

CE6304 : Computer Architecture

Project #1

Branch Prediction

Under the supervision of: Prof. Benjamin Carrion Schaefer

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Part 1

Branch Prediction

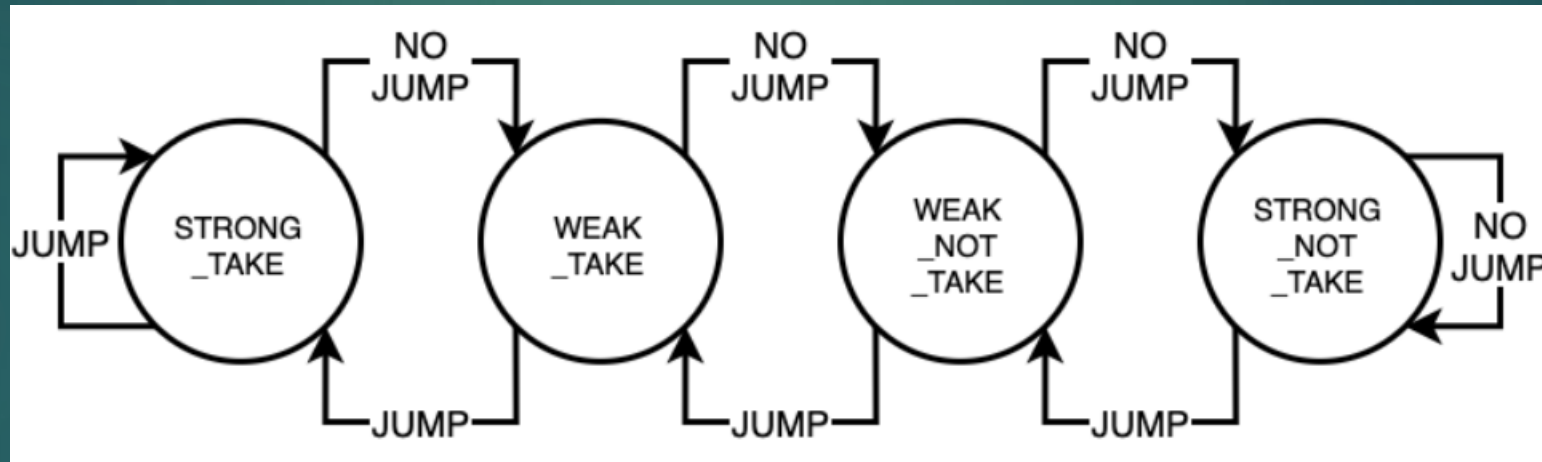
- ▶ Today's processors almost always employ the pipelining approach, which creates branch dangers when running programs. The hardware-level implementation of branch predictor aims to reduce the expenses of branching.
- ▶ The method entails only carrying out certain instructions when specific predicates are true. The processing of branch instructions is sped up by branch prediction.
- ▶ It enables the processor to begin executing instructions long before the branch outcome is certain.

The three branch predictor that are used are

1. Local Predictor
2. BiMode Predictor
3. Tournament Predictor

2 - bit Local Predictor

- ▶ In a local branch predictor, each conditional jump instruction has its own history buffer. Each conditional jump instruction has a separate history buffer, and the pattern history table may be independent for each instruction or shared by all conditional jumps.
- ▶ A 2 bit predictor simply adds another bit to the BHT to produce a state machine. First comes the prediction bit, followed by the hysteresis bit or conviction bit. Therefore, the 2-bit predictor should simply update its prediction after two false predictions.



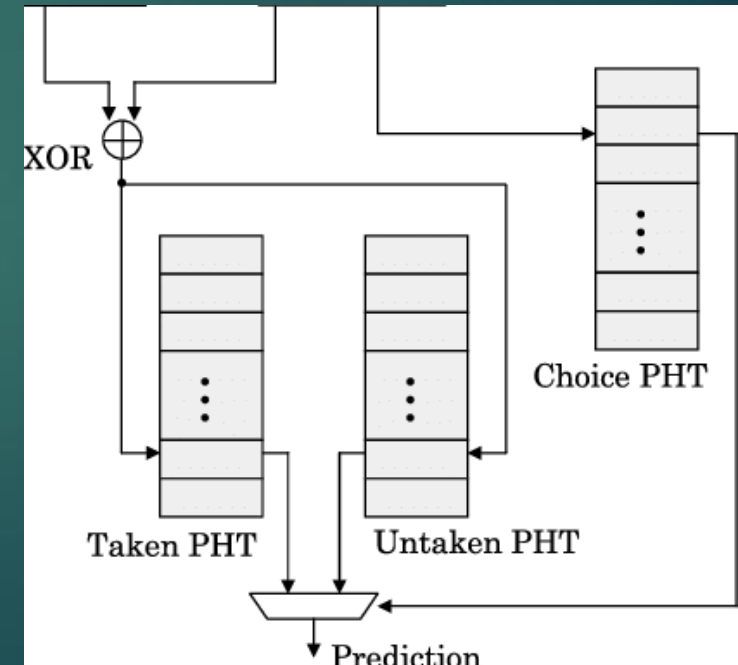
Reference :

https://github.com/kuanying/two_bit_predictor_simulation/blob/main/images/branch_result.png

BiMode Predictor

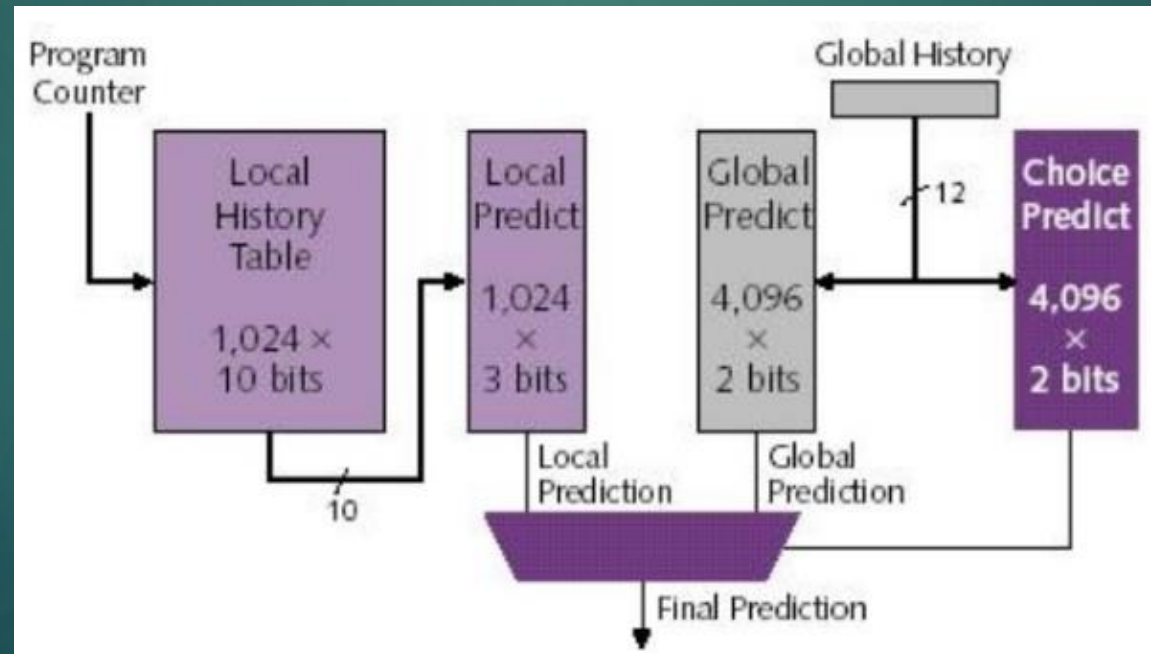
- ▶ The BiMode Predictor is a dynamic branch prediction approach that divides the prediction tables into two halves and dynamically chooses the appropriate half of the table for prediction based on the program's current mode. It is so simple that it has no effect on a processor's cycle time.
- ▶ A took array, a not-taken array, and a choice array are the three distinct history arrays that make up the bi-mode predictor, a two-level branch predictor. A hash of the PC and the entire history serves as the index for the taken/not-taken arrays. Only the PC has access to the choice array's index. The taken/not-taken arrays must be the same size because they share the same index.
- ▶ The destructive aliasing that happens when two branches with opposing biases share the same global history pattern is what the bi-mode branch predictor seeks to do away with. Destructive aliasing is minimized by dividing the predictors into taken/not-taken arrays and utilizing the branch's PC to choose between the two.

Reference : https://www.researchgate.net/figure/Bimode-plus-branch-predictor_fig2_421947



Tournament Predictor

- ▶ The Tournament Predictor has numerous predictions for each branch and a selection mechanism that determines which prediction to activate for a particular branch. Each branch index may have two predictions in a standard tournament predictor, one based on local information and the other on branch behavior globally.
- ▶ Which predictor to utilize for a particular prediction would be determined by a selector (Meta-Predictor). Predictors for PShare and GShare are trained on all branches. Whichever of the two predictors has been more accurate is preferred by the meta-predictor.
- ▶ The entry in the meta-predictor remains unchanged if both predictors are right or erroneous. The entry is increased if PShare is accurate but GShare is inaccurate. The entry is decreased if GShare is incorrect while PShare is accurate. PShare will be chosen by a higher Meta-Predictor entry, and GShare by a lower Meta-Predictor entry.



