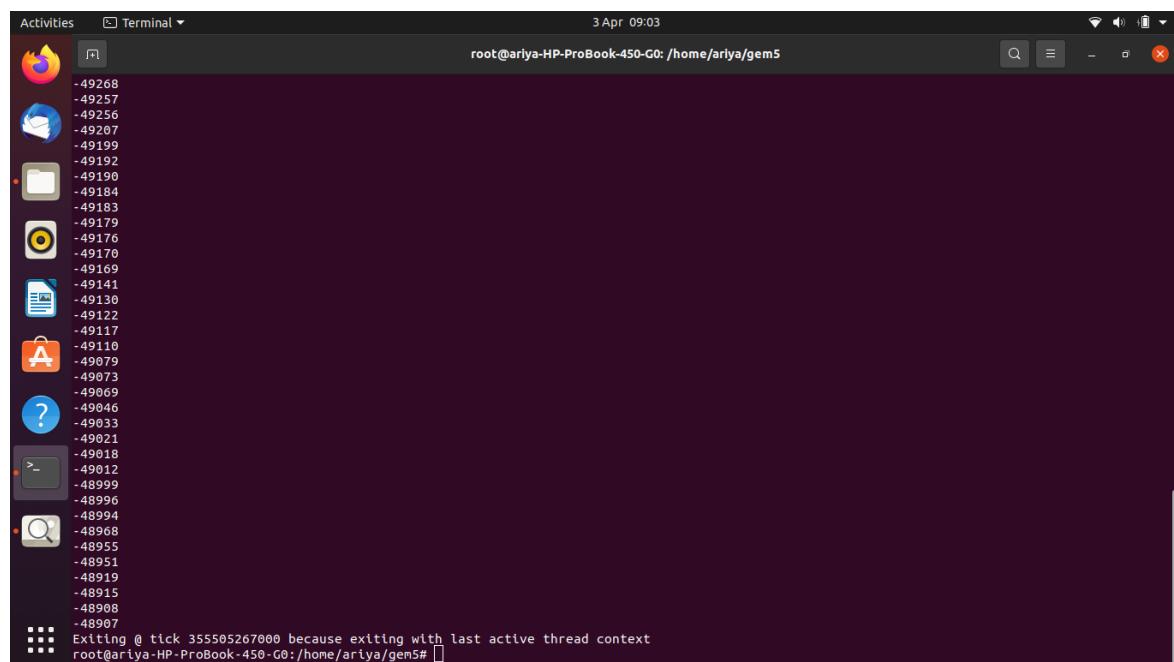


```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=TimingSimpleCPU --l1d_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 2 2023 09:52:02
gem5 started Apr 3 2023 08:47:04
gem5 executing on ariya-HP-ProBook-450-G0, pid 3324
command line: build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=TimingSimpleCPU --l1d_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/RISCV/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/RISCV/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/RISCV/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/RISCV/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)

-50000
-49999
-49997
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49817
-49814
```



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=TimingSimpleCPU --l1d_size=64kB --l1i_size=16kB --caches

-49268
-49257
-49256
-49207
-49199
-49192
-49190
-49184
-49183
-49179
-49176
-49170
-49169
-49141
-49138
-49122
-49117
-49110
-49079
-49073
-49069
-49046
-49033
-49021
-49018
-49012
-48999
-48996
-48994
-48968
-48955
-48951
-48919
-48915
-48908
-48907

Exiting @ tick 355505267000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5#
```

زمان اجرا برنامه محک Quicksort.c بر روی پردازنده RISCV

```

1
2 ----- Begin Simulation Statistics
3:iSeconds 0.355505 # Number of seconds simulated (Second)
4:iTicks 355505267000 # Number of ticks simulated (Tick)
5:iNalTick 355505267000 # Number of ticks from beginning of simulation (restored from
6:iFreq 1000000000000 # The number of ticks per simulated second ((Tick/Second))
7:iostSeconds 315.05 # Real time elapsed on the host (Second)
8:iostTickrate 1128417930 # The number of ticks simulated per host second (ticks/s)
9:iostMemory 636640 # Number of bytes of host memory used (Byte)
10:iInsts 206138907 # Number of instructions simulated (Count)
11:iMops 206139015 # Number of ops (including micro ops) simulated (Count)
12:iostInstRate 654310 # Simulator instruction rate (inst/s) ((Count/Second))
13:iostOPRate 654310 # Simulator op (including micro ops) rate (ops/s) ((Count/Second))
14:ystem.clk_domain.clock 1000
15:ystem.cpu.numCycles 711010534
16:ystem.cpu.numWorkItemsStarted 0
17:ystem.cpu.numWorkItemsCompleted 0
18:ystem.cpu.dcache.demandHits::cpu.data 102054002
19:ystem.cpu.dcache.demandHits::total 102054002
20:ystem.cpu.dcache.overallHits::cpu.data 102054002
21:ystem.cpu.dcache.overallHits::total 102054002
22:ystem.cpu.dcache.demandMisses::cpu.data 509
23:ystem.cpu.dcache.demandMisses::total 509
24:ystem.cpu.dcache.overallMisses::cpu.data 509
25:ystem.cpu.dcache.overallMisses::total 509
26:ystem.cpu.dcache.demandMissLatency::cpu.data 30750000
27:ystem.cpu.dcache.demandMissLatency::total 30750000
28:ystem.cpu.dcache.overallMissLatency::cpu.data 30750000
29:ystem.cpu.dcache.overallMissLatency::total 30750000
30:ystem.cpu.dcache.demandAccesses::cpu.data 102054511
31:ystem.cpu.dcache.demandAccesses::total 102054511

```

توان و انرژی مصرفی اجرا برنامه محک Quicksort.c بر روی پردازنده RISCV

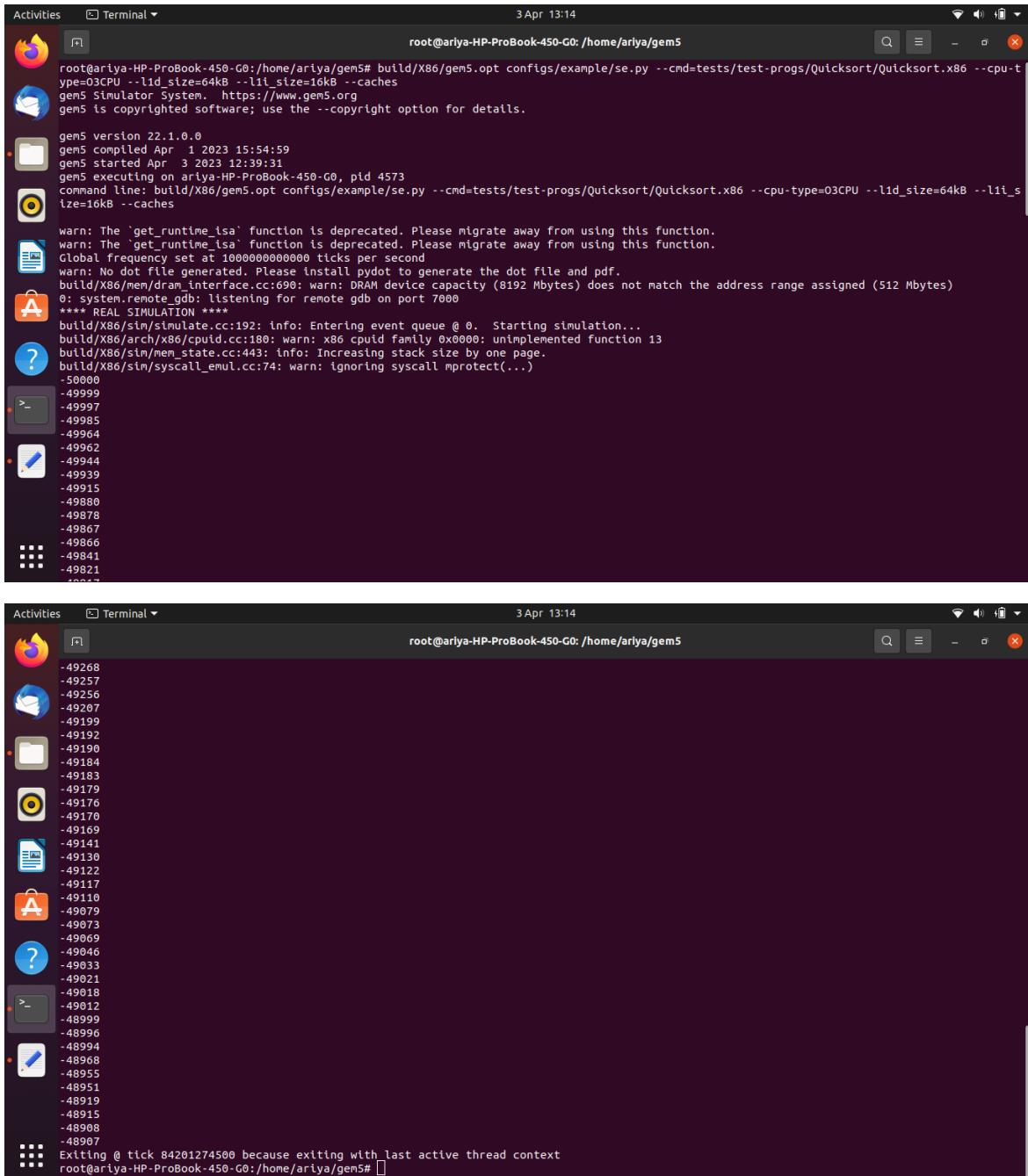
```

651:ystem.nem_ctrls.dram.rank0.actEnergy 985320
652:ystem.nem_ctrls.dram.rank0.preEnergy 519915
653:ystem.nem_ctrls.dram.rank0.readEnergy 3120180
654:ystem.nem_ctrls.dram.rank0.writeEnergy 271440
655:ystem.nem_ctrls.dram.rank0.refreshEnergy 28063233120.000004
656:ystem.nem_ctrls.dram.rank0.actBackgroundEnergy 5341939110
657:ystem.nem_ctrls.dram.rank0.preBackgroundEnergy 132015547680
658:ystem.nem_ctrls.dram.rank0.actPowerDownEnergy 0
659:ystem.nem_ctrls.dram.rank0.prePowerDownEnergy 0
660:ystem.nem_ctrls.dram.rank0.selfRefreshEnergy 0
661:ystem.nem_ctrls.dram.rank0.totalEnergy 165425616765
662:ystem.nem_ctrls.dram.rank0.averagePower 465.325361
663:ystem.nem_ctrls.dram.rank0.totalIdleTime 0
664:ystem.nem_ctrls.dram.rank0.pwrStateTime::IDLE 343161591750
665:ystem.nem_ctrls.dram.rank0.pwrStateTime::REF 11871080000
666:ystem.nem_ctrls.dram.rank0.pwrStateTime::SREF 0
667:ystem.nem_ctrls.dram.rank0.pwrStateTime::PRE_PDN 0
668:ystem.nem_ctrls.dram.rank0.pwrStateTime::ACT 472595250
669:ystem.nem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 0
670:ystem.nem_ctrls.dram.rank1.actEnergy 749700
671:ystem.nem_ctrls.dram.rank1.preEnergy 394680
672:ystem.nem_ctrls.dram.rank1.readEnergy 2748900
673:ystem.nem_ctrls.dram.rank1.writeEnergy 261000
674:ystem.nem_ctrls.dram.rank1.refreshEnergy 28063233120.000004
675:ystem.nem_ctrls.dram.rank1.actBackgroundEnergy 5226453120
676:ystem.nem_ctrls.dram.rank1.preBackgroundEnergy 132112799040
677:ystem.nem_ctrls.dram.rank1.actPowerDownEnergy 0
678:ystem.nem_ctrls.dram.rank1.prePowerDownEnergy 0
679:ystem.nem_ctrls.dram.rank1.selfRefreshEnergy 0
680:ystem.nem_ctrls.dram.rank1.totalEnergy 165406639560
681:ystem.nem_ctrls.dram.rank1.averagePower 465.271980
682:ystem.nem_ctrls.dram.rank1.totalIdleTime 0
683:ystem.nem_ctrls.dram.rank1.pwrStateTime::IDLE 34315455000
684:ystem.nem_ctrls.dram.rank1.pwrStateTime::REF 11871080000

```

:ب

خروجی اجرا اول برنامه محک Quicksort.c بر روی پردازنده X86



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 1 2023 15:54:59
gem5 started Apr 3 2023 12:39:31
gem5 executing on ariya-HP-ProBook-450-G0, pid 4573
command line: build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_isa' function is deprecated. Please migrate away from using this function.
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
Global frequency set at 100000000000 ticks per second
build/X86/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/X86/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/X86/arch/x86/cpuid.cc:180: warn: x86 cpuid family 0x0000: unimplemented function 13
build/X86/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/X86/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...
-50000
-49999
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49827

Activities Terminal 3 Apr 13:14 root@ariya-HP-ProBook-450-G0: /home/ariya/gem5#
```



```
-49268
-49257
-49256
-49207
-49199
-49192
-49190
-49184
-49183
-49179
-49176
-49170
-49169
-49141
-49130
-49122
-49117
-49110
-49079
-49073
-49069
-49046
-49033
-49021
-49018
-49012
-48999
-48996
-48994
-48968
-48955
-49951
-48919
-48915
-48908
-48907
Exiting @ tick 84201274500 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5#
```

