Why Tools Matter

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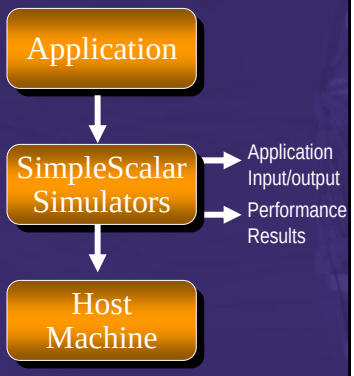
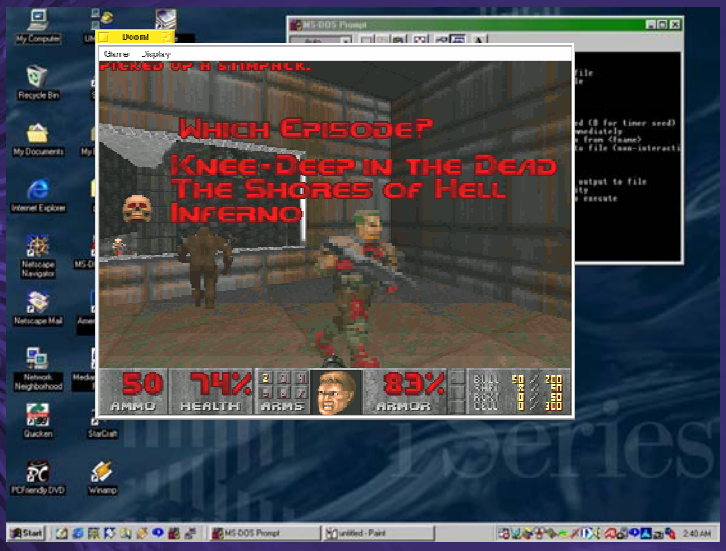
A long time ago, in a place far away…

My Experience: SimpleScalar Tool Set

- Computer system design and analysis infrastructure
  - Uniprocessor models
  - User-mode input/output
  - Supports many ISAs
  - Portable to host platforms
  - Deployed widely in academia and industry for more than a decade
- Available with source and docs from www.SimpleScalar.com



Obligatory Shot of Simulator Running DOOM



Reasons Against Building & Releasing Tools

- Don't want to loose your "competitive edge"
- Often, tools development is not viewed as "research"
- User support and code maintenance is very demanding, couldn't your time be spent better?
- Broken tools could be harmful to the state-of-the-art
- Vast majority of user feedback is negative

Goals of This Talk

Encourage aspiring tools hackers to build and release their tools.

Give you my best advice for undertaking such a challenge.

Suggest some promising (simulator) tool directions to pursue.

Why Tools Matter -- to the Community

The altruistic viewpoint…

- Accelerate the pace of research
  - Good tools enable researchers
- Accelerate the pace of tool development
  - Through enabling infrastructure development
  - Through the growth of a community of developers

Why Tools Matter -- to Me

The "narcissistic" viewpoint…

- Amplify your contribution to the research community
  - Take credit for other peoples research!
- Gain public recognition
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sim-safe: SimpleScalar/PISA Tool Set version 3.0 of August, 2003.
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Advice for Building Successful Tools

Based on my experiences with SimpleScalar.

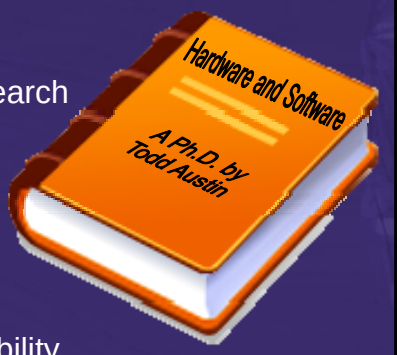
Plus, observations from other tool developers.

But don't forget… you'll need a lot of luck, too!

And now… six pieces of advice.