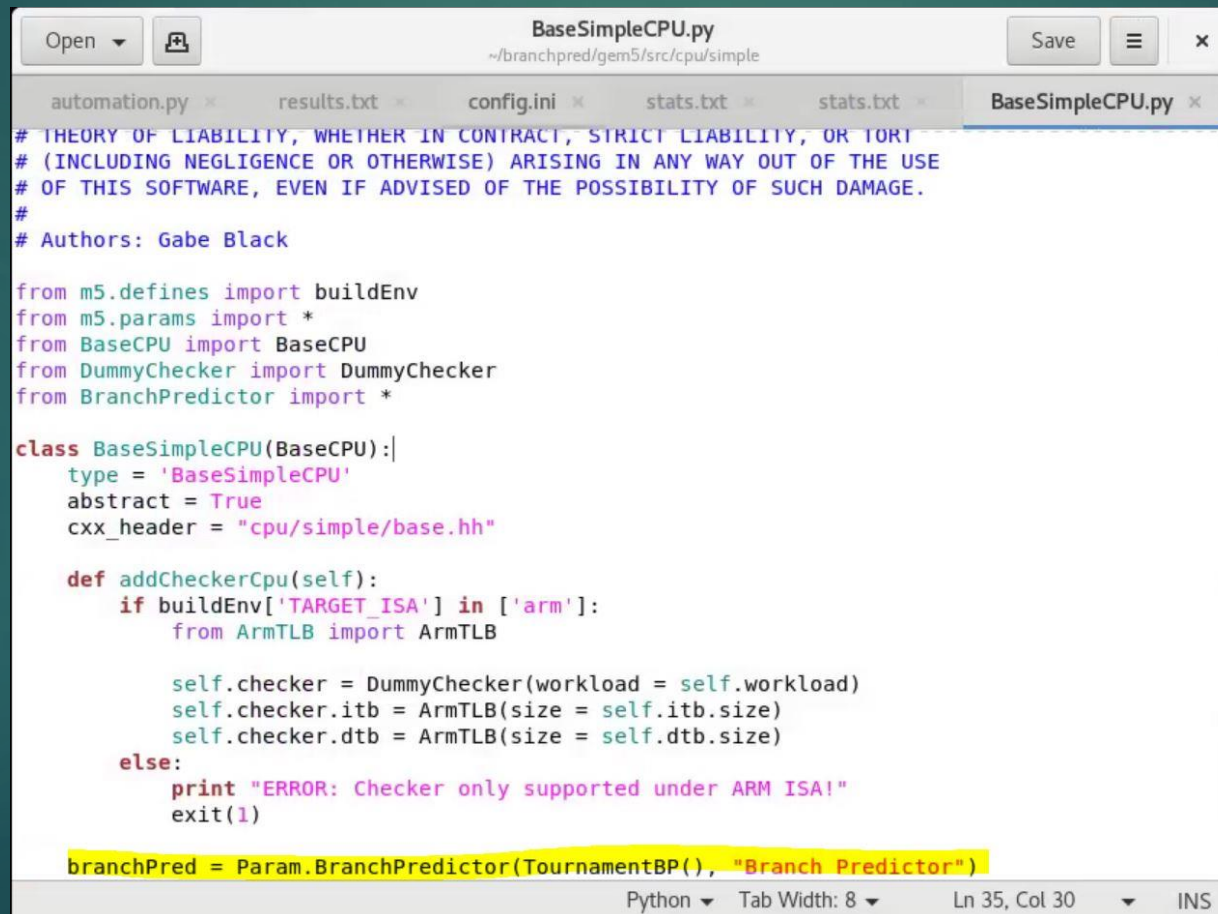
Gem5 - setup

- ▶ Setup done using UTD server (CE6304).
- ▶ Followed the steps according to the document shared.
- ▶ One of the problems faced was that the setup and execution took long time since multiple users were trying to access the same server.
- ▶ Path where the project is located in the server is
`/home/011/s/sx/sxm210368/branchpred/gem5`

Part 2

Changing branch predictor

- In the file named “Basesimplecpu.py” the line where branch predictor has to be changed was updated to TournamentBP.



```
BaseSimpleCPU.py
~/branchpred/gem5/src/cpu/simple

automation.py × results.txt × config.ini × stats.txt × stats.txt × BaseSimpleCPU.py ×

# THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
# (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE
# OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
#
# Authors: Gabe Black

from m5.defines import buildEnv
from m5.params import *
from BaseCPU import BaseCPU
from DummyChecker import DummyChecker
from BranchPredictor import *

class BaseSimpleCPU(BaseCPU):
    type = 'BaseSimpleCPU'
    abstract = True
    cxx_header = "cpu/simple/base.hh"

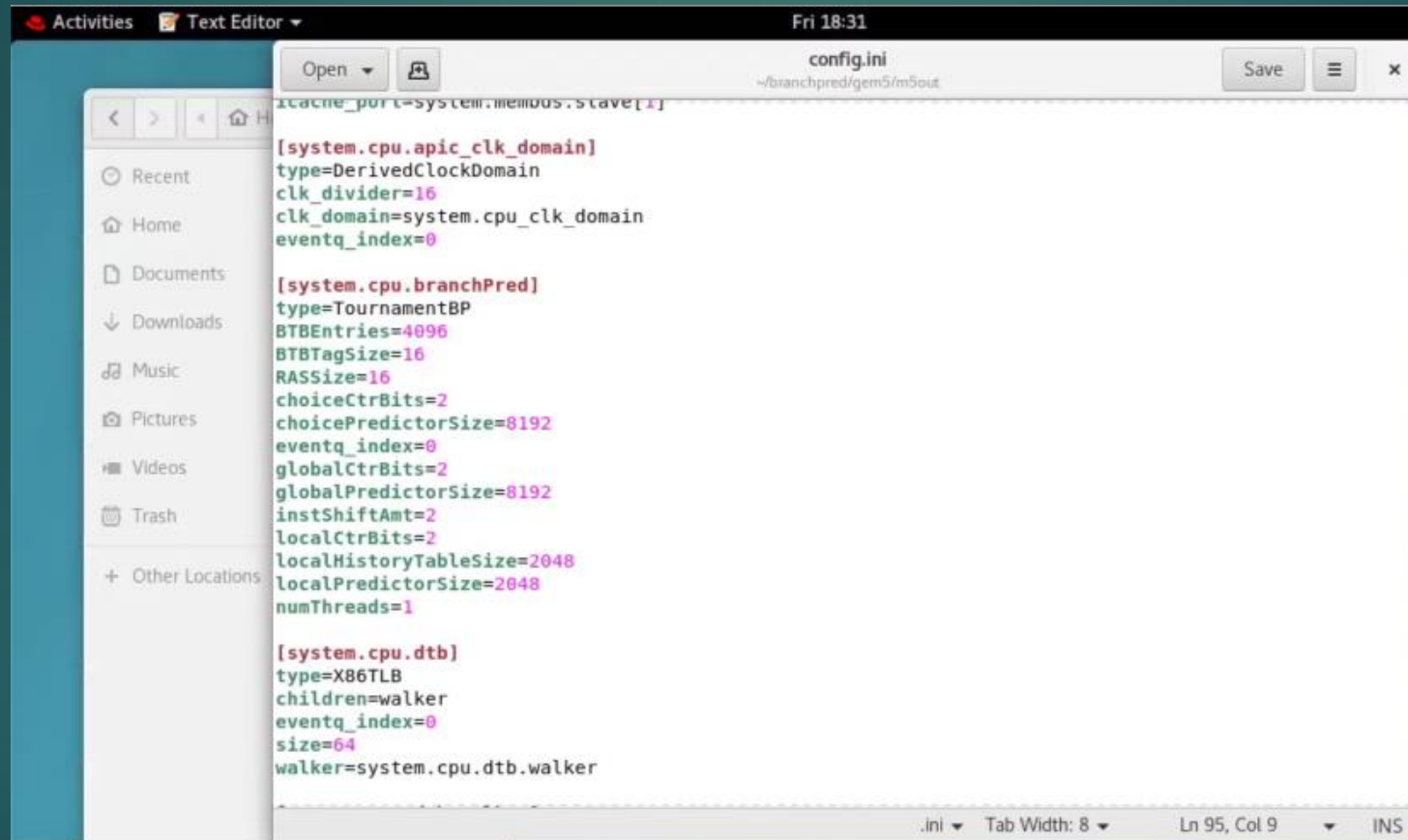
    def addCheckerCpu(self):
        if buildEnv['TARGET_ISA'] in ['arm']:
            from ArmTLB import ArmTLB

            self.checker = DummyChecker(workload = self.workload)
            self.checker.itb = ArmTLB(size = self.itb.size)
            self.checker.dtb = ArmTLB(size = self.dtb.size)
        else:
            print "ERROR: Checker only supported under ARM ISA!"
            exit(1)

branchPred = Param.BranchPredictor(TournamentBP(), "Branch Predictor")

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```

Result of changing Branch Predictor config.ini



The screenshot shows a text editor window titled 'config.ini' with the following content:

```
icache_port=system.membus.slave[1]

[system.cpu.apic_clk_domain]
type=DerivedClockDomain
clk_divider=16
clk_domain=system.cpu_clk_domain
eventq_index=0

[system.cpu.branchPred]
type=TournamentBP
BTBEntries=4096
BTBTagSize=16
RASSize=16
choiceCtrBits=2
choicePredictorSize=8192
eventq_index=0
globalCtrBits=2
globalPredictorSize=8192
instShiftAmt=2
localCtrBits=2
localHistoryTableSize=2048
localPredictorSize=2048
numThreads=1

[system.cpu.dtb]
type=X86TLB
children=walker
eventq_index=0
size=64
walker=system.cpu.dtb.walker
```

The status bar at the bottom indicates the file is '.ini', the tab width is 8, the cursor is at line 95, column 9, and the input mode is INS.

Part – 3

Changes made to add BTB Miss Percentage

File bpred_unit.hh

```
Stats::Scalar BTBLookups;  
/** Stat for number of BTB hits. */  
Stats::Scalar BTBHits;  
/** Stat for number of times the BTB is correct. */  
Stats::Scalar BTBCorrect;  
/** Stat for percent times an entry in BTB found. */  
Stats::Formula BTBHitPct;  
/** Stat for percent times an entry in BTB is miss */  
Stats::Formula BTBMissPct;  
/** Stat for number of times the RAS is used to get a target. */  
Stats::Scalar usedRAS;  
/** Stat for number of times the RAS is incorrect. */  
Stats::Scalar RASIncorrect;
```

File bpred_unit.cc

```
BTBHitPct  
    .name(name() + ".BTBHitPct")  
    .desc("BTB Hit Percentage")  
    .precision(6);  
BTBHitPct = (BTBHits / BTBLookups) * 100;  
BTBMissPct  
    .name(name() + ".BTBMissPct")  
    .desc("BTB Miss Percentage")  
    .precision(6);  
BTBMissPct = (1 - (BTBHits / BTBLookups)) * 100;  
usedRAS  
    .name(name() + ".usedRAS")  
    .desc("Number of times the RAS was used to get a target.")  
    ;
```

Stats.txt after adding BTBMissPct

system.cpu.branchPred.BTBCorrect	0	# Number of
correct BTB predictions (this stat may not work properly.		
system.cpu.branchPred.BTBHitPct	90.744378	# BTB Hit
Percentage		
system.cpu.branchPred.BTBMissPct	9.255622	# BTB Miss
Percentage		
system.cpu.branchPred.usedRAS	489567	# Number of
times the RAS was used to get a target.		

Changes made to add Branch MissPrediction Percentage

File exec_unit.hh

```
/// Number of branches predicted as taken
Stats::Scalar numPredictedBranches;
/// Number of mispredicted branches
Stats::Scalar numBranchMispred;
/// Percentage of mispredicted branches
Stats::Formula numBranchMispredPercent;
/// @}
```

File base.cc

```
prereq(t_info.numBranchMispred);
t_info.numBranchMispredPercent
    name(thread_str + ".numBranchMispredPercent")
    desc("Branch misprediction percentage")
    prereq(t_info.numBranchMispred);
t_info.numBranchMispredPercent=(t_info.numBranchMispred/t_info.numBranch
hes)*100;
}
```

Result of adding Branch MissPrediction Percentage in stats.txt

system.cpu.BranchMispred	3966			# Number of branch
mispredictions				
system.cpu.numBranchMispredPercent	0.382461			# Branch
misprediction percentage				
system.cpu.op_class::No_OpClass	26919	0.30%	0.30%	# Class of
executed instruction				
system.cpu.op_class::IntAlu	7050269	77.66%	77.96%	# Class of
executed instruction				
system.cpu.op_class::IntMult	17682	0.19%	78.16%	# Class of

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Part – 4

Changes made to BranchPredictor.py

