Search-Based Software Testing & Test Data Generation for a **Dynamic** Programming Language

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SBST for Complex Test Data & DynLang

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  - Complex data types
  - Dynamic programming language (Ruby)

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- Partly because of dynamisms + Object-oriented:
  - **More complex**/own data types

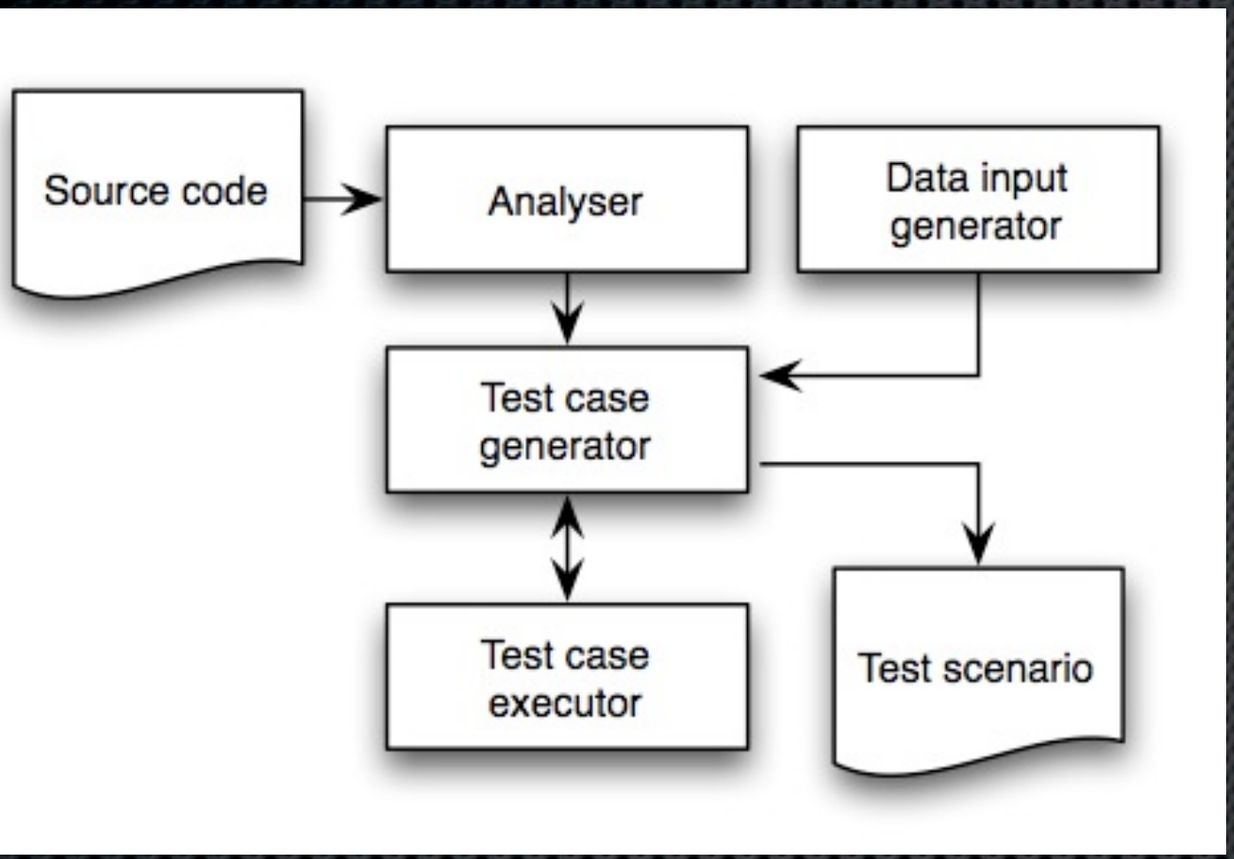
```
class TestClass

  def method1(a,b)
    sum = a + b
    puts sum
  end

  def method2(*c)
    l = c.length
    puts l
  end

end
```

