Using Conditional Mutation to Increase the Efficiency of Mutation Analysis

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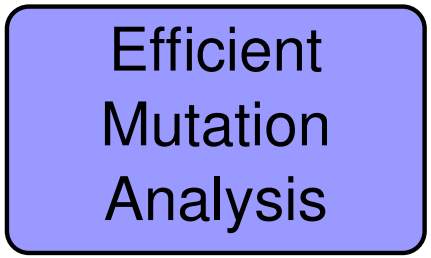
ALLEGHENY COLLEGE

Overview of the Presentation



Overview of the Presentation

Efficient Mutation Analysis

Challenges

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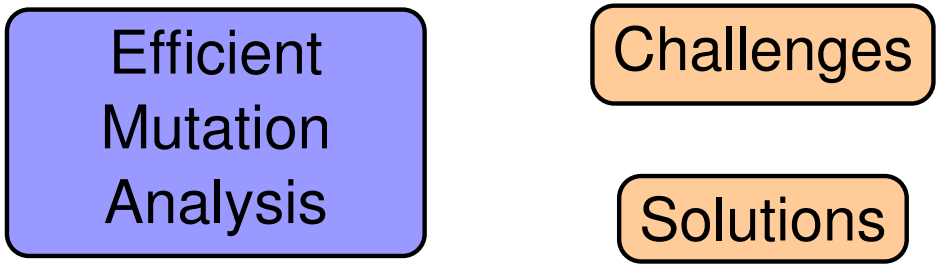

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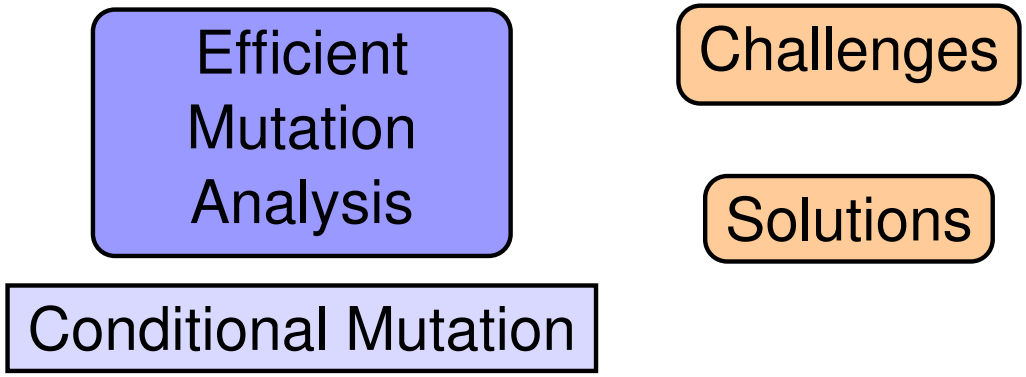