```
class BranchPredictor(SimObject):
    type = 'BranchPredictor'
    cxx_class = 'BPredUnit'
    cxx_header = "cpu/pred/bpred_unit.hh"
    abstract = True
    numThreads = Param.Unsigned(1, "Number of threads")
    BTBEntries = Param.Unsigned(2048, "Number of BTB entries")
    BTBTagSize = Param.Unsigned(16, "Size of the BTB tags, in bits")
    RASSize = Param.Unsigned(16, "RAS size")
    instShiftAmt = Param.Unsigned(2, "Number of bits to shift instructions by")

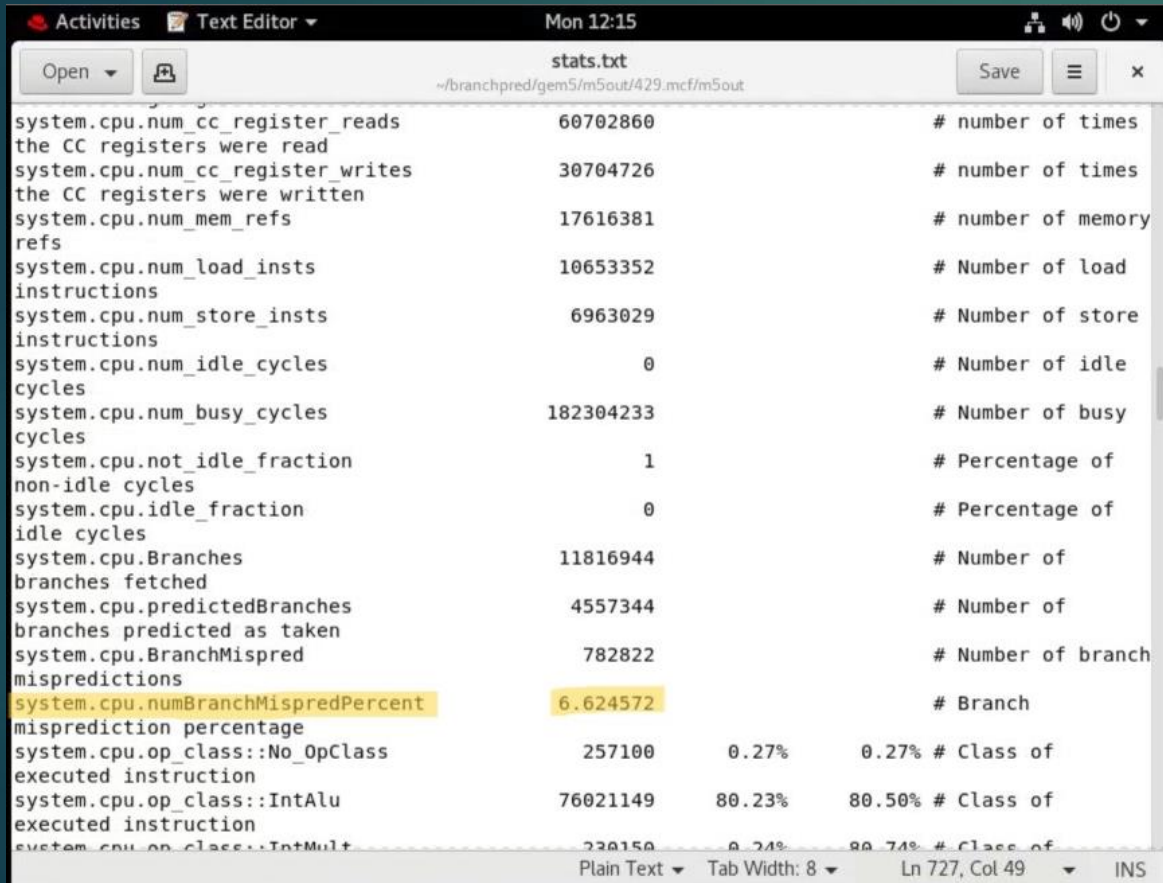
class LocalBP(BranchPredictor):
    type = 'LocalBP'
    cxx_class = 'LocalBP'
    cxx_header = "cpu/pred/2bit_local.hh"
    localPredictorSize = Param.Unsigned(1024, "Size of local predictor")
    localCtrBits = Param.Unsigned(2, "Bits per counter")
```

```
class TournamentBP(BranchPredictor):
    type = 'TournamentBP'
    cxx_class = 'TournamentBP'
    cxx_header = "cpu/pred/tournament.hh"
    localPredictorSize = Param.Unsigned(1024, "Size of local predictor")
    localCtrBits = Param.Unsigned(2, "Bits per counter")
    localHistoryTableSize = Param.Unsigned(2048, "size of local history table")
    globalPredictorSize = Param.Unsigned(4096, "Size of global predictor")
    globalCtrBits = Param.Unsigned(2, "Bits per counter")
    choicePredictorSize = Param.Unsigned(4096, "Size of choice predictor")
    choiceCtrBits = Param.Unsigned(2, "Bits of choice counters")