RUTEG = RUby Test Case Generator



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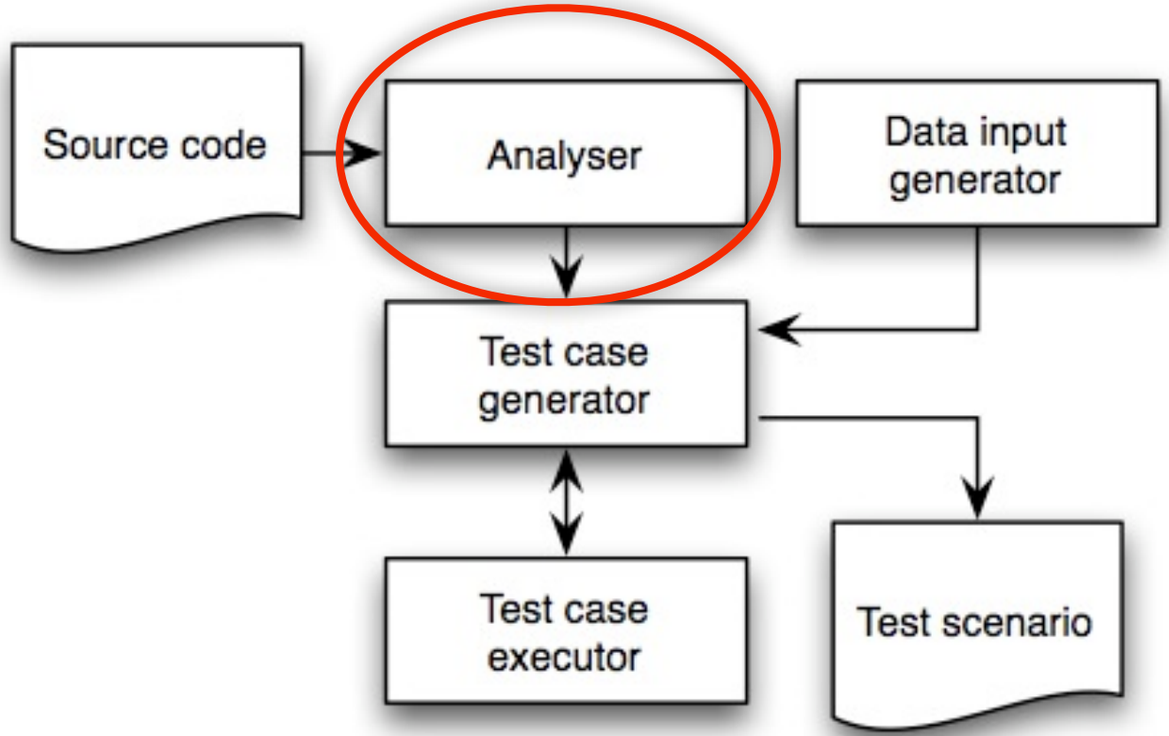

- Static code analysis
- Goal: Reduce search space
- Returns info on:
  - Method names
  - Argument lists
  - Mandatory/Optional args
  - Default values
  - Methods called on all args

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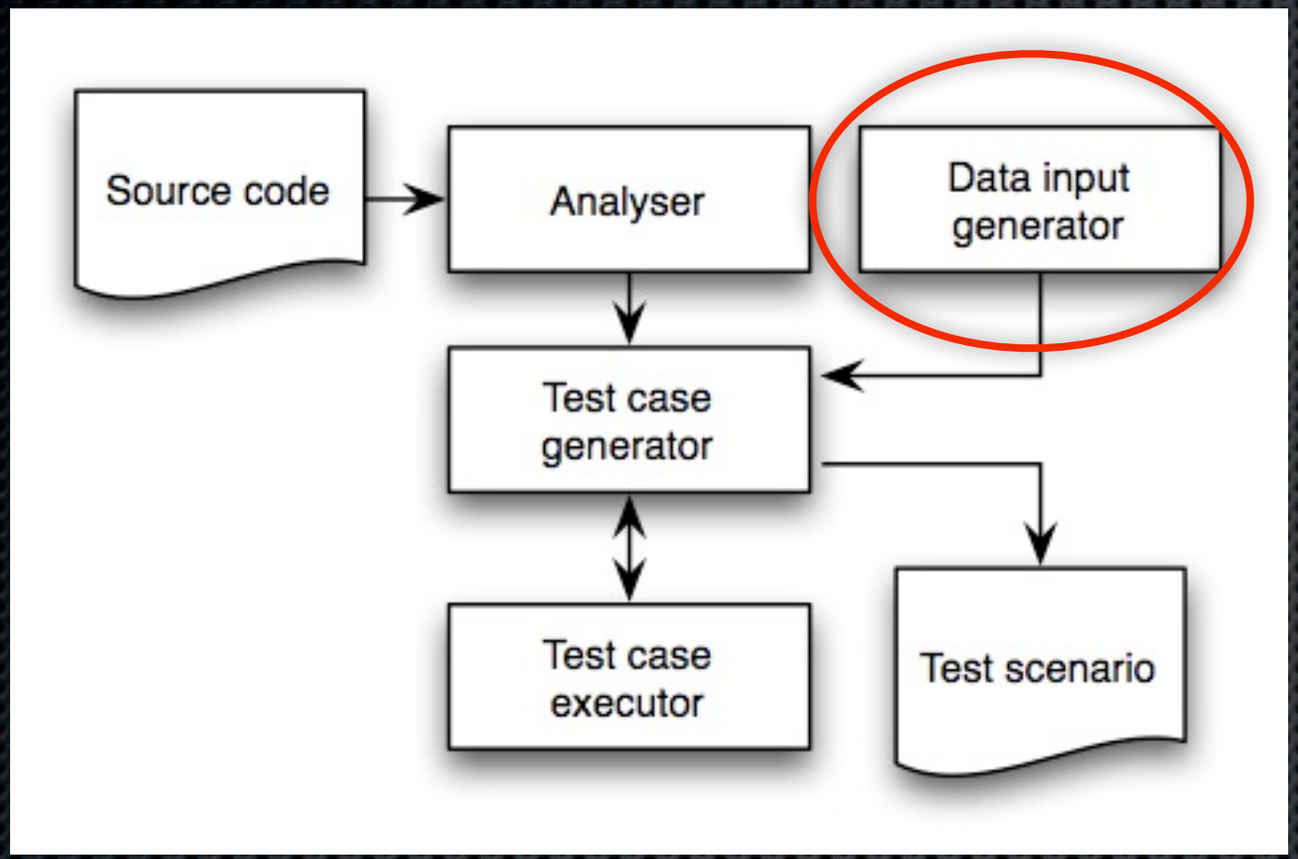

