

Testing a Computer Algebra System

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Outline

- Introduction to Computer Algebra
- Testing - big picture
- Testing – details
- Summary

Introduction to Computer Algebra

- Maple will be shown
- Mathematica and MuPAD are largely similar

Testing – Big Picture

- Fundamental Axiom:
 - Testing \equiv Automatic Testing
- Axiom 2:
 - Bugs are not closed until an automated test has been created

Statistics

- 11973 test files, ~40000 test cases
- Run on 14 `platforms' nightly @Maplesoft
- +5 extra at research labs around world
 - Roughly 750K test cases run daily
- Takes ~8hrs on 2.4Ghz Linux PC
 - Uses 298.3 Gigs of memory
 - Allocates 33.4 Gigs

Infrastructure

- SCM
 - (changes+author, sources)
- Test suite DB
 - (tests, functions called)
- Source code DB
 - (sources, functions defined)
- A = Test failure
 - A' = functions used
- B = Recent changes
 - B' = functions changed
 - $A' \cap B' =$ likely problem
 - Email author. Email manager?

Infrastructure

SCM	(changes+author, sources)
Test suite DB	(tests, functions called)
Source code DB	(sources, functions defined)

- Preventative
- `rtest `rfindtest solve/rec``

Infrastructure

SCM	(changes+author, sources)
Test suite DB	(tests, functions called)
Source code DB	(sources, functions defined)
Test suite DB	(tests, time + memory used)

- 40 days of data
- Use z-score to get `real' changes
 - Timings are noisy
 - Automated report
- Use student-t test for global trends
 - Can detect 0.5% slowdown with 1% noise

Robocop

- Given a test that fails,
 - Find most recent change that may be cause
 - Back out that change (locally)
 - Re-run test
 - Analyse results
- Repeat (backwards in time) if failure still present
- Works for failure as well as resource usage issues

Testing – Details

- Basic design

```
problem := define_problem();
```

```
answer := compute(problem);
```

```
expected := expected_answer();
```

```
verify(test#, problem, answer, expected);
```

Testing – Details

■ Sample test

```
#test
with(inttrans):
  r1 := 'r1':
  TRY(1,assign(r1, laplace(arctan(-2/5*t),t,s)));
  TRY(2, eval(laplace(arctan(x*t),t,s),x=-2/5), r1) assuming Re(x)<0;
  r1 := 'r1':
  TRY(3,assign(r1, laplace(arctan((I-2/5)*t),t,s)));
  TRY(4, eval(laplace(arctan(x*t),t,s),x=I-2/5), r1) assuming Re(x)<0;
  r1 := 'r1':
  TRY(5,assign(r1, laplace(arctan(I*t),t,s)));
  TRY[verify,simplify](6, eval(laplace(arctan(x*t),t,s),x=I), r1
    ) assuming Re(x)=0,Im(x)>0;
#end test
```

Testing - Failure reports

- Pass/Fail is only so useful
 - Need to know **why** a test failed
- First try: produce detailed output
 - Input, output, expected output
 - Problem: non-determinism + zero-testing
- Second try: produce script to reproduce
 - Input, output, command, expected output, all as a Maple script that can be re-executed
 - Very useful when testing long sequences

Testing - Selection

- For Unit tests:
 - + and not-not.
 - Minimum wanted coverage:
 - Structural: all code, all data shapes
 - Semantic: all specification cases, book cases
 - Hopeful coverage:
 - Structural: all paths, all data cases
 - Semantic: all book cases, functionally needed cases

Random Testing

- Done via generators
 - Generate random samples of a given length from data given by a grammar (CFG)
 - Grammar can describe data syntactically or semantically
- Good way to generate problems:
 - Generate answer
 - Invert computation to get problem
 - Solve problem forward
 - Compare
 - Think of testing an Eigenvalue solver for complex symmetric matrices

Summary

- Easier:
 - Mostly stateless
 - Automation
 - Integrated infrastructure
 - introspection

Summary

- Harder:
 - Equivalence problem
 - Specification = `classical mathematics`
 - Non-determinism. Eigenbugs.
 - Testing pdsolve involves ~50% of the library
 - 72938 if statements in the library
 - Untyped