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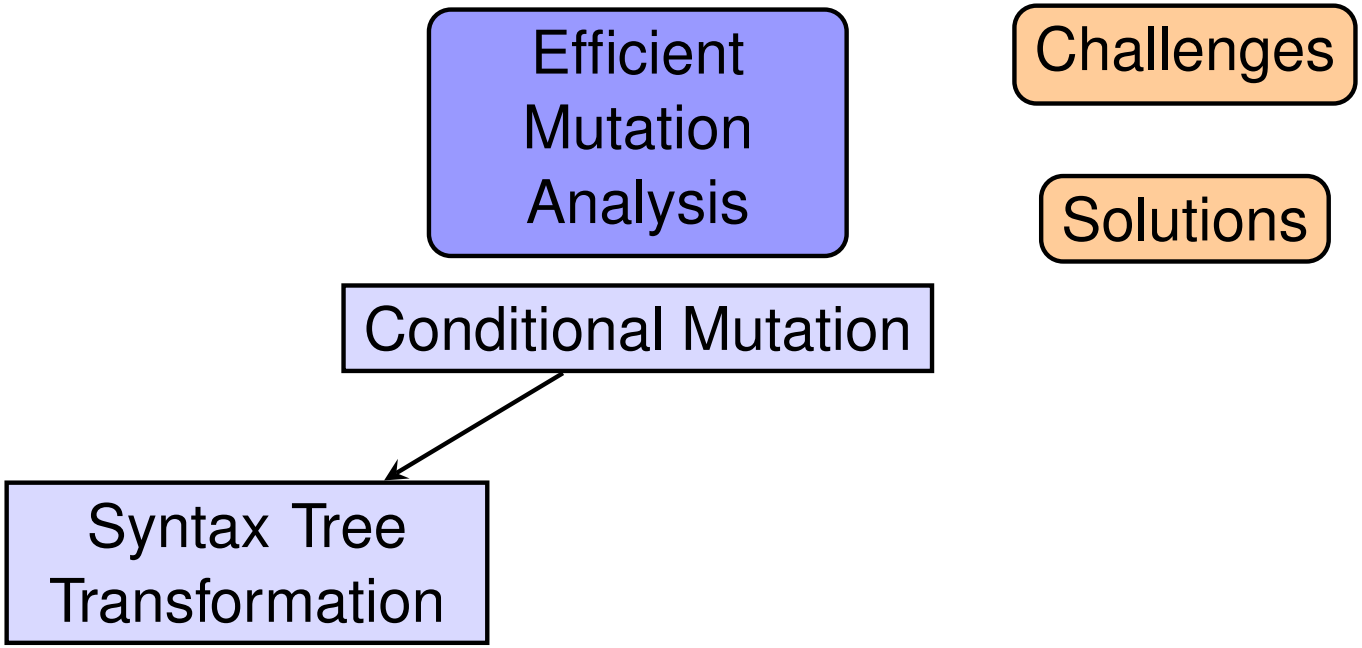

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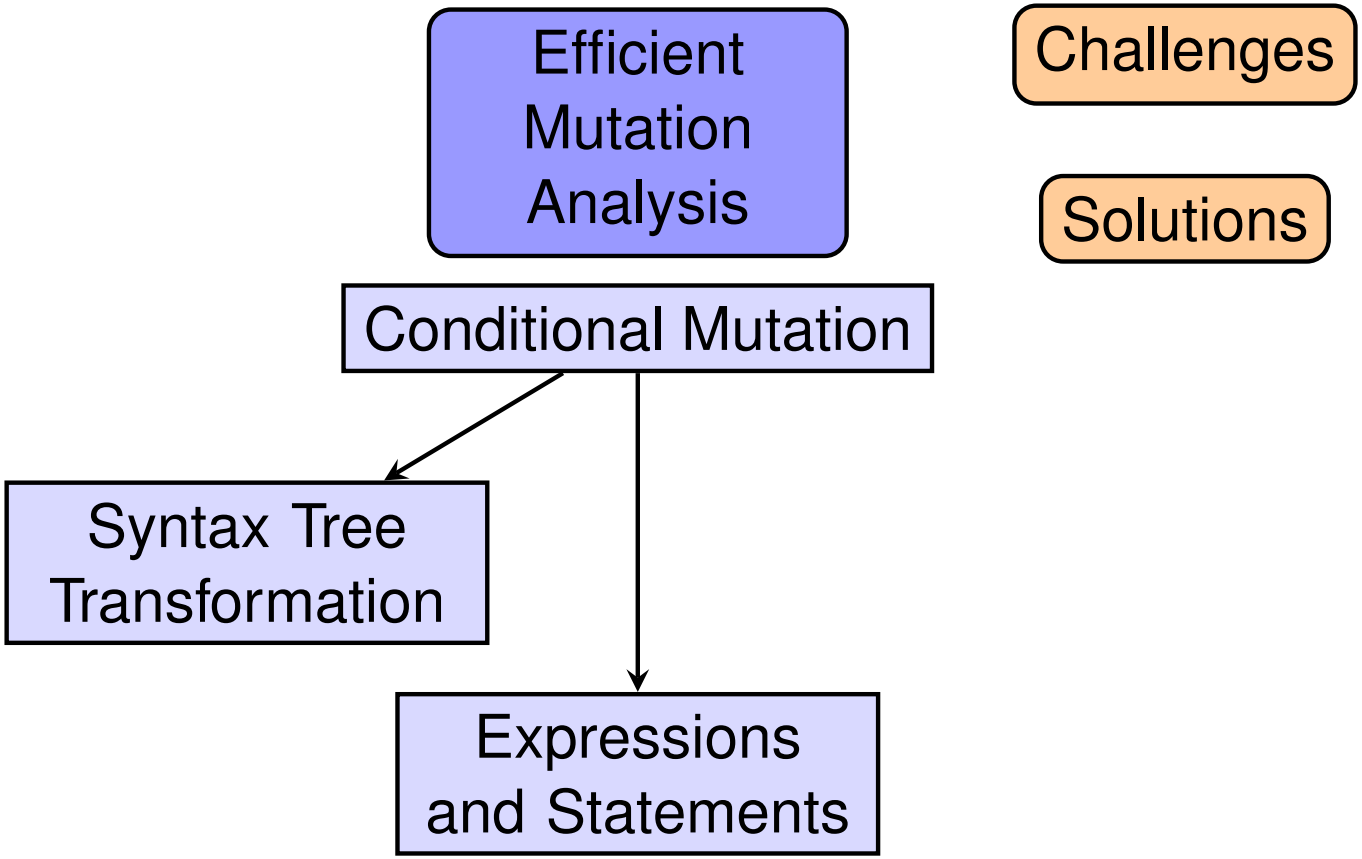

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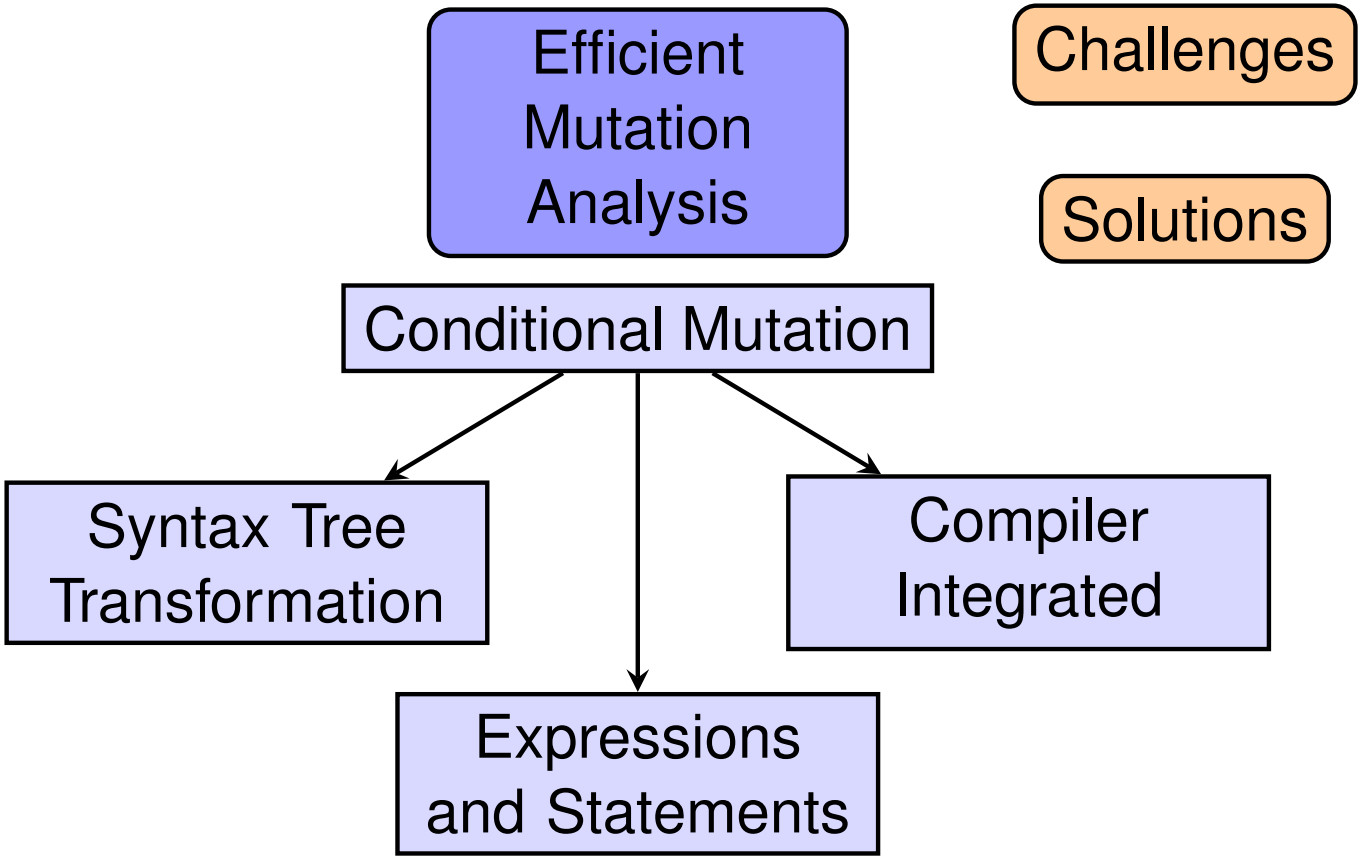

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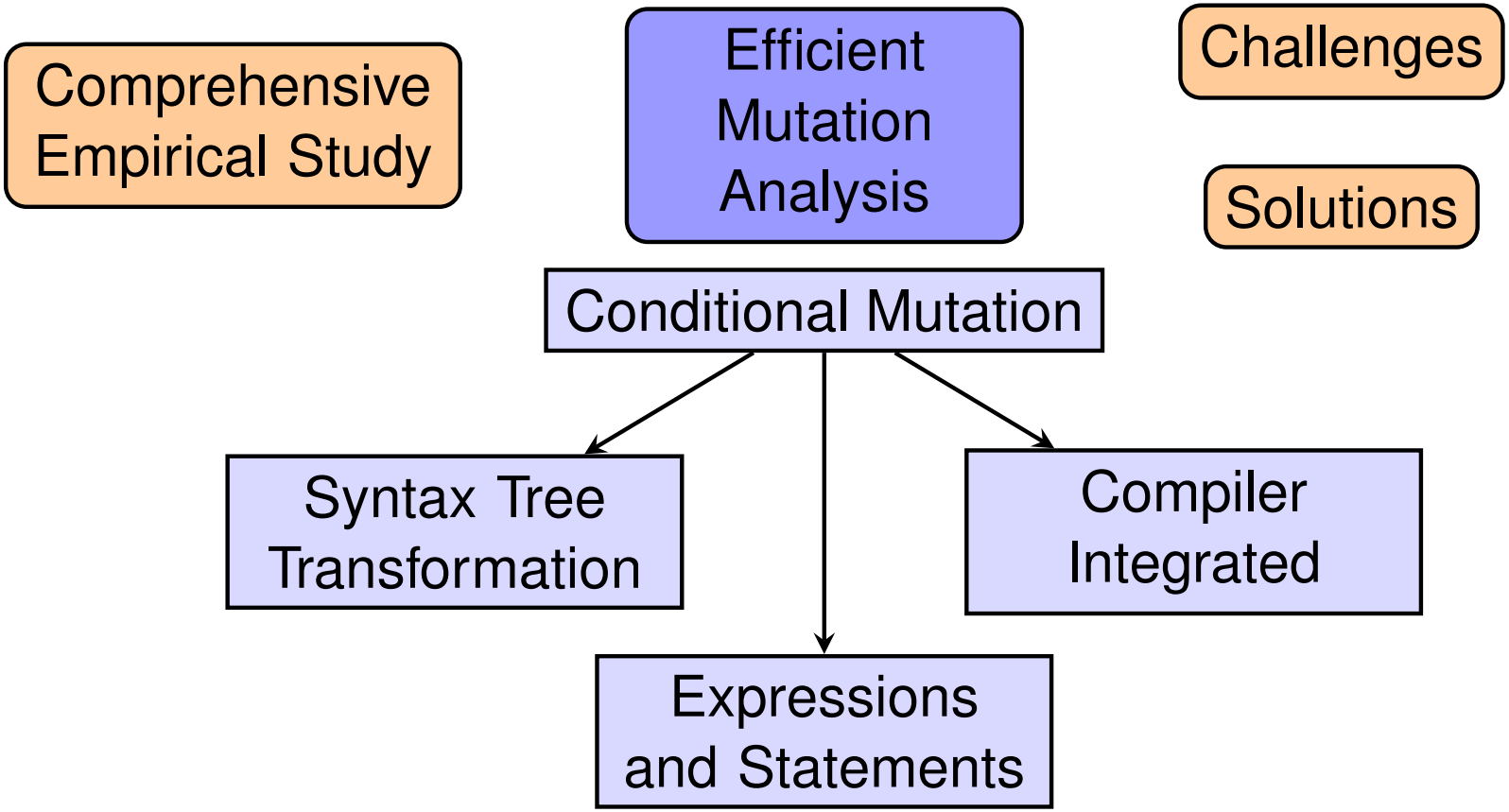

