Extending the Sparc-Sulima Computer Simulator

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1 Talk Outline

1. talk outline
2. performance analysis of computer systems and motivations for simulation (of computer systems via software)
3. introduction to Sparc-Sulima
4. structure of Sparc-Sulima
5. status of the Sparc-Sulima project
6. extending Sparc-Sulima

2 Motivations: Performance Analysis of Computer Systems

- One cannot understand the design tradeoffs or performance of multi-processors without understanding the interaction of algorithms and architecture – John L. Hennessey, 1999
- systematic performance analysis techniques now drives design
  - driven by key applications (commercial and scientific)
  - includes the use of performance instrumentation libraries:
    - here, we insert calls to manipulate hardware event counter registers in the application's source code
    - events affecting performance include branch mispredictions, TLB misses, cache misses etc (usually, memory-related events are the most important!)

  and computer simulation:
    - use software to interpret programs and predict their performance

  √ can have full visibility: actual H/W may not count all desired events

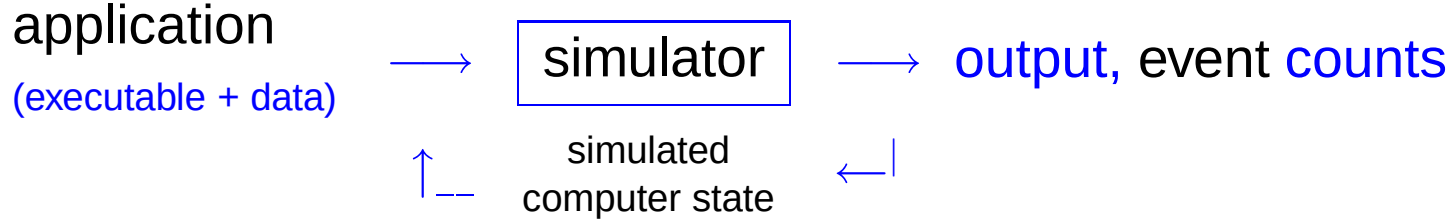
  √ the simulated computer may not even exist! (essential for design!)

  √ can vary parameters for architectural studies (eg. cache size)

  √ for operating systems development / debugging

3 Introduction to Sparc-Sulima

- a complete machine simulator for an UltraSPARC SMP
  - UltraSPARC: an implementation of the 64-bit SPARC V9 architecture
  - highly complex instruction set – hardly RISC anymore!
- interprets instruction-by-instruction:



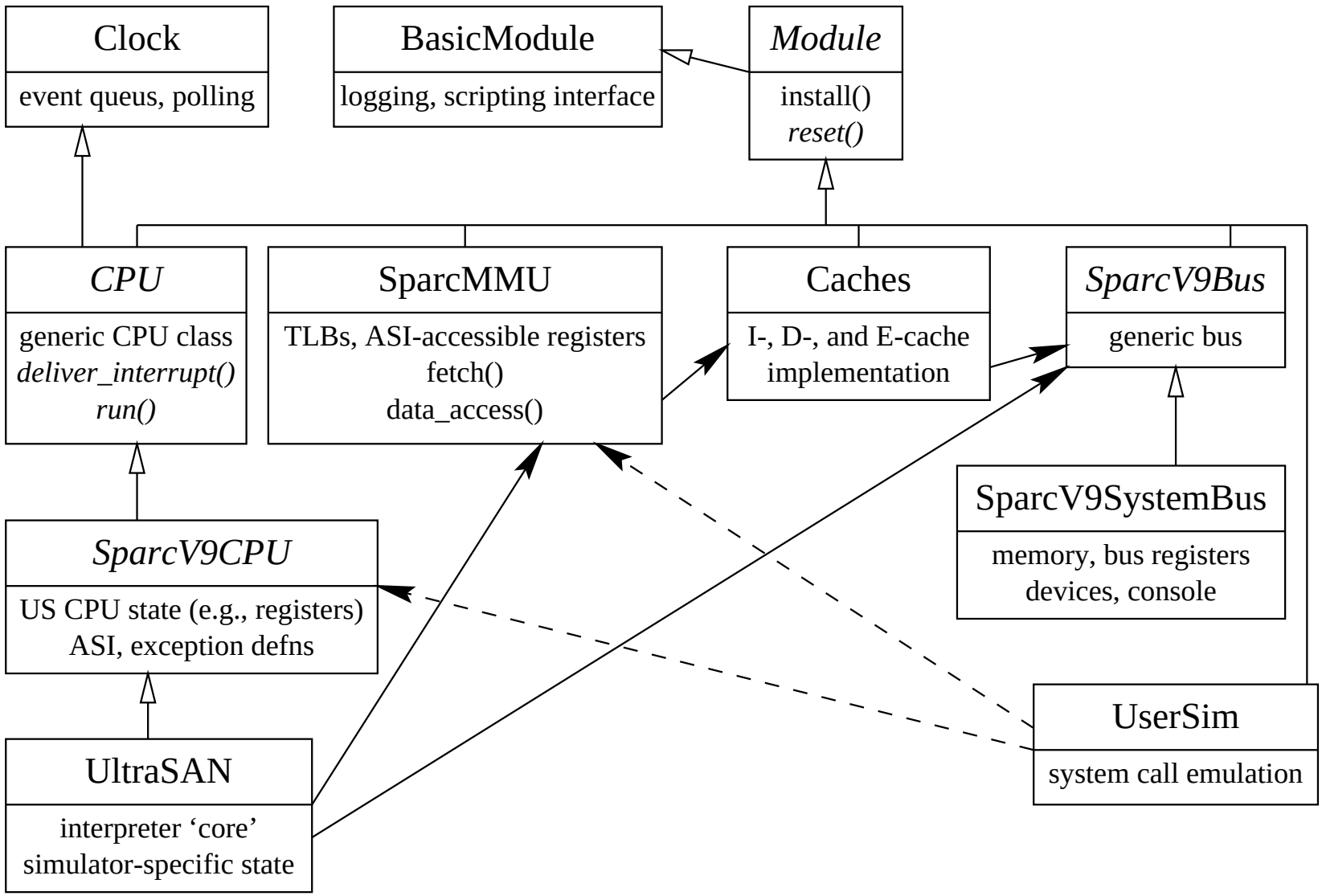
- some implementation highlights:
  - used SLED toolkit to generate instruction decoder (6K lines of C; rather slow)
    - no bugs found in decoder once integrated! (found bug in Solaris assembler!)
  - uses a heavily Object-Oriented approach (20K lines C++ code)
  - extensively optimized: a slowdown of ≈ 200 (state-of-the art)
    - for running simulator on an UltraSPARC, use inline assembler to capture exact semantic effects of instruction (eg. floating point, graphics)

- better reliability, speed; loss of portability
- 'cache' expensive calculations repeatedly carried out by simulator

- advanced debugging infrastructure: instruction-, exception- and call-level tracing
- has a Python scripting interface, allowing access to all main simulator components
  - using SWIG (Simplified Wrapper and Interface Generator)
  - eg. `runsim-swig.sh MatFact.sim -w 64 -C 100`
    `runsim-swig.sh` contains:

```
...
import SparcSulima
im = SparcSulima
bus = sim.SPARCV9SystemBus("bus")
cpu = sim.UltraSAN("cpu", 200L)
cpu.bus = bus
user = sim.UserSim("user")
user.exe_filename = "$1"
user.set_args(['printf '"%s",' "$@";printf "\n"'])
prom = sim.ROM("prom")
...
sim.reset()
sim.run()
```

4 Structure of Sparc Sulima



5 The Sparc-Sulima Project

- 2002–2002: the ANU-Fujitsu CAP Program:
  - 08/00: begun design
    - based on the Sulima simulator infrastructure (DiSY Group, UNSW)
  - 12/01: 1st code release (under GPL/BSD), + Developer's Manual
  - 08/02: 2nd second release
  - has full functionality of an UltraSPARC I/II computer system (down to 2nd-level buses)
- 2003–2005: ARC Grant on optimization of quantum chemistry applics. on non-uniform memory access SMPs (Rendell/Strazdins/ Gaussian/ Sun)
  - extend for UltraSPARC III, for performance analysis a large-scale application on a large-scale SMP
  - 1 Research Associate, 1 PhD + . . .

6 Extending Sparc-Sulima

- ‘generic’ extensions (click here for more details)
  - extend for configurability: easy change of architectural parameters
    - may involve some re-design; re-design for maintenance may also be valuable
  - extend for portability: run on many platforms
  - advanced debugging support: eg. gdb interface
- add check pointing support: important for large applications
  - challenging because of complex OO structure
- systematic (regression) testing (challenging: test space is enormous!)
- extend for a cluster configuration (some non-trivial research issues)
- such simulators are very complex software systems: good SE approaches and practices are important!