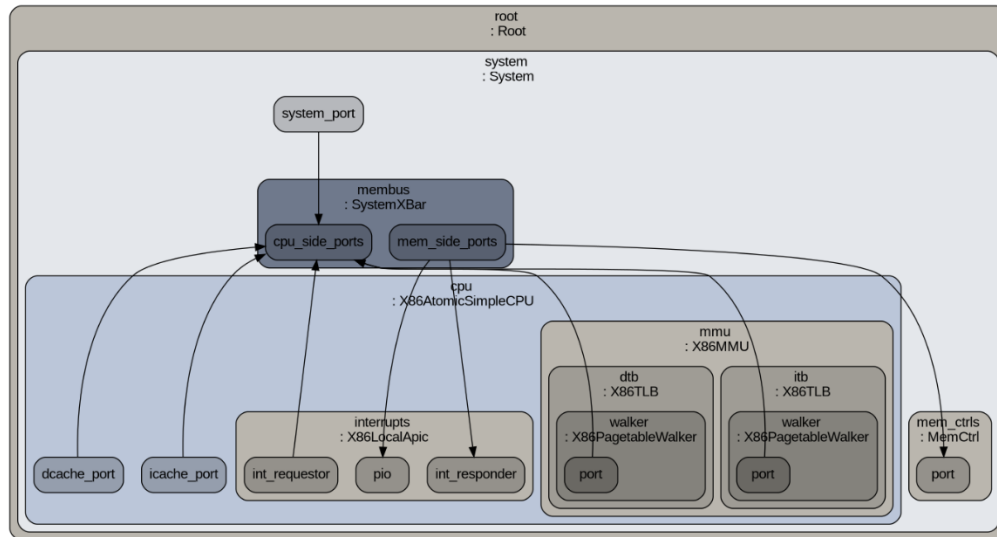


Taller #5

Se genera el diagrama de configuración del sistema.



Se procede a realizar la ejecución de ejemplo.

```
(johnnyzaet@ Kali) - [~/Documents/GEM5/gem5]
$ build/X86/gem5.opt configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/hello
gem5 Simulator System.  https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 23.0.0.1
gem5 compiled Oct 26 2023 12:50:53
gem5 started Oct 26 2023 13:12:50
gem5 executing on Kali, pid 1461384
command line: build/X86/gem5.opt configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/hello

warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
warn: The se.py script is deprecated. It will be removed in future releases of gem5.
warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
Global frequency set at 1000000000000 ticks per second
src/mem/dram_interface.cc:690: warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 M
bytes)
src/base/statistics.hh:279: warn: One of the stats is a legacy stat. Legacy stat is a stat that does not belong to any s
tatistics::Group. Legacy stat is deprecated.
system.remote_gdb: Listening for connections on port 7000
**** REAL SIMULATION ****
src/sim/simulate.cc:194: info: Entering event queue @ 0. Starting simulation...
Hello world!
Exiting @ tick 5943000 because exiting with last active thread context
```