زمان اجرا اول برنامه محک Quicksort.c بر روی پردازنده X86

```

Activities Text Editor 3 Apr 16:06
Open stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt
stats.txt -/Pictures/Step5/Step2/X86/1
1
2 ----- Begin Simulation Statistics -----
3 simSeconds 0.084201 # Number of seconds simulated (Second)
4 simTicks 84201274500 # Number of ticks simulated (Tick)
5 finalTick 84201274500 # Number of ticks from beginning of simulation (restored
from checkpoints and never reset) (Tick)
6 simFreq 10000000000000 # The number of ticks per simulated second ((Tick/Second))
7 hostSeconds 2054.67 # Real time elapsed on the host (Second)
8 hostTickrate 40980359 # The number of ticks simulated per host second (ticks/s)
((Tick/Second))
9 hostMemory 666544 # Number of bytes of host memory used (Byte)
10 simInstrs 172916971 # Number of instructions simulated (Count)
11 simOps 263412208 # Number of ops (including micro ops) simulated (Count)
12 hostInstRate 84158 # Simulator instruction rate (inst/s) ((Count/Second))
13 hostOpRate 128201 # Simulator op (including micro ops) rate (ops/s) ((Count/Second))
14 system.clk_domain.clock 1000 # Clock period in ticks (Tick)
15 system.cpu.numCycles 168402550 # Number of cpu cycles simulated (Cycle)
16 system.cpu.numWorkItemsStarted 0 # Number of work items this cpu started (Count)
17 system.cpu.numWorkItemsCompleted 0 # Number of work items this cpu completed (Count)
18 system.cpu.instsAdded (Count) 392789159 # Number of instructions added to the IQ (excludes non-spec)
19 system.cpu.nonSpecInstsAdded (Count) 1 # Number of non-speculative instructions added to the IQ
20 system.cpu.instsIssued 345472253 # Number of instructions issued (Count)
21 system.cpu.squashedInstsIssued 661189 # Number of squashed instructions issued (Count)
22 system.cpu.squashedInstsExamined 129376946 # Number of squashed instructions iterated over during
squash; mainly for profiling (Count)
23 system.cpu.squashedOperandsExamined 234142064 # Number of squashed operands that are examined and possibly
removed from graph (Count)
24 system.cpu.squashedNonSpecRemoved (Count) 1 # Number of squashed non-spec instructions that were removed
25 system.cpu.numIssuedDist:samples 168343127 # Number of insts issued each cycle (Count)
26 system.cpu.numIssuedDist:mean 2.052191 # Number of insts issued each cycle (Count)
27 system.cpu.numIssuedDist:stdev 1.501555 # Number of insts issued each cycle (Count)

```

Plain Text Tab Width: 8 Ln 212, Col 8 INS

توان و انرژی مصرفی اجرا اول برنامه محک Quicksort.c بر روی پردازنده X86

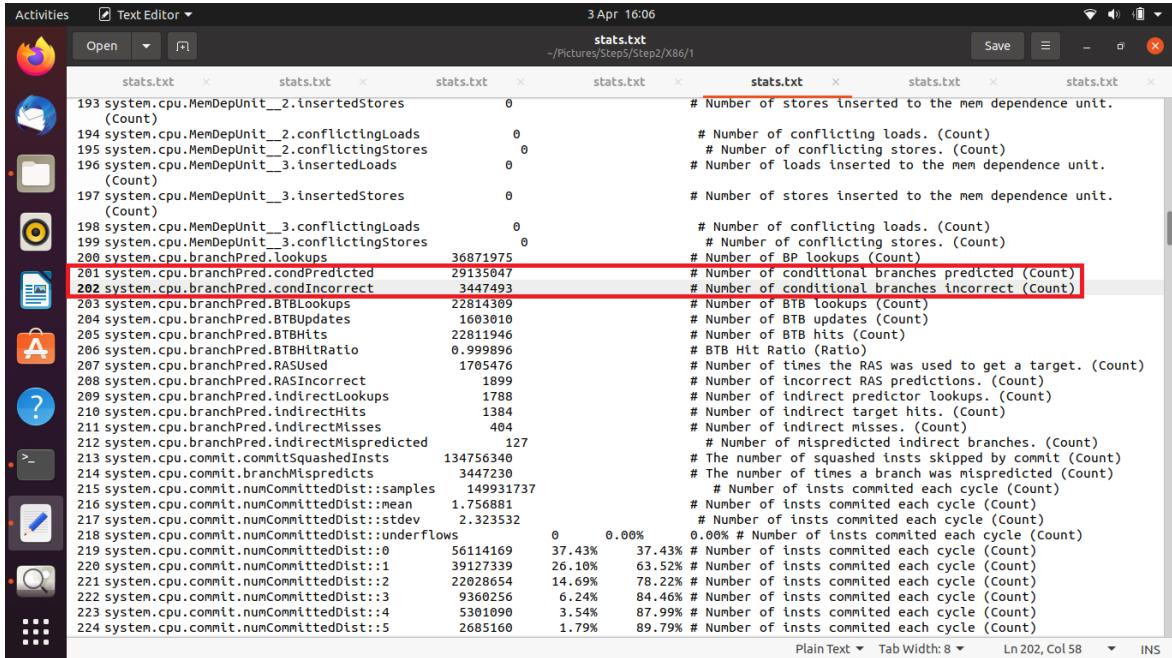
```

Activities Text Editor 3 Apr 16:07
Open stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt
stats.txt -/Pictures/Step5/Step2/X86/1
various power states (Tick)
934 system.mem_ctrls.dram.rank0.actEnergy 2570400 # Energy for activate commands per rank (pj) (Joule)
935 system.mem_ctrls.dram.rank0.preEnergy 1351020 # Energy for precharge commands per rank (pj) (Joule)
936 system.mem_ctrls.dram.rank0.readEnergy 5397840 # Energy for read commands per rank (pj) (Joule)
937 system.mem_ctrls.dram.rank0.writeEnergy 1367640 # Energy for write commands per rank (pj) (Joule)
938 system.mem_ctrls.dram.rank0.refreshEnergy 6646716960.000001 # Energy for refresh commands per rank (pj) (Joule)
939 system.mem_ctrls.dram.rank0.actBackEnergy 1462555590 # Energy for active background per rank (pj) (Joule)
940 system.mem_ctrls.dram.rank0.preBackEnergy 31101663840 # Energy for precharge background per rank (pj) (Joule)
941 system.mem_ctrls.dram.rank0.actPowerDownEnergy 0 # Energy for active power-down per rank (pj) (Joule)
942 system.mem_ctrls.dram.rank0.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pj) (Joule)
943 system.mem_ctrls.dram.rank0.selfRefreshEnergy 0 # Energy for self refresh per rank (pj) (Joule)
944 system.mem_ctrls.dram.rank0.totalEnergy 39221623290 # Total energy per rank (pj) (Joule)
945 system.mem_ctrls.dram.rank0.averagePower 465.807953 # Core power per rank (MW) (Watt)
946 system.mem_ctrls.dram.rank0.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
947 system.mem_ctrls.dram.rank0.pwrStateTime::IDLE 80843393500 # Time in different power states (Tick)
948 system.mem_ctrls.dram.rank0.pwrStateTime::REF 2811640000 # Time in different power states (Tick)
949 system.mem_ctrls.dram.rank0.pwrStateTime::SREF 0 # Time in different power states (Tick)
950 system.mem_ctrls.dram.rank0.pwrStateTime::PRE_PDN 0 # Time in different power states (Tick)
951 system.mem_ctrls.dram.rank0.pwrStateTime::ACT_546241000 # Time in different power states (Tick)
952 system.mem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 0 # Time in different power states (Tick)
953 system.mem_ctrls.dram.rank1.actEnergy 1742160 # Energy for activate commands per rank (pj) (Joule)
954 system.mem_ctrls.dram.rank1.preEnergy 910800 # Energy for precharge commands per rank (pj) (Joule)
955 system.mem_ctrls.dram.rank1.readEnergy 5147940 # Energy for read commands per rank (pj) (Joule)
956 system.mem_ctrls.dram.rank1.writeEnergy 1158840 # Energy for write commands per rank (pj) (Joule)
957 system.mem_ctrls.dram.rank1.refreshEnergy 6646716960.000001 # Energy for refresh commands per rank (pj) (Joule)
958 system.mem_ctrls.dram.rank1.actBackEnergy 1273555560 # Energy for active background per rank (pj) (Joule)
959 system.mem_ctrls.dram.rank1.preBackEnergy 31260821760 # Energy for precharge background per rank (pj) (Joule)
960 system.mem_ctrls.dram.rank1.actPowerDownEnergy 0 # Energy for active power-down per rank (pj) (Joule)
961 system.mem_ctrls.dram.rank1.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pj) (Joule)
962 system.mem_ctrls.dram.rank1.selfRefreshEnergy 0 # Energy for self refresh per rank (pj) (Joule)
963 system.mem_ctrls.dram.rank1.totalEnergy 39190054020 # Total energy per rank (pj) (Joule)
964 system.mem_ctrls.dram.rank1.averagePower 465.433026 # Core power per rank (MW) (Watt)
965 system.mem_ctrls.dram.rank1.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
966 system.mem_ctrls.dram.rank1.pwrStateTime::IDLE 81259290500 # Time in different power states (Tick)
967 system.mem_ctrls.dram.rank1.pwrStateTime::REF 2811640000 # Time in different power states (Tick)