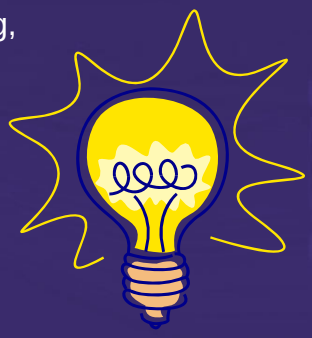
Advice: Let Research Drive the Outcome

- Tools serve research demands
  - Let your research agenda define these demands
- Great infrastructure enables research
  - Build the infrastructure and you will get there first!
  - E.g., SimpleScalar was first to recognize the positive benefits of mis-speculation [PAID'95]
- It will sharpen the focus and usability of the infrastructure



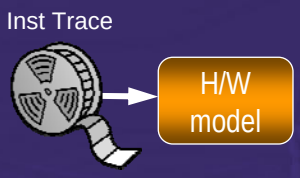
Advice: Be Innovative

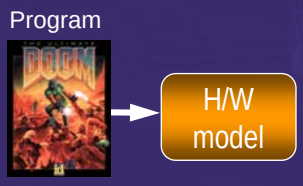
- Don't try to only improve engineering, re-imagine the design
- You will stay interested in the project longer
- It will become easier to publish your work



Innovation: Execution-Driven Simulation

- Trace-based simulation
  - Simulator reads instruction "trace"
  - Simple to implement, no functional component needed
- Execution-driven simulation
  - Simulator "runs" the program, generating complete execution
  - More difficult to implement, requires instruction function and I/O handling
  - Approach has many advantages, e.g., access to values, misspeculation

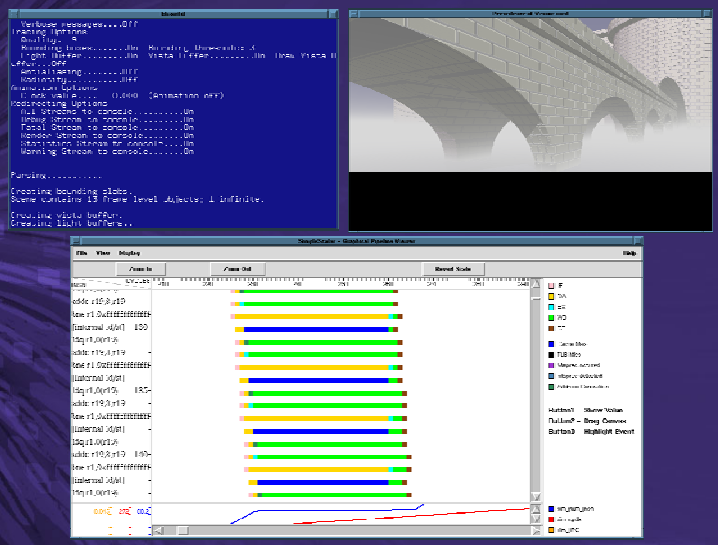




Innovation: External I/O Tracing (EIO)

- Addresses difficulties of creating reproducible experiments
  - 1000x compression over industry-standard branch tracing
  - Re-creates of all program data values (unlike branch tracing)
- External I/O events traced
  - System calls, external interrupts
  - All events time-stamped with processor cycle count

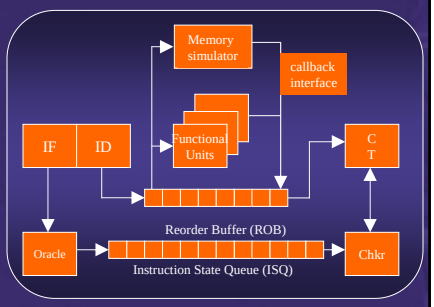
Innovation: GPV – Graphical Pipeline Viewer



Innovation: MASE Microarchitecture Simulator

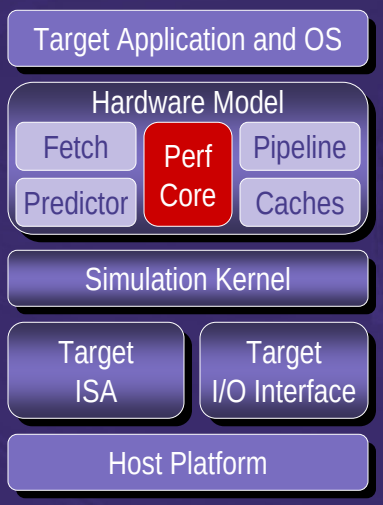
- Performance simulation model more detailed than sim-outorder
- Many simulation advances
  - x86 target and uArch support
  - Improves validation support
  - Oracle for "perfect" studies
  - Speculative state management facilities simplify speculation
  - Callback interface permits sophisticated memory simulation

MASE Internal Structure



Advice: Build a Platform

- Build a tool for building tools
  - "Separate mechanism and policy"
- Assume users will utilize components a-la-carte
- Strive to make the researchers code only glue that binds components



