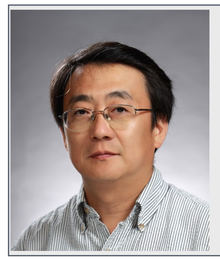
Program Analysis and Software Testing for System Dependability

Abstract **Dependability** is usually the most important property of a critical software system. The dimensions of dependability embrace availability, reliability, safety, and security, thus effective and efficient verification approaches are required to guarantee software dependability properly. We intend to improve **how we code, test, and debug software systems**, to help programmers to achieve higher levels of dependability. Especially, we focus on **computer-aided programming, program analysis, regression testing, failure reproducing, and bug detection.**



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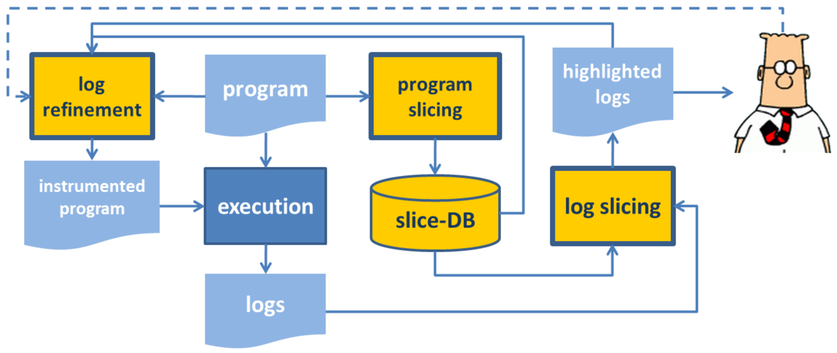
AutoLog: Facing Log Redundancy and Insufficiency

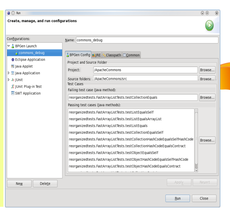


- Logging is the predominant practice when debugging:
  - Easy to add
  - (Usually) no side effects
  - A “program” over the program
- This freedom comes with a cost:
  - Log redundancy: too many irrelevant logs
  - Log insufficiency: critical logs may still be missing
- Log slicing to highlight relevant logs :
  - Identify relevant logs by analyzing program dependencies
- Log refinement to produce sufficient logs:
  - When existing logs are insufficient to cover the root cause
    - Log slicing can provide little help
  - Automatically insert new logging statements

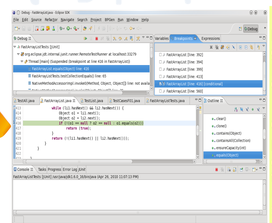
BPGen: An Automated Breakpoint Generator for Debugging

Select the failing and passing test cases.

Press the **RUN** button.



BPGen Process

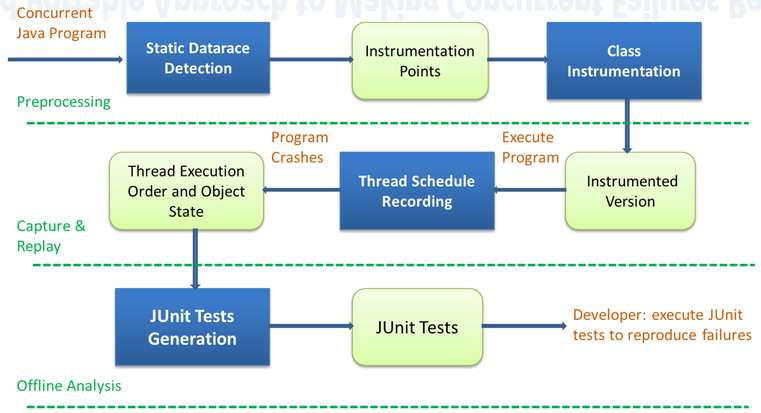


Debug with the generated breakpoints in the JDT debugger.

Optional function: Highlight the difference in execution traces and the dynamic program slice.

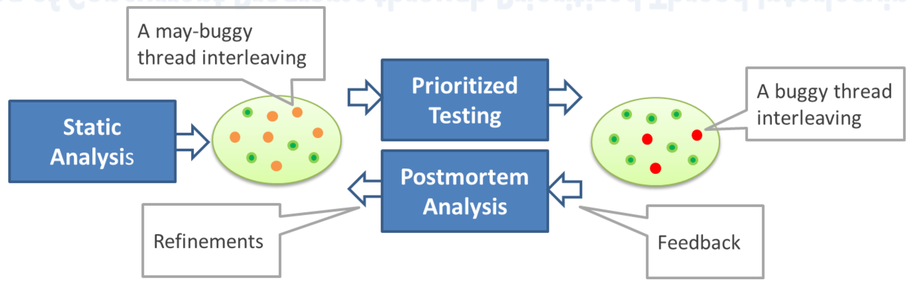
- Debugging and breakpoints:
  - Over 70% debugging developers use breakpoints
- Step 1. Nearest Neighbor Query:
  - Input: failing and passing test cases
  - Output: difference in execution traces
- Step 2. Dynamic Program Slicing:
  - Input: difference in execution traces
  - Output: dynamic program slice
- Step 3. Memory Graph Comparison:
  - Input: dynamic program slice
  - Output: unconditional breakpoints and difference in memory graphs
- Step 4. Breakpoint Condition Generation:
  - Input: difference in memory graphs
  - Output: breakpoint conditions

A Lightweight and Portable Approach to Making Concurrent Failures Reproducible



- Motivation:
  - Bug fixing in concurrent programs is even harder due to non-deterministic execution
- Contributions:
  - A bytecode instrumentation approach to reproducing concurrent failures
  - Lightweight and Portable implementation
- Steps:
  - Run record version program (seeded)
  - When program crashes, collect generated JUnit tests
  - Run JUnit tests on replay version, measure reproduction rate and overhead

Efficient Testing of Concurrent Programs through Prioritized Thread Interleavings



- Essential ideas:
  - Use static analysis to compute may-buggy thread interleavings soundly
  - Use static analysis to group may-buggy thread interleavings and prioritize the testing executions of thread interleavings within one group
  - Use postmortem analysis to detect concurrency bugs, propagate the feedback, re-group and re-prioritize the rest of thread interleavings
- Salient features:
  - Testing one group of may-buggy thread interleavings in a small number of testing executions
  - Testing different groups of the thread interleavings separately, thus different groups can be tested in parallel
  - Eliminating most false positives
  - No false negatives, giving high confidence in the correctness of the target program

NSFC

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