Dealing with Inheritance in OO Evolutionary Testing

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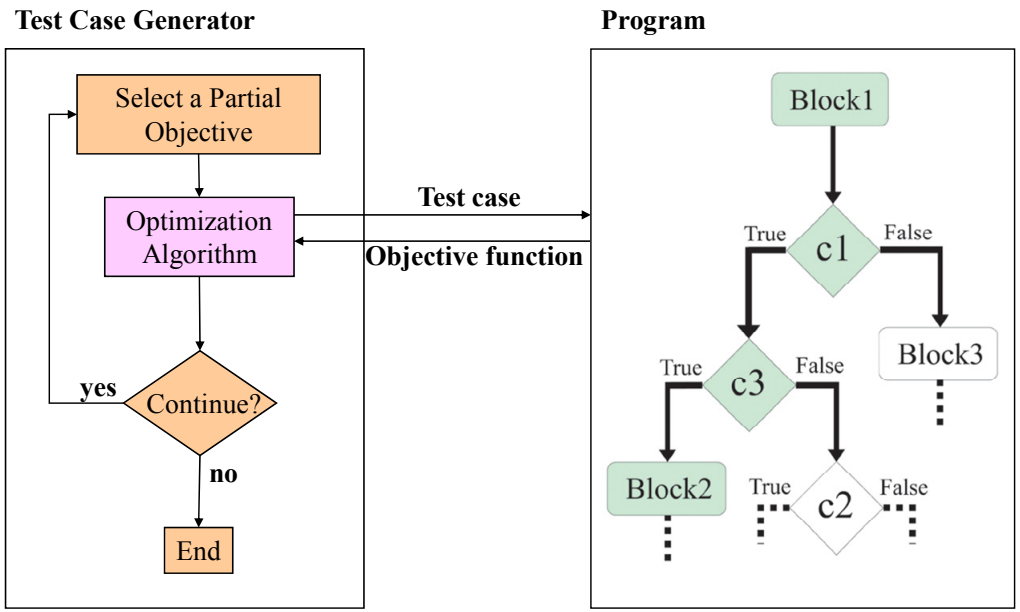
Introduction

- After codification, software products require a test phase
- The objective is to find errors
- Object Oriented paradigm is followed by most software developers
- Inheritance is an important issue of this paradigm
- We propose a distance measure for the `instanceof` operator that use the information of the class hierarchy
- We define two mutation operators based on the distance

The Test Case Generator



Genetic Algorithm

```
t := 0;
P(t) = Generate ();
Evaluate (P(t));
while not StopCriterion do
   P′(t) := VariationOps (P(t));
   Evaluate (P′(t));
   P(t+1) := Replace (P′(t),P(t));
   t := t+1;
endwhile;
```

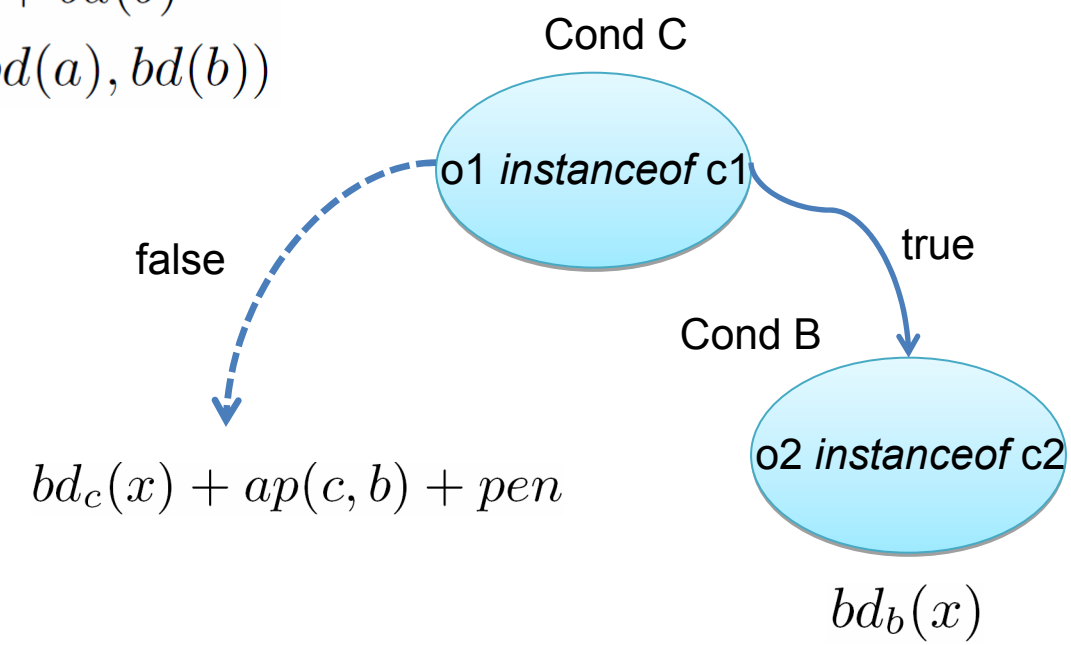
- The test case generator breaks the global objective into several partial objectives
- Our generator creates a coverage table with the values that traverses each branch

