/**********
** Multi2Sim Simulator @ LaCASA Laboratory (lacasa.uah.edu)
** This file illustrates how to configure a computer system for the detailed simulation in Multi2Sim.
**
** Intended audience: Those who would like to learn more about Multi2Sim simulator.
**
** Used: CPE 631 Advanced Computer Systems and Architectures
**
** Note: Tutorial is tested at blackhawk.ece.uah.edu
**
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** ver 1.0, Fall 2014
** ver 1.1, Spring 2019 (Multi2Sim-5.0)
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Multi2Sim Simulator: System Configuration

In this tutorial you will learn how to configure a computer system for the detailed simulation in Multi2Sim. We simulate a single-threaded matrix multiplication benchmark on a computer system with specified system parameters.

1 Copy Benchmark Files to Your Working Directory

First, set up the working directory and copy the benchmark files *mm_serial.c* as well as configuration files *x86_config*, *ctx_config*, and *mem_config* to current working directory.

```
<<
```

2 Compile and Run the Program (mm_serial.c)

As an example benchmark, we are using a serial matrix multiplication.

```
<<
```

```
; Simulation alpha-numeric ID: LKGCZ


A matrix =
   48.40    65.32    15.04    72.38
   25.89    46.03    15.49    50.65
    6.75    71.01    12.22    77.54
   61.55    31.51    46.85    89.48

B matrix =
   70.03    57.32    75.41    83.56
   91.78     7.74    40.08    11.17
   26.54    83.95    86.53    51.04
   65.34    85.27    77.00    49.00

C matrix =
14514.04 10714.23 13142.92  9088.00
 9758.44  7459.43  9037.62  5949.93
12380.98  8574.39 10383.19  5780.45
14293.44 15335.06 16848.88 12270.85

;
; Simulation Statistics Summary
;

[ General ]
RealTime = 0.04 [s]
SimEnd = ContextsFinished

[ x86 ]
RealTime = 0.04 [s]
Instructions = 206255
InstructionsPerSecond = 5175135
>>>
```

```
B matrix =
   70.03    57.32    75.41    83.56
   91.78     7.74    40.08    11.17
   26.54    83.95    86.53    51.04
   65.34    85.27    77.00    49.00

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14293.44 15335.06 16848.88 12270.85

;
; Simulation Statistics Summary
;

[ General ]
RealTime = 8.31 [s]
SimEnd = ContextsFinished
SimTime = 711433.00 [ns]
Frequency = 1000 [MHz]
Cycles = 711434

[ x86 ]
RealTime = 8.30 [s]
Instructions = 355242
InstructionsPerSecond = 42787
SimTime = 711434.00 [ns]
Frequency = 1000 [MHz]
Cycles = 711434
CyclesPerSecond = 85688
FastForwardInstructions = 0
CommittedInstructions = 206255
CommittedInstructionsPerCycle = 0.2899
CommittedMicroInstructions = 354836
CommittedMicroInstructionsPerCycle = 0.4988
BranchPredictionAccuracy = 0.8998
>>>
```

```
A matrix =
   48.40    65.32    15.04    72.38
   25.89    46.03    15.49    50.65
    6.75    71.01    12.22    77.54
   61.55    31.51    46.85    89.48

B matrix =
   70.03    57.32    75.41    83.56
   91.78     7.74    40.08    11.17
   26.54    83.95    86.53    51.04
   65.34    85.27    77.00    49.00

C matrix =
14514.04 10714.23 13142.92  9088.00
 9758.44  7459.43  9037.62  5949.93
12380.98  8574.39 10383.19  5780.45
14293.44 15335.06 16848.88 12270.85

;
; Simulation Statistics Summary
;

[ General ]
RealTime = 8.12 [s]
SimEnd = ContextsFinished
SimTime = 711433.00 [ns]
Frequency = 1000 [MHz]
Cycles = 711434

[ x86 ]
RealTime = 8.11 [s]
Instructions = 355242
InstructionsPerSecond = 43793
SimTime = 711434.00 [ns]
Frequency = 1000 [MHz]
Cycles = 711434
CyclesPerSecond = 87704
FastForwardInstructions = 0
CommittedInstructions = 206255
CommittedInstructionsPerCycle = 0.2899
CommittedMicroInstructions = 354836
CommittedMicroInstructionsPerCycle = 0.4988
BranchPredictionAccuracy = 0.8998
. . .
. . .
-bash-4.2$ ls -lat *Report
-rw-r--r-- 1 milenka facstaff  8335 Feb 21 21:25 mm_Memory_Report
-rw-r--r-- 1 milenka facstaff 20753 Feb 21 21:04 mm_x86_Report
>>>
```

- Configuration model for x86 CPU; for details explore *--x86-help*
- Configuration model for AMD Evergreen GPU Model; for details explore *--evg-help*
- Configuration model for AMD Southern Islands GPU Model; for details explore *--si-help*
- Configuration model for General Memory Systems; for details explore *--mem-help*
- Configuration model for x86 Network Options; for details explore *--net-help*

