

Introduction

Heterogeneous Architecture Configurations Generator for Multi2Sim simulator (HeteroArchGen4M2S)

HeteroArchGen4M2S: An automatic generator software for configuring and running heterogeneous CPU-GPU architectures on Multi2Sim (M2S) simulator. This tool runs on top of M2S simulator, it allows us to configure the various heterogeneous CPU-GPU architectures (e.g., number of CPU cores, GPU cores, L1, L2, memory (size and latency (via `CACTI 6.5`)), network topologies (currently support 2D-Mesh, customized 2D-Mesh, and Torus networks)...). The output files include the results of network throughput and latency, caches/memory access time, and and dynamic power of the cores (can be collected after running McPAT).

HeteroArchGen4M2S is free software, which is freely to be redistributed and modified it under the terms of the GNU General Public License as published by the Free Software Foundation (For more details <http://www.gnu.org/licenses>).

HeteroArchGen4M2S is written to help you configure M2S easily, but non-warranty and non-mechantability.

A pdf version of this manual is also available in **HeteroArchGen4M2S.pdf**.

Please cite my tool using this [bibtex](#):

```
@article{HeteroArchGen4M2S,
  Author = {Tung Thanh Le},
  Journal = {https://github.com/ttunگل/HeteroArchGen4M2S},
  Title = {{HeteroArchGen4M2S: An automatic generator tool for configuring and running heterog
  Year = {2017}}
```

Note, paper reference will be updated soon. Enjoy it!

Setup Requirements

1. Currently HeteroArchGen4M2S has been tested on 64-bit platforms:
 - Ubuntu 14.04 (final)
2. Required tools to build and run with HeteroArchGen4M2S:
 - Python 2.7
3. Download and install `multi2sim` from:
 - `git clone https://github.com/Multi2Sim/multi2sim.git`

4. Download McPAT (current version-1.3) from:

- <https://code.google.com/archive/p/mcpat/>.
- Unzip it, compile it using `make`, and then go back under `multi2sim` directory, use `mv mcpat/* .` to copy all files from `mcpat` folder to under `multi2sim` directory. Now, you are ready to use McPAT, using `./mcpat -h` to check it out.

5. Download and install CACTI6.5 from:

- <http://www.hpl.hp.com/research/cacti/cacti65.tgz>.
- CACTI 6.5 is used to obtain the cache and memory latency.

6. Required benchmarks to run:

- Download benchmarks. Note that, type the commands under the installed `multi2sim` directory.

```
git clone https://github.com/Multi2Sim/m2s-bench-splash2.git
```

```
git clone https://github.com/Multi2Sim/m2s-bench-spec2006.git
```

```
git clone https://github.com/Multi2Sim/m2s-bench-parsec-3.0.git
```

```
git clone https://github.com/Multi2Sim/m2s-bench-cudasdk-6.5.git
```

```
git clone https://github.com/Multi2Sim/m2s-bench-heteromark.git
```

- Compile the benchmarks following the README file.

Note: All the packages are compiled to binary. If you want to modify the benchmarks, you can download the source codes from <https://github.com/Multi2Sim>. In case you want to run CUDA benchmarks, you can download other benchmarks for CPU-GPU systems such as Rodinia, Parboil, etc. Your desktop should have a NVIDIA graphic card (e.g., NVIDIA Quadro 4000), and you need to install the graphic card driver for running the simulation. (When compiling benchmarks, use `-m32` flag after `gcc` to make compatible with `multi2sim` 32-bit (no support 64-bit at this time)).

Download HeteroArchGen4M2S

```
git clone https://github.com/ttungl/HeteroArchGen4M2S.git
```

Build configuration files with HeteroArchGen4M2S

Let's assume you are in the home directory (`$multi2sim/HeteroArchGen4M2S`)

Where are the configuration files?

- Run `/multi2sim/HeteroArchGen4M2S$ python create_sim_configs_files.py`.
- The output files will be saved in the `configs` directory.
- `cd configs >>>` the `configs` folder contains four files, including `memconfig`, `netconfig`, `x86_cpuconfig`, and `si_gpuconfig`.

How to run the simulation?

- Previous steps show how to generate the configuration files. By running `create_sim_configs_files.py`, it also generated a shell script file inside `run_simulation_files` folder. The bash file (shell script) has been `chmod 777` for running.
- Go back under `multi2sim` directory.
- Run `./HeteroArchGen4M2S/run_simulation_files/run-bash-sim.sh`.
- This will create the output files which are the results of the simulation.

Where are the output files after simulation?

- `cd results >>>` Note that, `results` folder contains two files at this point, including `pipeline.out`, `mem.out`.
- With `net_report.out` file, it is generated under the `multi2sim` directory (outside of `HeteroArchGen4M2S` folder), you need to copy this file to `HeteroArchGen4M2S/results`.
- Now, there are three files should be in `results` folder, including `pipeline.out`, `mem.out`, and `net_report.out`(just copied).