- Problem-specific generators
- Simple OO design
- Basic types supported:
  - Fixnum, Float, String
  - Nil, Object, ArrayOf

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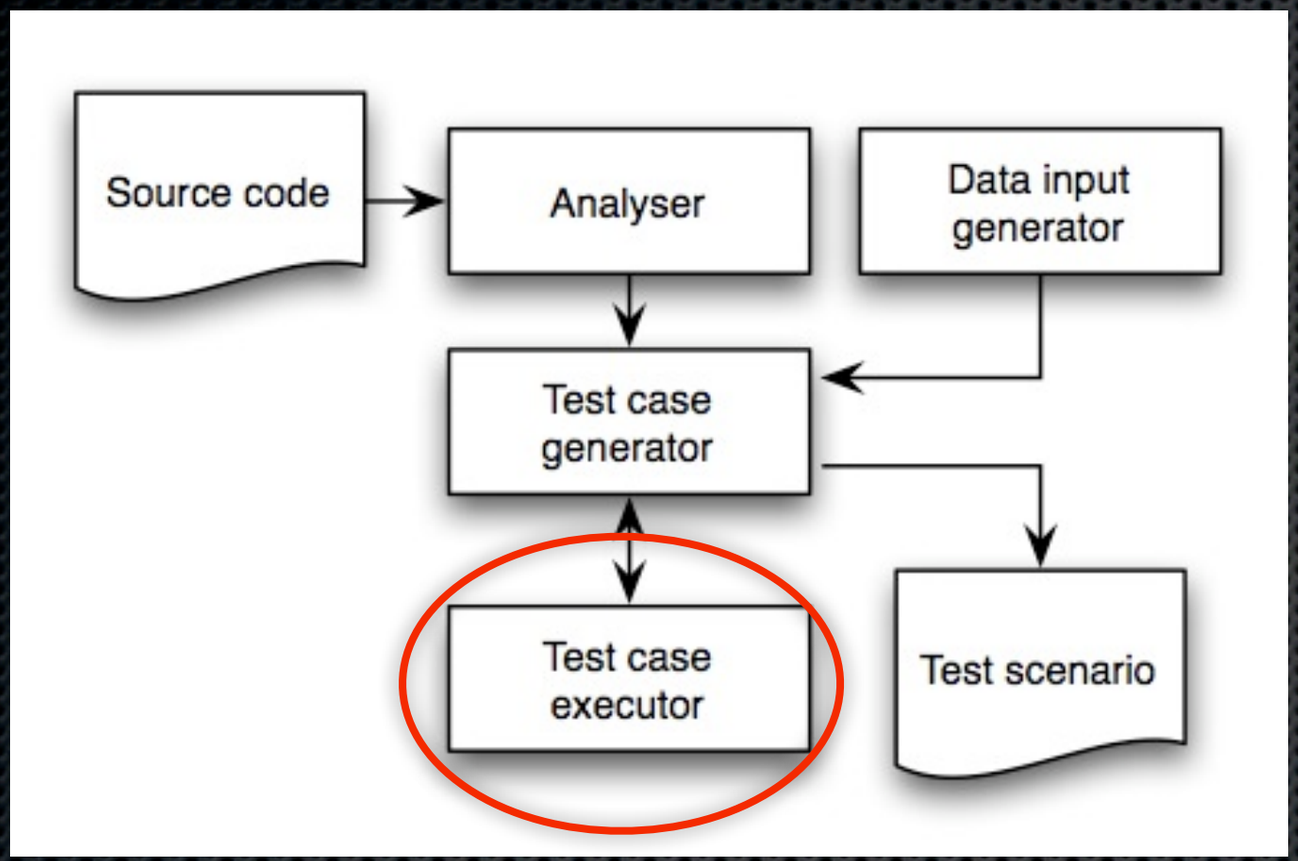