Now let us make a general configuration file. You can specify the command line parameters in a file *ctx_config*. In the example below we specify the matrix multiplication program, its argument, and the output file to redirect the standard output.

```
Configuration file name: ctx_config.dat
<<~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
        [ Context 0 ]
        Exe = /path/to/m2s/Serial_MM/Mm_serial
        Args = 8
        Cwd = /path/to/m2s/Serial_MM
        StdOut = SerialContextOutputFile.txt
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~>>
```

Below is an example of using the configuration file in a command.

```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
[ Context 0 ]
Exe = /home/facstaff/milenka/m2s.test/mm_serial.exe
Args = 4
Cwd = /home/facstaff/milenka/m2s.test
StdOut = SerialContextOutputFile.txt

-bash-4.2$ m2s --x86-sim detailed --ctx-config ctx_config.dat

; Multi2Sim 5.0 - A Simulation Framework for CPU-GPU Heterogeneous Computing
; Please use command 'm2s --help' for a list of command-line options.
; Simulation alpha-numeric ID: RW47d


;
; Simulation Statistics Summary
;

[ General ]
RealTime = 7.34 [s]
SimEnd = ContextsFinished
SimTime = 642618.00 [ns]
Frequency = 1000 [MHz]
Cycles = 642619

[ x86 ]
RealTime = 7.33 [s]
Instructions = 329356
InstructionsPerSecond = 44926
SimTime = 642619.00 [ns]
Frequency = 1000 [MHz]
Cycles = 642619
CyclesPerSecond = 87657
```

```
FastForwardInstructions = 0
CommittedInstructions = 182605
CommittedInstructionsPerCycle = 0.2842
CommittedMicroInstructions = 312892
CommittedMicroInstructionsPerCycle = 0.4869
BranchPredictionAccuracy = 0.8841
>>>
```

```
; Simulation Statistics Summary
;

[ General ]
RealTime = 8.75 [s]
SimEnd = ContextsFinished
SimTime = 720844.50 [ns]
Frequency = 2000 [MHz]
Cycles = 1441690

[ x86 ]
RealTime = 8.74 [s]
Instructions = 403237
InstructionsPerSecond = 46139
SimTime = 720845.00 [ns]
Frequency = 2000 [MHz]
Cycles = 1441690
CyclesPerSecond = 164961
FastForwardInstructions = 0
CommittedInstructions = 206255
CommittedInstructionsPerCycle = 0.1431
CommittedMicroInstructions = 354836
CommittedMicroInstructionsPerCycle = 0.2461
BranchPredictionAccuracy = 0.8701
>>>
```

```
        [CacheGeometry geo-l2]
        Sets = 256
        Assoc = 4
        BlockSize = 256
        Latency = 4
        Policy = LRU
        Ports = 2

        [Module mod-l1-0]
        Type = Cache
        Geometry = geo-l1
        LowNetwork = net-l1-l2
        LowModules = mod-l2-0

        [Module mod-l2-0]
        Type = Cache
        Geometry = geo-l2
        HighNetwork = net-l1-l2
        LowNetwork = net-l2-mm
        LowModules = mod-mm

        [Module mod-mm]
        Type = MainMemory
        BlockSize = 256
        Latency = 200
        HighNetwork = net-l2-mm

        [Network net-l1-l2]
        DefaultInputBufferSize = 1024
        DefaultOutputBufferSize = 1024
        DefaultBandwidth = 256

        [Network net-l2-mm]
        DefaultInputBufferSize = 1024
        DefaultOutputBufferSize = 1024
        DefaultBandwidth = 256

        [Entry core-0]
        Arch = x86
        Core = 0
        Thread = 0
        DataModule = mod-l1-0
        InstModule = mod-l1-0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~>>
```

Run a simulation with the given memory configuration. What is the execution time? How does it compare with the default configuration?

```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
-bash-4.2$ m2s --x86-sim detailed --ctx-config ctx_config.dat --x86-config
x86_config.dat --mem-config mem_config.dat --mem-report mm_Memory_Report

; Multi2Sim 5.0 - A Simulation Framework for CPU-GPU Heterogeneous Computing
; Please use command 'm2s --help' for a list of command-line options.
; Simulation alpha-numeric ID: UsXtd
```

```
;
; Simulation Statistics Summary
;

[ General ]
RealTime = 4.10 [s]
SimEnd = ContextsFinished
SimTime = 193842.50 [ns]
Frequency = 2000 [MHz]
Cycles = 387686

[ x86 ]
RealTime = 4.10 [s]
Instructions = 383504
InstructionsPerSecond = 93600
SimTime = 193843.00 [ns]
Frequency = 2000 [MHz]
Cycles = 387686
CyclesPerSecond = 94620
FastForwardInstructions = 0
CommittedInstructions = 182605
CommittedInstructionsPerCycle = 0.471
CommittedMicroInstructions = 312892
CommittedMicroInstructionsPerCycle = 0.8071
BranchPredictionAccuracy = 0.8626
>>>
```