Distance for `instanceof`

- We defined an ***objective function*** (fitness) to be minimized

$$f_b(x) = \begin{cases} bd_b(x) & \text{if } b \text{ is traversed by } x \\ bd_c(x) + ap(c,b) + pen & \text{otherwise} \end{cases}$$

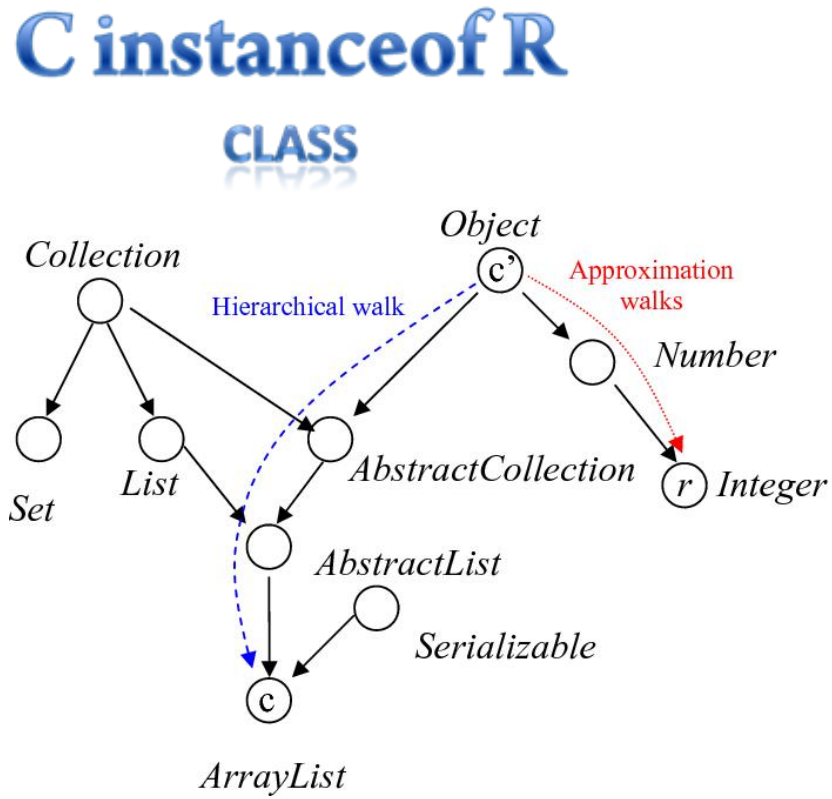
$$bd(a\&b) = bd(a) + bd(b)$$
$$bd(a|b) = \min(bd(a), bd(b))$$