Runs test case and collects coverage info

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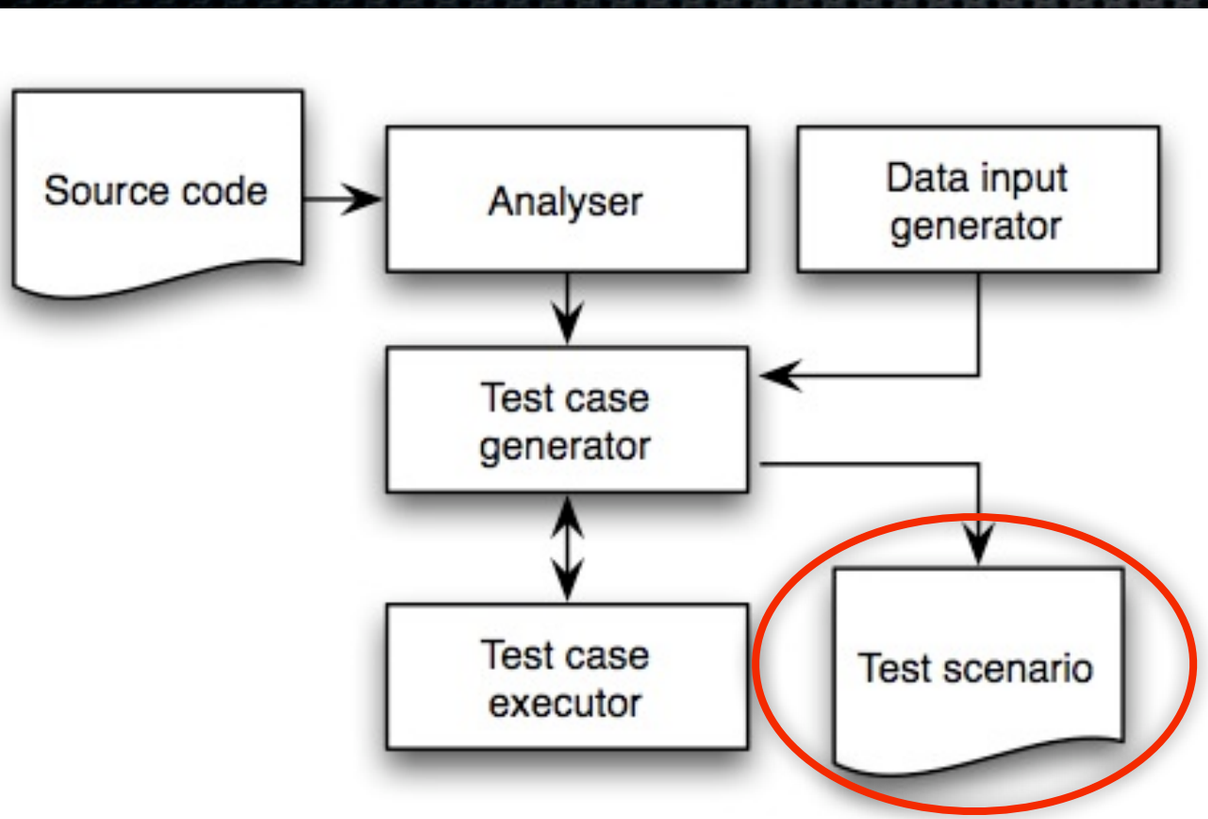

Individuals can be dumped