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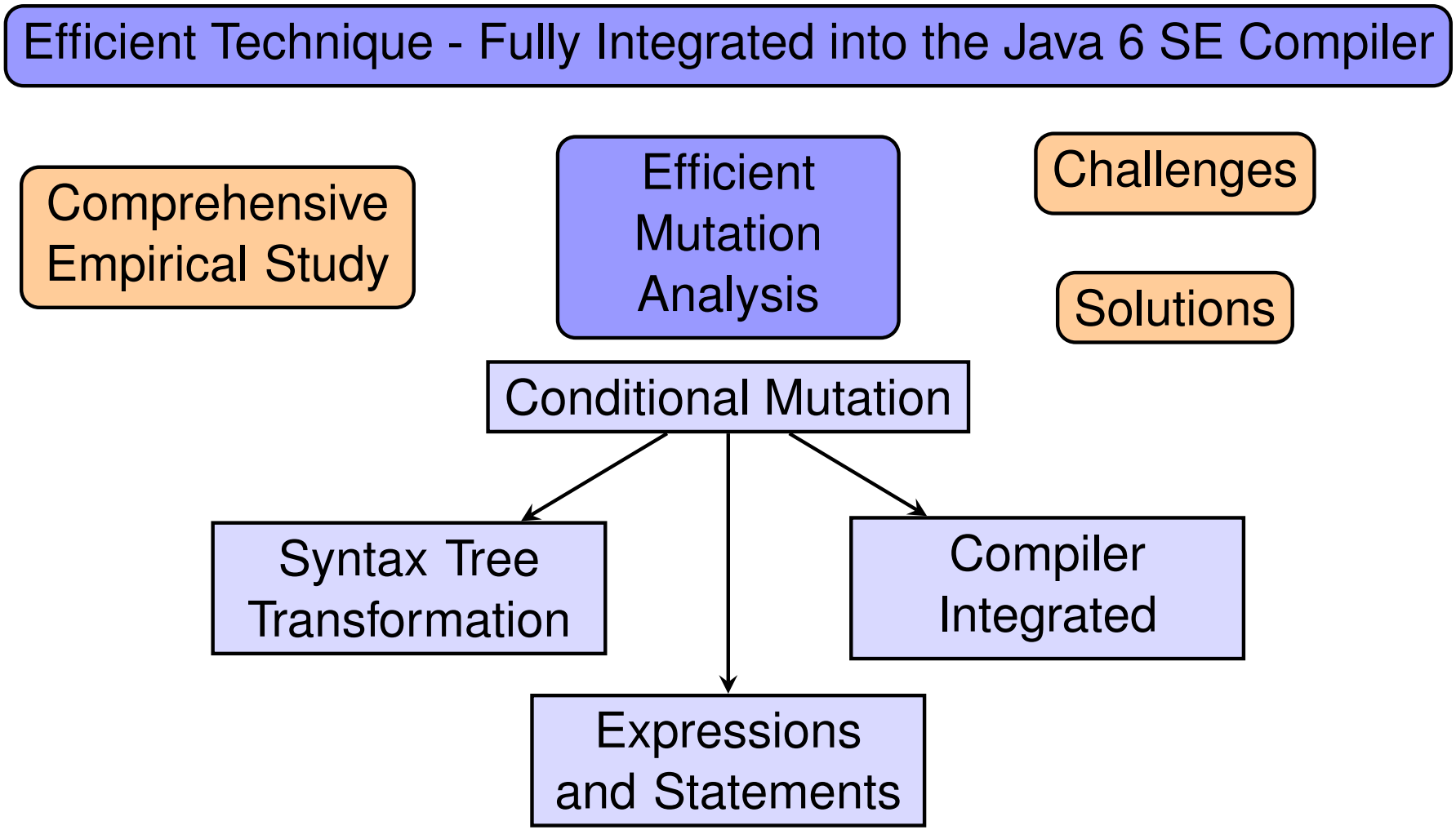

Overview of Mutation Analysis

```
public int eval(int x){
    int a=3, b=1, y;

    y = a * x;

    y += b;
    return y;
}

public int max(int a, int b){
   int max = a;

   if(b>a){
      max=b;
   }

   return max;
}
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Methodically inject small syntactical faults into the program under test

Overview of Mutation Analysis