class BiModeBP(BranchPredictor):
    type = 'BiModeBP'
    cxx_class = 'BiModeBP'
    cxx_header = "cpu/pred/bi_mode.hh"
    globalPredictorSize = Param.Unsigned(2048, "Size of global predictor")
    globalCtrBits = Param.Unsigned(2, "Bits per counter")
    choicePredictorSize = Param.Unsigned(2048, "Size of choice predictor")
    choiceCtrBits = Param.Unsigned(2, "Bits of choice counters")
```

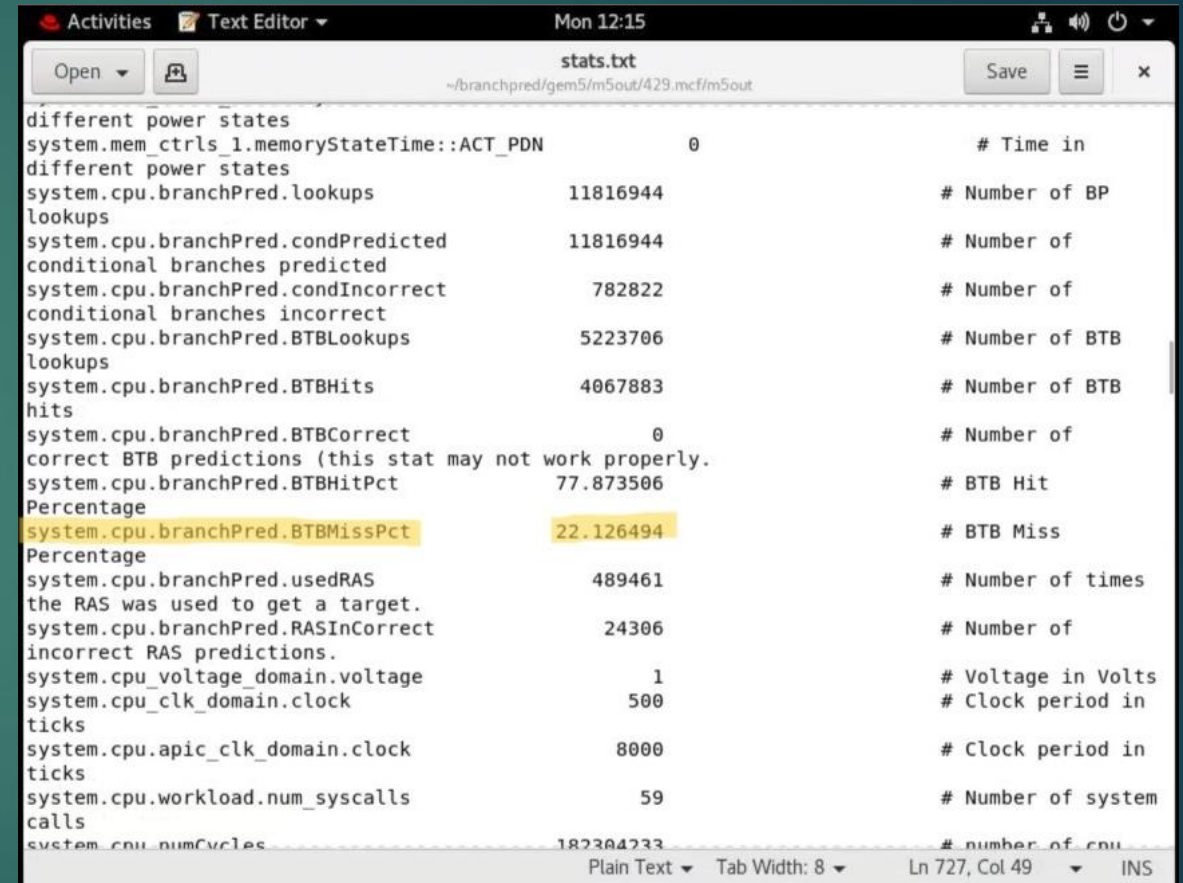

Part 4 – Benchmark 429

LocalBP



system.cpu.num_cc_register_reads	60702860			# number of times
the CC registers were read				
system.cpu.num_cc_register_writes	30704726			# number of times
the CC registers were written				
system.cpu.num_mem_refs	17616381			# number of memory
refs				
system.cpu.num_load_insts	10653352			# Number of load
instructions				
system.cpu.num_store_insts	6963029			# Number of store
instructions				
system.cpu.num_idle_cycles	0			# Number of idle
cycles				
system.cpu.num_busy_cycles	182304233			# Number of busy
cycles				
system.cpu.not_idle_fraction	1			# Percentage of
non-idle cycles				
system.cpu.idle_fraction	0			# Percentage of
idle cycles				
system.cpu.Branches	11816944			# Number of
branches fetched				
system.cpu.predictedBranches	4557344			# Number of
branches predicted as taken				
system.cpu.BranchMispred	782822			# Number of branch
mispredictions				
system.cpu.numBranchMispredPercent	6.624572			# Branch
misprediction percentage				
system.cpu.op_class::No_OpClass	257100	0.27%	0.27%	# Class of
executed instruction				
system.cpu.op_class::IntAlu	76021149	80.23%	80.50%	# Class of
executed instruction				
system.cpu.op_class::IntMult	230150	0.24%	0.74%	# Class of
executed instruction				

Branch misprediction percentage

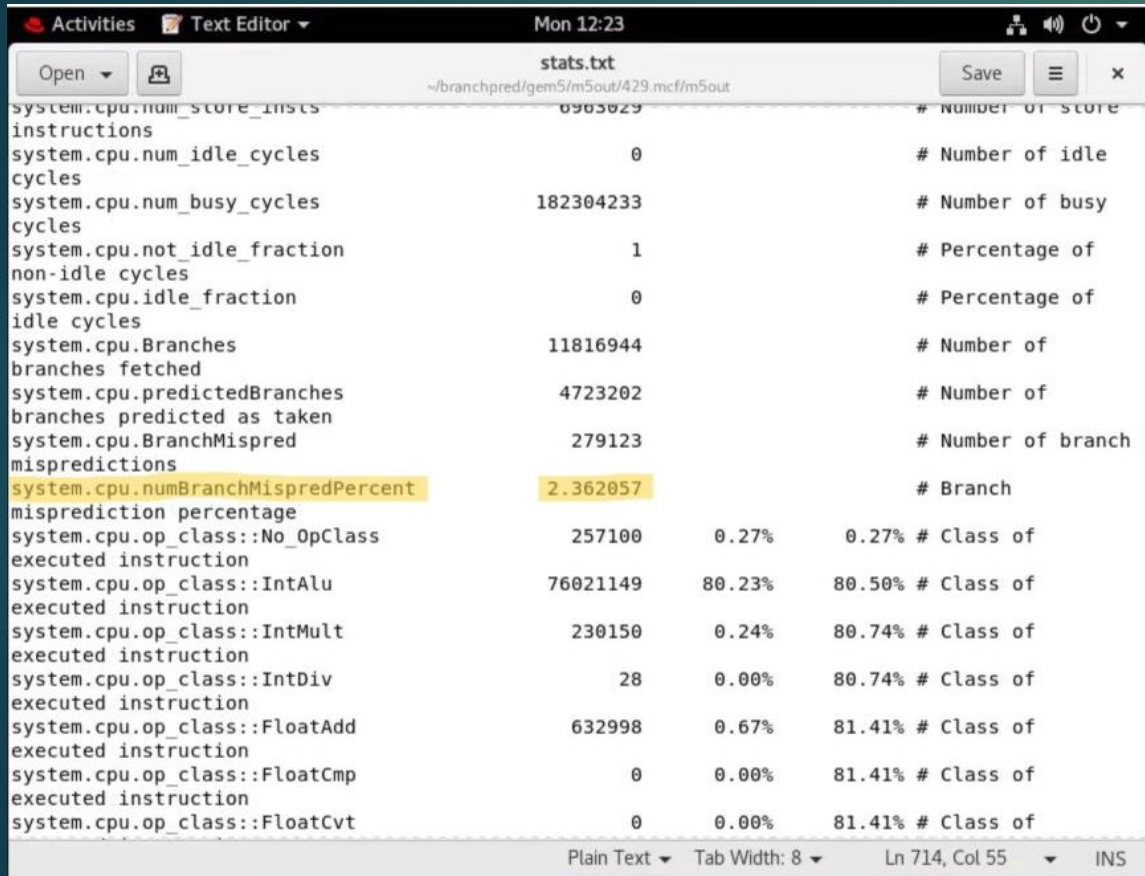


different power states				
system.mem_ctrls_1.memoryStateTime::ACT_PDN	0			# Time in
different power states				
system.cpu.branchPred.lookups	11816944			# Number of BP
lookups				
system.cpu.branchPred.condPredicted	11816944			# Number of
conditional branches predicted				
system.cpu.branchPred.condIncorrect	782822			# Number of
conditional branches incorrect				
system.cpu.branchPred.BTBLookups	5223706			# Number of BTB
lookups				
system.cpu.branchPred.BTBHits	4067883			# Number of BTB
hits				
system.cpu.branchPred.BTBCorrect	0			# Number of
correct BTB predictions (this stat may not work properly.				
system.cpu.branchPred.BTBHitPct	77.873506			# BTB Hit
Percentage				
system.cpu.branchPred.BTBMissPct	22.126494			# BTB Miss
Percentage				
system.cpu.branchPred.usedRAS	489461			# Number of times
the RAS was used to get a target.				
system.cpu.branchPred.RASInCorrect	24306			# Number of
incorrect RAS predictions.				
system.cpu_voltage_domain.voltage	1			# Voltage in Volts
system.cpu_clk_domain.clock	500			# Clock period in
ticks				
system.cpu.apic_clk_domain.clock	8000			# Clock period in
ticks				
system.cpu.workload.num_syscalls	59			# Number of system
calls				
system.cpu.numCycles	182304233			# number of cpu

BTB Miss percentage

Part 4 – Benchmark 429

BiModeBP



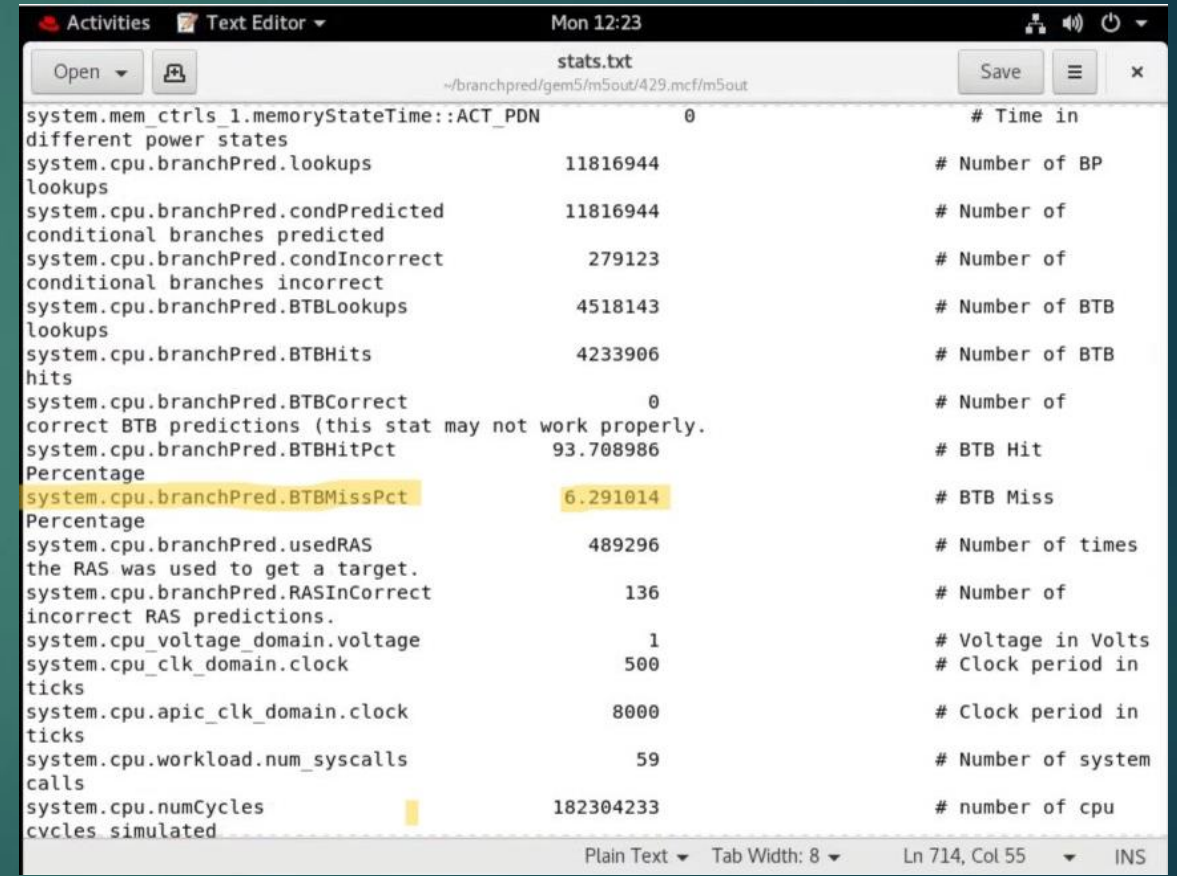
Mon 12:23

stats.txt
~/branchpred/gem5/m5out/429.mcf/m5out

system.cpu.num_store_insts	8963829			# Number of store instructions
system.cpu.num_idle_cycles	0			# Number of idle cycles
system.cpu.num_busy_cycles	182304233			# Number of busy cycles