```

Plain Text Tab Width: 8 Ln 967, Col 121 INS

تعداد Incorrect Branch Predictions در اجرا اول برنامه محک X86 بر روی پردازنده Quicksort.c



```

Activities  Text Editor  3 Apr 16:06
          Open  Save  -  X
          stats.txt  stats.txt  stats.txt  stats.txt  stats.txt  stats.txt  stats.txt  stats.txt
          -/Pictures/Step5/Step2/X86/1
          stats.txt  stats.txt  stats.txt  stats.txt  stats.txt  stats.txt  stats.txt  stats.txt
          # Number of stores inserted to the mem dependence unit.
193 system.cpu.MemDepUnit__2.insertedStores 0
          # Number of conflicting loads. (Count)
194 system.cpu.MemDepUnit__2.conflictingLoads 0
          # Number of conflicting stores. (Count)
195 system.cpu.MemDepUnit__2.conflictingStores 0
          # Number of loads inserted to the mem dependence unit.
196 system.cpu.MemDepUnit__3.insertedLoads
          (Count) 0
          # Number of stores inserted to the men dependence unit.
197 system.cpu.MemDepUnit__3.insertedStores
          (Count) 0
          # Number of conflicting loads. (Count)
198 system.cpu.MemDepUnit__3.conflictingLoads 0
          # Number of conflicting stores. (Count)
199 system.cpu.MemDepUnit__3.conflictingStores 0
          # Number of BP lookups. (Count)
200 system.cpu.branchPred.lookups 36871975
          # Number of conditional branches predicted (Count)
201 system.cpu.branchPred.condPredicted 29135047
          # Number of conditional branches incorrect (Count)
202 system.cpu.branchPred.condIncorrect 3447493
          # Number of BTB lookups (Count)
203 system.cpu.branchPred.BTBUpdates 1603010
          # Number of BTB updates (Count)
204 system.cpu.branchPred.BTBHits 22811946
          # Number of BTB hits (Count)
205 system.cpu.branchPred.BTBHTRatio 0.999896
          # BTB Hit Ratio (Ratio)
207 system.cpu.branchPred.RASUsed 1705476
          # Number of times the RAS was used to get a target. (Count)
208 system.cpu.branchPred.RASIncorrect 1899
          # Number of incorrect RAS predictions. (Count)
209 system.cpu.branchPred.indirectLookups 1788
          # Number of indirect predictor lookups. (Count)
210 system.cpu.branchPred.indirectHits 1384
          # Number of indirect target hits. (Count)
211 system.cpu.branchPred.indirectMisses 464
          # Number of indirect misses. (Count)
212 system.cpu.branchPred.indirectMispredicted 127
          # Number of mispredicted indirect branches. (Count)
213 system.cpu.commit.commitsSquashedInsts 134756340
          # The number of squashed insts skipped by commit (Count)
214 system.cpu.commit.branchMispredicts 3447230
          # The number of times a branch was mispredicted (Count)
215 system.cpu.commit.numCommittedDist::samples 149931737
          # Number of insts committed each cycle (Count)
216 system.cpu.commit.numCommittedDist::mean 1.756881
          # Number of insts committed each cycle (Count)
217 system.cpu.commit.numCommittedDist::stdev 2.323532
          # Number of insts committed each cycle (Count)
218 system.cpu.commit.numCommittedDist::underflows 0 0.00%
          0.00% # Number of insts committed each cycle (Count)
219 system.cpu.commit.numCommittedDist::0 56114169 37.43% 37.43% # Number of insts committed each cycle (Count)
220 system.cpu.commit.numCommittedDist::1 39127339 26.10% 63.52% # Number of insts committed each cycle (Count)
221 system.cpu.commit.numCommittedDist::2 22028654 14.69% 78.22% # Number of insts committed each cycle (Count)
222 system.cpu.commit.numCommittedDist::3 9360256 6.24% 84.46% # Number of insts committed each cycle (Count)
223 system.cpu.commit.numCommittedDist::4 5301090 3.54% 87.99% # Number of insts committed each cycle (Count)
224 system.cpu.commit.numCommittedDist::5 2685160 1.79% 89.79% # Number of insts committed each cycle (Count)

```

PlainText Tab Width: 8 Ln 202, Col 58 INS

خروجی اجرا دوم برنامه محک Quicksort.c بر روی پردازنده X86

```
Activities Terminal 3 Apr 12:34
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5# build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=O3CPU --lid_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 1 2023 15:54:59
gem5 started Apr 3 2023 11:56:05
gem5 executing on ariya-HP-ProBook-450-G0, pid 4323
command line: build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=O3CPU --lid_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_tsa' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_tsa' function is deprecated. Please migrate away from using this function.
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/X86/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/X86/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/X86/arch/x86/cpuid.cc:180: warn: x86 cpuid family 0x0000: unimplemented function 13
build/X86/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/X86/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)

-50000
-49999
-49997
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49827

Activities Terminal 3 Apr 12:34
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

```
-49268
-49257
-49256
-49207
-49199
-49192
-49190
-49184
-49183
-49179
-49176
-49170
-49169
-49141
-49138
-49122
-49117
-49110
-49079
-49073
-49069
-49046
-49033
-49021
-49018
-49012
-48999
-48996
-48994
-48968
-48955
-48951
-48919
-48915
-48908
-48907
Exiting @ tick 88169311000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

زمان اجرا دوم برنامه محک Quicksort.c بر روی پردازنده X86

```

Activities Text Editor
Open stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt
3 Apr 16:08
stats.txt -/Pictures/Step5/Step2/X86/2
Save - x
----- Begin Simulation Statistics -----
1
2 ----- Begin Simulation Statistics -----
3 simSeconds 0.088169 # Number of seconds simulated (Second)
4 simTicks 88169311000 # Number of ticks simulated (Tick)
5 finalTick 88169311000 # Number of ticks from beginning of simulation (restored
from checkpoints and never reset) (Tick)
6 simFreq 1000000000000 # The number of ticks per simulated second ((Tick/Second))
7 hostSeconds 2295.75 # Real time elapsed on the host (Second)
8 hostTickrate 38405525 # The number of ticks simulated per host second (ticks/s)
((Tick/Second))
9 hostMemory 666544 # Number of bytes of host memory used (Byte)
10 simInsts 172916971 # Number of instructions simulated (Count)
11 simOps 263412208 # Number of ops (including micro ops) simulated (Count)
12 hostInstRate 75321 # Simulator instruction rate (inst/s) ((Count/Second))
13 hostOpRate 114739 # Simulator op (including micro ops) rate (ops/s) ((Count/-
Second))
14 system.clk_domain.clock 1000 # Clock period in ticks (Tick)
15 system.cpu.numCycles 176338623 # Number of cpu cycles simulated (Cycle)
16 system.cpu.numWorkItemsStarted 0 # Number of work items this cpu started (Count)
17 system.cpu.numWorkItemsCompleted 0 # Number of work items this cpu completed (Count)
18 system.cpu.instsAdded (Count) 518063133 # Number of instructions added to the IQ (excludes non-spec)
19 system.cpu.nonSpecInstsAdded (Count) 7 # Number of non-speculative instructions added to the IQ
20 system.cpu.instsIssued 391453314 # Number of instructions issued (Count)
21 system.cpu.squashedInstsIssued 207950 # Number of squashed instructions issued (Count)
22 system.cpu.squashedInstsExamined 254650926 # Number of squashed instructions iterated over during
squash; mainly for profiling (Count)
23 system.cpu.squashedOperandsExamined 580831158 # Number of squashed operands that are examined and possibly
removed from graph (Count)
24 system.cpu.squashedNonSpecRemoved (Count) 7 # Number of squashed non-spec instructions that were removed
25 system.cpu.numIssuedDist::samples 176271985 # Number of insts issued each cycle (Count)
26 system.cpu.numIssuedDist::mean 2.220735 # Number of insts issued each cycle (Count)
27 system.cpu.numIssuedDist::stdev 2.005165 # Number of insts issued each cycle (Count)

Plain Text Tab Width: 8 Ln 967, Col 138 INS

```

توان و انرژی مصرفی اجرا دوم برنامه محک Quicksort.c بر روی پردازنده X86

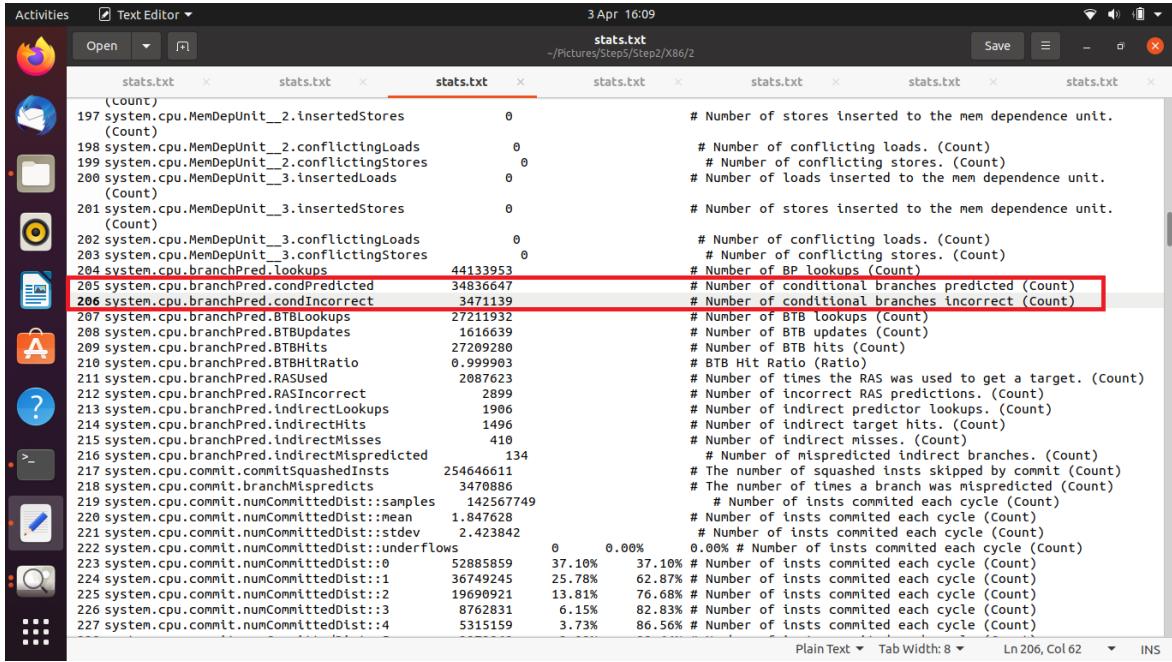
```

Activities Text Editor
Open stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt
3 Apr 16:09
stats.txt -/Pictures/Step5/Step2/X86/2
Save - x
940 system.mem_ctrls.dram.rank0.actEnergy 2578400 # Energy for activate commands per rank (pJ) (Joule)
941 system.mem_ctrls.dram.rank0.preEnergy 1351020 # Energy for precharge commands per rank (pJ) (Joule)
942 system.mem_ctrls.dram.rank0.readEnergy 5419260 # Energy for read commands per rank (pJ) (Joule)
943 system.mem_ctrls.dram.rank0.writeEnergy 1320660 # Energy for write commands per rank (pJ) (Joule)
944 system.mem_ctrls.dram.rank0.refreshEnergy 6959568720.000001 # Energy for refresh commands per rank (pJ) (Joule)
945 system.mem_ctrls.dram.rank0.actBackEnergy 1518672090 # Energy for active background per rank (pJ) (Joule)
946 system.mem_ctrls.dram.rank0.preBackEnergy 32578133760 # Energy for precharge background per rank (pJ) (Joule)
947 system.mem_ctrls.dram.rank0.actPowerDownEnergy 0 # Energy for active power-down per rank (pJ) (Joule)
948 system.mem_ctrls.dram.rank0.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pJ) (Joule)
949 system.mem_ctrls.dram.rank0.selfRefreshEnergy 0 # Energy for self refresh per rank (pJ) (Joule)
950 system.mem_ctrls.dram.rank0.totalEnergy 41067035910 # Total energy per rank (pJ) (Joule)
951 system.mem_ctrls.dram.rank0.averagePower 465.774717 # Core power per rank (mW) (Watt)
952 system.mem_ctrls.dram.rank0.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
953 system.mem_ctrls.dram.rank0.pwrStateTime::IDLE 84681347000 # Time in different power states (Tick)
954 system.mem_ctrls.dram.rank0.pwrStateTime::REF 29439800000 # Time in different power states (Tick)
955 system.mem_ctrls.dram.rank0.pwrStateTime::SREF 0 # Time in different power states (Tick)
956 system.mem_ctrls.dram.rank0.pwrStateTime::PRE_PDN 0 # Time in different power states (Tick)
957 system.mem_ctrls.dram.rank0.pwrStateTime::ACT 543984000 # Time in different power states (Tick)
958 system.mem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 0 # Time in different power states (Tick)
959 system.mem_ctrls.dram.rank1.actEnergy 1635060 # Energy for activate commands per rank (pJ) (Joule)
960 system.mem_ctrls.dram.rank1.preEnergy 842490 # Energy for precharge commands per rank (pJ) (Joule)
961 system.mem_ctrls.dram.rank1.readEnergy 5112240 # Energy for read commands per rank (pJ) (Joule)
962 system.mem_ctrls.dram.rank1.writeEnergy 1059660 # Energy for write commands per rank (pJ) (Joule)
963 system.mem_ctrls.dram.rank1.refreshEnergy 6959568720.000001 # Energy for refresh commands per rank (pJ) (Joule)
964 system.mem_ctrls.dram.rank1.actBackEnergy 1329963330 # Energy for active background per rank (pJ) (Joule)
965 system.mem_ctrls.dram.rank1.preBackEnergy 32737046400 # Energy for precharge background per rank (pJ) (Joule)
966 system.mem_ctrls.dram.rank1.actPowerDownEnergy 0 # Energy for active power-down per rank (pJ) (Joule)
967 system.mem_ctrls.dram.rank1.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pJ) (Joule)
968 system.mem_ctrls.dram.rank1.selfRefreshEnergy 0 # Energy for self refresh per rank (pJ) (Joule)
969 system.mem_ctrls.dram.rank1.totalEnergy 41035227900 # Total energy per rank (pJ) (Joule)
970 system.mem_ctrls.dram.rank1.averagePower 465.413957 # Core power per rank (mW) (Watt)
971 system.mem_ctrls.dram.rank1.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
972 system.mem_ctrls.dram.rank1.pwrStateTime::IDLE 85096622250 # Time in different power states (Tick)
973 system.mem_ctrls.dram.rank1.pwrStateTime::REF 2943980000 # Time in different power states (Tick)
974 system.mem_ctrls.dram.rank1.pwrStateTime::SREF 0 # Time in different power states (Tick)

Bracket match found on line 974
Plain Text Tab Width: 8 Ln 974, Col 122 INS