Distance for instanceof

Hierarchical walk= 3
Approximation walk= 2

d=3h+2a



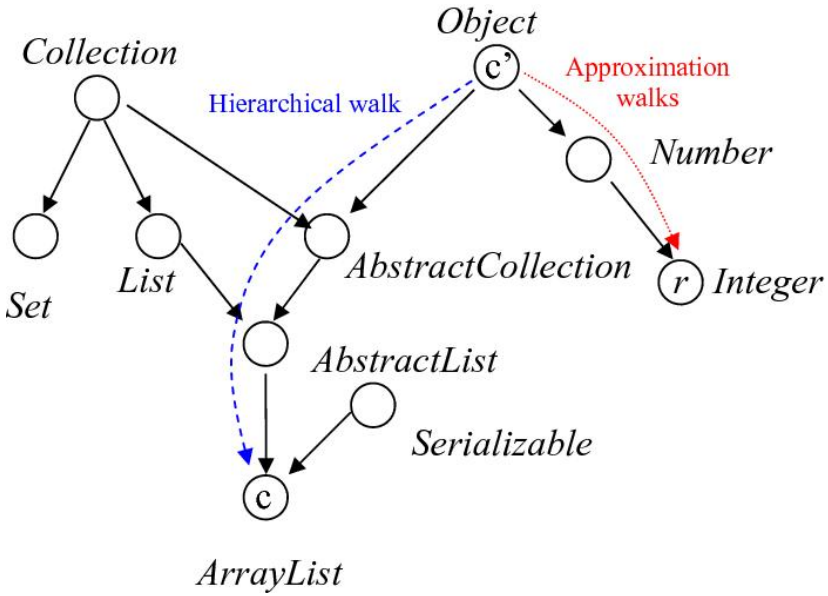
$$d(c,r) = h|w_{c' \to c}| + a|w_{c' \to r}| \text{ , if } r \in C_R$$