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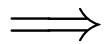
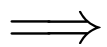


- `y = a - x;`
- `y = a + x;`
- `y = a / x;`



- `if(b < a)`
- `if(b != a)`
- `if(b == a)`

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Unbiased and powerful method for assessing oracles and input values

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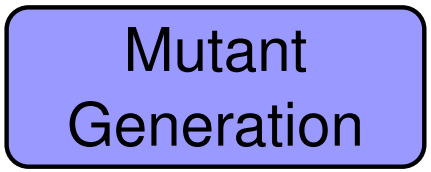
Unbiased and powerful method for assessing oracles and input values

Useful method for fault seeding during the empirical study of testing techniques

Mutation Analysis Challenges



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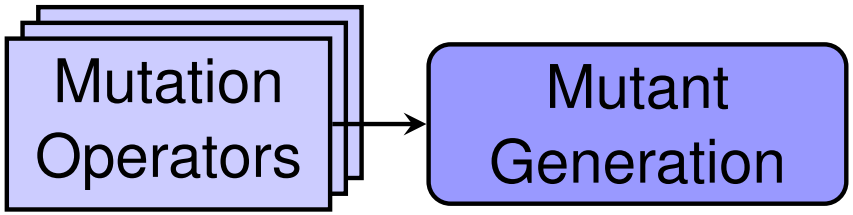

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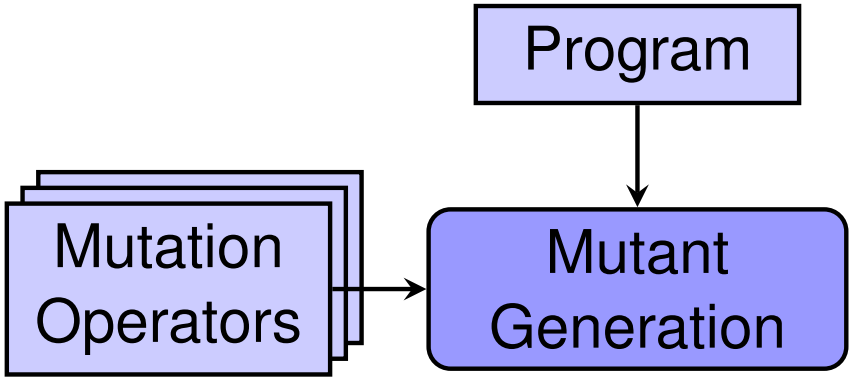

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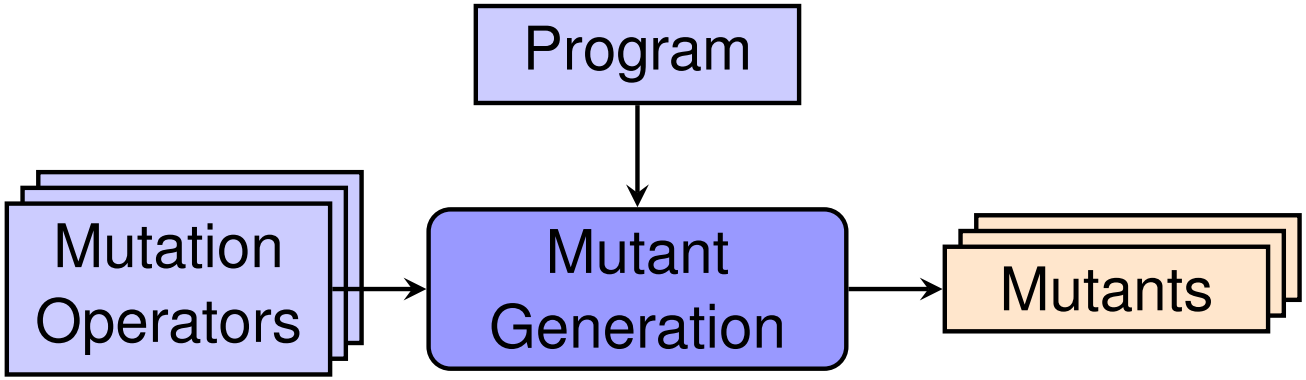