```

تعداد Incorrect Branch Predictions در اجرا دوم برنامه محک Quicksort.c بر روی پردازنده X86



The screenshot shows a terminal window with multiple tabs open, all titled "stats.txt". The active tab is highlighted in red and displays the following data:

System.CPU.MemDepUnit_2.InsertedStores	0	# Number of stores inserted to the mem dependence unit.
System.CPU.MemDepUnit_2.ConflictingLoads	0	# Number of conflicting loads. (Count)
System.CPU.MemDepUnit_2.ConflictingStores	0	# Number of conflicting stores. (Count)
System.CPU.MemDepUnit_3.InsertedLoads	0	# Number of loads inserted to the mem dependence unit.
System.CPU.MemDepUnit_3.InsertedStores	0	# Number of stores inserted to the mem dependence unit.
System.CPU.MemDepUnit_3.ConflictingLoads	0	# Number of conflicting loads. (Count)
System.CPU.MemDepUnit_3.ConflictingStores	0	# Number of conflicting stores. (Count)
System.CPU.BranchPred.Lookups	44133953	# Number of BP lookups. (Count)
System.CPU.BranchPred.CondPredicted	34836647	# Number of conditional branches predicted (Count)
System.CPU.BranchPred.CondIncorrect	3471139	# Number of conditional branches incorrect (Count)
System.CPU.BranchPred.BTBLookups	27211932	# Number of BTB lookups (Count)
System.CPU.BranchPred.BTBUpdates	1616639	# Number of BTB updates (Count)
System.CPU.BranchPred.BTBHits	27209280	# Number of BTB hits (Count)
System.CPU.BranchPred.BTBHitRatio	0.999903	# BTB Hit Ratio (Ratio)
System.CPU.BranchPred.RASUsed	2087623	# Number of times the RAS was used to get a target. (Count)
System.CPU.BranchPred.RASIncorrect	2899	# Number of incorrect RAS predictions. (Count)
System.CPU.BranchPred.IndirectLookups	1906	# Number of indirect predictor lookups. (Count)
System.CPU.BranchPred.IndirectHits	1496	# Number of indirect target hits. (Count)
System.CPU.BranchPred.IndirectMisses	410	# Number of indirect misses. (Count)
System.CPU.BranchPred.IndirectMispredicted	134	# Number of mispredicted indirect branches. (Count)
System.CPU.Commit.CommitSquashedInsts	254646611	# The number of squashed insts skipped by commit (Count)
System.CPU.Commit.BranchHitsPredicts	3470886	# The number of times a branch was mispredicted (count)
System.CPU.Commit.NumCommittedDist::Samples	142567749	# Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::Mean	1.847628	# Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::StDev	2.423842	# Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::Underflows	0 0.00%	0.00% # Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::0	52885859	37.10% # Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::1	36749245	25.78% 62.87% # Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::2	19690921	13.81% 76.68% # Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::3	8762831	6.15% 82.83% # Number of insts committed each cycle (Count)
System.CPU.Commit.NumCommittedDist::4	5315159	3.73% 86.56% # Number of insts committed each cycle (Count)

خروجی اجرا سوم برنامه محک Quicksort.c بر روی پردازنده X86

```
Activities Terminal 3 Apr 14:01
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5$ build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=O3CPU --lid_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 1 2023 15:54:59
gem5 started Apr 3 2023 13:23:17
gem5 executing on ariya-HP-ProBook-450-G0, pid 4860
command line: build/X86/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort.x86 --cpu-type=O3CPU --lid_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_tsa' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_tsa' function is deprecated. Please migrate away from using this function.
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/X86/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/X86/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/X86/arch/x86/cpuid.cc:180: warn: x86 cpuid family 0x0000: unimplemented function 13
build/X86/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/X86/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)

-50000
-49999
-49997
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49827

Activities Terminal 3 Apr 14:01
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5$
```

```
-49268
-49257
-49256
-49207
-49199
-49192
-49190
-49184
-49183
-49179
-49176
-49170
-49169
-49141
-49138
-49122
-49117
-49110
-49079
-49073
-49069
-49046
-49033
-49021
-49018
-49012
-48999
-48996
-48994
-48968
-48955
-48951
-48919
-48915
-48908
-48907
Exiting @ tick 87977376000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5$
```

زمان اجرا سوم برنامه محک بر روی پردازنده X86

```

1 ----- Begin Simulation Statistics -----
2 simSeconds          0.087977 # Number of seconds simulated (Second)
3 simTicks            87977376000 # Number of ticks simulated (Tick)
4 finalTick           87977376000 # Number of ticks from beginning of simulation (restored
from checkpoints and never reset) (Tick)
5 simFreq             10000000000000 # The number of ticks per simulated second ((Tick/Second))
6 hostSeconds         2257.88 # Real time elapsed on the host (Second)
7 hostTickrate        3894530 # The number of ticks simulated per host second (ticks/s)
8 ((Tick/Second))
9 hostMemory          666544 # Number of bytes of host memory used (Byte)
10 simInsts           172916971 # Number of instructions simulated (Count)
11 simOps             263412208 # Number of ops (including micro ops) simulated (Count)
12 hostInstRate       76584 # Simulator instruction rate (inst/s) ((Count/Second))
13 hostOpRate         116663 # Simulator op (including micro ops) rate (ops/s) ((Count/-
Second))
14 system.clk_domain.clock      1000 # Clock period in ticks (Tick)
15 system.cpu.numCycles        175954753 # Number of cpu cycles simulated (Cycle)
16 system.cpu.numWorkItemsStarted 0 # Number of work items this cpu started (Count)
17 system.cpu.numWorkItemsCompleted 0 # Number of work items this cpu completed (Count)
18 system.cpu.instsAdded      520382109 # Number of Instructions added to the IQ (excludes non-spec)
(count)
19 system.cpu.nonSpecInstsAdded 7 # Number of non-speculative instructions added to the IQ
(count)
20 system.cpu.instsIssued     392180644 # Number of instructions issued (Count)
21 system.cpu.squashedInstsIssued 204433 # Number of squashed instructions issued (Count)
22 system.cpu.squashedInstsExamined 256969902 # Number of squashed instructions iterated over during
squash; mainly for profiling (Count)
23 system.cpu.squashedOperandsExamined 586990991 # Number of squashed operands that are examined and possibly
removed from graph (Count)
24 system.cpu.squashedNonSpecRemoved 7 # Number of squashed non-spec instructions that were removed
(count)
25 system.cpu.numIssuedDist::samples 175890570 # Number of insts issued each cycle (Count)
26 system.cpu.numIssuedDist::mean 2.229685 # Number of insts issued each cycle (Count)
27 system.cpu.numIssuedDist::stdev 2.028779 # Number of insts issued each cycle (Count)

```

توان و انرژی مصرفی اجرا سوم برنامه محک بر روی پردازنده X86

```

945 system.mem_ctrls.dram.rank0.actEnergy    2577540 # Energy for activate commands per rank (p3) (Joule)
946 system.mem_ctrls.dram.rank0.preEnergy   1369955 # Energy for precharge commands per rank (p3) (Joule)
947 system.mem_ctrls.dram.rank0.readEnergy  5562660 # Energy for read commands per rank (p3) (Joule)
948 system.mem_ctrls.dram.rank0.writeEnergy 1362420 # Energy for write commands per rank (p3) (Joule)
949 system.mem_ctrls.dram.rank0.refreshEnergy 6944817360.000001 # Energy for refresh commands per rank (p3) (Joule)
950 system.mem_ctrls.dram.rank0.actBackEnergy 1515392880 # Energy for active background per rank (p3) (Joule)
951 system.mem_ctrls.dram.rank0.preBackEnergy 32507192160 # Energy for precharge background per rank (p3) (Joule)
952 system.mem_ctrls.dram.rank0.actPowerDownEnergy 0 # Energy for active power-down per rank (p3) (Joule)
953 system.mem_ctrls.dram.rank0.prePowerDownEnergy 0 # Energy for precharge power-down per rank (p3) (Joule)
954 system.mem_ctrls.dram.rank0.selfRefreshEnergy 0 # Energy for self refresh per rank (p3) (Joule)
955 system.mem_ctrls.dram.rank0.totalEnergy 40978274415 # Total energy per rank (p3) (Joule)
956 system.mem_ctrls.dram.rank0.averagePower 465.781958 # Core power per rank (mW) (Watt)
957 system.mem_ctrls.dram.rank0.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
958 system.mem_ctrls.dram.rank0.pwrStateTime::IDLE 84496987750 # Time in different power states (Tick)
959 system.mem_ctrls.dram.rank0.pwrStateTime::REF 2937740000 # Time in different power states (Tick)
960 system.mem_ctrls.dram.rank0.pwrStateTime::SREF 0 # Time in different power states (Tick)
961 system.mem_ctrls.dram.rank0.pwrStateTime::PRE_PDN 0 # Time in different power states (Tick)
962 system.mem_ctrls.dram.rank0.pwrStateTime::ACT 542648250 # Time in different power states (Tick)
963 system.mem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 0 # Time in different power states (Tick)
964 system.mem_ctrls.dram.rank1.actEnergy 1685040 # Energy for activate commands per rank (p3) (Joule)
965 system.mem_ctrls.dram.rank1.preEnergy 884235 # Energy for precharge commands per rank (p3) (Joule)
966 system.mem_ctrls.dram.rank1.readEnergy 5269320 # Energy for read commands per rank (p3) (Joule)
967 system.mem_ctrls.dram.rank1.writeEnergy 1247580 # Energy for write commands per rank (p3) (Joule)
968 system.mem_ctrls.dram.rank1.refreshEnergy 6944817360.000001 # Energy for refresh commands per rank (p3) (Joule)
969 system.mem_ctrls.dram.rank1.actBackEnergy 1325206110 # Energy for active background per rank (p3) (Joule)
970 system.mem_ctrls.dram.rank1.preBackEnergy 32667349440 # Energy for precharge background per rank (p3) (Joule)
971 system.mem_ctrls.dram.rank1.actPowerDownEnergy 0 # Energy for active power-down per rank (p3) (Joule)
972 system.mem_ctrls.dram.rank1.prePowerDownEnergy 0 # Energy for precharge power-down per rank (p3) (Joule)
973 system.mem_ctrls.dram.rank1.selfRefreshEnergy 0 # Energy for self refresh per rank (p3) (Joule)
974 system.mem_ctrls.dram.rank1.totalEnergy 40946459085 # Total energy per rank (p3) (Joule)
975 system.mem_ctrls.dram.rank1.averagePower 465.420327 # Core power per rank (mW) (Watt)
976 system.mem_ctrls.dram.rank1.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
977 system.mem_ctrls.dram.rank1.pwrStateTime::IDLE 84915454500 # Time in different power states (Tick)
978 system.mem_ctrls.dram.rank1.pwrStateTime::REF 2937740000 # Time in different power states (Tick)
979 system.mem_ctrls.dram.rank1.pwrStateTime::SREF 0 # Time in different power states (Tick)