ArrayList `instanceof` **Integer**

Distance for instanceof

C instanceof R

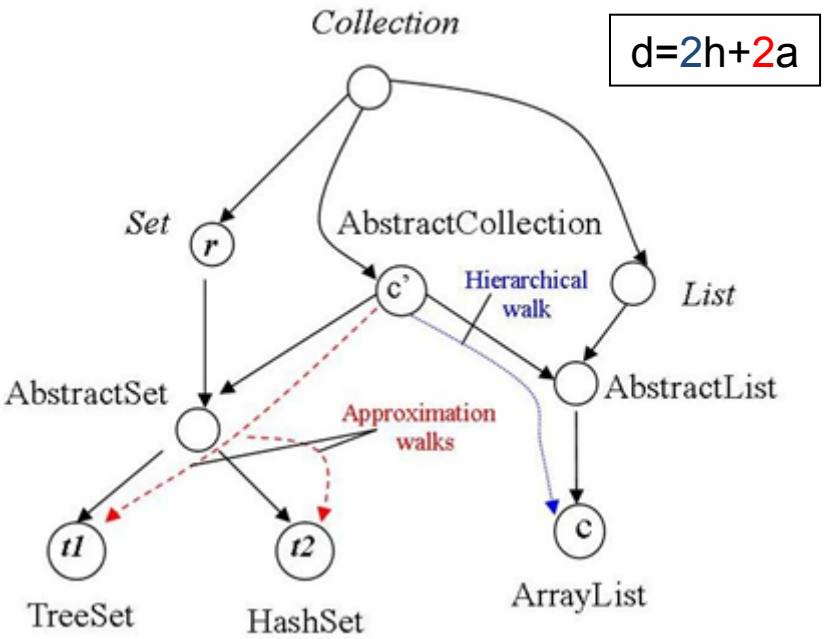
CLASS



$$d(c,r) = h|w_{c' \to c}| + a|w_{c' \to r}| \quad \text{, if } r \in C_R$$

ArrayList `instanceof` **Integer**

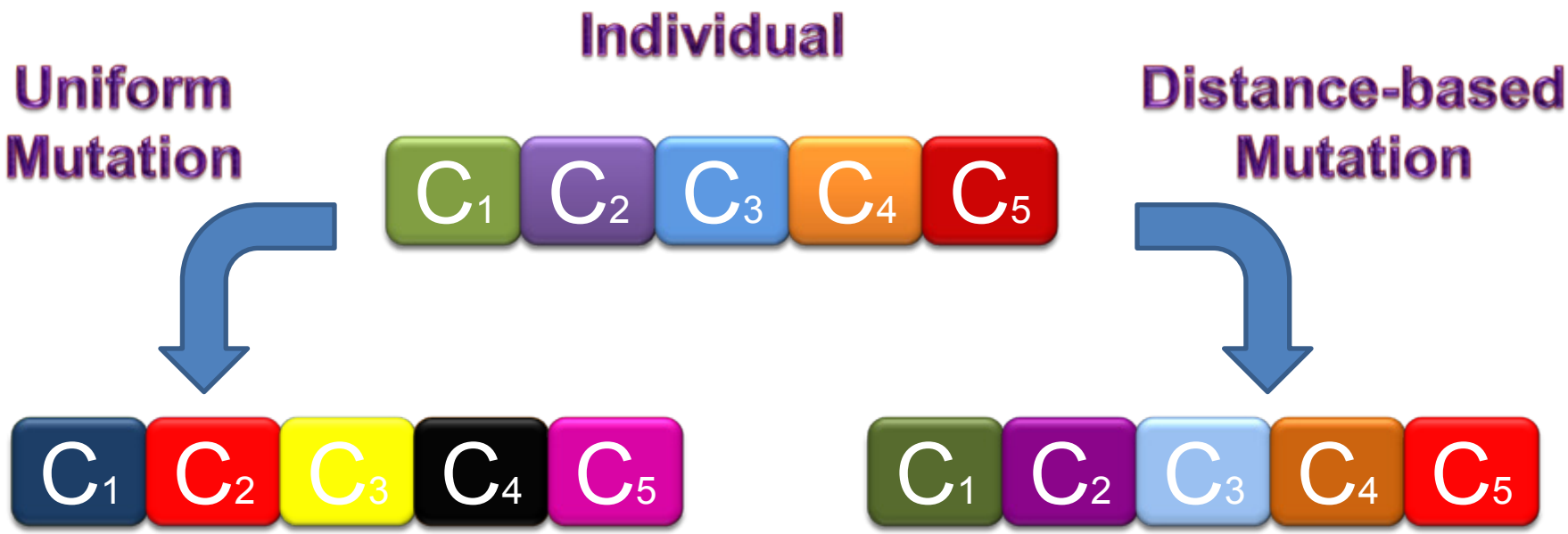
INTERFACE



$$d(c,r) = \min_{t \in S_r} d(c,t)$$

ArrayList `instanceof` **Set**

Distance-based and Uniform Mutation

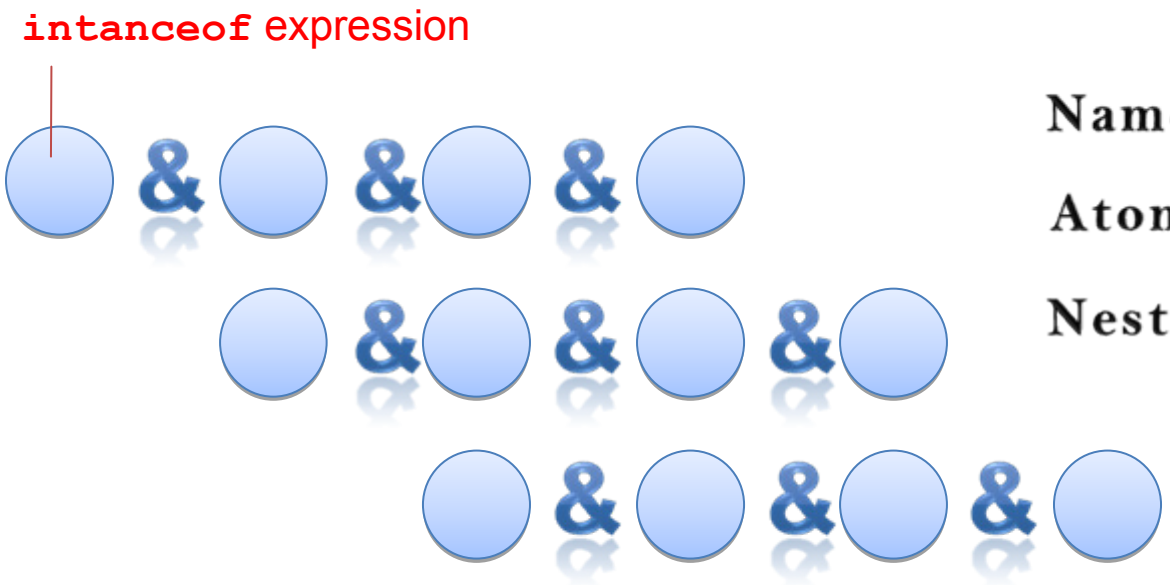


$$p(c, c') = \begin{cases} \frac{1}{|U|-1} & \text{if } c \neq c' \\ 0 & \text{if } c = c' \end{cases}$$

$$p(c, c') = \begin{cases} \frac{\frac{1}{d(c,c')}}{\sum_{r \in U, r \neq c} \frac{1}{d(c,r)}} & \text{if } c \neq c' \\ 0 & \text{if } c = c' \end{cases}$$