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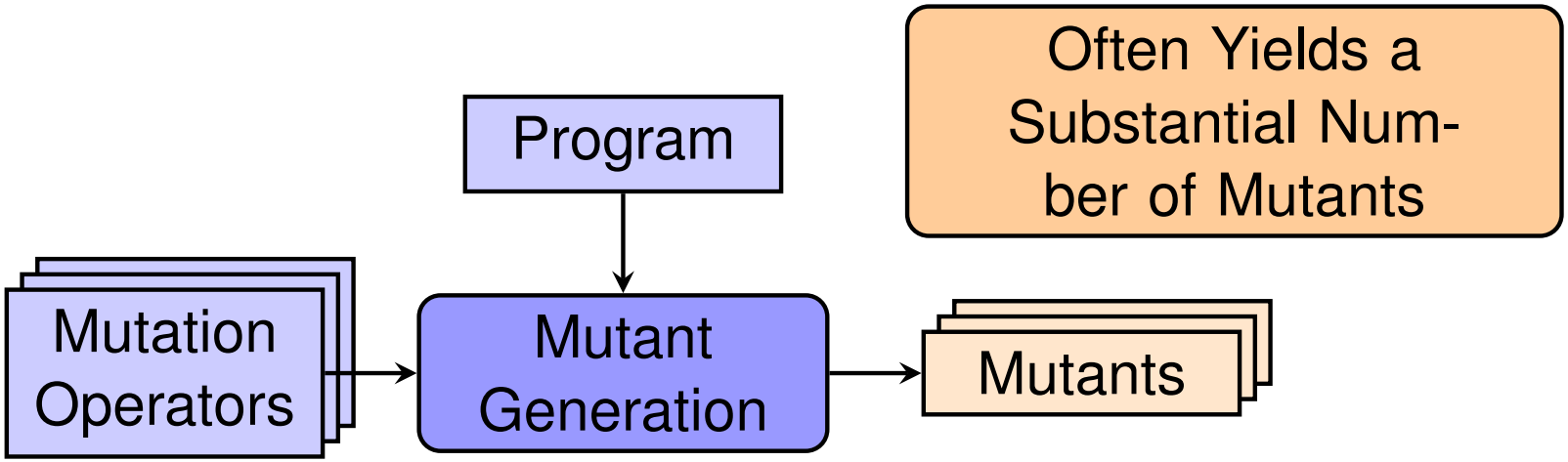

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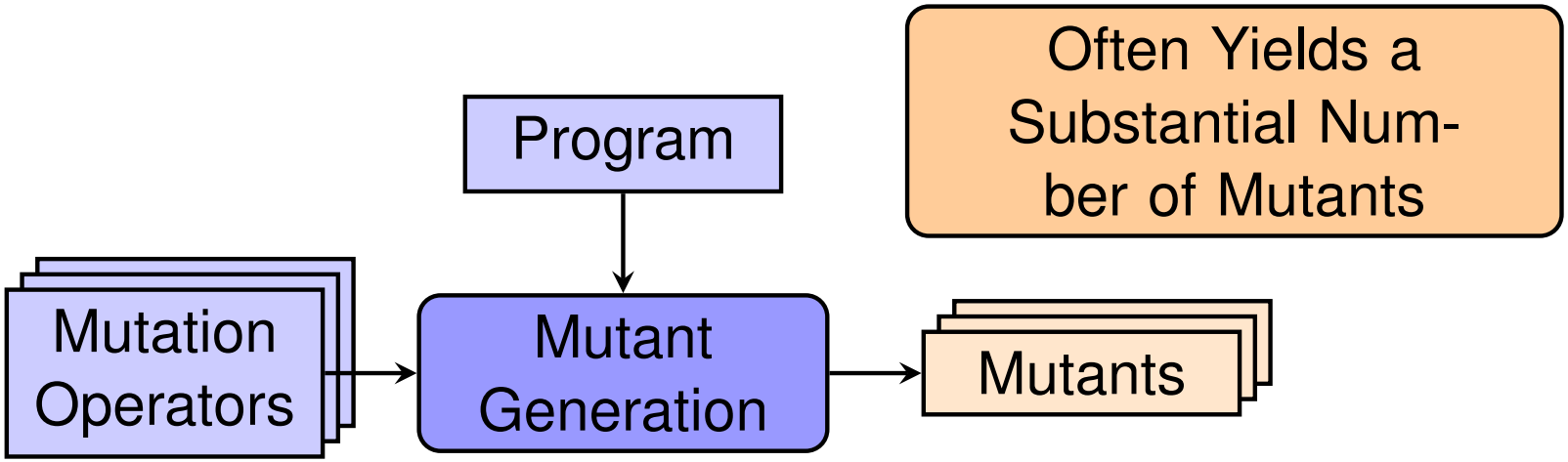
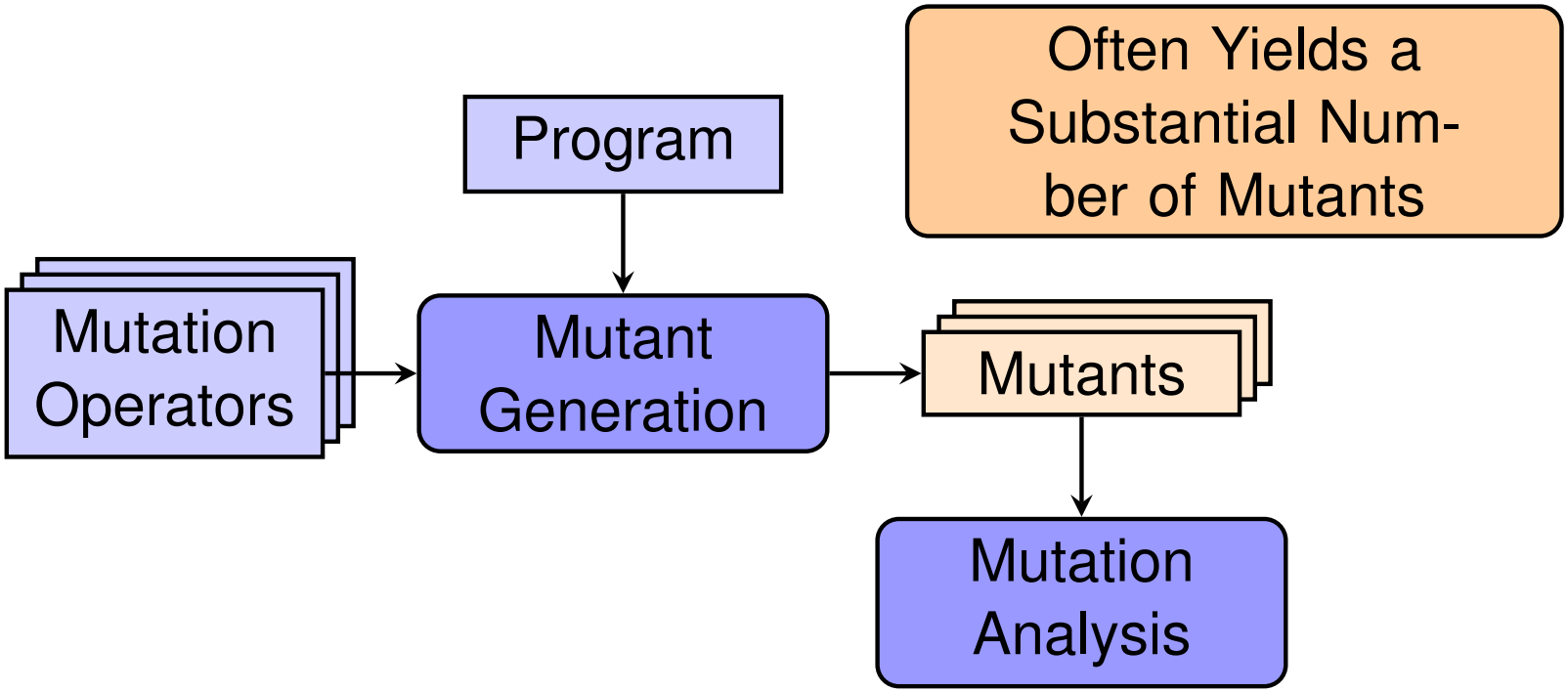


High Time Overhead for Generation

Mutation Analysis Challenges



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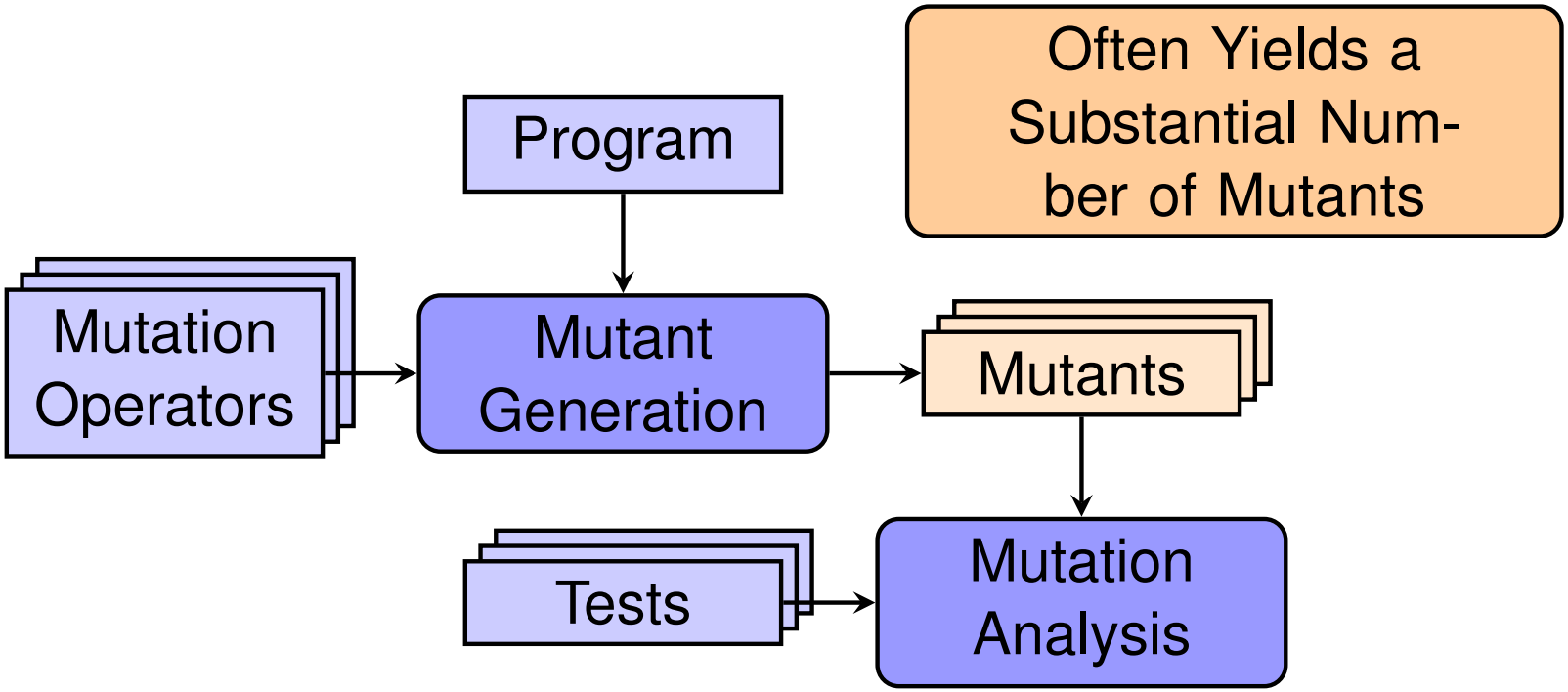

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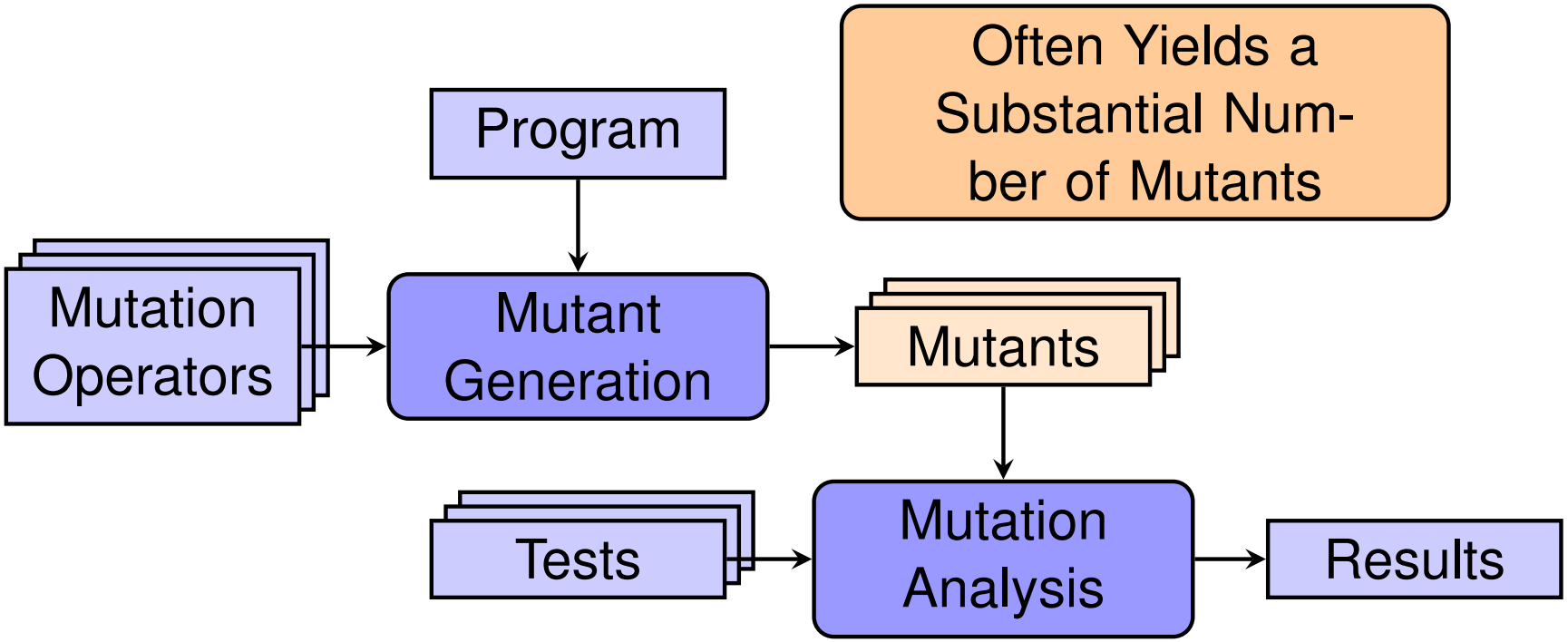