```

تعداد Incorrect Branch Predictions در اجرا سوم برنامه محک Quicksort.c بر روی پردازنده X86:

Activities Text Editor 3 Apr 16:11

stats.txt -/Pictures/Step5/Step2/X86/3 Save

194	system.cpu.MemDepUnit__0.conflictingLoads	105481948		# Number of conflicting loads. (Count)				
195	system.cpu.MemDepUnit__0.conflictingStores	22827973		# Number of conflicting stores. (Count)				
196	system.cpu.MemDepUnit__1.insertedLoads (Count)	0		# Number of loads inserted to the mem dependence unit.				
197	system.cpu.MemDepUnit__1.insertedStores (Count)	0		# Number of stores inserted to the mem dependence unit.				
198	system.cpu.MemDepUnit__1.conflictingLoads	0		# Number of conflicting loads. (Count)				
199	system.cpu.MemDepUnit__1.conflictingStores	0		# Number of conflicting stores. (Count)				
200	system.cpu.MemDepUnit__2.insertedLoads (Count)	0		# Number of loads inserted to the mem dependence unit.				
201	system.cpu.MemDepUnit__2.insertedStores (Count)	0		# Number of stores inserted to the mem dependence unit.				
202	system.cpu.MemDepUnit__2.conflictingLoads	0		# Number of conflicting loads. (Count)				
203	system.cpu.MemDepUnit__2.conflictingStores	0		# Number of conflicting stores. (Count)				
204	system.cpu.MemDepUnit__3.insertedLoads (Count)	0		# Number of loads inserted to the mem dependence unit.				
205	system.cpu.MemDepUnit__3.insertedStores (Count)	0		# Number of stores inserted to the mem dependence unit.				
206	system.cpu.MemDepUnit__3.conflictingLoads	0		# Number of conflicting loads. (Count)				
207	system.cpu.MemDepUnit__3.conflictingStores	0		# Number of conflicting stores. (Count)				
208	system.cpu.branchPred.lookups	45356375		# Number of BP lookups (Count)				
209	system.cpu.branchPred.condPredicted	35889347		# Number of conditional branches predicted (Count)				
210	system.cpu.branchPred.condIncorrect	3471893		# Number of conditional branches incorrect (Count)				
211	system.cpu.branchPred.BTBLookups	27856606		# Number of BTB lookups (Count)				
212	system.cpu.branchPred.BTBUpdates	1617355		# Number of BTB updates (Count)				
213	system.cpu.branchPred.BTBHits	27854016		# Number of BTB hits (Count)				
214	system.cpu.branchPred.BTBHitRatio	0.999987		# BTB Hit Ratio (Ratio)				
215	system.cpu.branchPred.RASUsed	2124144		# Number of times the RAS was used to get a target. (Count)				
216	system.cpu.branchPred.RASIncorrect	2840		# Number of incorrect RAS predictions. (Count)				
217	system.cpu.branchPred.IndirectLookups	2066		# Number of indirect predictor lookups. (Count)				
218	system.cpu.branchPred.IndirectHits	1593		# Number of indirect target hits. (Count)				
219	system.cpu.branchPred.IndirectMisses	467		# Number of indirect misses. (Count)				
220	system.cpu.branchPred.IndirectMispredicted	138		# Number of mispredicted indirect branches. (Count)				
221	system.cpu.commit.commitSquashedInsts	256964314		# The number of squashed insts skipped by commit (Count)				
222	system.cpu.commit.branchMispredicts	3471636		# The number of times a branch was mispredicted (Count)				

خروجی اجرا اول برنامه محک Quicksort.c بر روی پردازنده RISCV

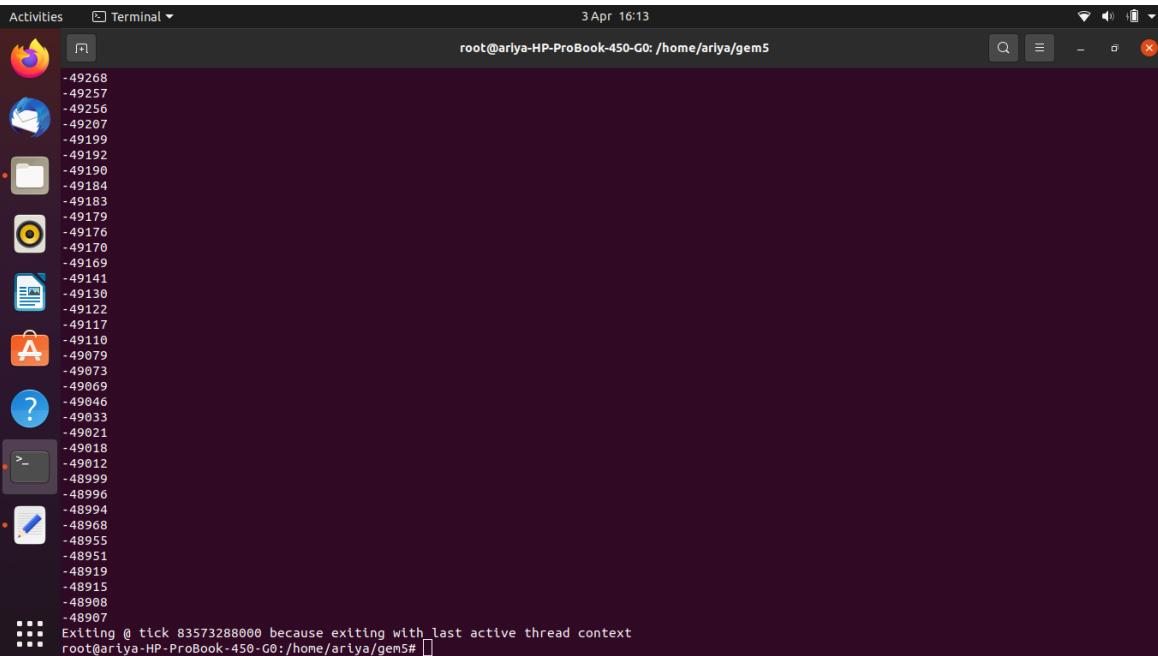


```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 2 2023 09:52:23
gem5 started Apr 3 2023 15:34:23
gem5 executing on ariya-HP-ProBook-450-G0, pid 6036
command line: build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/RISCV/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/RISCV/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/RISCV/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/RISCV/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)

-50000
-49999
-49997
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49817
-49814
```



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# -49268
-49257
-49256
-49207
-49199
-49192
-49190
-49184
-49183
-49179
-49176
-49170
-49169
-49141
-49138
-49122
-49117
-49110
-49079
-49073
-49069
-49046
-49033
-49021
-49018
-49012
-48999
-48996
-48994
-48968
-48955
-48951
-48919
-48915
-48908
-48907
Exiting @ tick 83573288000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

زمان اجرا اول برنامه محک Quicksort.c بر روی پردازنده RISC-V

```

Activities Text Editor 3 Apr 16:14
stats.txt -/Pictures/Step5/Step2/Riscv/1 Save
Open
----- Begin Simulation Statistics -----
1 simSeconds 0.083573 # Number of seconds simulated (Second)
2 simTicks 83573288000 # Number of ticks simulated (Tick)
3 finalTick 83573288000 # Number of ticks from beginning of simulation (restored
from checkpoints and never reset) (Tick)
4 simFreq 1000000000000 # The number of ticks per simulated second ((Tick/Second))
5 hostSeconds 1833.45 # Real time elapsed on the host (Second)
6 hostTickrate 45582430 # The number of ticks simulated per host second (ticks/s)
7 hostMemory 642280 # Number of bytes of host memory used (Byte)
8 simInstrs 206138907 # Number of instructions simulated (Count)
9 simOps 206139015 # Number of ops (including micro ops) simulated (Count)
10 hostInstRate 112432 # Simulator instruction rate (inst/s) ((Count/Second))
11 hostOpRate 112432 # Simulator op (including micro ops) rate (ops/s) ((Count/Second))
12 system.clk_domain.clock 1000 # Clock period in ticks (Tick)
13 system.cpu.numCycles 167146577 # Number of cpu cycles simulated (Cycle)
14 system.cpu.numWorkItemsStarted 0 # Number of work items this cpu started (Count)
15 system.cpu.numWorkItemsCompleted 0 # Number of work items this cpu completed (Count)
16 system.cpu.instsAdded 323187093 # Number of instructions added to the IQ (excludes non-spec)
17 system.cpu.nonSpecInstsAdded 563 # Number of non-speculative instructions added to the IQ
18 system.cpu.instsIssued 270945645 # Number of instructions issued (Count)
19 system.cpu.squashedInstsIssued 1035142 # Number of squashed instructions issued (Count)
20 system.cpu.squashedInstsExamined 117048640 # Number of squashed instructions iterated over during
squash; mainly for profiling (Count)
21 system.cpu.squashedOperandsExamined 83386633 # Number of squashed operands that are examined and possibly
removed from graph (Count)
22 system.cpu.squashedNonSpecRemoved 20 # Number of squashed non-spec instructions that were removed
(Count)
23 system.cpu.numIssuedDist:samples 167115654 # Number of insts issued each cycle (Count)
24 system.cpu.numIssuedDist:mean 1.621386 # Number of insts issued each cycle (Count)
25 system.cpu.numIssuedDist:stdev 1.423946 # Number of insts issued each cycle (Count)