system.cpu.not_idle_fraction	1			# Percentage of non-idle cycles
system.cpu.idle_fraction	0			# Percentage of idle cycles
system.cpu.Branches	11816944			# Number of branches fetched
system.cpu.predictedBranches	4723202			# Number of branches predicted as taken
system.cpu.BranchMispred	279123			# Number of branch mispredictions
system.cpu.numBranchMispredPercent	2.362057			# Branch misprediction percentage
system.cpu.op_class::No_OpClass	257100	0.27%	0.27%	# Class of executed instruction
system.cpu.op_class::IntAlu	76021149	80.23%	80.50%	# Class of executed instruction
system.cpu.op_class::IntMult	230150	0.24%	80.74%	# Class of executed instruction
system.cpu.op_class::IntDiv	28	0.00%	80.74%	# Class of executed instruction
system.cpu.op_class::FloatAdd	632998	0.67%	81.41%	# Class of executed instruction
system.cpu.op_class::FloatCmp	0	0.00%	81.41%	# Class of executed instruction
system.cpu.op_class::FloatCvt	0	0.00%	81.41%	# Class of executed instruction

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Branch misprediction percentage



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stats.txt
~/branchpred/gem5/m5out/429.mcf/m5out

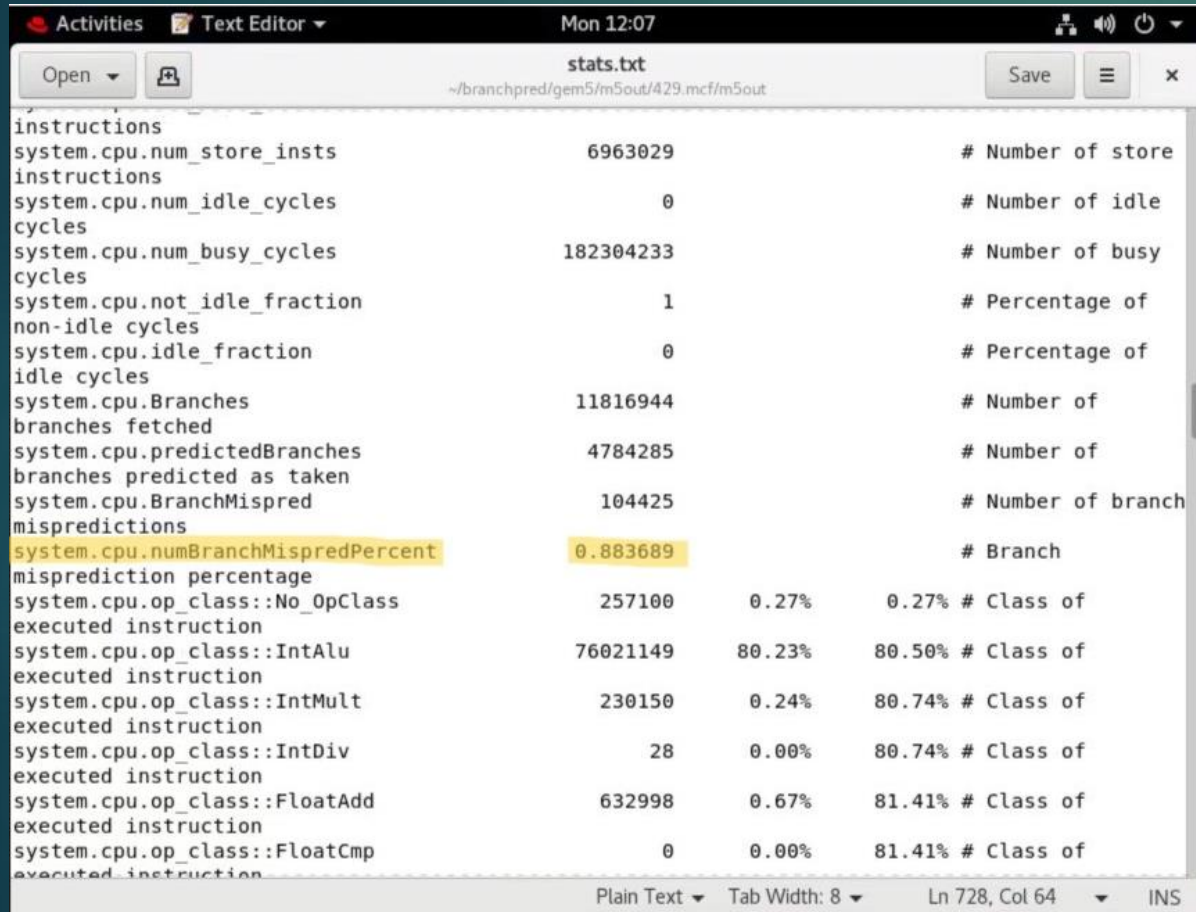
system.mem_ctrls.1.memoryStateTime::ACT_PDN	0			# Time in different power states
system.cpu.branchPred.lookups	11816944			# Number of BP lookups
system.cpu.branchPred.condPredicted	11816944			# Number of conditional branches predicted
system.cpu.branchPred.condIncorrect	279123			# Number of conditional branches incorrect
system.cpu.branchPred.BTBLookups	4518143			# Number of BTB lookups
system.cpu.branchPred.BTBHits	4233906			# Number of BTB hits
system.cpu.branchPred.BTBCorrect	0			# Number of correct BTB predictions (this stat may not work properly).
system.cpu.branchPred.BTBHitPct	93.708986			# BTB Hit Percentage
system.cpu.branchPred.BTBMissPct	6.291014			# BTB Miss Percentage
system.cpu.branchPred.usedRAS	489296			# Number of times the RAS was used to get a target.
system.cpu.branchPred.RASInCorrect	136			# Number of incorrect RAS predictions.
system.cpu_voltage_domain.voltage	1			# Voltage in Volts
system.cpu_clk_domain.clock	500			# Clock period in ticks
system.cpu.apic_clk_domain.clock	8000			# Clock period in ticks
system.cpu.workload.num_syscalls	59			# Number of system calls
system.cpu.numCycles	182304233			# number of cpu cycles simulated

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BTB Miss percentage

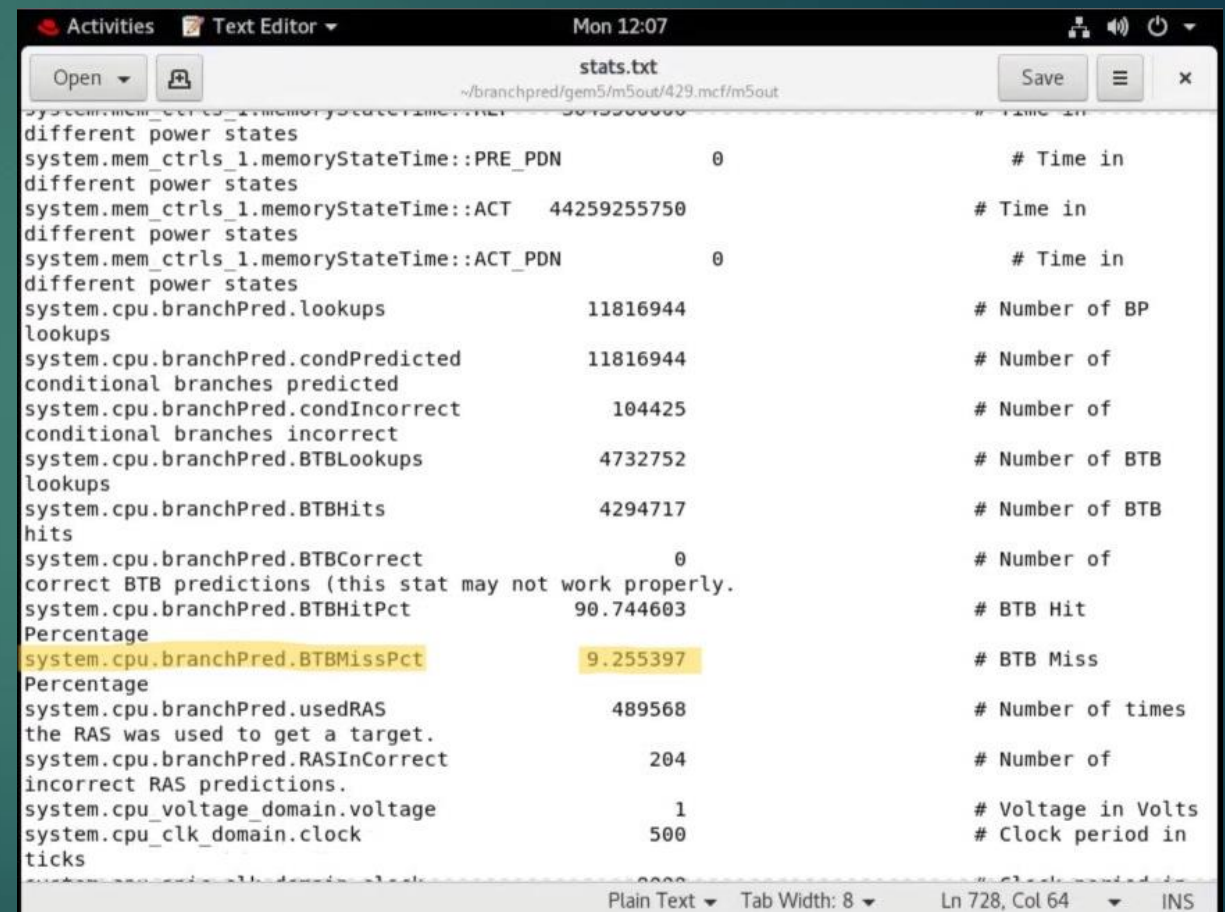
Part 4 – Benchmark 429

TournamentBP



instructions	6963029			# Number of store
system.cpu.num_store_insts				
instructions	0			# Number of idle
system.cpu.num_idle_cycles				
cycles	182304233			# Number of busy
system.cpu.num_busy_cycles				
cycles	1			# Percentage of
system.cpu.not_idle_fraction				
non-idle cycles	0			# Percentage of
system.cpu.idle_fraction				
idle cycles	11816944			# Number of
system.cpu.Branches				
branches fetched	4784285			# Number of
system.cpu.predictedBranches				
branches predicted as taken	104425			# Number of branch
system.cpu.BranchMispred				
mispredictions	0.883689			# Branch
system.cpu.numBranchMispredPercent				
misprediction percentage	257100	0.27%	0.27%	# Class of
system.cpu.op_class::No_OpClass				
executed instruction	76021149	80.23%	80.50%	# Class of
system.cpu.op_class::IntAlu				