Experiments: Programs

Test Programs instanceof



Named: Obj i_ j

Atomic Conditions (i): 2-4

Nesting degree (j): 1-3

Experiments : Approximation and Hierarchical Constants

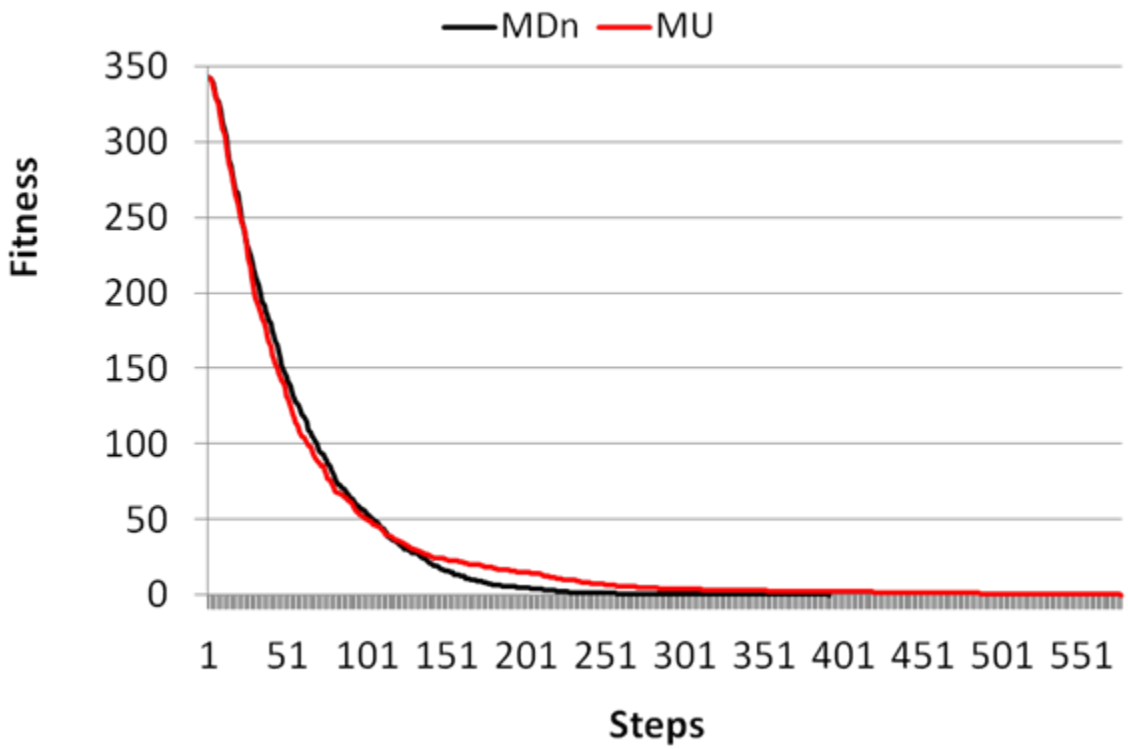
TABLE OF COVERAGE

	h = 1	h = 25	h = 50	h = 100
a = 200	*75.45 %*	*75.33 %*	*74.93 %*	*75.68 %*
a = 100	*75.53 %*	*74.74 %*	*75.10 %*	*74.79 %*
a = 50	*74.85 %*	*75.81 %*	*74.44 %*	***73.56 %***

- Does it hold that *a>h?*
- Yes, because **a** weights how close the test case is to satisfy the condition

