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Gem5 Intro

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- **Abstract**
- **Basics of gem5**
- **Simulation modes**
  - SE & FS
- **Benchmarks on gem5**
  - A Mickey mouse benchmark
  - PAESEC benchmark
  - Obtained Statistics

Abstract

- **gem5 Simulator**
  - The gem5 simulation is the merger of the best aspects of the M5 and GEMS simulators.
- **M5 Simulator**
  - M5 provides a configurable simulation framework , multiple ISAs, diverse CPU models.
- **GEMS simulator**
  - GEMS complements these features with a detailed and flexible memory system, including support for multiple cache coherence protocols and interconnect models.

Abstract

- **Gem5 has been a multi-year effort from both academy and industry.**
- **Main goals**
  - ***Open source*** *tool focused on architectural modeling*
  - Flexibility
    - Multiple CPU models, memory systems, and device models
    - Across the speed vs accuracy spectrum
  - Availability
    - For both academic and corporate researchers
    - No dependence on proprietary code
    - BSD license
  - Collaboration
    - Combined effort of many with different specialties
    - Active community leveraging collaborative technologies

High-level Features

- **Configurable CPU models**
  - Simple one-IPC (SimpleAtomic/Timing)
  - Detailed in-order execution (InOrder)
  - Detailed out-of-order execution (O3)
- **Pluggable memory system**
  - Classic memory model
  - Ruby memory model
- **Device Models**
  - Enough device models to boot Linux
- **Boot real operating systems**
  - Linux, Android
- **Many ISAs**
  - ARM, ALPHA, MIPS, SPARC, POWER, X86

Basic of gem5

- **Compile targets**
  - scons build/<isa>/<binary>
  - ISAs: ARM, ALPHA, MIPS, SPARC, POWER, X86
- **Binaries**
  - **gem5.debug** debug build, symbols, tracing, assert
  - **gem5.opt** optimized build, symbols, tracing, assert
  - **gem5.fast** optimized build, no debugging, no symbols, no tracing, no assertions
  - **gem5.prof** gem5.fast + profiling support

Simulation modes

- **Syscall emulation (SE)**
  - For running individual applications, or set of applications on MP
  - Models user-visible ISA plus common system calls
  - System calls emulated, typically by calling host OS
  - Simplified address translation model, no scheduling
- **Full system (FS)**
  - For booting operating systems
  - Models bare hardware, including devices
  - Interrupts, exceptions, privileged instructions, fault handlers
  - Simulated UART output
  - Simulated frame buffer output

Simulation mods - System Call Emulation

```
gg@gg-pc:~/simulators/gem5$ ./build/ARM/gem5.opt configs/example/se.py -c tests/
test-progs/hello/bin/arm/linux/hello
gem5 Simulator System.  http://gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 compiled May 22 2013 16:50:32
gem5 started May 27 2013 21:44:43
gem5 executing on gg-pc
command line: ./build/ARM/gem5.opt configs/example/se.py -c tests/test-progs/he
lo/bin/arm/linux/hello
Global frequency set at 1000000000000 ticks per second
0: system.remote_gdb.listener: listening for remote gdb #0 on port 7000
**** REAL SIMULATION ****
info: Entering event queue @ 0.  Starting simulation...
Hello world!
hack: be nice to actually delete the event here
Exiting @ tick 3102500 because target called exit()
gg@gg-pc:~/simulators/gem5$
```

Simulation modes - Full System (Linux on ARM)

```
gg@gg-pc:~/simulators/gem5$ export M5_PATH=~/simulators/arm_full_system/
gg@gg-pc:~/simulators/gem5$ ./build/ARM/gem5.opt configs/example/fs.py
gem5 Simulator System.  http://gem5.org
gem5 is copyrighted software; use the --copyright option for details.

gem5 compiled May 22 2013 16:50:32
gem5 started May 27 2013 21:54:01
gem5 executing on gg-pc
command line: ./build/ARM/gem5.opt configs/example/fs.py
Global frequency set at 1000000000000 ticks per second
info: kernel located at: /home/gg/simulators/arm_full_system/binaries/vmlinux.ar
m.smp.fb.2.6.38.8
Listening for system connection on port 5900
Listening for system connection on port 3456
0: system.remote_gdb.listener: listening for remote gdb #0 on port 7000
info: Using bootloader at address 0x80000000
**** REAL SIMULATION ****
info: Entering event queue @ 0.  Starting simulation...
```

```
[     2.260723] Freeing init memory: 132K
init started: BusyBox v1.15.3 (2010-05-07 01:27:07 BST)
starting pid 331, tty '': '/etc/rc.d/rc.local'
warning: can't open /etc/mtab: No such file or directory
Thu Jan  1 00:00:02 UTC 1970
S: devpts
Thu Jan  1 00:00:02 UTC 1970
starting pid 354, tty '': '/sbin/getty -L ttySA0 38400 vt100'

AEL login: root


BusyBox v1.15.3 (2010-05-07 01:27:07 BST) built-in shell (ash)
Enter 'help' for a list of built-in commands.

# ls
# pwd
/root
# cd /
# ls
bin         etc         lost+found  proc        sys         var
boot        home        media       root        tmp         writable
dev         lib         mnt         sbin        usr
#
```