as Ruby test/unit tests

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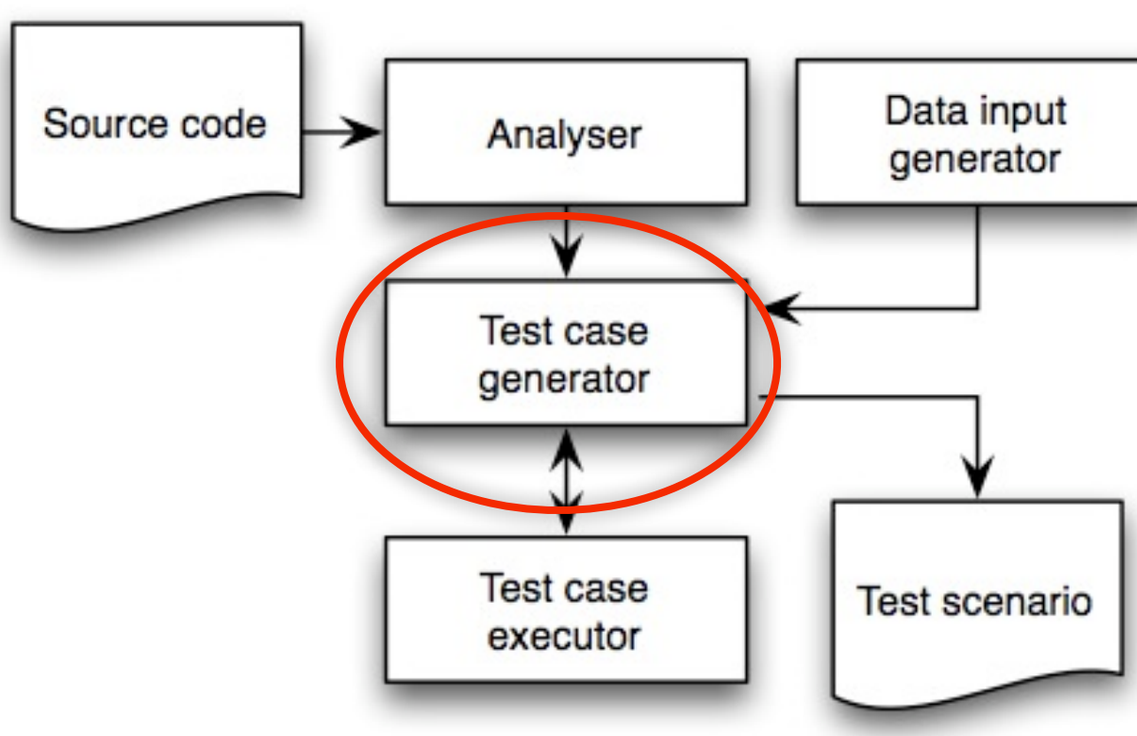
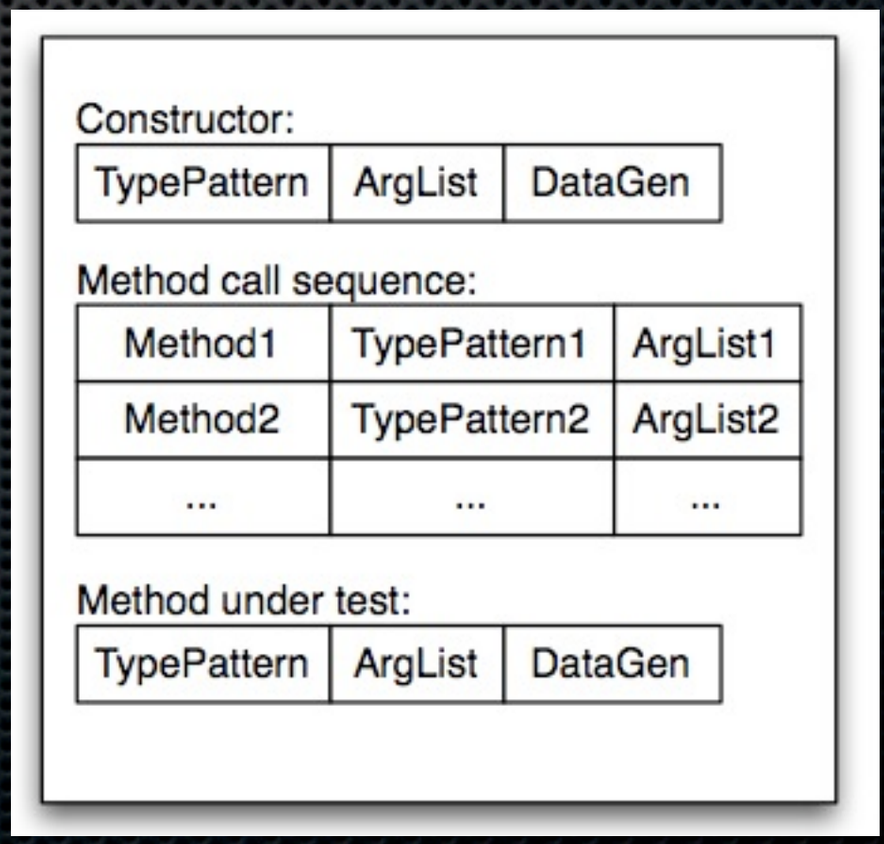