Experiments: Distance-based and Uniform mutation

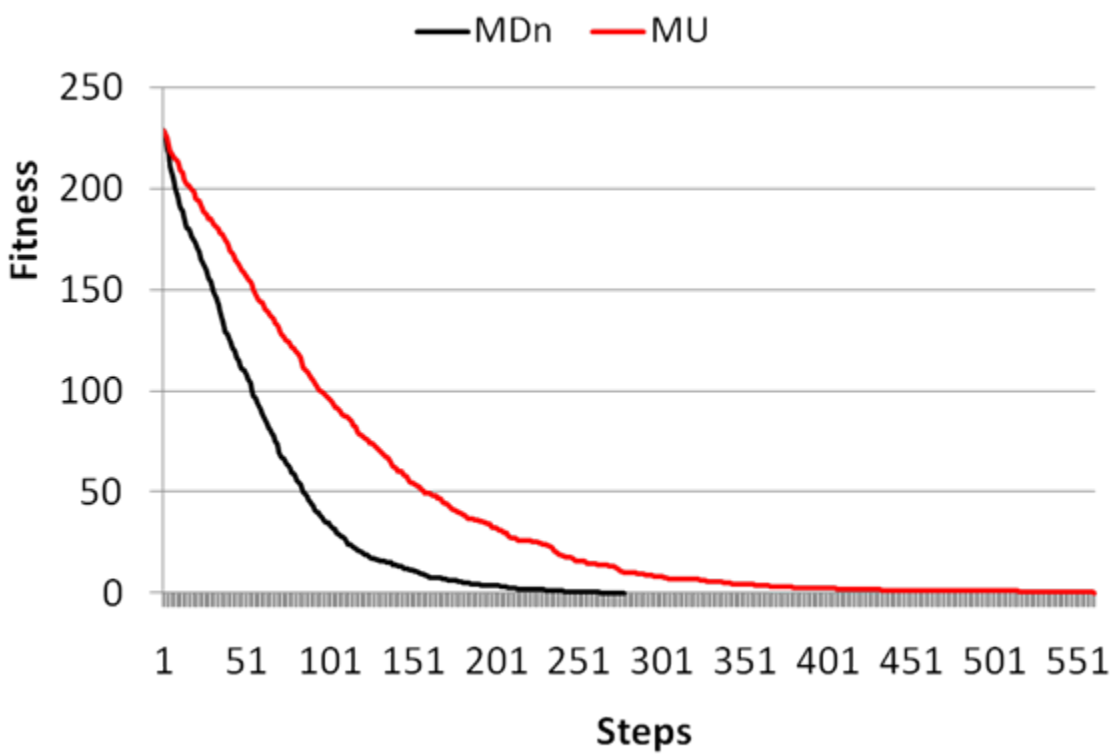
Fitness evolution with a random uniform initialization



- Average of 200 executions

Experiments: Distance-based and Uniform Mutation

Fitness evolution with greedy seeding initialization



- Average of 200 executions
- MDn is better than MU
- MU is faster at the beginning

New proposal:

Adaptive Mutation

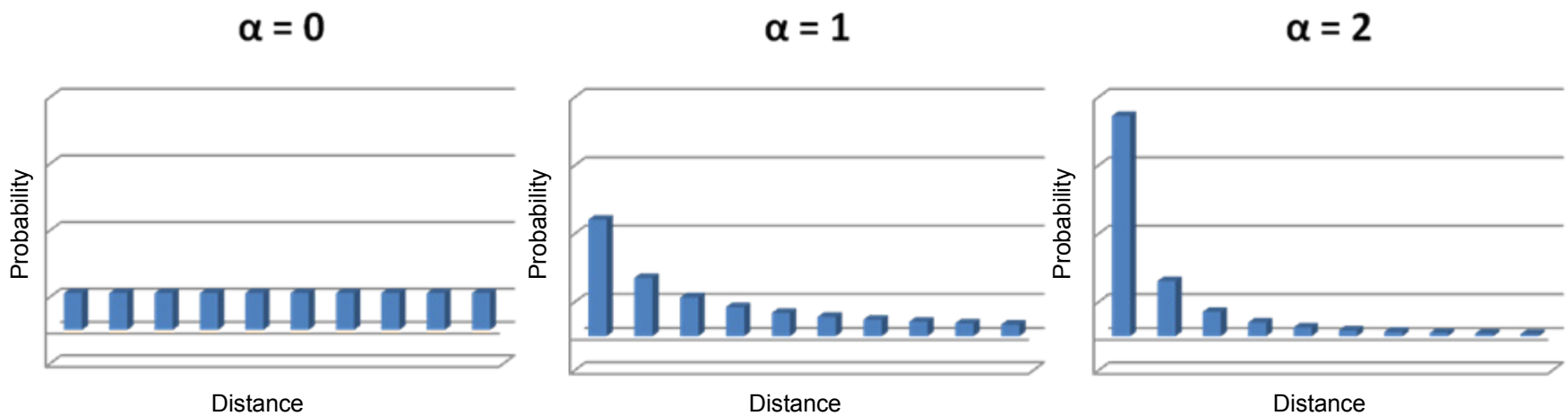
Adaptive Mutation : New Proposal

$$p(c,c') = \begin{cases} \dfrac{\left(\frac{1}{d(c,c')}\right)^{\alpha}}{\sum_{r \in U, r \neq c} \left(\frac{1}{d(c,r)}\right)^{\alpha}} & \text{if } c \neq c' \\ 0 & \text{if } c = c' \end{cases}$$