Warning: Flexibility vs. Barrier-to-Entry

- A single file describes all aspects of the architecture
  - Used to generate decoders, dependency analyzers, functional components, disassemblers, appendices, etc.
  - Machine definition + 10 line main == functional simulator

```
DEFINST(ADDI,          0x41,
        "addi",        "t,s,i",
        IntALU,        F_ICOMP|F_IMM,
        GPR(RT),NA,    GPR(RS),NA,NA
        SET_GPR(RT, GPR(RS)+IMM))
```

opcode
inst flags
assembly template
FU req's
output deps
semantics
input deps

- Optimizing performance has similar effects

Advice: Make Usability a Priority

- Make it work out of the box
  - Include everything the user needs
  - Lots of pre-built simulators
  - Cross-compilers
  - Workload
  - Documentation and tutorials
- Open source is a must-have!
- Build portable code
- Be your first and best customer

Usability: SimpleScalar's Abstraction "Knob"

Sim-Fast	Sim-Safe	Sim-Profile	Sim-Cache Sim-Bpred	Sim-Outorder
- 420 lines - no timing - 8+ MIPS	- 350 lines - no timing - w/ checks	- 900 lines - no timing - lot of stats	- ~1000 lines - functional - cache stats	- 3900 lines - performance - OoO issue - branch pred. - mis-speculation - ALUs - cache, TLB - 500+ KIPS

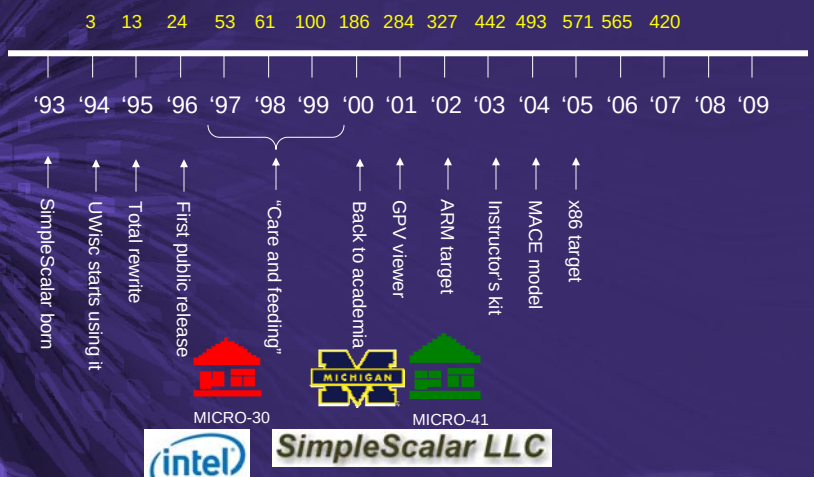
Performance ← → Detail

Advice: Work at Gaining Market Share

- Be a champion
  - Centralize decisions and integration
  - End result will be more coherent, focused
- Strive for quality, but avoid perfection
  - "Be prepared to throw one away."
  - Build a regression test suite
  - Incorporate debugging features
- Listen to users
  - Understand how the current infrastructure limits their work
  - Track users with an easy-to-google name

SimpleScalar Timeline

SimpleScalar Citations (as per Google Scholar)



Advice: Don't Ignore Business Considerations

- Use a license that meets your needs
  - Users often confuse "open" with "free"
  - See www.OpenSource.org for licenses
- Secure university rights early
  - Before the lawyers smell the money!
- Be aware of intellectual property issues
  - More difficult to accept contributions
  - Get trademarks, web addresses, and copyrights ASAP

Tomorrow's Tools

- First, look at some of today's successes:
  - SimpleScalar – uniprocessor uArch
  - Trimaran – VLIW architectures
  - Wattch – power modeling
  - HotSpot – thermal modeling
  - CACTI – cache modeling
  - GEMS, M5, RSIM – multiprocessor simulation
  - PIN – binary instrumentation
- Their recipe for success?
- Some research arenas that need more tools…
  - Reliability, Security, Application-Specific Processors, GPUs, Sensor Networking, Virtualization, Nano-technologies, Non-traditional computation models

Summary

- The “Why’s” far outweigh the “Why Not’s”
- Six tips for undertaking tool development and release
  - Let Research Drive the Outcome
  - Be Innovative
  - Build a Platform
  - Make Usability a Priority
  - Work at Gaining Market Share
  - Don’t Ignore Business Considerations

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Questions
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