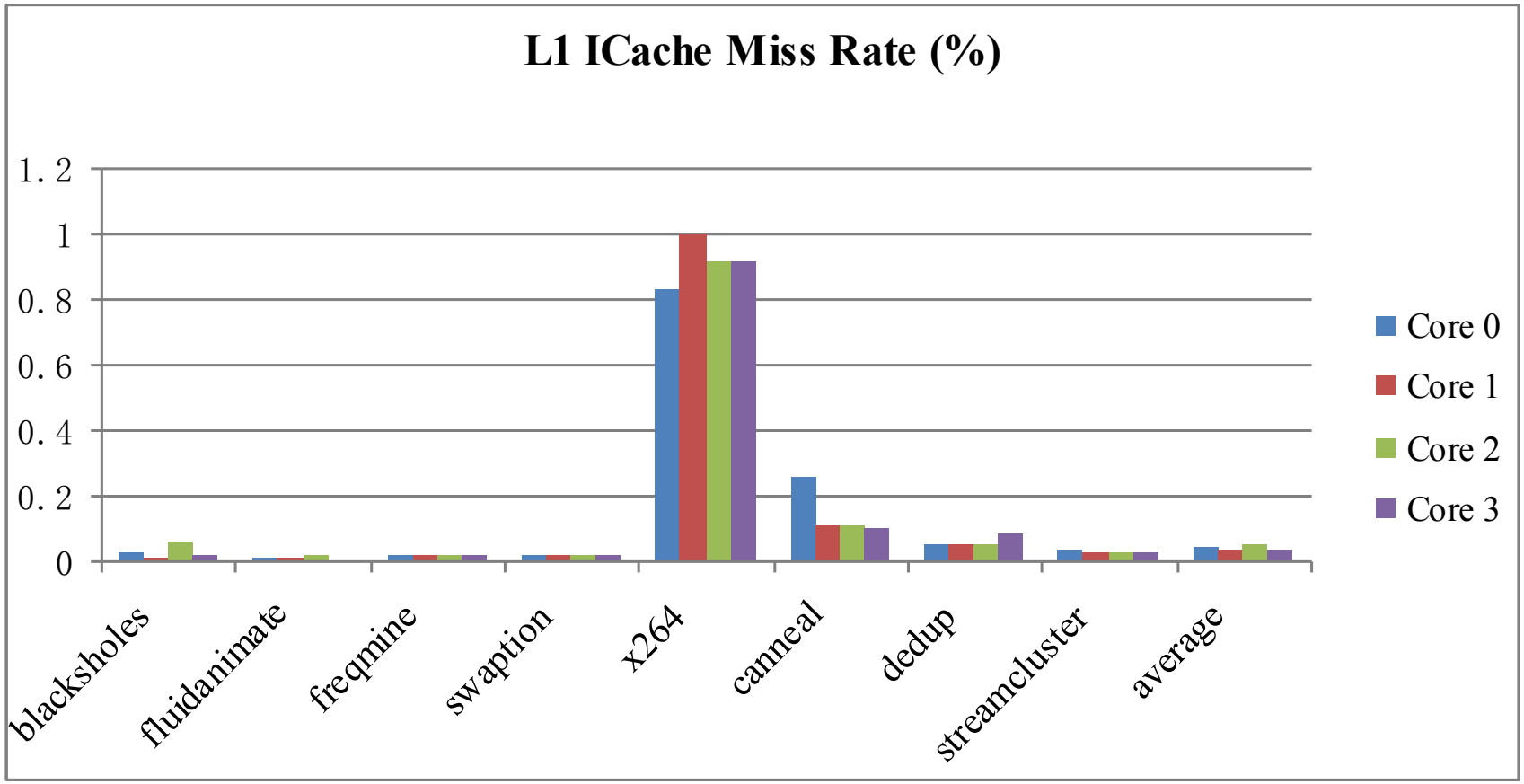
Benchmarks on gem5 - PARSEC

- The Princeton Application Repository for Shared-Memory Computers (PARSEC) is a benchmark suite composed of multithreaded programs.
- The suite focuses on emerging workloads and was designed to contain a diverse selection of applications that is representative of next-generation shared-memory programs for chip-multiprocessors.

