Correctness of Parallel Programs: Testing, Debugging, Specification, and Verification

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Where We Started

- Difficult to write correct parallel software.
  - **Key:** Interference between parallel threads
  - **New bugs:** races, atomicity, deadlocks, …
  - Complicates reasoning, testing, debugging

- Great need for tools to automatically find and reproduce parallelism errors.
- **Our Technique:** **Active Testing**
Active Testing: Key Ideas

- **Existing Techniques:**
  - Detect and predict possible bugs (static and dynamic program analysis)
  - Bias/control the thread schedule (stress testing, noise making, model checking, etc.)

- **Active Testing**: Use both.
  - **Phase I**: Dynamic or static program analysis to predict possible bugs
  - **Phase 2**: Biased random execution to find and reproduce real executions exhibiting bugs
Active Testing I: Prediction

Potential Collision
Active Testing II: Directed Testing
Active Testing Advantages

- **Key:** Practical, easy-to-use testing tools, with sophisticated analysis internally.
  - Tested Java, C programs up to 500 kLoC
  - Finds many bugs quickly
  - Finds rare bugs with high probability
  - Creates an actual run showing a bug
Active Testing Successes

- Found many parallel bugs in apps, libraries.
  - Data races [PLDI ‘08]
  - Atomicity and typestate errors, and deadlocks [FSE‘08, ASE‘08, ICSE’09 (best paper), PLDI‘09]
  - Memory consistency errors [ISSTA ‘11]
  - Simplifying error traces [FSE ’10]

- **CalFuzzer** for Java, **THRILLE** for C
  - Bug benchmark suite [HotPar ‘11]
  - Commercial tool **ZVM** from Parallocity
**Demo: Active Testing for UPC**

- **Goal:** Make active testing to work for UPC and other PGAS languages.
  - **Challenge:** Efficient for 1000’s distributed cores

- **UPC-THRILLE:** Active testing for UPC
  - Effective race detection, reasonable overhead
  - Now official part of Berkeley UPC
  - Winter ’11 retreat, SC ‘11, PPoPP ’13, ICS ‘13
  - Chang-Seo Park will now demo
  - Testimonial from Costin Iancu at end of talk