Computer Architecture Term Project Simulators

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I. Basic Information

- ✓ Simulators are commonly used in computer architecture field. Most simulators are open source software, and experiments are performed by modifying simulators.
- ✓ You can run applications on the simulators. For example, you will get simulation results such as execution time and the number of cache accesses. There are many simulators and each simulator has different characteristics. Thus, it is very important to investigate various simulators before starting the project.
- ✓ You may feel dizzy because there are too many simulators. This paper introduces several popular simulators. They are widely used and have documents, papers, and tutorial slides. You should learn simulators and search information for the project.
- ✓ Following simulators are just examples. If you find better simulator for your term project, you can use that. Please search simulators as many as you can.

II. Overall CPU Architecture Simulator

1. gem5

- Main page: http://gem5.org/Main_Page
- Tutorial slides in ISCA 2011: http://www.gem5.org/dist/tutorials/isca_pres_2011.pdf
- It is one of the most widely used simulator. It supports various architecture. This simulator is maintained by ARM. Therefore, ARM architecture is highly recommended.
- Pros.
  A. Detailed cycle accurate simulator (very accurate).
  B. There are many materials and documents you can use.
  C. You can attach other simulator (like 'Ramulator' and 'Dramsim2') to gem5 for the whole system simulation.
- Cons.
  A. Since gem5 is detailed cycle accurate simulator, the simulation can be very slow. The simulation time is about 1,000 times slower than the real execution time.

2. Sniper

- Main page: http://snipersim.org/w/The_Sniper_Multi-Core_Simulator
- Tutorial slides in IIWSC 2013: http://snipersim.org/documents/2013-09-22%20Sniper%20IISWC%20Tutorial.pdf
- Paper in SC 2011 (657 citations): http://www.exascience.com/wp-content/uploads/2011/09/Sc2011carlson-final.pdf
- This simulator is specialized to multi-core or many-core systems. You can simulate 100+ cores with fast speed. SPLASH-2 and PARSEC 2.1 benchmarks are given.
- Pros.
  A. Fast simulation is possible.
  B. Intel PIN-based trace simulation.
  C. It is still being updated by Intel Corp.
- Cons.
  A. Since it is based on Intel PIN, it can simulate x86 ISA only.
  B. Compared to gem5, it has less accuracy.
  C. It is mainly for the many-core system. So, it can be hard to understand about multi-core related parts: MESI protocol, mutual exclusion locking process, etc.

3. SimpleScalar

- Main page: http://www.simplescalar.com/
- Tutorial slides: http://www.simplescalar.com/docs/simple_tutorial_v2.pdf
- Paper (3,996 citations): https://minds.wisconsin.edu/bitstream/handle/1793/60110/TR1342.pdf?sequence=1
- Another simulator like gem5. But it is simpler and easier to use.
- Pros.
  A. Easy to use.
  B. Since it is simple, its simulation time is not long.
- Cons.
  A. Less accuracy than gem5.
  B. Old simulator. It cannot support latest computer architectures.

4. Z-Sim

- Main page (GitHub): https://github.com/s5z/zsim
- Tutorial slides in MICRO: http://zsim.csail.mit.edu/tutorial/
- Paper (286 citations): https://core.ac.uk/download/pdf/78055910.pdf
- Intel PIN based simulator like Sniper. It also supports many-core system.
- Pros.
  A. Easier to understand than Sniper.
  B. Fast to simulate.
- Cons.
  A. Not accurate.
  B. Similar to Sniper, you should understand communication process between cores.
  C. There are not enough documentations.

III. DRAM Memory System Simulator

1. DRAMSim2

- Main Page: https://user.eng.umd.edu/~blj/dramsim/
- Tutorial Manual: https://user.eng.umd.edu/~blj/dramsim/v1/download/DRAMsim2.pdf
- Pros.
  A. DRAMSim2 wrapper code is already attached into gem5.
  B. There are few documentation you can use.
  C. It is widely used DRAM simulator.
- Cons.
  A. Simulation speed is slow.