Benchmarks on gem5 - configuration

- **CPU: x86, 4-core, in-order**
- **L1 I-Cache**
  - 32 KB, 2-way set-associative, latency 3 cycles
- **L1 D-Cache**
  - 64 KB, 2-way set-associative, latency 3 cycles
- **L2 Cache**
  - Unified, 2 MB 8-way set-associative, latency 15 cycles, MESI CMP directory cache coherence protocol
- **Cacheline size: 64B**
- **Memory size: 2GB**
- **OS: Linux 2.6.28.4.smp**

Benchmarks on gem5 - cache statistics



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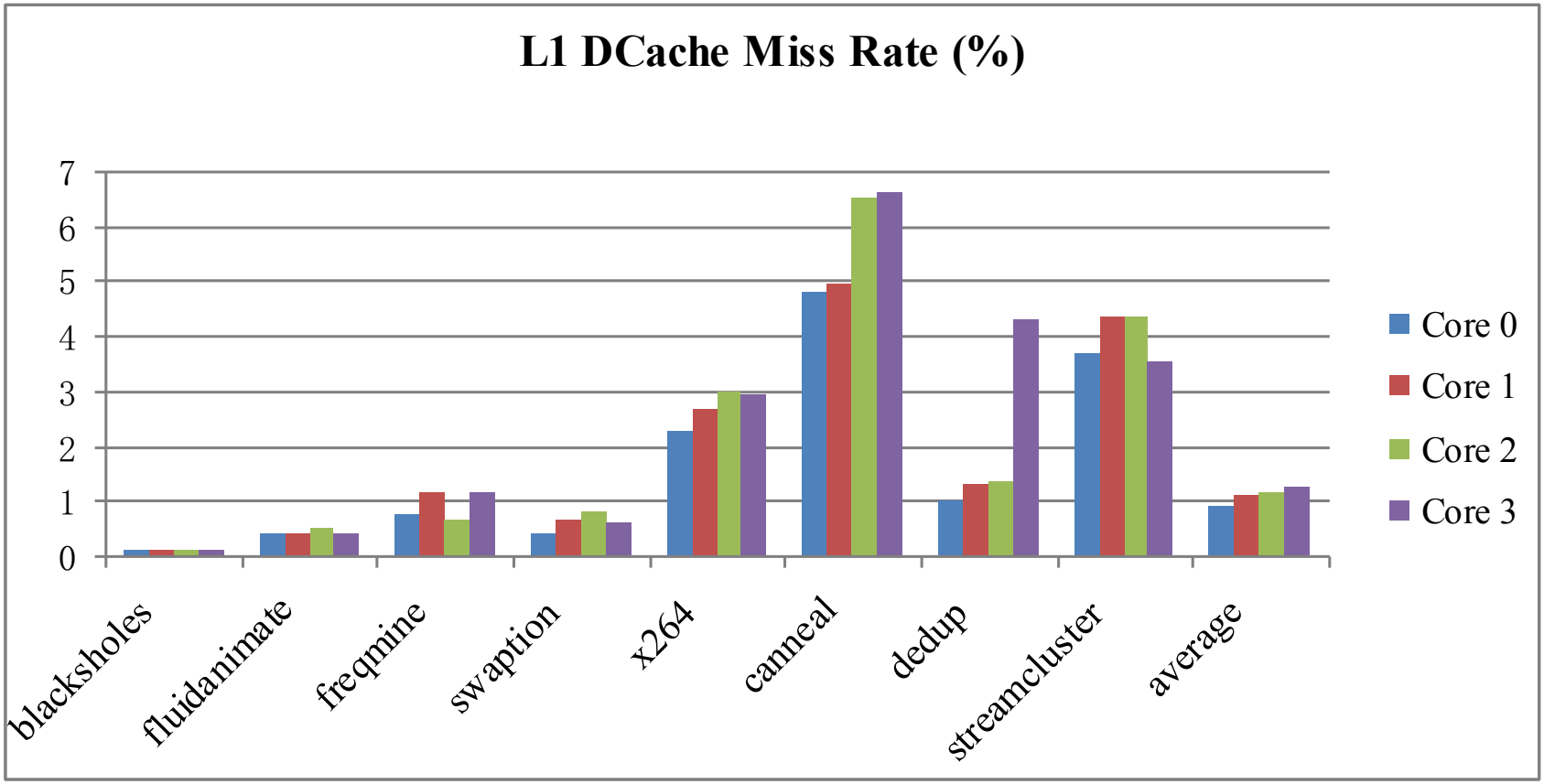