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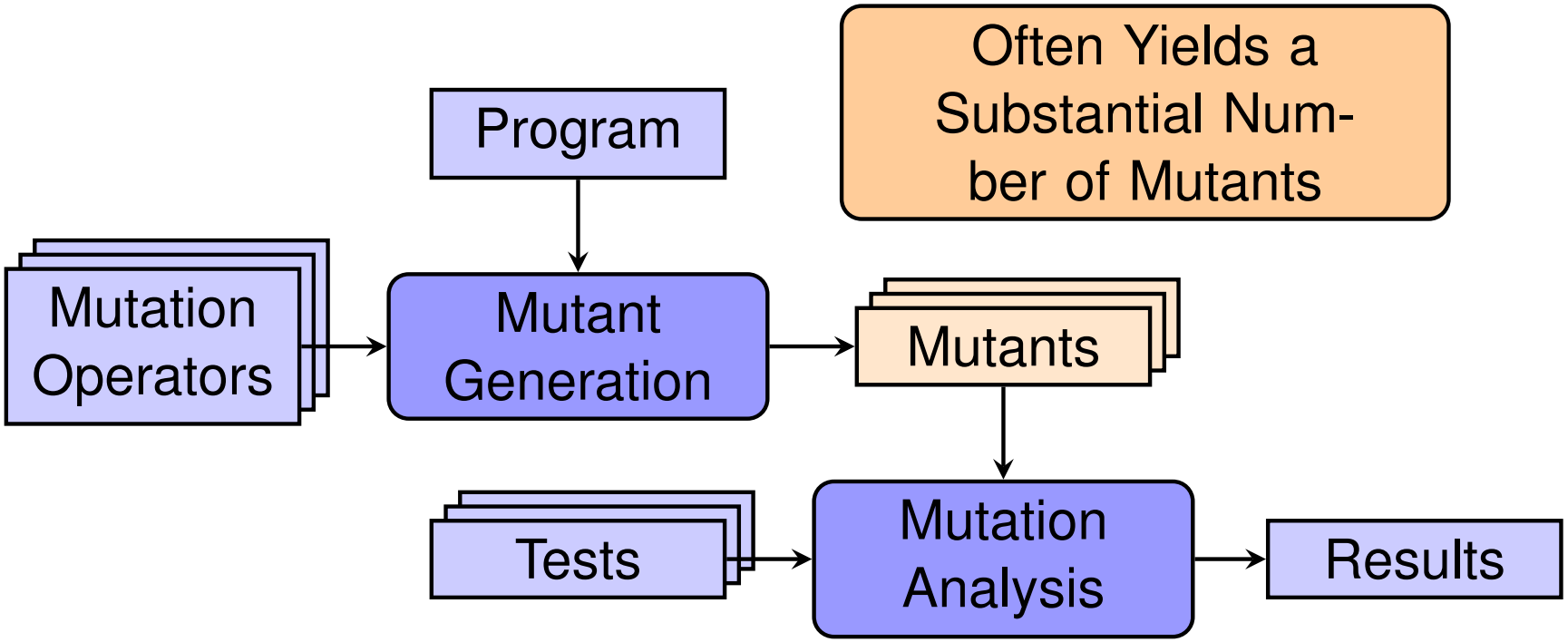

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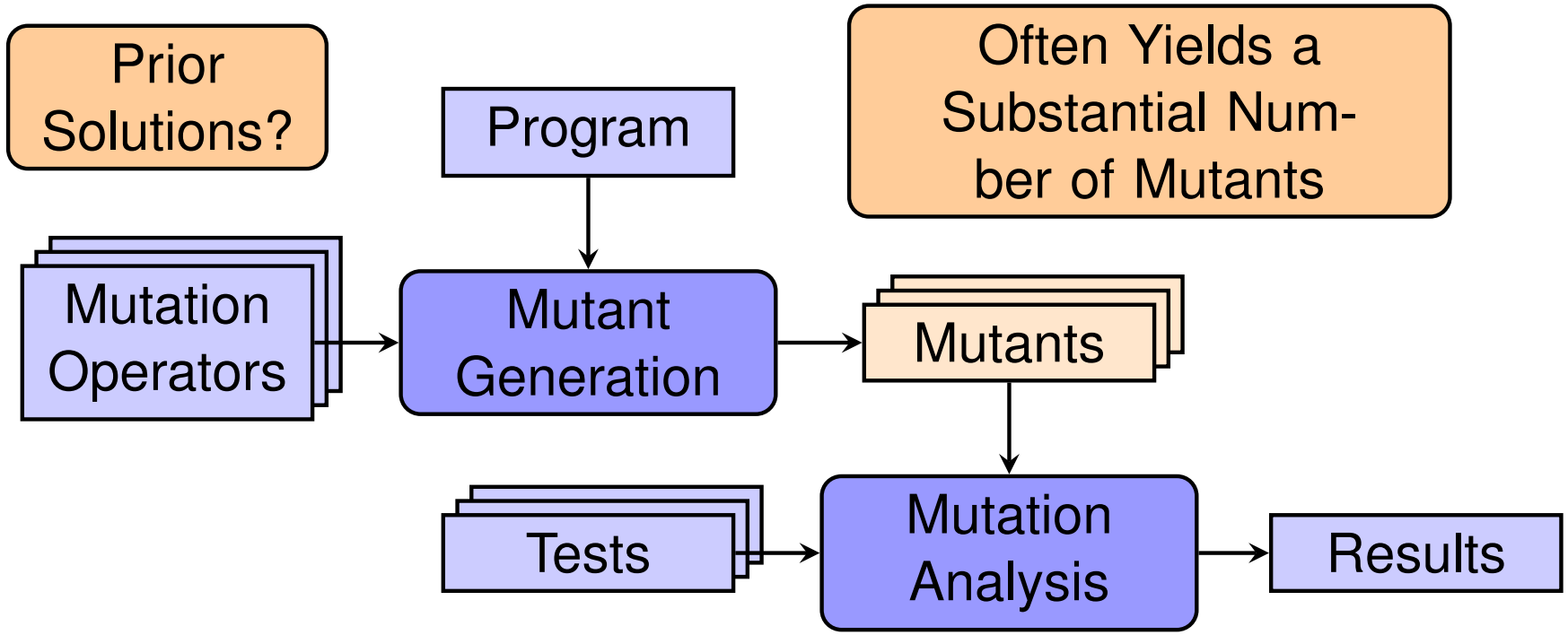

Prior Work in Mutation Analysis

Improving Mutation Analysis

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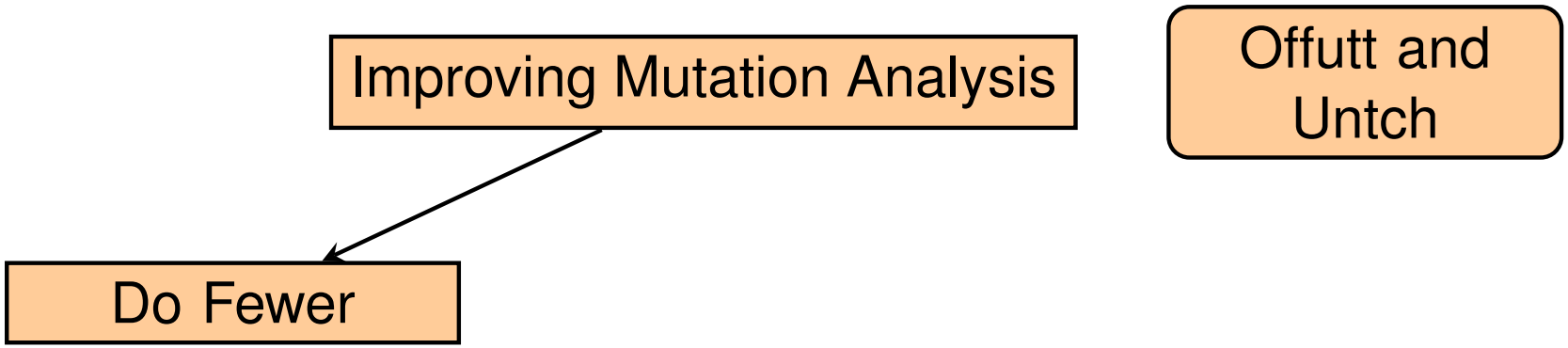

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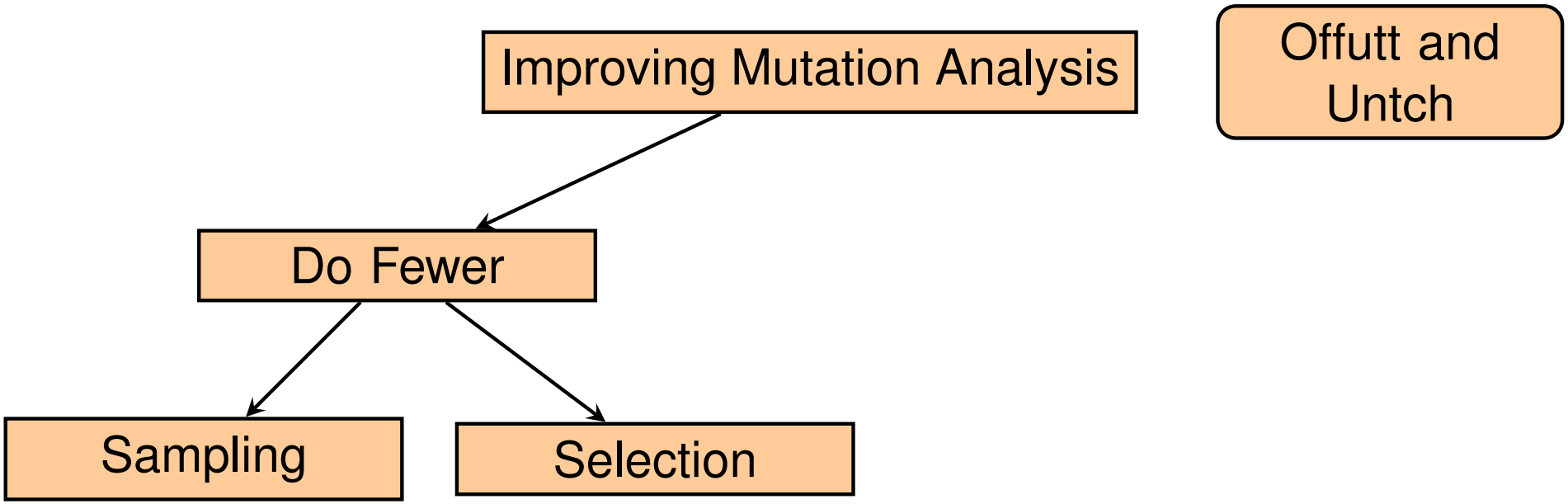