executed instruction	230150	0.24%	80.74%	# Class of
system.cpu.op_class::IntMult				
executed instruction	28	0.00%	80.74%	# Class of
system.cpu.op_class::IntDiv				
executed instruction	632998	0.67%	81.41%	# Class of
system.cpu.op_class::FloatAdd				
executed instruction	0	0.00%	81.41%	# Class of
system.cpu.op_class::FloatCmp				
executed instruction				

Branch misprediction percentage

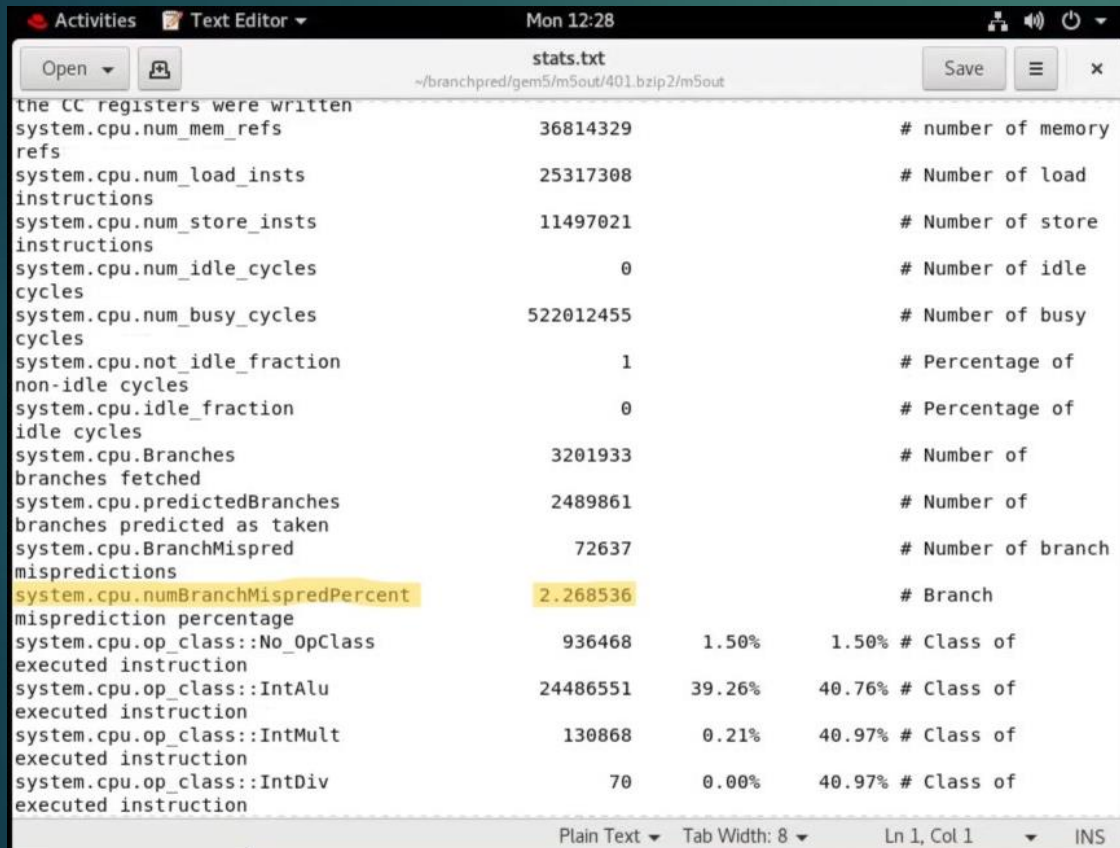


different power states				# Time in
system.mem_ctrls_1.memoryStateTime::PRE_PDN	0			
different power states				# Time in
system.mem_ctrls_1.memoryStateTime::ACT	44259255750			
different power states				# Time in
system.mem_ctrls_1.memoryStateTime::ACT_PDN	0			
different power states				# Time in
system.cpu.branchPred.lookups	11816944			# Number of BP
lookups				
system.cpu.branchPred.condPredicted	11816944			# Number of
conditional branches predicted				
system.cpu.branchPred.condIncorrect	104425			# Number of
conditional branches incorrect				
system.cpu.branchPred.BTBLookups	4732752			# Number of BTB
lookups				
system.cpu.branchPred.BTBHits	4294717			# Number of BTB
hits				
system.cpu.branchPred.BTBCorrect	0			# Number of
correct BTB predictions (this stat may not work properly.				
system.cpu.branchPred.BTBHitPct	90.744603			# BTB Hit
Percentage				
system.cpu.branchPred.BTBMissPct	9.255397			# BTB Miss
Percentage				
system.cpu.branchPred.usedRAS	489568			# Number of times
the RAS was used to get a target.				
system.cpu.branchPred.RASInCorrect	204			# Number of
incorrect RAS predictions.				
system.cpu_voltage_domain.voltage	1			# Voltage in Volts
system.cpu_clk_domain.clock	500			# Clock period in
ticks				

BTB Miss percentage

Part 4 – Benchmark 401

BiModeBP



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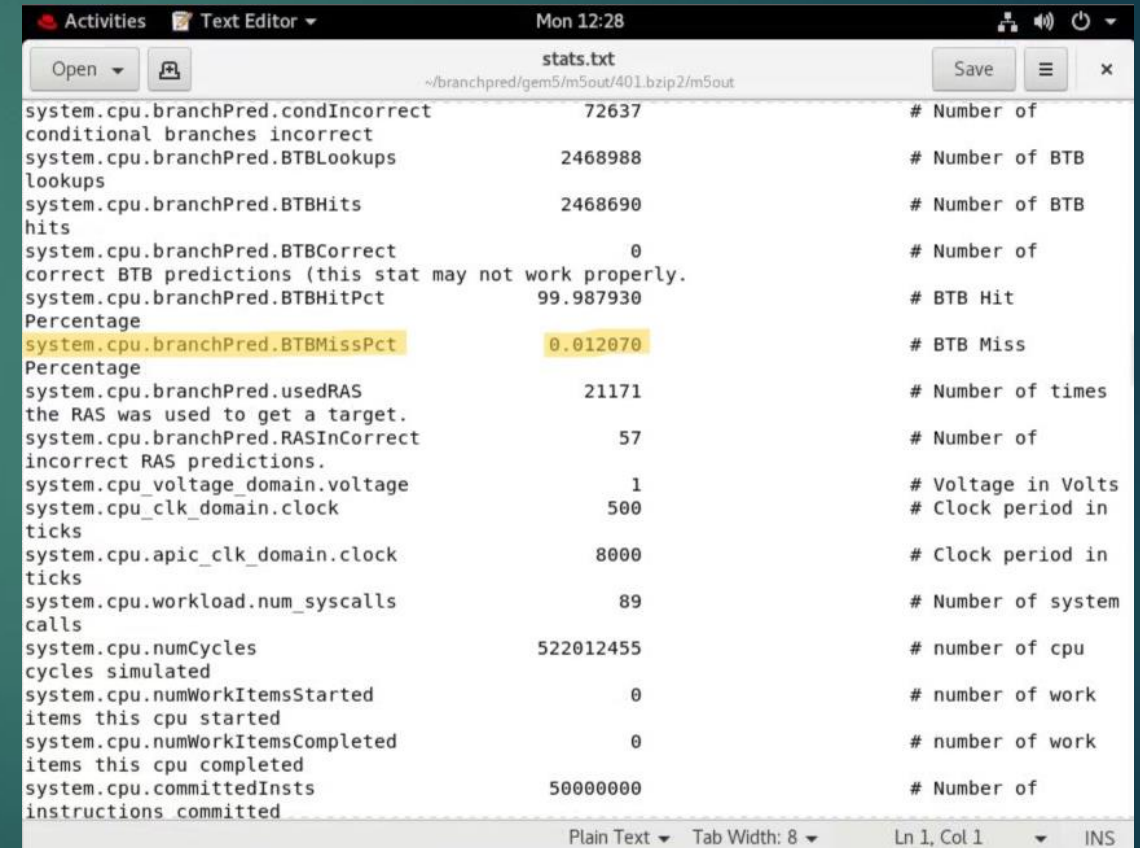
stats.txt

~/branchpred/gem5/m5out/401.bzip2/m5out

the CC registers were written			
system.cpu.num_mem_refs	36814329		# number of memory refs
system.cpu.num_load_insts	25317308		# Number of load instructions
system.cpu.num_store_insts	11497021		# Number of store instructions
system.cpu.num_idle_cycles	0		# Number of idle cycles
system.cpu.num_busy_cycles	522012455		# Number of busy cycles
system.cpu.not_idle_fraction	1		# Percentage of non-idle cycles
system.cpu.idle_fraction	0		# Percentage of idle cycles
system.cpu.Branches	3201933		# Number of branches fetched
system.cpu.predictedBranches	2489861		# Number of branches predicted as taken
system.cpu.BranchMispred	72637		# Number of branch mispredictions
system.cpu.numBranchMispredPercent	2.268536		# Branch misprediction percentage
system.cpu.op_class::No_OpClass	936468	1.50%	1.50% # Class of executed instruction
system.cpu.op_class::IntAlu	24486551	39.26%	40.76% # Class of executed instruction
system.cpu.op_class::IntMult	130868	0.21%	40.97% # Class of executed instruction
system.cpu.op_class::IntDiv	70	0.00%	40.97% # Class of executed instruction

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Branch misprediction percentage



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stats.txt

~/branchpred/gem5/m5out/401.bzip2/m5out

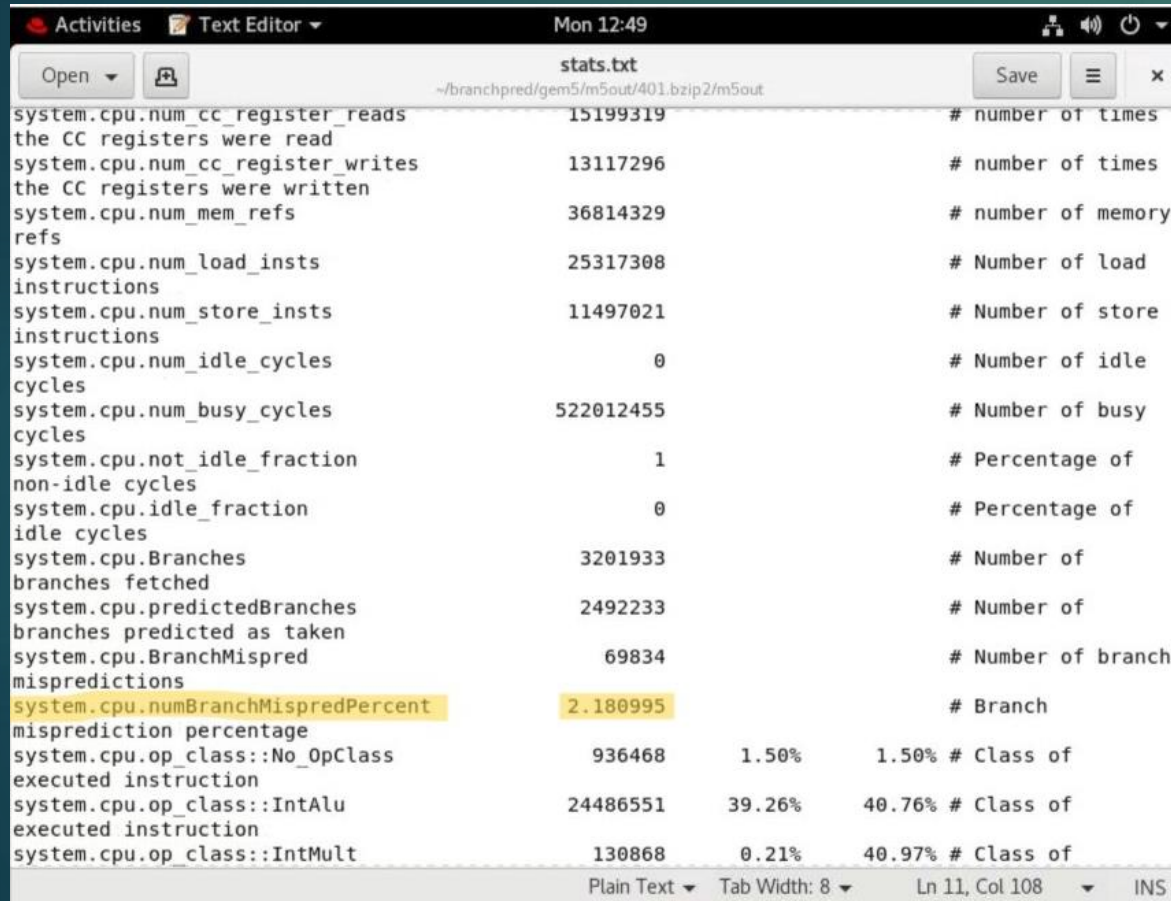
system.cpu.branchPred.condIncorrect	72637		# Number of conditional branches incorrect
system.cpu.branchPred.BTBLookups	2468988		# Number of BTB lookups
system.cpu.branchPred.BTBHits	2468690		# Number of BTB hits