Posterior a esto, luego se genera una lista de los posibles procesadores que se pueden utilizar. Para poder utilizarlos y analizar su respectivo stats.txt.

```
gem5 version 23.0.0.1
gem5 compiled Oct 26 2023 12:50:53
gem5 started Oct 26 2023 13:17:43
gem5 executing on Kali, pid 1463982
command line: build/X86/gem5.opt configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/hello --list-cpu-types

warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
warn: The se.py script is deprecated. It will be removed in future releases of gem5.
Available BaseCPU classes:
  AtomicSimpleCPU
    Simple CPU model executing a configurable number of instructions per cycle. This model uses the simplified 'atomic' memory mode.
  BaseAtomicSimpleCPU
    Simple CPU model executing a configurable number of instructions per cycle. This model uses the simplified 'atomic' memory mode.
  BaseMinorCPU
  BaseNonCachingSimpleCPU
    Simple CPU model based on the atomic CPU. Unlike the atomic CPU, this model causes the memory system to bypass caches and is therefore slightly faster in some cases. However, its main purpose is as a substitute for hardware virtualized CPUs when stress-testing the memory system.
  BaseO3CPU
  BaseTimingSimpleCPU
  DerivO3CPU
  NonCachingSimpleCPU
    Simple CPU model based on the atomic CPU. Unlike the atomic CPU, this model causes the memory system to bypass caches and is therefore slightly faster in some cases. However, its main purpose is as a substitute for hardware virtualized CPUs when stress-testing the memory system.
  O3CPU
  TimingSimpleCPU
  TraceCPU
    Trace CPU model which replays traces generated in a prior simulation using DerivO3CPU or its derived classes. It interfaces with L1 caches.
  X86AtomicSimpleCPU
    Simple CPU model executing a configurable number of instructions per cycle. This model uses the simplified 'atomic' memory mode.
  X86KvmCPU
  X86MinorCPU
  X86NonCachingSimpleCPU
    Simple CPU model based on the atomic CPU. Unlike the atomic CPU, this model causes the memory system to bypass caches and is therefore slightly faster in some cases. However, its main purpose is as a substitute for hardware virtualized CPUs when stress-testing the memory system.
```

Posteriormente se procede ejecutar los comandos cambiando el CPU.

AtomicSimple Example:

```
ou_atomic/ ou_o3/ ou_non_caching/
(johnnyzaet@ Kali) - [~/Documents/GEM5/gem5]
$ build/X86/gem5.opt -d ou_atomic/ configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/hello --cpu-type=AtomicSimpleCPU --caches
gem5 Simulator System. https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 23.0.0.1
gem5 compiled Oct 26 2023 12:50:53
gem5 started Oct 26 2023 13:23:24
gem5 executing on Kali, pid 1467028
command line: build/X86/gem5.opt -d ou_atomic/ configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/hello --cpu-type=AtomicSimpleCPU --caches

warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
warn: The se.py script is deprecated. It will be removed in future releases of gem5.
warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
Global frequency set at 100000000000 ticks per second
src/mem/dram_interface.cc:690: warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 M bytes)
src/base/statistics.hh:279: warn: One of the stats is a legacy stat. Legacy stat is a stat that does not belong to any statistics::Group. Legacy stat is deprecated.
system.remote_gdb: Listening for connections on port 7000
**** REAL SIMULATION ****
src/sim/simulate.cc:194: info: Entering event queue @ 0. Starting simulation...
Hello world!
Exiting @ tick 5943000 because exiting with last active thread context
```

Timing Example:

```
(johnnyzaet@ Kali)-[~/Documents/GEM5/gem5]
$ build/X86/gem5.opt -d out_timing/ configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/hello --cpu-type=TimingSimpleCPU --caches
gem5 Simulator System.  https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 23.0.0.1
gem5 compiled Oct 26 2023 12:50:53
gem5 started Oct 26 2023 13:19:54
gem5 executing on Kali, pid 1465138
command line: build/X86/gem5.opt -d out_timing/ configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/hello --cpu-type=TimingSimpleCPU --caches

warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
warn: The `se.py` script is deprecated. It will be removed in future releases of `gem5`.
warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
Global frequency set at 1000000000000 ticks per second
src/mem/dram_interface.cc:690: warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 Mbytes)
src/base/statistics.hh:279: warn: One of the stats is a legacy stat. Legacy stat is a stat that does not belong to any statistics::Group. Legacy stat is deprecated.
system.remote_gdb: Listening for connections on port 7000
**** REAL SIMULATION ****
src/sim/simulate.cc:194: info: Entering event queue @ 0. Starting simulation...
Hello world!
Exiting @ tick 31497000 because exiting with last active thread context
```