GA with individuals:



Argument Type Selection

- Fitness of *type* for *arg*:
  - For fitness-proportionate type selection
  - Ratio of existing methods to invoked methods (for each arg.)
- Not enough since not independent between arguments:

```
def add(a, b)
  a+b
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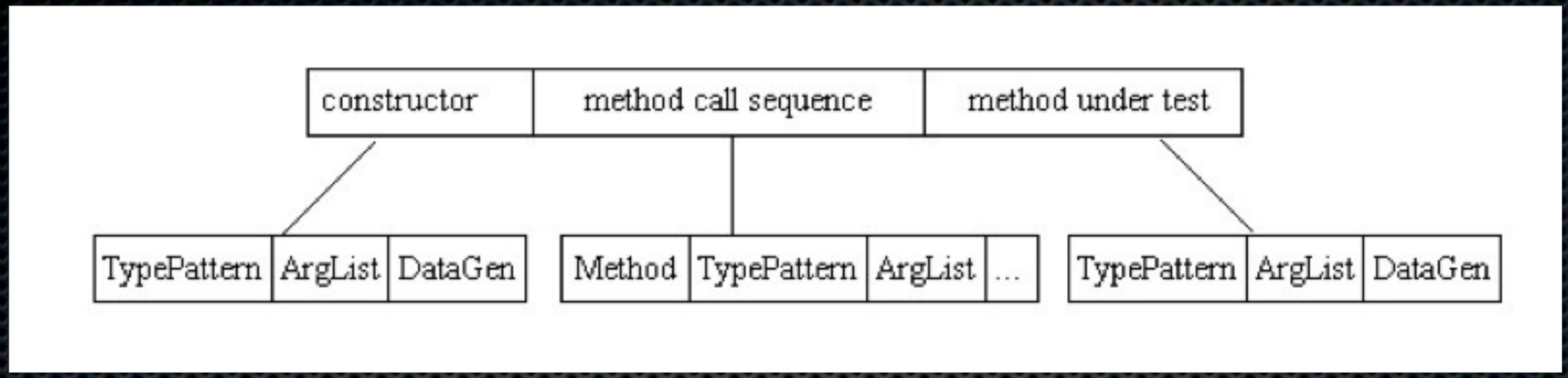
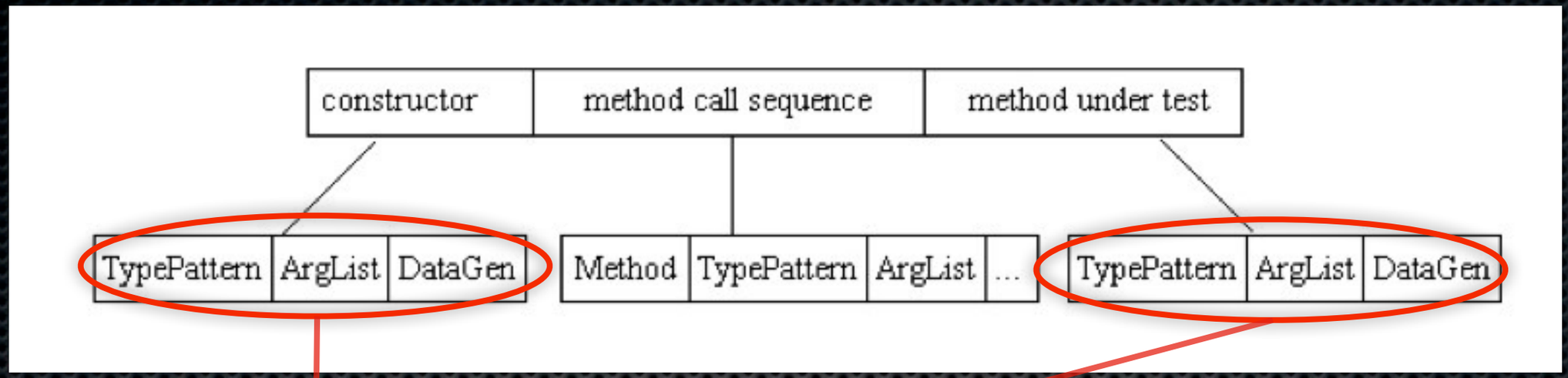


XOver:

Mutation:



XOver:

One-point xover that handles default & var.length

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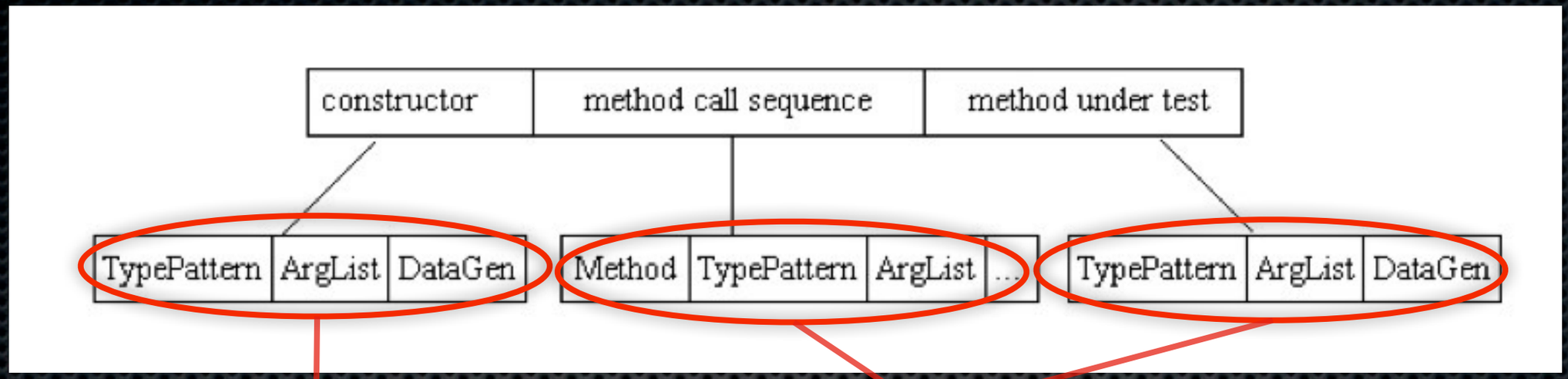

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Cut & Splice xover

Mutation:

- New type patterns
- New data generators for given type pattern
- New methods in call sequence (randomly from CUT)

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0.5

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Experiment

- RUTEG vs Random Testing on 14 methods under test:

Project	Method	SLOC	CC
Triangle	triangle_type	26	8
ISBN Checker	valid_isbn10?	18	7
	valid_isbn13?	13	6
AddressBook	add_address	10	3
RBTree	rb_insert	49	7
Bootstrap	bootstrapping	38	9
RubyStat	gamma	116	6
RubyGraph	bfs	39	12