system.cpu.branchPred.BTBCorrect	0		# Number of correct BTB predictions (this stat may not work properly.)
system.cpu.branchPred.BTBHitPct	99.987930		# BTB Hit Percentage
system.cpu.branchPred.BTBMissPct	0.012070		# BTB Miss Percentage
system.cpu.branchPred.usedRAS	21171		# Number of times the RAS was used to get a target.
system.cpu.branchPred.RASInCorrect	57		# Number of incorrect RAS predictions.
system.cpu_voltage_domain.voltage	1		# Voltage in Volts
system.cpu_clk_domain.clock	500		# Clock period in ticks
system.cpu.apic_clk_domain.clock	8000		# Clock period in ticks
system.cpu.workload.num_syscalls	89		# Number of system calls
system.cpu.numCycles	522012455		# number of cpu cycles simulated
system.cpu.numWorkItemsStarted	0		# number of work items this cpu started
system.cpu.numWorkItemsCompleted	0		# number of work items this cpu completed
system.cpu.committedInsts	50000000		# Number of instructions committed

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BTB Miss Percentage

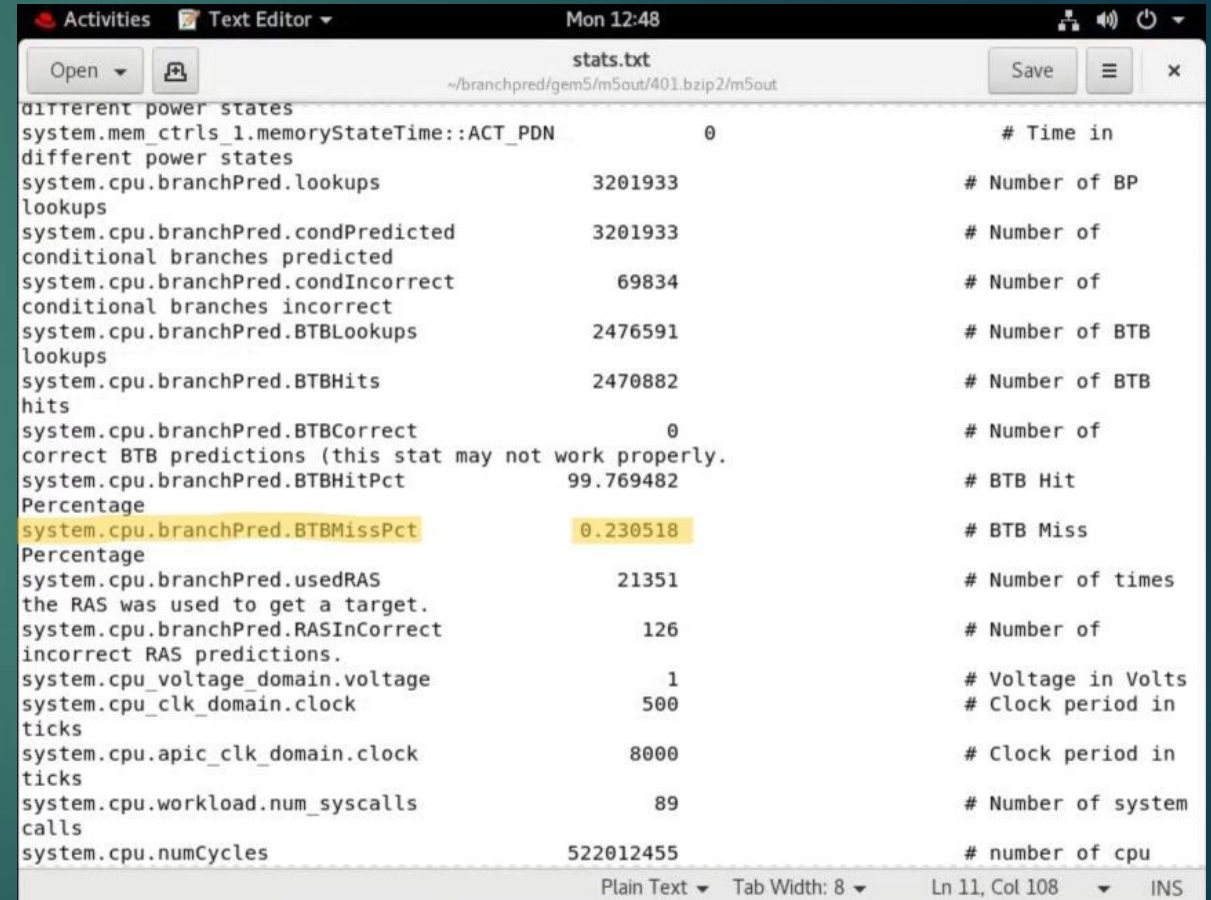
Part 4 – Benchmark 401

TournamentBP



system.cpu.num_cc_register_reads	15199319			# number of times
the CC registers were read				
system.cpu.num_cc_register_writes	13117296			# number of times
the CC registers were written				
system.cpu.num_mem_refs	36814329			# number of memory
refs				
system.cpu.num_load_insts	25317308			# Number of load
instructions				
system.cpu.num_store_insts	11497021			# Number of store
instructions				
system.cpu.num_idle_cycles	0			# Number of idle
cycles				
system.cpu.num_busy_cycles	522012455			# Number of busy
cycles				
system.cpu.not_idle_fraction	1			# Percentage of
non-idle cycles				
system.cpu.idle_fraction	0			# Percentage of
idle cycles				
system.cpu.Branches	3201933			# Number of
branches fetched				
system.cpu.predictedBranches	2492233			# Number of
branches predicted as taken				
system.cpu.BranchMispred	69834			# Number of branch
mispredictions				
system.cpu.numBranchMispredPercent	2.180995			# Branch
misprediction percentage				
system.cpu.op_class::No_OpClass	936468	1.50%	1.50%	# Class of
executed instruction				
system.cpu.op_class::IntAlu	24486551	39.26%	40.76%	# Class of
executed instruction				
system.cpu.op_class::IntMult	130868	0.21%	40.97%	# Class of

Branch misprediction percentage

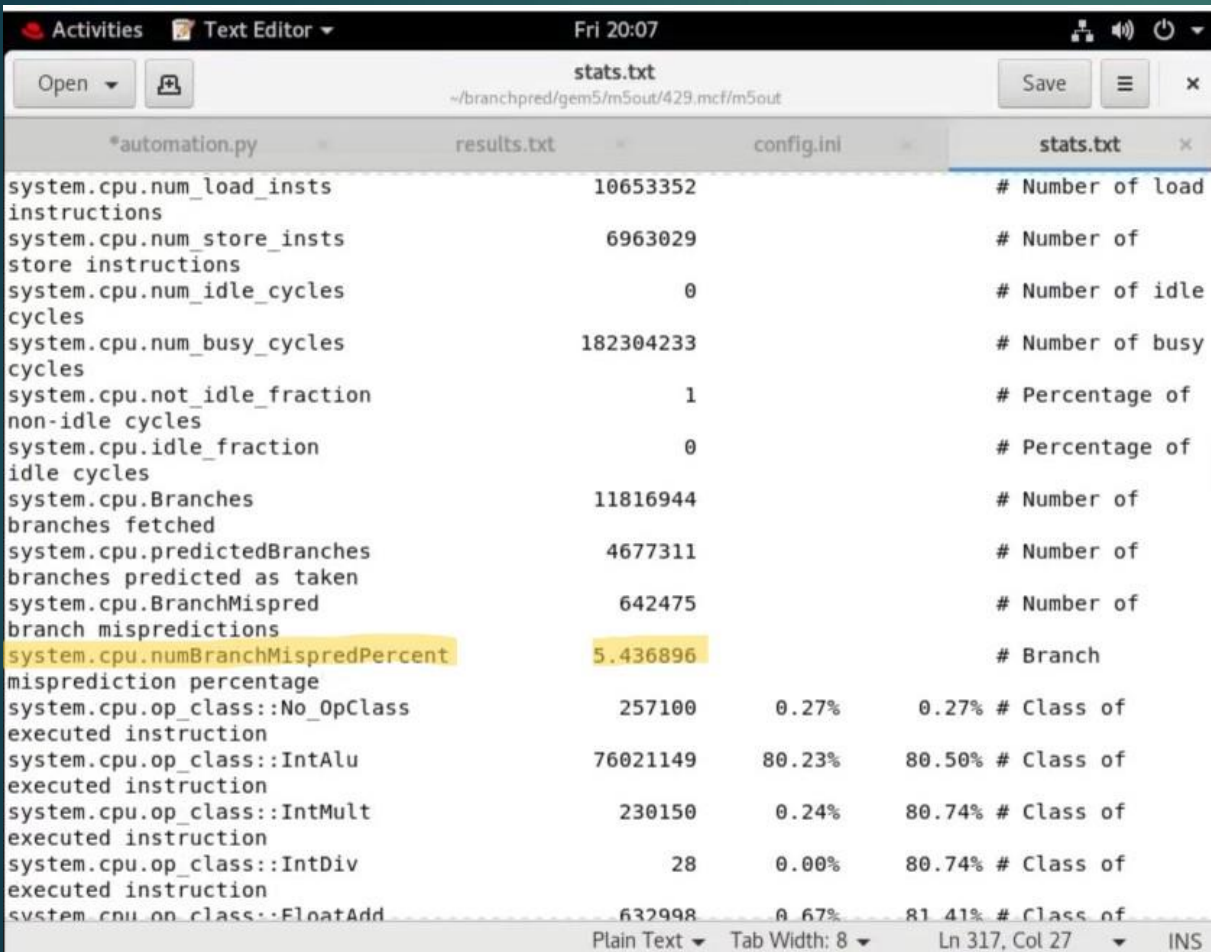


different power states				
system.mem_ctrls_1.memoryStateTime::ACT_PDN	0			# Time in
different power states				
system.cpu.branchPred.lookups	3201933			# Number of BP
lookups				
system.cpu.branchPred.condPredicted	3201933			# Number of
conditional branches predicted				
system.cpu.branchPred.condIncorrect	69834			# Number of
conditional branches incorrect				
system.cpu.branchPred.BTBLookups	2476591			# Number of BTB
lookups				
system.cpu.branchPred.BTBHits	2470882			# Number of BTB
hits				
system.cpu.branchPred.BTBCorrect	0			# Number of
correct BTB predictions (this stat may not work properly.				
system.cpu.branchPred.BTBHitPct	99.769482			# BTB Hit
Percentage				
system.cpu.branchPred.BTBMissPct	0.230518			# BTB Miss
Percentage				
system.cpu.branchPred.usedRAS	21351			# Number of times
the RAS was used to get a target.				
system.cpu.branchPred.RASInCorrect	126			# Number of
incorrect RAS predictions.				
system.cpu_voltage_domain.voltage	1			# Voltage in Volts