O3 Example:

```
(johnnyzaet@ Kali)-[~/Documents/GEM5/gem5]
$ build/X86/gem5.opt -d out_o3/ configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/ --cpu-type=DerivO3CPU --caches
gem5 Simulator System.  https://www.gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 23.0.0.1
gem5 compiled Oct 26 2023 12:50:53
gem5 started Oct 26 2023 13:21:41
gem5 executing on Kali, pid 1466106
command line: build/X86/gem5.opt -d out_o3/ configs/deprecated/example/se.py -c tests/test-progs/hello/bin/x86/linux/ --cpu-type=DerivO3CPU --caches

warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
warn: The `se.py` script is deprecated. It will be removed in future releases of `gem5`.
warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
src/base/loader/image_file_data.cc:53: panic: panic condition sz != 2 occurred: Couldn't read magic bytes from object file
Memory Usage: 132760 KBytes
Program aborted at tick 0
--- BEGIN LIBC BACKTRACE ---
build/X86/gem5.opt(+0x798de9)[0x55617f9dade9]
build/X86/gem5.opt(+0x7bf0dd)[0x55617fa010dd]
/lib/x86_64-linux-gnu/libc.so.6(+0x3c510)[0x7f10a2055510]
/lib/x86_64-linux-gnu/libc.so.6(+0x8a0fc)[0x7f10a20a30fc]
/lib/x86_64-linux-gnu/libc.so.6(gsignal+0x12)[0x7f10a2055472]
/lib/x86_64-linux-gnu/libc.so.6(abort+0xd3)[0x7f10a203f4b2]
build/X86/gem5.opt(+0x473acf)[0x55617feb5acf]
build/X86/gem5.opt(+0x13b6ea0)[0x5561805f8ea0]
build/X86/gem5.opt(+0x13b78dd)[0x5561805f98dd]
build/X86/gem5.opt(+0x12d3d1b)[0x556180515d1b]
build/X86/gem5.opt(+0x458297)[0x55617f69a297]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(+0x1c4133)[0x7f10a31c4133]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(PyObject_MakeTpCall+0x7d)[0x7f10a3175aed]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(PyEval_EvalFrameDefault+0x3977)[0x7f10a3108d27]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(+0x3c781c)[0x7f10a33c781c]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(PyEval_EvalCode+0xc1)[0x7f10a3260931]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(+0x261060)[0x7f10a3261060]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(+0x1c4632)[0x7f10a31c4632]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(PyObject_Vectorcall+0x33)[0x7f10a31772b3]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(PyEval_EvalFrameDefault+0x3977)[0x7f10a3108d27]
/lib/x86_64-linux-gnu/libpython3.11.so.1.0(+0x262d6a)[0x7f10a3262d6a]
build/X86/gem5.opt(+0x7c0775)[0x55617fa02775]
build/X86/gem5.opt(+0x3fd3a6)[0x55617f63f3a6]
/lib/x86_64-linux-gnu/libc.so.6(+0x276ca)[0x7f10a20406ca]
/lib/x86_64-linux-gnu/libc.so.6(__libc_start_main+0x85)[0x7f10a2040785]
build/X86/gem5.opt(+0x449661)[0x55617f68b661]
--- END LIBC BACKTRACE ---
For more info on how to address this issue, please visit https://www.gem5.org/documentation/general_docs/common-errors/

Aborted
```


Se procede a realizar el benchmark para utilizarlo, en este caso se correrá primero el benchmark 401.bzip2. Para esto se procede a modificar el runGem.sh de la siguiente forma.

```
(johnnyzaet@ Kali) - [~/Documents/spec/Project1_SPEC/401.bzip2]
$ cat runGem5.sh
# -- an example to run SPEC 429.mcf on gem5, put it under 429.mcf folder --
export GEM5_DIR=/home/johnnyzaet/Documents/GEM5/gem5
export BENCHMARK=./src/benchmark
export ARGUMENT=./data/input.program
time $GEM5_DIR/build/X86/gem5.opt -d m5out/ $GEM5_DIR/configs/deprecated/example/se.py -c $BENCHMARK -o $ARGUMENT -I 100
000000 --cpu-type=TimingSimpleCPU --caches --l2cache --l1d_size=128kB --l1i_size=128kB --l2_size=1MB --l1d_assoc=2 --l1i
_assoc=2 --l2_assoc=1 --cacheline_size=64
```