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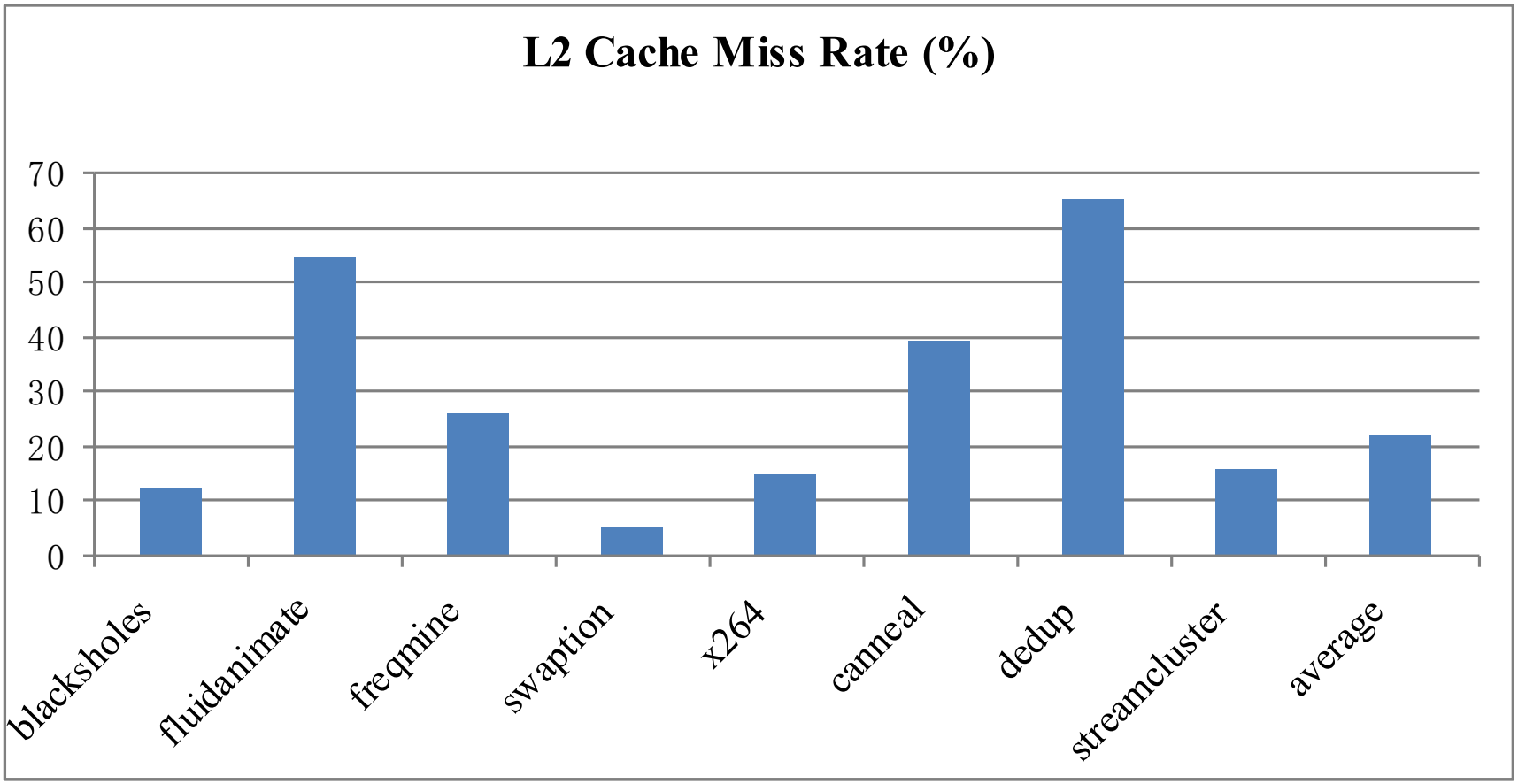


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