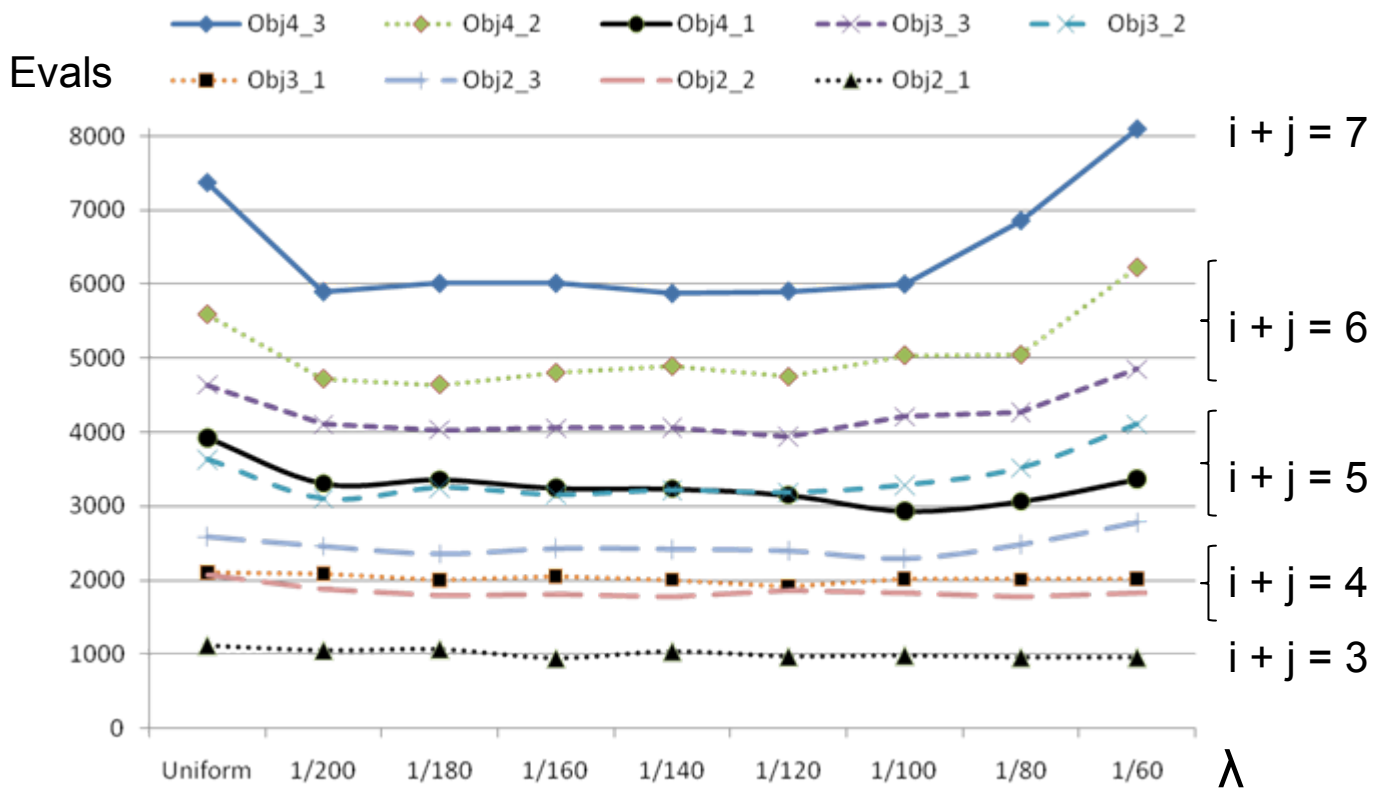
Adaptive Speed

$$\alpha = \lambda \cdot step$$

Mutation probability VS Distance between classes



Adaptive Mutation: Experiments



- 100% coverage obtained in all programs
- The GA with adaptive mutation is much better than the Random Search
- Difficult to test is correlated to the expression *i + j*

Conclusions & Future Work

- We created a test case generator able of dealing with inheritance
- A new branch distance has been defined for inheritance
- We have proposed and compared two mutation operators based on the distance
- The MDn operator is better when using a greedy seeding of the GA
- The number of atomic conditions and the nesting degree have a great influence on the automatic testing complexity

- Combine our proposal with other OO features
- Analysis of the impact of our proposal in real-world software

FINAL

THANKS FOR YOUR ATTENTION

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