Posterior a la modificación, se ejecuta el BenchMark.

```
johnnyzaet@Kali: ~/Documents/spec/Project1_SPEC/401.bzip2
gem5 is copyrighted software; use the --copyright option for details.

gem5 version 23.0.0.1
gem5 compiled Oct 26 2023 12:50:53
gem5 started Oct 26 2023 13:53:19
gem5 executing on Kali, pid 1482908
command line: /home/johnnyzaet/Documents/GEM5/gem5/build/X86/gem5.opt -d m5out/ /home/johnnyzaet/Documents/GEM5/gem5/con
figs/deprecated/example/se.py -c ./src/benchmark -o ./data/input.program -I 100000000 --cpu-type=TimingSimpleCPU --cache
s --l2cache --l1d_size=128kB --l1i_size=128kB --l2_size=1MB --l1d_assoc=2 --l1i_assoc=2 --l2_assoc=1 --cacheline_size=64

warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
warn: The se.py script is deprecated. It will be removed in future releases of gem5.
warn: The `get_runtime_isa` function is deprecated. Please migrate away from using this function.
Global frequency set at 100000000000 ticks per second
src/mem/dram_interface.cc:690: warn: DRAM device capacity (8192 Mbytes) does not match the address range assigned (512 M
bytes)
src/base/statistics.hh:279: warn: One of the stats is a legacy stat. Legacy stat is a stat that does not belong to any s
tatistics::Group. Legacy stat is deprecated.
system.remote_gdb: Listening for connections on port 7000
**** REAL SIMULATION ****
src/sim/simulate.cc:194: info: Entering event queue @ 0. Starting simulation...
src/sim/syscall_emul.cc:74: warn: ignoring syscall set_robust_list(...)
src/sim/syscall_emul.cc:74: warn: ignoring syscall rseq(...)
src/sim/syscall_emul.cc:74: warn: ignoring syscall mprotect(...)
src/sim/mem_state.cc:443: info: Increasing stack size by one page.
src/sim/mem_state.cc:443: info: Increasing stack size by one page.
Exiting @ tick 196940953500 because a thread reached the max instruction count

real    3m55.685s
user    3m55.312s
sys     0m0.273s
```

Por último, en la siguiente parte se tratará con el benchmark 740.lbm, para el cual se proponen 3 diferentes cambios que podrían mejorar el rendimiento del sistema.

Qué es el Benchmark 740.lbm

El benchmark 470.lbm es parte del conjunto SPEC CPU2006, que es una colección de programas de computadora utilizada para evaluar el rendimiento de la CPU en tareas computacionales. 470.lbm es un programa que simula la dinámica de fluidos utilizando el método Lattice Boltzmann. Este método es útil para simular la dinámica de fluidos en situaciones complejas, como flujos en medios porosos.

Dado que 470.lbm simula la dinámica de fluidos, es computacionalmente intensivo y depende en gran medida de la capacidad de la CPU para realizar cálculos rápidos y acceder eficientemente a la memoria

Propuestas de Cambio

Aumento del Tamaño de Caché L1: Dado que 470.lbm es computacionalmente intensivo, un aumento en el tamaño de la caché L1 podría reducir la cantidad de fallos de caché y, por lo tanto, mejorar el rendimiento. Al tener más datos almacenados en la caché L1, la CPU podría acceder a ellos más rápidamente sin tener que buscar en cachés de nivel superior o en la memoria principal.

Aumento de la Asociatividad de Caché: Un aumento en la asociatividad de la caché puede reducir los fallos de caché, especialmente en programas con patrones de acceso a memoria no uniformes. Al aumentar la asociatividad, se permite que más bloques de datos ocupen un conjunto particular en la caché, lo que puede reducir los conflictos y, por lo tanto, los fallos de caché.