```

توان و انرژی مصرفی اجرا اول برنامه محک Quicksort.c بر روی پردازنده RISC-V

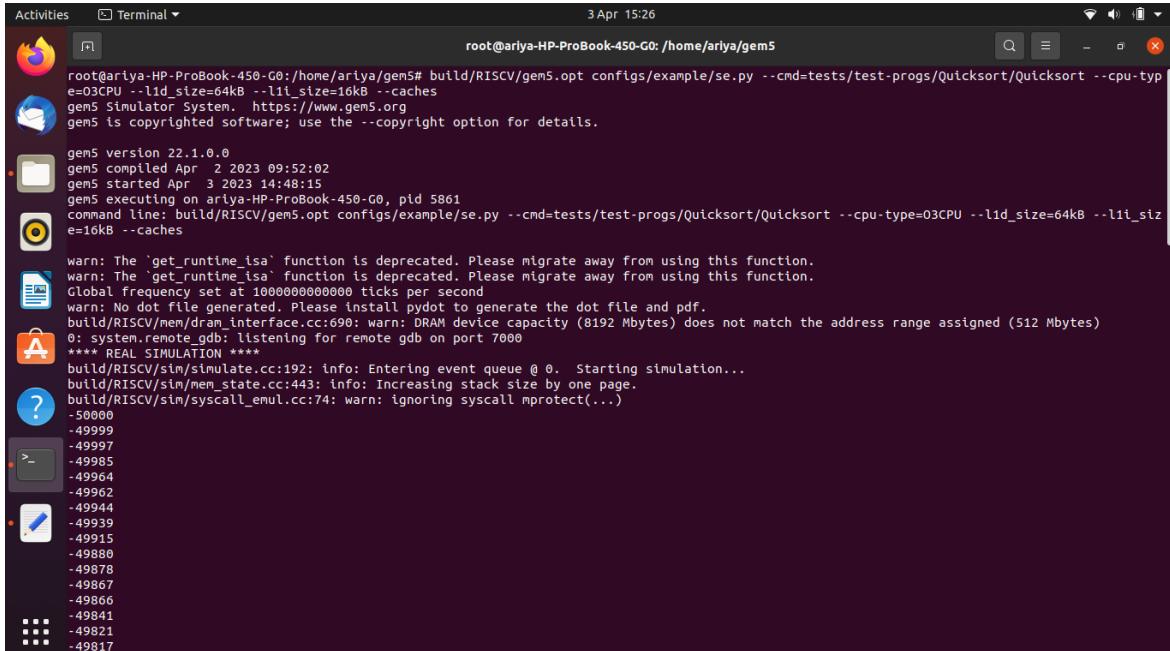
```

Activities Text Editor 3 Apr 16:15
stats.txt -/Pictures/Step5/Step2/Riscv/1 Save
Open
970 system.mem_ctrls.dram.rank0.actEnergy 678300 # Energy for activate commands per rank (pJ) (Joule)
971 system.mem_ctrls.dram.rank0.preEnergy 333960 # Energy for precharge commands per rank (pJ) (Joule)
972 system.mem_ctrls.dram.rank0.readEnergy 3470940 # Energy for read commands per rank (pJ) (Joule)
973 system.mem_ctrls.dram.rank0.writeEnergy 381060 # Energy for write commands per rank (pJ) (Joule)
974 system.mem_ctrls.dram.rank0.refreshEnergy 6596931120.000001 # Energy for refresh commands per rank (pJ) (Joule)
975 system.mem_ctrls.dram.rank0.actBackEnergy 1248807300 # Energy for active background per rank (pJ) (Joule)
976 system.mem_ctrls.dram.rank0.preBackEnergy 31040515680 # Energy for precharge background per rank (pJ) (Joule)
977 system.mem_ctrls.dram.rank0.actPowerDownEnergy 0 # Energy for active power-down per rank (pJ) (Joule)
978 system.mem_ctrls.dram.rank0.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pJ) (Joule)
979 system.mem_ctrls.dram.rank0.selfRefreshEnergy 0 # Energy for self refresh per rank (pJ) (Joule)
980 system.mem_ctrls.dram.rank0.totalEnergy 38891117460 # Total energy per rank (pJ) (Joule)
981 system.mem_ctrls.dram.rank0.averagePower 465.353445 # Core power per rank (mW) (Watt)
982 system.mem_ctrls.dram.rank0.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
983 system.mem_ctrls.dram.rank0.pwrStateTime::IDLE 80686652750 # Time in different power states (Tick)
984 system.mem_ctrls.dram.rank0.pwrStateTime::REF 2790580000 # Time in different power states (Tick)
985 system.mem_ctrls.dram.rank0.pwrStateTime::SREF 0 # Time in different power states (Tick)
986 system.mem_ctrls.dram.rank0.pwrStateTime::PRE_PDN 0 # Time in different power states (Tick)
987 system.mem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 96055250 # Time in different power states (Tick)
988 system.mem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 0 # Time in different power states (Tick)
989 system.mem_ctrls.dram.rank1.actEnergy 714000 # Energy for activate commands per rank (pJ) (Joule)
990 system.mem_ctrls.dram.rank1.preEnergy 352935 # Energy for precharge commands per rank (pJ) (Joule)
991 system.mem_ctrls.dram.rank1.readEnergy 3177300 # Energy for read commands per rank (pJ) (Joule)
992 system.mem_ctrls.dram.rank1.writeEnergy 574200 # Energy for write commands per rank (pJ) (Joule)
993 system.mem_ctrls.dram.rank1.refreshEnergy 6596931120.000001 # Energy for refresh commands per rank (pJ) (Joule)
994 system.mem_ctrls.dram.rank1.actBackEnergy 1238322720 # Energy for active background per rank (pJ) (Joule)
995 system.mem_ctrls.dram.rank1.preBackEnergy 31049344800 # Energy for precharge background per rank (pJ) (Joule)
996 system.mem_ctrls.dram.rank1.actPowerDownEnergy 0 # Energy for active power-down per rank (pJ) (Joule)
997 system.mem_ctrls.dram.rank1.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pJ) (Joule)
998 system.mem_ctrls.dram.rank1.selfRefreshEnergy 0 # Energy for self refresh per rank (pJ) (Joule)
999 system.mem_ctrls.dram.rank1.totalEnergy 38889417075 # Total energy per rank (pJ) (Joule)
1000 system.mem_ctrls.dram.rank1.averagePower 465.333099 # Core power per rank (mW) (Watt)
1001 system.mem_ctrls.dram.rank1.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
1002 system.mem_ctrls.dram.rank1.pwrStateTime::IDLE 80709851250 # Time in different power states (Tick)
1003 system.mem_ctrls.dram.rank1.pwrStateTime::REF 2790580000 # Time in different power states (Tick)
1004 system.mem_ctrls.dram.rank1.pwrStateTime::SREF 0 # Time in different power states (Tick)

```

تعداد Incorrect Branch Predictions بر روی پردازنده RISCV در اجرا اول برنامه محک Quicksort.c

خروجی اجرا دوم برنامه محک RISCV بر روی پردازنده Quicksort.c



```
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5# build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 22.1.0.0
gem5 compiled Apr 2 2023 09:52:02
gem5 started Apr 3 2023 14:48:15
gem5 executing on ariya-HP-ProBook-450-G0, pid 5861
command line: build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches

warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/RISCV/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/RISCV/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/RISCV/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/RISCV/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)

-50000
-49999
-49997
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49817
-49814

Activities Terminal 3 Apr 15:26 root@ariya-HP-ProBook-450-G0: /home/ariya/gem5
-49268
-49257
-49256
-49207
-49199
-49192
-49190
-49184
-49183
-49179
-49176
-49170
-49169
-49141
-49138
-49122
-49117
-49110
-49079
-49073
-49069
-49046
-49033
-49021
-49018
-49012
-48999
-48996
-48994
-48968
-48955
-48951
-48919
-48915
-48908
-48907
Exiting @ tick 87290851000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

زمان اجرا دوم برنامه محک Quicksort.c بر روی پردازنده RISC-V

```

1 ----- Begin Simulation Statistics -----
2
3 simSeconds 0.087291 # Number of seconds simulated (Second)
4 simTicks 8729851000 # Number of ticks simulated (Tick)
5 finalTick 8729851000 # Number of ticks from beginning of simulation (restored
from checkpoints and never reset) (Tick)
6 simFreq 10000000000000 # The number of ticks per simulated second ((Tick/Second))
7 hostSeconds 1924.45 # Real time elapsed on the host (Second)
8 hostTickrate 45358892 # The number of ticks simulated per host second (ticks/s)
((Tick/Second))
9 hostMemory 642280 # Number of bytes of host memory used (Byte)
10 simInstrs 206138907 # Number of instructions simulated (Count)
11 simOps 206139015 # Number of ops (including micro ops) simulated (Count)
12 hostInstRate 107116 # Simulator instruction rate (inst/s) ((Count/Second))
13 hostOpRate 107116 # Simulator op (including micro ops) rate (ops/s) ((Count/Second))
14 system.clk_domain.clock 1000 # Clock period in ticks (Tick)
15 system.cpu.numCycles 174581703 # Number of cpu cycles simulated (Cycle)
16 system.cpu.numWorkItemsStarted 0 # Number of work items this cpu started (Count)
17 system.cpu.numWorkItemsCompleted 0 # Number of work items this cpu completed (Count)
18 system.cpu.instsAdded (Count) 409399950 # Number of instructions added to the IQ (excludes non-spec)
19 system.cpu.nonSpecInstsAdded (Count) 571 # Number of non-speculative instructions added to the IQ
20 system.cpu.instsIssued 285745398 # Number of instructions issued (Count)
21 system.cpu.squashedInstsIssued 448436 # Number of squashed instructions issued (Count)
22 system.cpu.squashedInstsExamined 203261505 # Number of squashed instructions iterated over during
squash; mainly for profiling (Count)
23 system.cpu.squashedOperandsExamined 177468031 # Number of squashed operands that are examined and possibly
removed from graph (Count)
24 system.cpu.squashedNonSpecRemoved (Count) 28 # Number of squashed non-spec instructions that were removed
25 system.cpu.numIssuedDist:samples 174550830 # Number of insts issued each cycle (Count)
26 system.cpu.numIssuedDist:mean 1.637033 # Number of insts issued each cycle (Count)
27 system.cpu.numIssuedDist:stdev 1.697513 # Number of insts issued each cycle (Count)

```

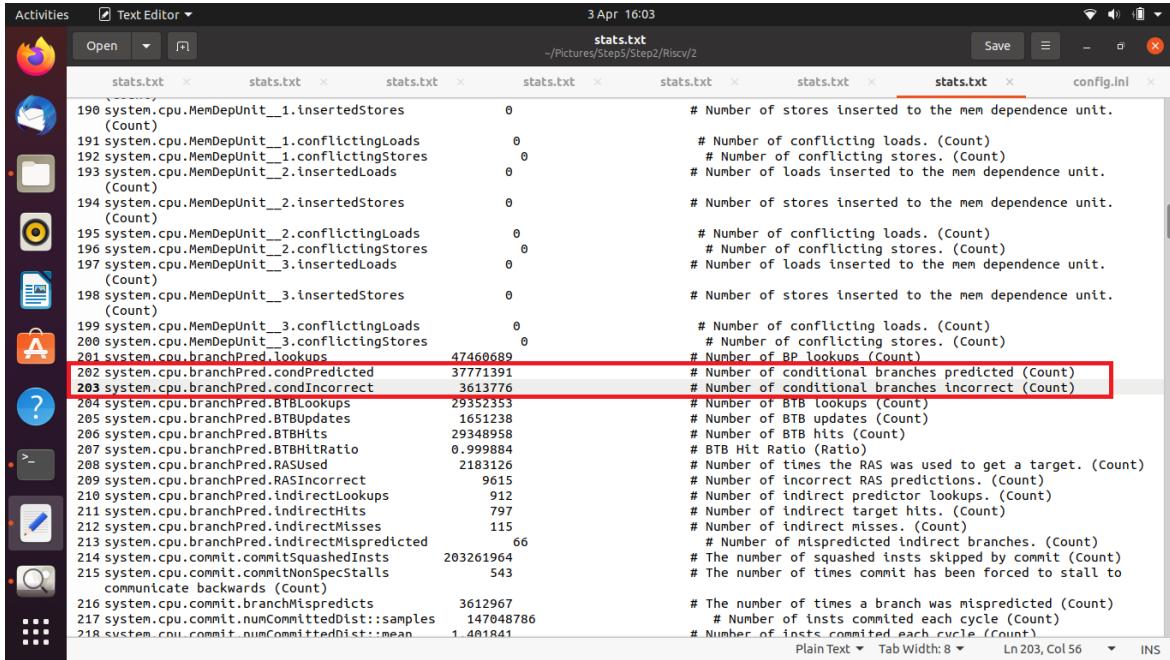
توان و انرژی مصرفی اجرا دوم برنامه محک Quicksort.c بر روی پردازنده RISC-V