2. Ramulator

- Main Page: https://github.com/CMU-SAFARI/ramulator
- Pros.
  A. Simulation speed is very fast.
  B. DRAM timing modification and configuration are intuitive.
  C. Ramulator can be attached into gem5.
- Cons.
  A. Since recursive function calls are widely used, code analyze is a little bit tricky.

3. NVMain

- Main Page (Bitbucket): https://bitbucket.org/mrp5060/nvmain/
- Paper in VLSI 2012 (99 citations): https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6296505
- Emerging non-volatile memory simulator. You can simulate STT-RAM, and PCRAM.
- Pros.
  A. You can simulate emerging memory.
- Cons.
  A. Not enough documentations.
  B. You should use it with other simulators like gem5, since it simulates memory only.

IV. GPU Simulator

1. gpgpu-sim

- Main Page: http://gpgpu-sim.org/manual/index.php/Main_Page
- Tutorial Slides in MICRO 2009: http://www.gpgpu-sim.org/micro2009-tutorial/
- The basic GPU simulator. If you want to simulate about GPU, there are not much possible solutions, but gpgpu-sim can be a solution.
- Pros.
  A. Almost unique GPU simulator.
  B. gem5-gpu simulator is also based on it (gem5 + gpgpu-sim).
- Cons.
  A. Too old GPU architecture (Fermi series). So, it does not support latest techniques.
  B. It is based on NVIDIA GPU. Other gpus cannot be simulated.
  C. Because it is GPU simulator, you need CUDA compiled applications as inputs.

2. gem5-gpu

- Main Page: https://gem5-gpu.cs.wisc.edu/wiki/
- Workshop Slides in MICRO 2012: http://www.gem5.org/wiki/images/7/7d/2012_12_gem5_gpu.pdf
- Paper (138 citations): https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6709764
- The advanced GPU simulator. It is accumulated version of gem5 and gpgpu-sim.
- Pros.
  A. It can simulate both CPU and GPU.
  B. It has higher accuracy than gpgpu-sim.
- Cons.
  A. Hard to use. You should understand both gem5 and gpgpu-sim.
  B. Long simulation time.
  C. Similar to gpgpu-sim, you need CUDA based applications.

V. SSD Simulator

1. simpleSSD

- Main Page: https://docs.simplessd.org/
- Paper (9 citations): https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8031080
- Simulator for flash storage, SSD. You can simulate file I/O, RAID, and etc. on SSD.
- Pros.
  A. There are well organized documentation.
  B. simpleSSD can be attached into gem5 for full system simulation. So, you can use it as standalone or full system simulation.
- Cons.
  A. Simulation speed is slow. When you use full system simulation, it takes more time.

2. MQSim

- Main Page (GitHub): https://github.com/CMU-SAFARI/MQSim
- Paper in the 16th USENIZ Association (11 citations): https://www.usenix.org/system/files/conference/fast18/fast18-tavakkol.pdf
- Simulator for the latest NAND flash drive architecture. MQ means ‘multi-queue’ which is the core architecture for large size I/O stream process.
- Pros.
  A. State-of-art multi-queue architecture is supported.
  B. It is faster than simpleSSD.
- Cons.
  A. Since the simulator was released last year, it is not stable.
  B. The simulator is less accurate than simpleSSD.

VI. Mobile Platform Simulator

1. MofySim

- Main Page: http://www.ecl.kaist.ac.kr/tools
- Paper in ISPASS 2016 (7 citations):
  https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7482099
- MofySim consists of a simulated mobile system, a simulated server system, a simulated Ethernet, an architectural statistics file, a system configuration file, and converters for analyzing the energy consumption.
  MofySim includes an enhanced gem5 simulator with source codes, Android and Linux Kernel images for a mobile system, embedded ARM Linux and Kernel images for a server system, energy converter tools, and McPAT configuration files.
  MofySim provides the configuration of network conditions and power models for CPU/caches, DRAM, network interfaces, and display.
- Pros.
  A. Mobile platform simulator based on gem5.
  B. You can simulate server-client model through Ethernet network interfaces.
  C. Since it includes McPAT, energy consumption analysis are supported.
- Cons.
  A. For mobile platform simulation, you should understand Android.
  B. There should be appropriate applications which can be executed on Android.
  C. Since it is based on gem5, its simulation time can be slow.