Aumento del Tamaño de Caché L2: Si el tamaño de la caché L1 no es suficiente para contener todos los datos necesarios, un aumento en el tamaño de la caché L2 podría ser beneficioso. La caché L2 actúa como un respaldo para la caché L1 y almacena datos que no caben en L1. Un tamaño de caché L2 más grande podría reducir el número de veces que la CPU necesita acceder a la memoria principal, que es más lenta.

Implementaciones

Aumento del Tamaño de Caché L1:

```
$ cat runGem5.sh
# -- an example to run SPEC 429.mcf on gem5, put it under 429.mcf folder
--
export GEM5_DIR=/home/johnnyzaet/Documents/GEM5/gem5
export BENCHMARK=./src/benchmark
export ARGUMENT=./data/input.program
time $GEM5_DIR/build/X86/gem5.opt -d m5out/ $GEM5_DIR/configs/deprecated
/example/se.py -c $BENCHMARK -o $ARGUMENT -I 100000000 --cpu-type=Timing
SimpleCPU --caches --l2cache --l1d_size=512kB --l1i_size=128kB --l2_size
=1MB --l1d_assoc=2 --l1i_assoc=2 --l2_assoc=1 --cacheline_size=64
```

Aumento de la Asociatividad de Caché:

```
$ cat runGem5.sh
# -- an example to run SPEC 429.mcf on gem5, put it under 429.mcf folder
--
export GEM5_DIR=/home/johnnyzaet/Documents/GEM5/gem5
export BENCHMARK=./src/benchmark
export ARGUMENT=./data/input.program
time $GEM5_DIR/build/X86/gem5.opt -d m5out/ $GEM5_DIR/configs/deprecated
/example/se.py -c $BENCHMARK -o $ARGUMENT -I 100000000 --cpu-type=Timing
SimpleCPU --caches --l2cache --l1d_size=128kB --l1i_size=128kB --l2_size
=1MB --l1d_assoc=4 --l1i_assoc=2 --l2_assoc=1 --cacheline_size=64
```

Aumento del Tamaño de Caché L2:

```
$ cat runGem5.sh
# -- an example to run SPEC 429.mcf on gem5, put it under 429.mcf folder
--
export GEM5_DIR=/home/johnnyzaet/Documents/GEM5/gem5
export BENCHMARK=./src/benchmark
export ARGUMENT=./data/input.program
time $GEM5_DIR/build/X86/gem5.opt -d m5out/ $GEM5_DIR/configs/deprecated
/example/se.py -c $BENCHMARK -o $ARGUMENT -I 100000000 --cpu-type=Timing
SimpleCPU --caches --l2cache --l1d_size=128kB --l1i_size=128kB --l2_size
=4MB --l1d_assoc=2 --l1i_assoc=2 --l2_assoc=1 --cacheline_size=64
```

Resultados obtenidos y explicación

Aumento del Tamaño de Caché L1: El aumento del tamaño de la caché L1D de 128kB a 512kB tuvo un impacto positivo mínimo en la reducción de la tasa de fallos de caché L1D. Sin embargo, la tasa de fallos de la caché L2 se vio afectada negativamente, alcanzando el 100%. Esto sugiere que los datos que antes estaban en L2 ahora están en L1D, pero a costa de aumentar los fallos en L2.

Aumento de la Asociatividad de Caché: El aumento en la asociatividad de la caché L1D de 2 a 4 no tuvo un impacto en la tasa de fallos de caché L1D. Sin embargo, la tasa de fallos de la caché L2 se mantuvo en el 100%, lo que indica que la mayor asociatividad no ayudó en este caso.

Aumento del Tamaño de Caché L2: El aumento del tamaño de la caché L2 de 1MB a 4MB no tuvo un impacto en la tasa de fallos de caché L1D ni en la tasa de fallos de caché L2 para datos. Esto sugiere que el benchmark no está utilizando eficientemente el espacio adicional en L2.

Conclusión

A pesar de las modificaciones realizadas en la caché L1D y L2, el IPC se mantuvo constante en todas las configuraciones, lo que indica que estos cambios no tuvieron un impacto significativo en el rendimiento general del benchmark 470.lbm en este escenario particular.