Demonstration:

How to run multi2sim with HeteroArchGen4M2S ?

Let's use the `blacksholes` example with 16 cores CPUs (8 x86 CPUs), 16 cores GPUs (4 Southern Islands GPUs), 4 Memory Controllers, in a 2D-Mesh for demonstration.

Important: You need to download `parsec` benchmark from <https://github.com/Multi2Sim/m2s-bench-parsec-3.0>, then unzip it under the `benchmarks` folder in `multi2sim` directory for demonstration.

1. Suppose that you already got the cache and memory latencies for your proposed architecture by running `CACTI6.5`.
2. Suppose that you are under the `multi2sim\HeteroArchGen4M2S$` directory:
 - `sudo vim create_sim_configs_files.py` to configure your architecture. This file includes many parameters that need to be configured.
 - For CPU cores, a set of CPU includes two cores. Each core in the set can have its own L1\$ (Data&Instr) or it can share the Instruction-L1\$ with the other core in that set, by enabling `L1_Inst_shared` flag in the CPU Memory Parameters settings.
 - For GPU cores, a set of GPU includes four compute units. Each two compute units share with one L1, *each two* L1 shares with one L2\$.
 - For benchmarks, you need to modify the name of specific benchmark you want to run, and modify the command line of this benchmark and its path in `create_shell_script` file.
 - For network topologies, `HeteroArchGen4M2S` currently supports three types of network, including `2D-Mesh`, `customized 2D-Mesh`, and `2D-Torus`. For `customized 2D-Mesh`, you need to specify the paths for local links and hybrid links in your network, as well as their linkwidths.
3. After modifying `create_sim_configs_files.py`:
 - Run `\HeteroArchGen4M2S$ python create_sim_configs_files.py` to generate the configuration files.
 - Checking the configuration files in the `configs` folder.
 - A shell script (`.sh`) has also been generated in the `run_simulation_files` folder. The shell script looks like as below.

```
m2s -x86-sim detailed -x86-report
HeteroArchGen4M2S/results/blackscholes_pipeline.out
-mem-report HeteroArchGen4M2S/results/blackscholes_mem.out
-x86-config ./HeteroArchGen4M2S/configs/x86_cpuconfig
-si-sim detailed -si-config ./HeteroArchGen4M2S/configs/si_gpuconfig
-mem-config ./HeteroArchGen4M2S/configs/memconfig
-net-config ./HeteroArchGen4M2S/configs/netconfig
-x86-max-inst 100000000 -net-report blackscholes_net_report.out
benchmarks/m2s-bench-parsec-3.0/blackscholes/blackscholes
16 in_4K.txt primes.txt data-small
```

- `cd ..` to `multi2sim` directory.
 - `./HeteroArchGen4M2S/run_simulation_files/run-sim-16-CPU-16-\SouthernIslands-GPU-benchmark-blacksholes.sh`
4. To check the results, all of them are in the `results` folder, including:
- `blacksholes_mem.out`
 - `blacksholes_pipeline.out`
 - With `net-12-mm_blacksholes_net_report.out`, it is saved under the `multi2sim` directory, so just copy into the `results` folder.
5. To read the results:
- Make sure you are in `HeteroArchGen4M2S` directory.
 - Run `python read_results.py`, the total cycles and network performance results are saved in `results` folder, under the names: `blacksholes_totalCycles.out` and `blacksholes_network_performance.out`.
- For `blacksholes_totalCycles.out`:
- Cycles: 306794
 - Time (seconds): 3.94
- For `blacksholes_network_performance.out`:
- Network Throughput (MBps): 32366.64
 - Network Latency (cycles): 23.6969
6. To run the network-only mode, in the file `create_sim_configs_files`, you just need to modify the value of `network_only` to 1. Thereby, now when running `HeteroArchGen4M2S$ python create_sim_configs_files`, the software will generate the bash file with network-only simulation.
7. To get the dynamic power from McPAT. (Note, this section is finalizing. Available soon.)
- Make sure you are in `multi2sim` directory.
 - Run `m2s2xml4mcpat.sh` with the input files `hetero_mcpat.xml` file and `blacksholes_pipeline.out` to get the `mcpat.xml` file.
 - Run `./mcpat -infile mcpat.xml -opt_for_clk 1 -print_level 5 > HeteroArchGen4M2S/results/mcpat_result.txt`
 - `mcpat_result.txt` contains the results of McPAT.

Now you are ready to go. Happy hacking the code!

Claims:

I would like to thank the open source multi2sim community. This work is also inspired by [M2StoMcPAT](#) in Matlab, but I implemented completely in Python, with heterogeneous CPU-GPU architectures.

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