```

various power states (TICK)
975 system.nem_ctrls.dram.rank0.actEnergy 678300 # Energy for activate commands per rank (pj) (Joule)
976 system.nem_ctrls.dram.rank0.preEnergy 341550 # Energy for precharge commands per rank (pj) (Joule)
977 system.nem_ctrls.dram.rank0.readEnergy 3470840 # Energy for read commands per rank (pj) (Joule)
978 system.nem_ctrls.dram.rank0.writeEnergy 386280 # Energy for write commands per rank (pj) (Joule)
979 system.nem_ctrls.dram.rank0.refreshEnergy 6890114400.000001 # Energy for refresh commands per rank (pj) (Joule)
980 system.nem_ctrls.dram.rank0.actBackEnergy 1380179690 # Energy for active background per rank (pj) (Joule)
981 system.nem_ctrls.dram.rank0.preBackEnergy 32424798720 # Energy for precharge background per rank (pj) (Joule)
982 system.nem_ctrls.dram.rank0.actPowerDownEnergy 0 # Energy for active power-down per rank (pj) (Joule)
983 system.nem_ctrls.dram.rank0.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pj) (Joule)
984 system.nem_ctrls.dram.rank0.selfRefreshEnergy 0 # Energy for self refresh per rank (pj) (Joule)
985 system.nem_ctrls.dram.rank0.totalEnergy 40619968980 # Total energy per rank (pj) (Joule)
986 system.nem_ctrls.dram.rank0.averagePower 465.340508 # Core power per rank (mW) (Watt)
987 system.nem_ctrls.dram.rank0.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
988 system.nem_ctrls.dram.rank0.pwrStateTime:IDLE 64285025500 # Time in different power states (Tick)
989 system.nem_ctrls.dram.rank0.pwrStateTime:REF 29146000000 # Time in different power states (Tick)
990 system.nem_ctrls.dram.rank0.pwrStateTime:SREF 0 # Time in different power states (Tick)
991 system.nem_ctrls.dram.rank0.pwrStateTime:PRE_PDN 0 # Time in different power states (Tick)
992 system.nem_ctrls.dram.rank0.pwrStateTime:ACT 91225500 # Time in different power states (Tick)
993 system.nem_ctrls.dram.rank0.pwrStateTime:ACT_PDN 0 # Time in different power states (Tick)
994 system.nem_ctrls.dram.rank1.actEnergy 714000 # Energy for activate commands per rank (pj) (Joule)
995 system.nem_ctrls.dram.rank1.preEnergy 349140 # Energy for precharge commands per rank (pj) (Joule)
996 system.nem_ctrls.dram.rank1.readEnergy 3184440 # Energy for read commands per rank (pj) (Joule)
997 system.nem_ctrls.dram.rank1.writeEnergy 574200 # Energy for write commands per rank (pj) (Joule)
998 system.nem_ctrls.dram.rank1.refreshEnergy 6890114400.000001 # Energy for refresh commands per rank (pj) (Joule)
999 system.nem_ctrls.dram.rank1.actBackEnergy 1292665950 # Energy for active background per rank (pj) (Joule)
1000 system.nem_ctrls.dram.rank1.preBackEnergy 32431126080 # Energy for precharge background per rank (pj) (Joule)
1001 system.nem_ctrls.dram.rank1.actPowerDownEnergy 0 # Energy for active power-down per rank (pj) (Joule)
1002 system.nem_ctrls.dram.rank1.prePowerDownEnergy 0 # Energy for precharge power-down per rank (pj) (Joule)
1003 system.nem_ctrls.dram.rank1.selfRefreshEnergy 0 # Energy for self refresh per rank (pj) (Joule)
1004 system.nem_ctrls.dram.rank1.totalEnergy 40618728210 # Total energy per rank (pj) (Joule)
1005 system.nem_ctrls.dram.rank1.averagePower 465.326294 # Core power per rank (mW) (Watt)
1006 system.nem_ctrls.dram.rank1.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
1007 system.nem_ctrls.dram.rank1.pwrStateTime:IDLE 64301682750 # Time in different power states (Tick)
1008 system.nem_ctrls.dram.rank1.pwrStateTime:REF 29146000000 # Time in different power states (Tick)

```

تعداد Incorrect Branch Predictions در اجرا دوم برنامه محک Quicksort.c بر روی پردازندۀ RISC-V



```
3 Apr 16:03
stats.txt
~/Pictures/Step5/Step2/Riscv/2
Save
Activities Text Editor
Open
stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt config.ini
190 system.cpu.MemDepUnit__1.insertedStores 0 # Number of stores inserted to the men dependence unit.
191 system.cpu.MemDepUnit__1.conflictingLoads 0 # Number of conflicting loads. (Count)
192 system.cpu.MemDepUnit__1.conflictingStores 0 # Number of conflicting stores. (Count)
193 system.cpu.MemDepUnit__2.insertedLoads 0 # Number of loads inserted to the mem dependence unit.
194 system.cpu.MemDepUnit__2.insertedStores 0 # Number of stores inserted to the mem dependence unit.
195 system.cpu.MemDepUnit__2.conflictingLoads 0 # Number of conflicting loads. (Count)
196 system.cpu.MemDepUnit__2.conflictingStores 0 # Number of conflicting stores. (Count)
197 system.cpu.MemDepUnit__3.insertedLoads 0 # Number of loads inserted to the mem dependence unit.
198 system.cpu.MemDepUnit__3.insertedStores 0 # Number of stores inserted to the mem dependence unit.
199 system.cpu.MemDepUnit__3.conflictingLoads 0 # Number of conflicting loads. (Count)
200 system.cpu.MemDepUnit__3.conflictingStores 0 # Number of conflicting stores. (Count)
201 system.cpu.branchPred.lookups 47460689 # Number of BP lookups. (Count)
202 system.cpu.branchPred.condPredicted 37771391 # Number of conditional branches predicted (Count)
203 system.cpu.branchPred.condIncorrect 3613776 # Number of conditional branches incorrect (Count)
204 system.cpu.branchPred.BTBLookups 29352353 # Number of BTB lookups (Count)
205 system.cpu.branchPred.BTBUpdates 1651238 # Number of BTB updates (Count)
206 system.cpu.branchPred.BTBHits 29348958 # Number of BTB hits (Count)
207 system.cpu.branchPred.BTBHitRatio 0.999884 # BTB Hit Ratio (Ratio)
208 system.cpu.branchPred.RASUsed 2183126 # Number of times the RAS was used to get a target. (Count)
209 system.cpu.branchPred.RASIncorrect 9615 # Number of incorrect RAS predictions. (Count)
210 system.cpu.branchPred.indirectLookups 912 # Number of indirect predictor lookups. (Count)
211 system.cpu.branchPred.indirectHits 797 # Number of indirect target hits. (Count)
212 system.cpu.branchPred.indirectMisses 115 # Number of Indirect misses. (Count)
213 system.cpu.branchPred.indirectMispredicted 66 # Number of mispredicted indirect branches. (Count)
214 system.cpu.commit.commitsquashedInsts 203261964 # The number of squashed insts skipped by commit (Count)
215 system.cpu.commit.commitNonSpecStalls 543 # The number of times commit has been forced to stall to communicate backwards (Count)
216 system.cpu.commit.branchMispredicts 3612967 # The number of times a branch was mispredicted (Count)
217 system.cpu.commit.numCommittedDist::samples 147048786 # Number of insts committed each cycle (Count)
218 system.cpu.commit.numCommittedDist::mean 1.461841 # Number of insts committed each cycle (Count)
```

خروجی اجرا سوم برنامه محک RISCV بر روی پردازنده Quicksort.c

```
Activities Terminal 3 Apr 14:39
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5
gem5 version 22.1.0.0
gem5 compiled Apr 2 2023 09:52:02
gem5 started Apr 3 2023 14:07:27
gem5 executing on ariya-HP-ProBook-450-G0, pid 5032
command line: build/RISCV/gem5.opt configs/example/se.py --cmd=tests/test-progs/Quicksort/Quicksort --cpu-type=O3CPU --l1d_size=64kB --l1i_size=16kB --caches
gem5 is copyrighted software; use the --copyright option for details.

warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
warn: The 'get_runtime_iss' function is deprecated. Please migrate away from using this function.
Global frequency set at 1000000000000 ticks per second
warn: No dot file generated. Please install pydot to generate the dot file and pdf.
build/RISCV/mem/dram_interface.cc:690: 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
**** REAL SIMULATION ****
build/RISCV/sim/simulate.cc:192: info: Entering event queue @ 0. Starting simulation...
build/RISCV/sim/mem_state.cc:443: info: Increasing stack size by one page.
build/RISCV/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)

-50000
-49999
-49997
-49985
-49964
-49962
-49944
-49939
-49915
-49880
-49878
-49867
-49866
-49841
-49821
-49817
-49814
```

```
Activities Terminal 3 Apr 14:39
root@ariya-HP-ProBook-450-G0: /home/ariya/gem5
-49268
-49257
-49256
-49207
-49199
-49192
-49190
-49184
-49183
-49179
-49176
-49170
-49169
-49141
-49138
-49122
-49117
-49110
-49079
-49073
-49069
-49046
-49033
-49021
-49018
-49012
-48999
-48996
-48994
-48968
-48955
-48951
-48919
-48915
-48908
-48907
Exiting @ tick 87624449000 because exiting with last active thread context
root@ariya-HP-ProBook-450-G0:/home/ariya/gem5#
```

زمان اجرا سوم برنامه محک RISCV بر روی پردازنده Quicksort.c