system.cpu_clk_domain.clock	500			# Clock period in
ticks				
system.cpu.apic_clk_domain.clock	8000			# Clock period in
ticks				
system.cpu.workload.num_syscalls	89			# Number of system
calls				
system.cpu.numCycles	522012455			# number of cpu

BTB Miss Percentage

Part 4 – Benchmark 401

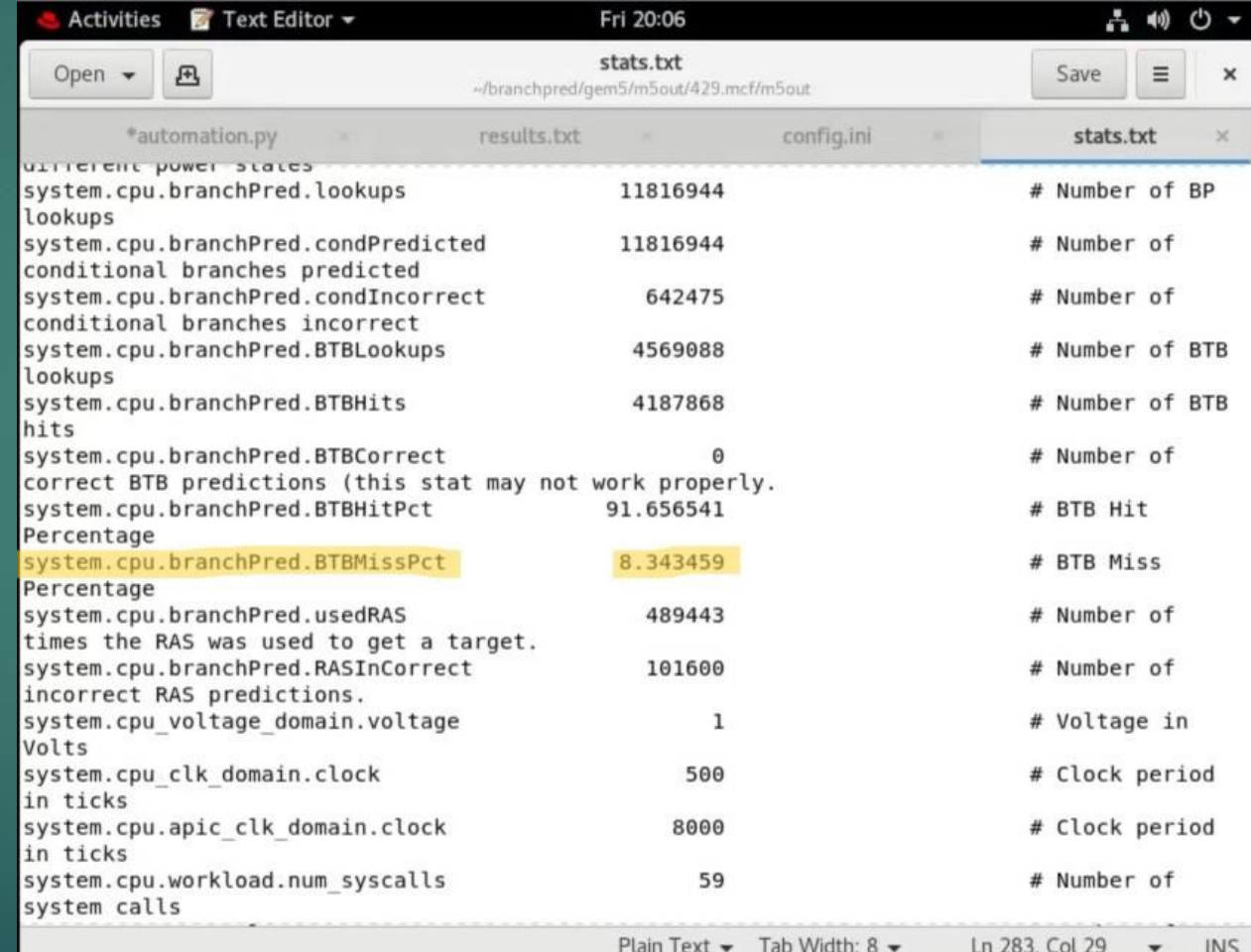
LocalBP



The screenshot shows a text editor window titled 'stats.txt' with the following content:

system.cpu.num_load_insts	10653352		# Number of load instructions
system.cpu.num_store_insts	6963029		# Number of store instructions
system.cpu.num_idle_cycles	0		# Number of idle cycles
system.cpu.num_busy_cycles	182304233		# Number of busy cycles
system.cpu.not_idle_fraction	1		# Percentage of non-idle cycles
system.cpu.idle_fraction	0		# Percentage of idle cycles
system.cpu.Branches	11816944		# Number of branches fetched
system.cpu.predictedBranches	4677311		# Number of branches predicted as taken
system.cpu.BranchMispred	642475		# Number of branch mispredictions
system.cpu.numBranchMispredPercent	5.436896		# Branch misprediction percentage
system.cpu.op_class::No_OpClass	257100	0.27%	0.27% # Class of executed instruction
system.cpu.op_class::IntAlu	76021149	80.23%	80.50% # Class of executed instruction
system.cpu.op_class::IntMult	230150	0.24%	80.74% # Class of executed instruction
system.cpu.op_class::IntDiv	28	0.00%	80.74% # Class of executed instruction
system.cpu.op_class::FloatAdd	632998	0.67%	81.41% # Class of executed instruction

Branch Misprediction Percentage

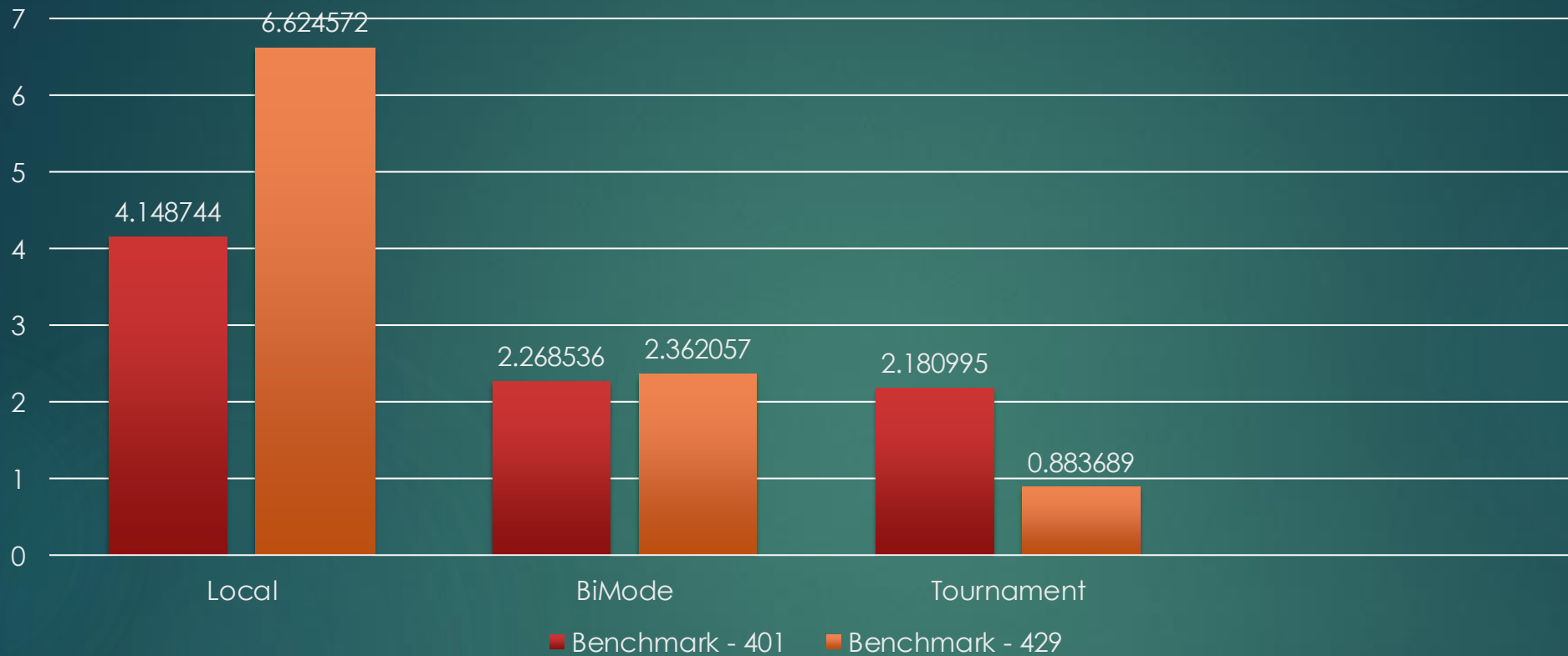


The screenshot shows a text editor window titled 'stats.txt' with the following content:

system.cpu.branchPred.lookups	11816944		# Number of BP lookups
system.cpu.branchPred.condPredicted	11816944		# Number of conditional branches predicted
system.cpu.branchPred.condIncorrect	642475		# Number of conditional branches incorrect
system.cpu.branchPred.BTBLookups	4569088		# Number of BTB lookups
system.cpu.branchPred.BTBHits	4187868		# Number of BTB hits
system.cpu.branchPred.BTBCorrect	0		# Number of correct BTB predictions (this stat may not work properly.)
system.cpu.branchPred.BTBHitPct	91.656541		# BTB Hit Percentage
system.cpu.branchPred.BTBMissPct	8.343459		# BTB Miss Percentage
system.cpu.branchPred.usedRAS	489443		# Number of times the RAS was used to get a target.
system.cpu.branchPred.RASInCorrect	101600		# Number of incorrect RAS predictions.
system.cpu_voltage_domain.voltage	1		# Voltage in Volts
system.cpu_clk_domain.clock	500		# Clock period in ticks
system.cpu.apic_clk_domain.clock	8000		# Clock period in ticks
system.cpu.workload.num_syscalls	59		# Number of system calls

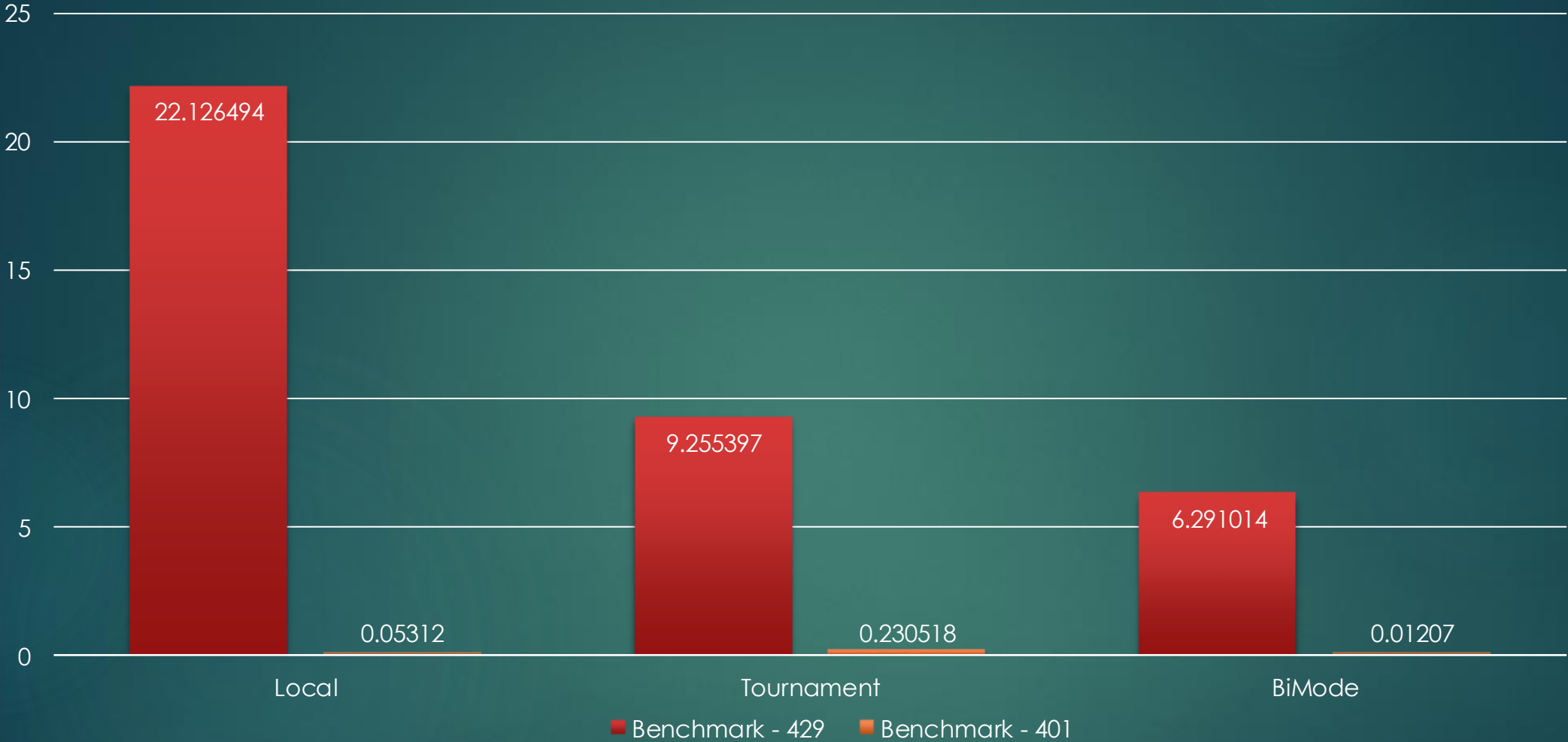
BTB Miss Percentage

Percent of Branch Mispredict



TournamentBP has the lowest misprediction rate for both the benchmarks whereas LocalBP has the highest.

BTB Miss Percentage



BiModeBP has the lowest BTB Miss Pct for both the benchmarks.

Conclusion

- ▶ BiModeBP shows better branch misprediction percentage and BTB Miss percentage.

Automation

- ▶ Part – 2 and part – 4 of the project have been automated.

File path

`/home/011/s/sx/sxm210368/branchpred/gem5/automation.py`

- ▶ Results of the automation will be stored in results.txt

File path

`/home/011/s/sx/sxm210368/branchpred/gem5/results.txt`