Jazz: A Tool for Demand-Driven Structural Testing

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Structural Software Testing

- Assure quality, robust software
  - Collect coverage information about the program
- Coverage types
  - Node coverage determines basic blocks executed
  - Branch coverage determines edges executed
  - Def-use coverage determines pairs of variable definitions and uses that are executed
- Over multiple inputs until coverage criteria

Current Tools and Approaches

- E.g., JCover, PurifyPlus
- Use static program instrumentation
  - Injected prior to program execution
  - E.g., instrument basic blocks with “hit counter” to indicate when a block is executed
- Limitations
  - Not scalable: Instrumentation remains in program
  - Inflexible: Only certain tests, languages, platforms

Our Approach

- A scalable & flexible framework
  - Automatically apply multiple test strategies
  - Multiple languages and platforms
  - Handle large programs
- Demand-driven structural testing [ICSE'05]
  - **Specification driven:** User written test
  - **Test plans:** Recipe of how & where to test
  - **Path specific:** Instrument only what is needed
  - **Dynamic:** Insert & remove instrumentation

Jazz – A Framework Instance

- Structural testing for Java programs
  - Branch, node, def-use coverage
  - User-written specification, demand-driven testing, result reports
- Implementation
  - Eclipse 3.01 plug-in: Test specification & reporting
  - Jikes RVM: Demand-driven testing
  - Works on all programs runnable by Jikes
  - x86/Linux

Jazz Demo

- Branch coverage of music player
  - Test region is whole program (JOrbis)
  - Test input is a song
- Compared
  - Traditional approach with static instrumentation
  - Demand-driven approach with dynamic instrumentation

Traditional Approach **Demand-driven Approach**

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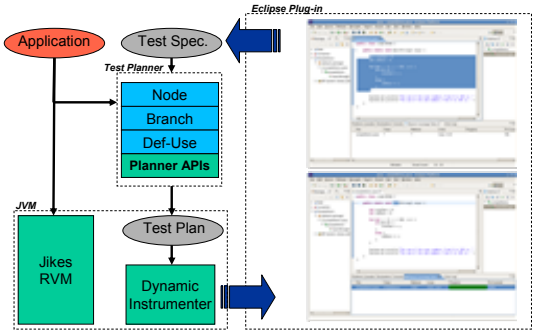
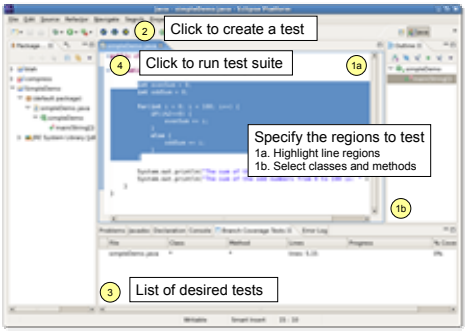
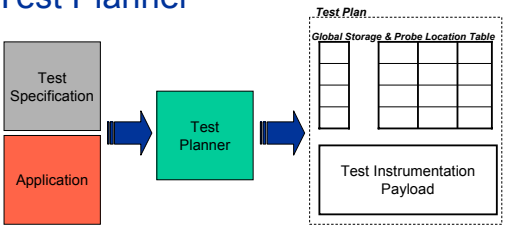
Jazz Tool Flow



Test Specification



Test Planner

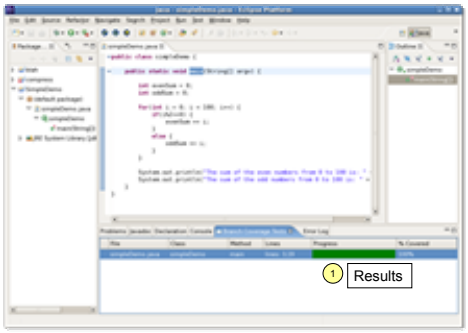


- **Test plan**: Where and how to test program
- **Test storage**, **probe location table**, **instrumentation payload**
- Combine payloads to create custom strategies

Dynamic Instrumentation

- Test plan targets an instrumentation API
- FIST instrumentation engine [WOSS'04]
  - Retargetable & reconfigurable
  - Dynamic insertion & removal of instrumentation
  - Binary level instrumentation (post JIT)
- Uses ***fast breakpoints*** [Kessler]: Replace existing instruction with a jump to instrumentation

Test Results



Branch Coverage Example

- Record which edges are executed
  - Determine (source, sink) edge pairs hit at run-time
  - Source is a branch
  - Sink can be taken & not-taken target of branch
- Within a test region, dynamically instrument along path of execution
  - Insert instrumentation at edge sink blocks
  - Remove instrumentation at edge source as soon as branch covered

Branch Coverage Example

Example program: *simpleDemo.java*

```
public class simpleDemo {
    public static void main(String[] args) {
        int evenSum = 0;
        int oddSum = 0;

        for(int i = 0; i < 100; i++) {
                if(i%2==0) {
                        evenSum += i;
                }
                else {
                        oddSum += i;
                }
        }
        System.out.println("The sum of the even numbers from 0 to 100 is: " + evenSum);
        System.out.println("The sum of the odd numbers from 0 to 100 is: " + oddSum);
    }
}
```

Coverage 100%

Use Jazz GUI to determine test specification: *simpleDemo.testspec*

```
DEFINITIONS {
      NAME: method_main, REGION_D,
      LOCATION: FILE simpleDemo.java {
            CLASS simpleDemo, METHOD main
      }
}
BODY {
      DO BRANCH_TEST ON REGION method_main UNTIL: 100%
}
```

Branch Coverage Example

Probe Loc Tab

Block	Next
1	2,3
2	4
3	4
4	1

Storage

Covered

M, M

M

M

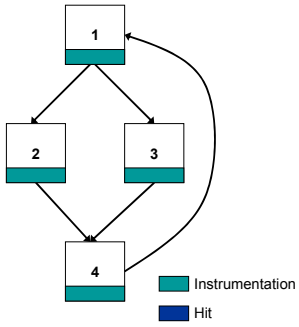
M

Test Payload

Mark edge hit

Insert at next point

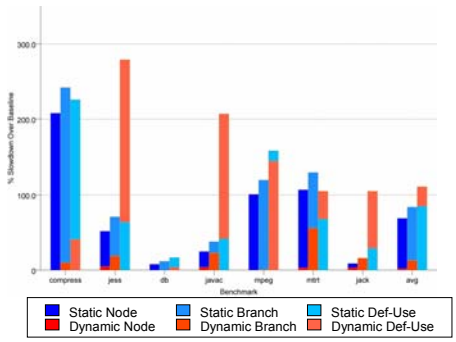
Remove instrumentation



Experiments

- Traditional vs. Jazz (in same implementation)
  - Compared coverage and run-time
- SPECjvm98 benchmarks
  - unloaded 2.4 Ghz Pentium IV, 1GB of memory
  - RedHat Linux 7.3
- Coverage – same reported by both tools
  - Branch coverage: 38.9-58%
  - Node coverage: 75-90.6%
  - Def-use coverage: 66.9-90.5%

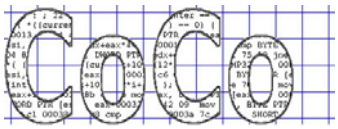
Run-time Performance



Summary

- A new tool (**Jazz**) for structural testing
  - Implements demand-driven approach
  - Test specification in Eclipse IDE
  - Test planner & dynamic instrumentation in Jikes
- Very low overhead
  - E.g., branch coverage tool is 3-4x faster than traditional approaches

For Further Information…



Continuous Compilation

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