	dfs	34	10
	warshall_floyd_shortest_paths	26	11
Ruby 1.8	rank	56	13
	** (power!)	59	16
RubyChess	canBlockACheck	23	10
	move	111	26
TOTAL (Average):		44.1	10.3

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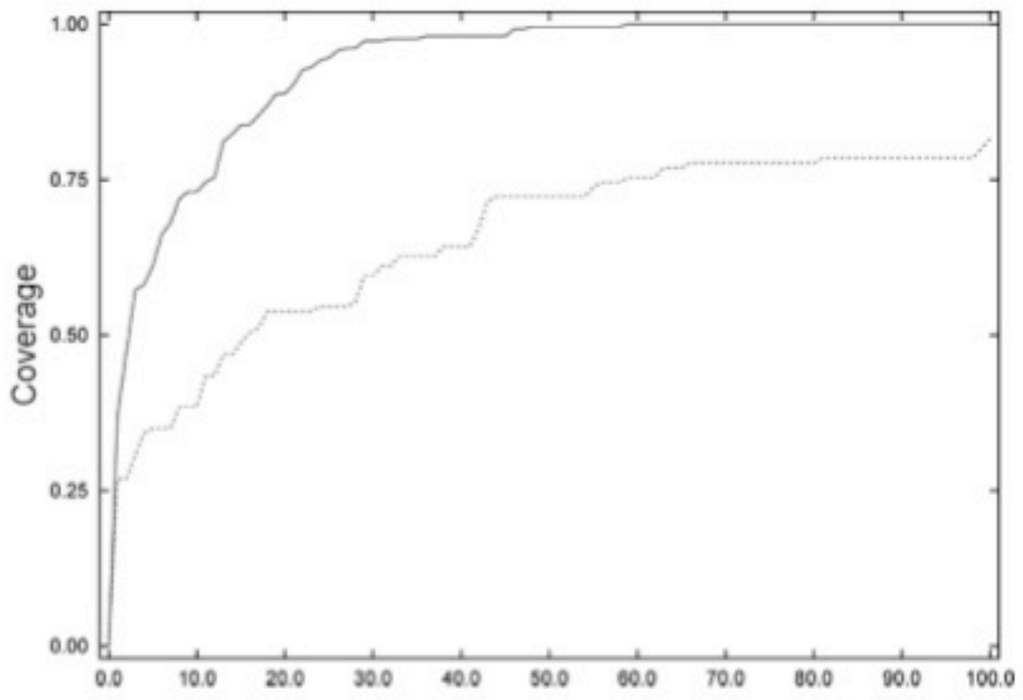
- 30 runs for each method
- RUTEG-specific code is 780 LOCs

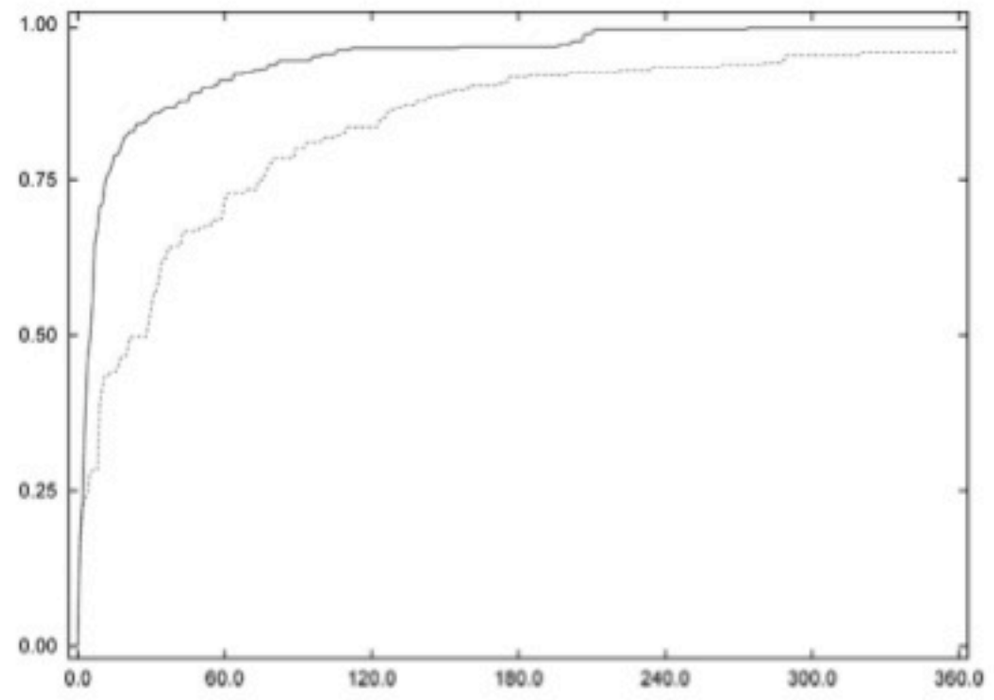
Experiment: Results

Method	Cov. RuTeG	Cov. RT		Time RuTeG	Time RT
triangle_type	100%	81%	**	59	99
valid_isbn10?	100%	100%		29	84
valid_isbn13?	100%	100%		34	80
add_address	100%	100%		56	97
rb_insert	100%	88%	**	68	92
bootstrapping	100%	86%	*	54	88
gamma	98%	92%	**	209	213
bfs	100%	93%	*	79	86
dfs	100%	96%	*	70	72
warshall_floyd_shortest_paths	100%	100%		155	196
rank	100%	92%	*	111	202
** (power!)	100%	96%	**	274	356
canBlockACheck	94%	74%	**	285	333
move	88%	68%	**	356	143
	98.6%	90.4%		131.4	152.9

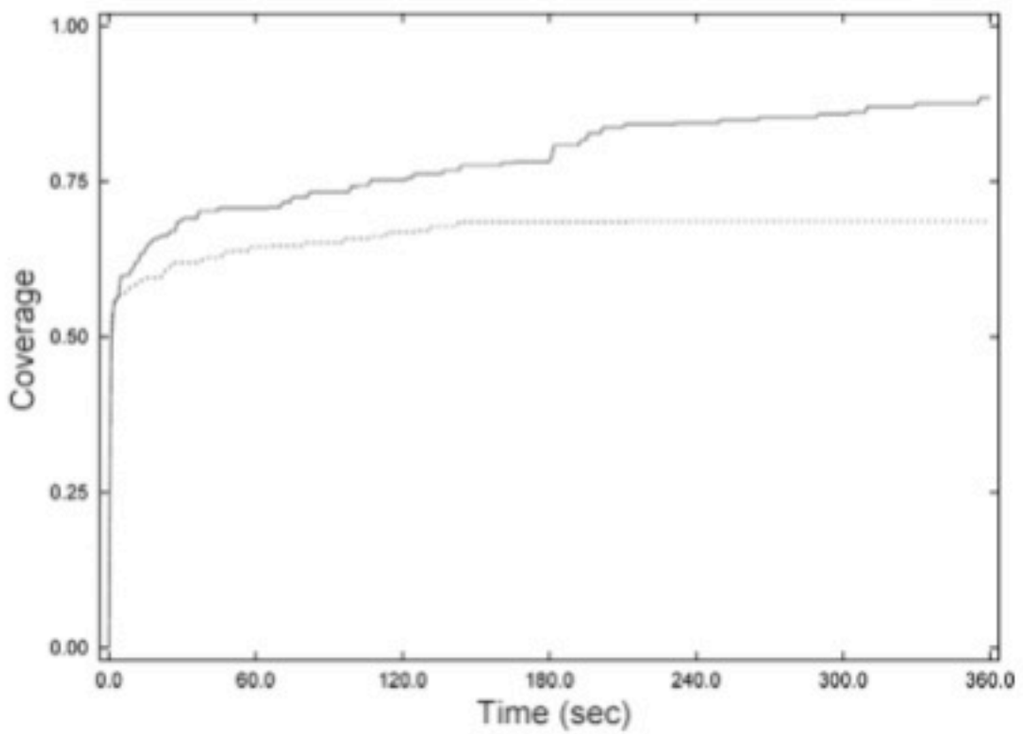
Table 2: Average code coverage achieved by RuTeG and random testing (RT), with t-test where * indicates $p < 0.05$ and ** indicates $p < 0.01$; and the time to maximum coverage expressed in seconds.

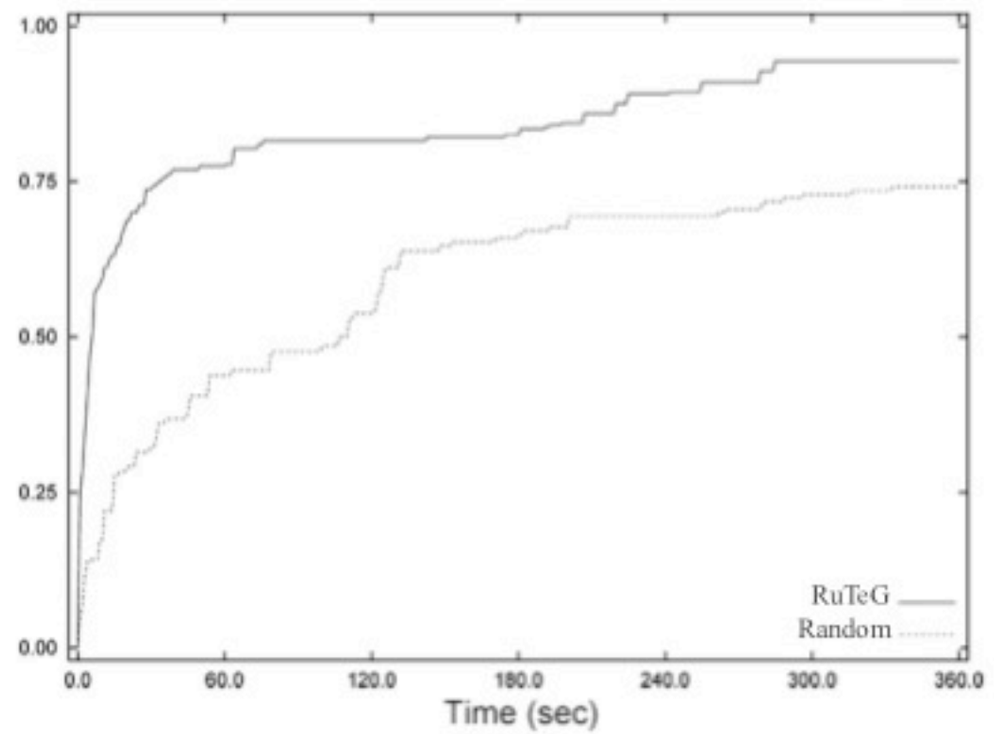


(a) triangle_type



(b) ** (power!)





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  - To keep things simple! Would need more advanced parser and fitness function
  - Basic (line) coverage enough!
  - Controversial: SBST research often overfits to eval examples. Why use general search if adaptation needed?
- What is the “right” random generator to compare to?
  - Hard question for much of SBST, there is often a continuum

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  - Took non-linearly longer when dependencies in call sequence
  - Tester need to add problem-specific Data Generators
  - Cannot generate code blocks

Table 1: Parameter settings for the experiment.

Param.	Setting	Comment
Population size	50	
Selection method	Tournament	Tournament size = 4
Mutation rate	0.2	Mutate the input pattern or mutate an input value
Cross-over rate	1.0	One-point xover for argument lists, cut & splice for method call lists
Initial sequence length	Random	Random with a max length of two times the number of methods in the class under test, cut & splice cross-over can change length dynamically
Weight param. α	0.5	Half fitness on coverage, half on covering control structures