```

1 ----- Begin Simulation Statistics -----
2 simSeconds 0.087624 # Number of seconds simulated (Second)
3 simTicks 8762449000 # Number of ticks simulated (Tick)
4 finalTick 8762449000 # Number of ticks from beginning of simulation (restored
from checkpoints and never reset) (Tick)
5 simFreq 1000000000000 # The number of ticks per simulated second ((Tick/Second))
6 hostSeconds 1913.50 # Real time elapsed on the host (Second)
7 hostTickrate 45792780 # The number of ticks simulated per host second (ticks/s)
8 ((Tick/Second))
9 hostMemory 642276 # Number of bytes of host memory used (Byte)
10 simInstrs 206138907 # Number of instructions simulated (Count)
11 simOps 206139015 # Number of ops (including micro ops) simulated (Count)
12 hostInstRate 107729 # Simulator instruction rate (inst/s) ((Count/Second))
13 hostOpRate 107729 # Simulator op (including micro ops) rate (ops/s) ((Count/-
Second))
14 system.clk_domain.clock 1000 # Clock period in ticks (Tick)
15 system.cpu.numCycles 175248997 # Number of cpu cycles simulated (Cycle)
16 system.cpu.numWorkItemsStarted 0 # Number of work items this cpu started (Count)
17 system.cpu.numWorkItemsCompleted 0 # Number of work items this cpu completed (Count)
18 system.cpu.instsAdded (Count) 412018949 # Number of instructions added to the IQ (excludes non-spec)
19 system.cpu.nonSpecInstsAdded (Count) 576 # Number of non-speculative instructions added to the IQ
20 system.cpu.instsIssued 286108487 # Number of instructions issued (Count)
21 system.cpu.squashedInstsIssued 460127 # Number of squashed instructions issued (Count)
22 system.cpu.squashedInstsExamined 205880509 # Number of squashed instructions iterated over during
squash; mainly for profiling (Count)
23 system.cpu.squashedOperandsExamined 180501213 # Number of squashed operands that are examined and possibly
removed from graph (Count)
24 system.cpu.squashedNonSpecRemoved (Count) 33 # Number of squashed non-spec instructions that were removed
25 system.cpu.numIssuedDist:samples 175218848 # Number of insts issued each cycle (Count)
26 system.cpu.numIssuedDist:mean 1.632864 # Number of insts issued each cycle (Count)
27 system.cpu.numIssuedDist:stdev 1.696556 # Number of insts issued each cycle (Count)

```

توان و انرژی مصرفی اجرا سوم برنامه محک RISCV بر روی پردازنده Quicksort.c

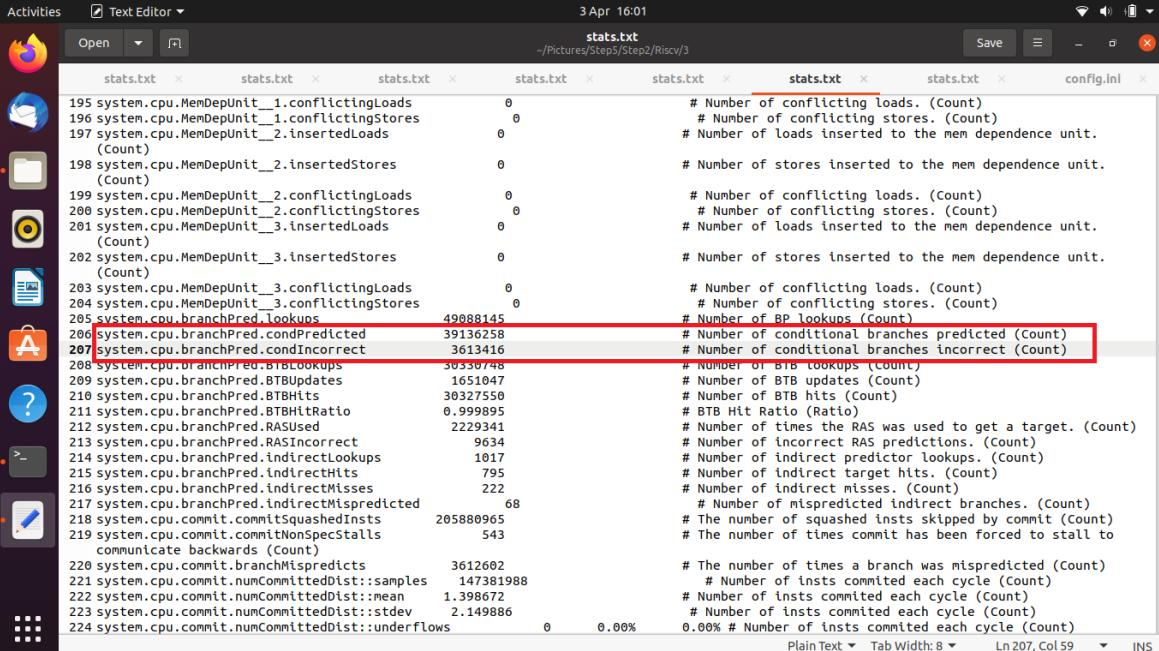
```

various power states (TICK)
983 system.nem_ctrls.dram.rank0.actEnergy 714000 # Energy for activate commands per rank (pj) (Joule)
984 system.mem_ctrls.dram.rank0.preEnergy 360525 # Energy for precharge commands per rank (pj) (Joule)
985 system.nem_ctrls.dram.rank0.readEnergy 3548580 # Energy for read commands per rank (pj) (Joule)
986 system.nem_ctrls.dram.rank0.writeEnergy 464580 # Energy for write commands per rank (pj) (Joule)
987 system.nem_ctrls.dram.rank0.refreshEnergy 6916543920.000001 # Energy for refresh commands per rank (pj) (Joule)
988 system.nem_ctrls.dram.rank0.aEBackEnergy 1305879690 # Energy for active background per rank (pj) (Joule)
989 system.nem_ctrls.dram.rank0.aEPowerDownEnergy 324598100640 # Energy for precharge background per rank (pj) (Joule)
990 system.nem_ctrls.dram.rank0.aPPowerDownEnergy 0 # Energy for active power-down per rank (pj) (Joule)
991 system.nem_ctrls.dram.rank0.pPowerDownEnergy 0 # Energy for precharge power-down per rank (pj) (Joule)
992 system.nem_ctrls.dram.rank0.selfRefreshEnergy 0 # Energy for self refresh per rank (pj) (Joule)
993 system.nem_ctrls.dram.rank0.totalEnergy 40775611935 # Total energy per rank (pj) (Joule)
994 system.nem_ctrls.dram.rank0.averagePower 465.345145 # Core power per rank (mW) (Watt)
995 system.nem_ctrls.dram.rank0.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
996 system.nem_ctrls.dram.rank0.pwrStateTime::IDLE 846055060000 # Time in different power states (Tick)
997 system.nem_ctrls.dram.rank0.pwrStateTime::REF 29257800000 # Time in different power states (Tick)
998 system.nem_ctrls.dram.rank0.pwrStateTime::SREF 0 # Time in different power states (Tick)
999 system.nem_ctrls.dram.rank0.pwrStateTime::PRE_PDN 0 # Time in different power states (Tick)
1000 system.nem_ctrls.dram.rank0.pwrStateTime::ACT 93163000 # Time in different power states (Tick)
1001 system.nem_ctrls.dram.rank0.pwrStateTime::ACT_PDN 0 # Time in different power states (Tick)
1002 system.nem_ctrls.dram.rank1.actEnergy 728280 # Energy for activate commands per rank (pj) (Joule)
1003 system.nem_ctrls.dram.rank1.preEnergy 360525 # Energy for precharge commands per rank (pj) (Joule)
1004 system.mem_ctrls.dram.rank1.readEnergy 3198728 # Energy for read commands per rank (pj) (Joule)
1005 system.nem_ctrls.dram.rank1.writeEnergy 558540 # Energy for write commands per rank (pj) (Joule)
1006 system.nem_ctrls.dram.rank1.refreshEnergy 6916543920.000001 # Energy for refresh commands per rank (pj) (Joule)
1007 system.nem_ctrls.dram.rank1.aEBackEnergy 130364370 # Energy for active background per rank (pj) (Joule)
1008 system.nem_ctrls.dram.rank1.prePowerDownEnergy 32552745120 # Energy for precharge background per rank (pj) (Joule)
1009 system.nem_ctrls.dram.rank1.aEPowerDownEnergy 0 # Energy for active power-down per rank (pj) (Joule)
1010 system.nem_ctrls.dram.rank1.pPowerDownEnergy 0 # Energy for precharge power-down per rank (pj) (Joule)
1011 system.nem_ctrls.dram.rank1.selfRefreshEnergy 0 # Energy for self refresh per rank (pj) (Joule)
1012 system.nem_ctrls.dram.rank1.totalEnergy 40774499475 # Total energy per rank (pj) (Joule)
1013 system.nem_ctrls.dram.rank1.averagePower 465.332449 # Core power per rank (mW) (Watt)
1014 system.nem_ctrls.dram.rank1.totalIdleTime 0 # Total Idle time Per DRAM Rank (Tick)
1015 system.nem_ctrls.dram.rank1.pwrStateTime::IDLE 84617789250 # Time in different power states (Tick)
1016 system.nem_ctrls.dram.rank1.pwrStateTime::REF 29257800000 # Time in different power states (Tick)

```

تعداد در اجرا سوم برنامه محک Quicksort.c بر روی پردازنده Incorrect Branch Predictions

:RISCV



```
Activities Text Editor 3 Apr 16:01
Open stats.txt stats.txt stats.txt stats.txt stats.txt stats.txt config.ini
stats.txt -/Pictures/Step5/Step2/Riscv/3
195 system.cpu.MemDepUnit__1.conflictingLoads 0 # Number of conflicting loads. (Count)
196 system.cpu.MemDepUnit__1.conflictingStores 0 # Number of conflicting stores. (Count)
197 system.cpu.MemDepUnit__2.insertedLoads 0 # Number of loads inserted to the mem dependence unit.
198 system.cpu.MemDepUnit__2.insertedStores 0 # Number of stores inserted to the mem dependence unit.
199 system.cpu.MemDepUnit__2.conflictingLoads 0 # Number of conflicting loads. (Count)
200 system.cpu.MemDepUnit__2.conflictingStores 0 # Number of conflicting stores. (Count)
201 system.cpu.MemDepUnit__3.insertedLoads 0 # Number of loads inserted to the mem dependence unit.
202 system.cpu.MemDepUnit__3.insertedStores 0 # Number of stores inserted to the mem dependence unit.
203 system.cpu.MemDepUnit__3.conflictingLoads 0 # Number of conflicting loads. (Count)
204 system.cpu.MemDepUnit__3.conflictingStores 0 # Number of conflicting stores. (Count)
205 system.cpu.branchPred.lookups 49088145 # Number of BP lookups (Count)
206 system.cpu.branchPred.condPredicted 39136258 # Number of conditional branches predicted (Count)
207 system.cpu.branchPred.condIncorrect 3613416 # Number of conditional branches incorrect (Count)
208 system.cpu.branchPred.BTBLookups 30330748 # Number of BTB lookups (Count)
209 system.cpu.branchPred.BTBUpdates 1651047 # Number of BTB updates (Count)
210 system.cpu.branchPred.BTBHits 30327550 # Number of BTB hits (Count)
211 system.cpu.branchPred.BTBHitRatio 0.999895 # BTB Hit Ratio (Ratio)
212 system.cpu.branchPred.RASUsed 2229341 # Number of times the RAS was used to get a target. (Count)
213 system.cpu.branchPred.RASIncorrect 9634 # Number of incorrect RAS predictions. (Count)
214 system.cpu.branchPred.indirectLookups 1017 # Number of indirect predictor lookups. (Count)
215 system.cpu.branchPred.indirectHits 795 # Number of indirect target hits. (Count)
216 system.cpu.branchPred.indirectMisses 222 # Number of indirect misses. (Count)
217 system.cpu.branchPred.indirectMispredicted 68 # Number of mispredicted indirect branches. (Count)
218 system.cpu.commit.commitsquashedInsts 205880965 # The number of squashed insts skipped by commit (Count)
219 system.cpu.commit.commitNonSpecStalls 543 # The number of times commit has been forced to stall to communicate backwards (Count)
220 system.cpu.commit.branchMispredicts 3612602 # The number of times a branch was mispredicted (Count)
221 system.cpu.commit.numCommittedDist::samples 147381988 # Number of insts committed each cycle (Count)
222 system.cpu.commit.numCommittedDist::mean 1.398672 # Number of insts committed each cycle (Count)
223 system.cpu.commit.numCommittedDist::stdev 2.149886 # Number of insts committed each cycle (Count)
224 system.cpu.commit.numCommittedDist::underflows 0 0.00% 0.00% # Number of insts committed each cycle (Count)
```

مقایسه بین اجرا *Inorder* و *Out of Order* برنامه محک Quicksort.c بر روی پردازنده X86:

زمان اجرا:

OUT_ORDER_RUN_1 < OUT_ORDER_RUN_3 < OUT_ORDER_RUN_2 < Inorder

در نتیجه زمان اجرا *Inorder* کم تر از زمان اجرا *Out of Order* است.

توان و انرژی مصرفی:

Inorder < OUT_ORDER_RUN_2 < OUT_ORDER_RUN_3 < OUT_ORDER_RUN_1

در نتیجه توان و انرژی مصرفی *Inorder* بیش تر از توان و انرژی مصرفی *Out of Order* است.

مقایسه بین اجرا *Inorder* و *Out of Order* برنامه محک Quicksort.c بر روی پردازنده RISCV:

زمان اجرا:

OUT_ORDER_RUN_1 < OUT_ORDER_RUN_2 < OUT_ORDER_RUN_3 < Inorder

در نتیجه زمان اجرا *Inorder* کم تر از زمان اجرا *Out of Order* است.

توان و انرژی مصرفی:

Inorder < OUT_ORDER_RUN_2 < OUT_ORDER_RUN_3 < OUT_ORDER_RUN_1

در نتیجه توان و انرژی مصرفی *Inorder* بیش تر از توان و انرژی مصرفی *Out of Order* است.