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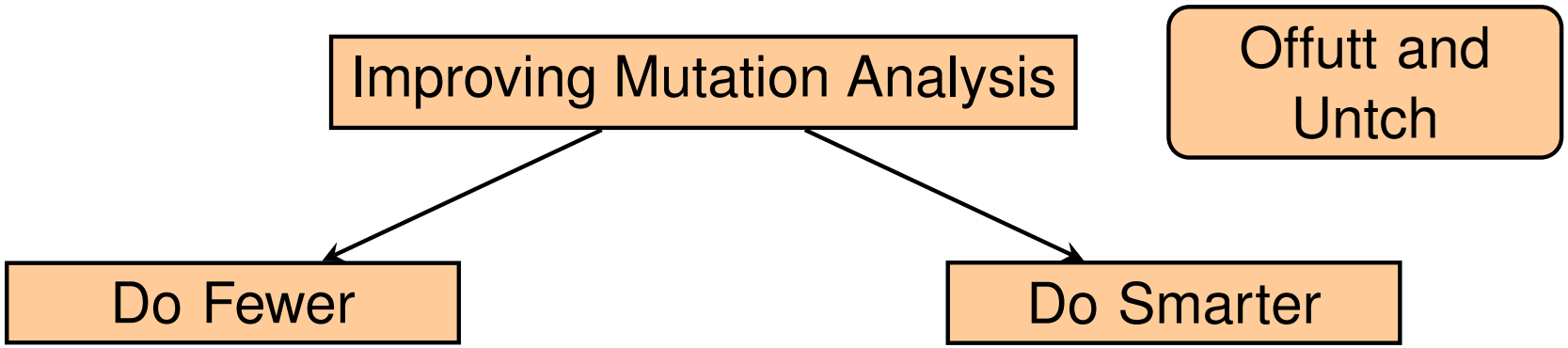

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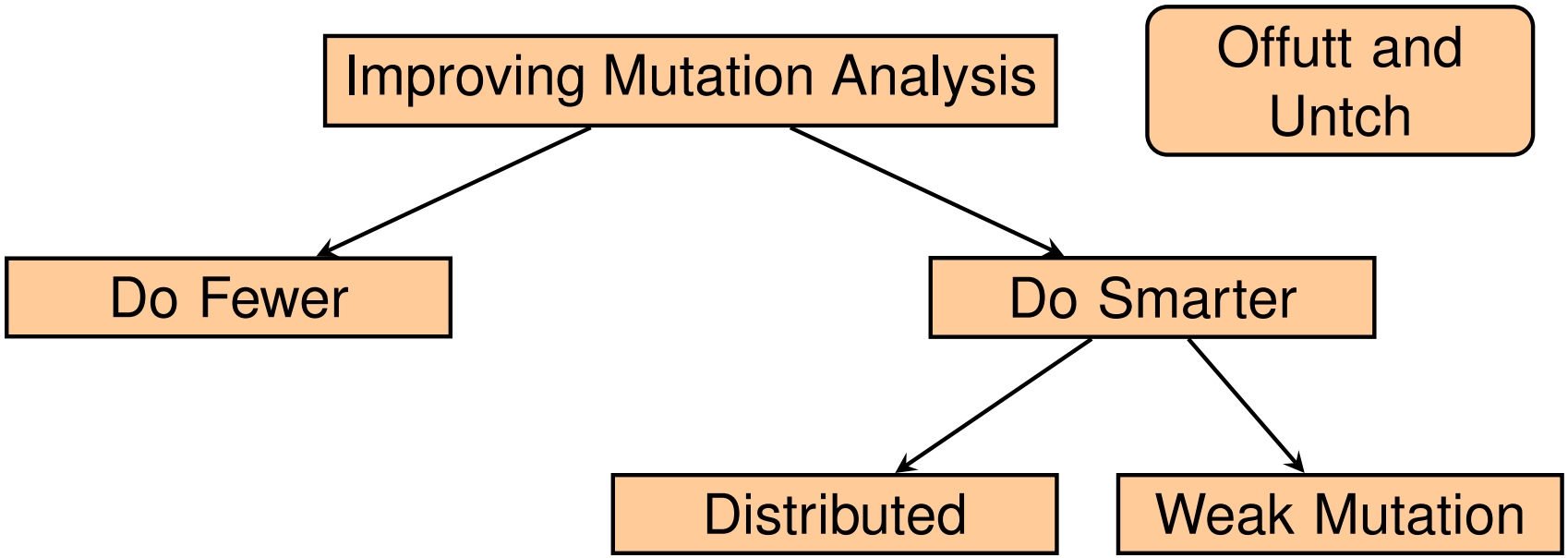

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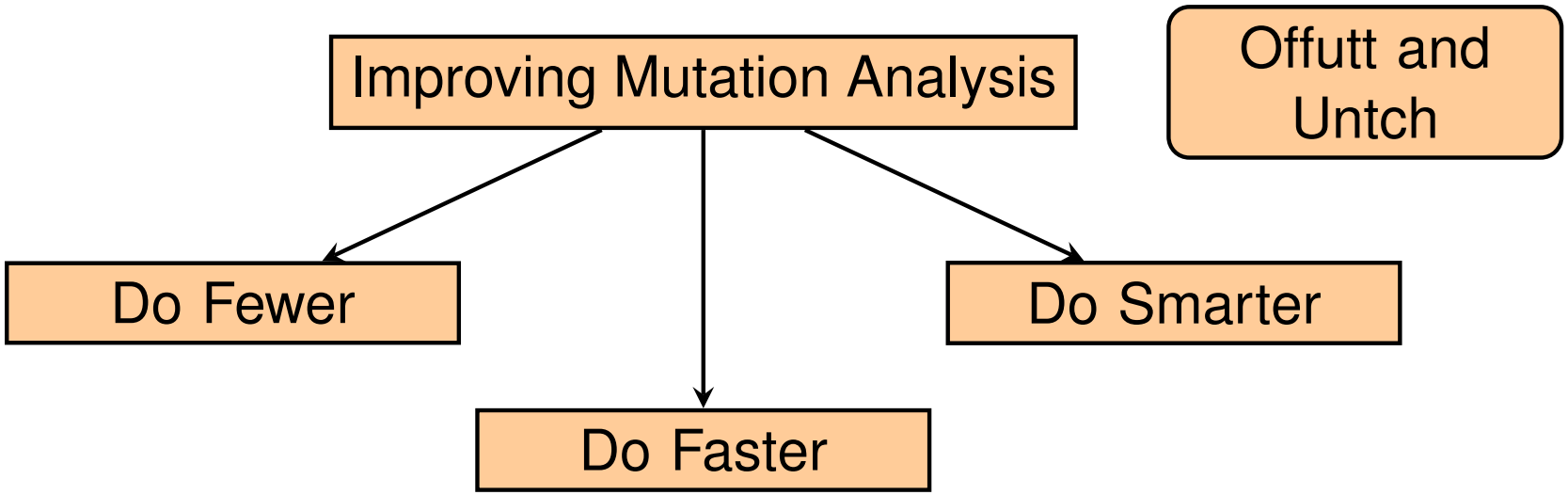

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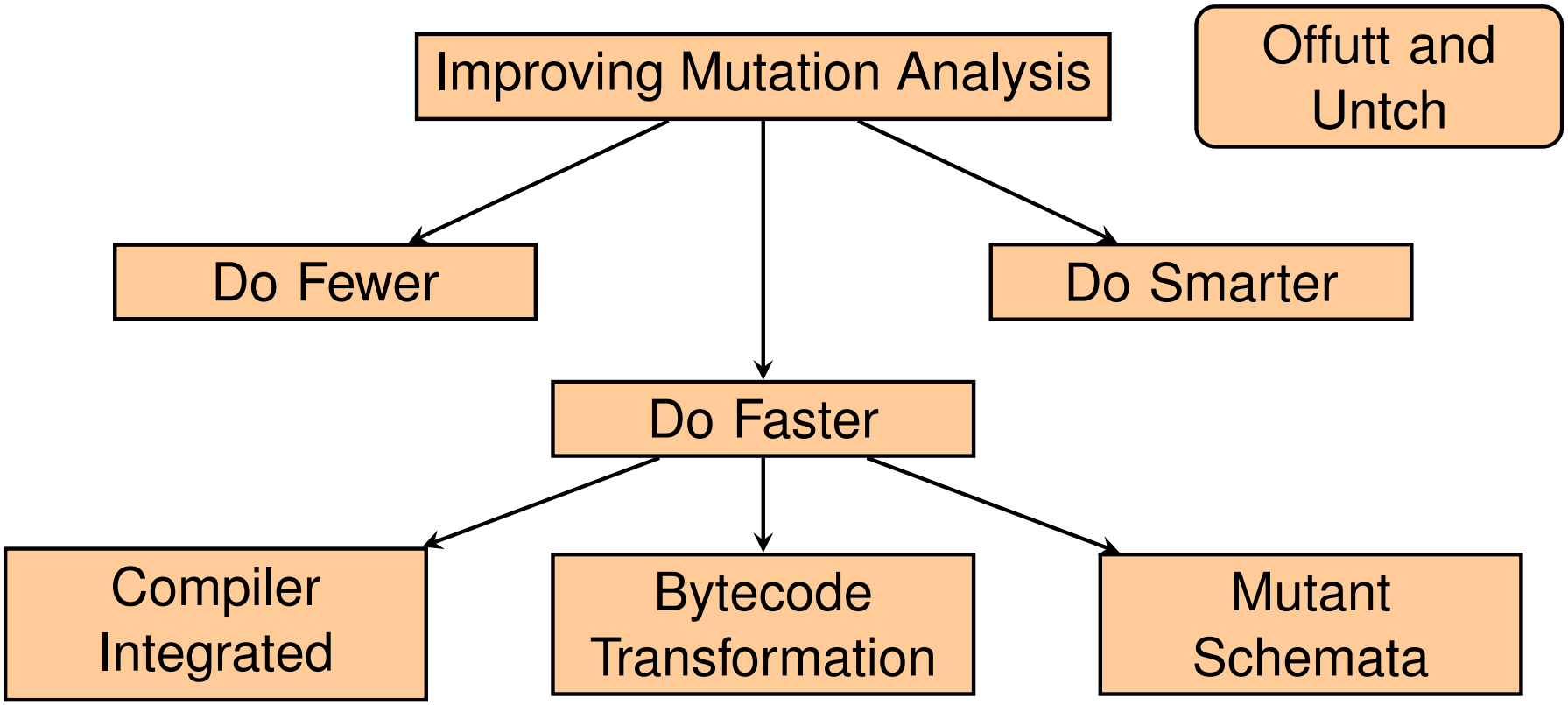

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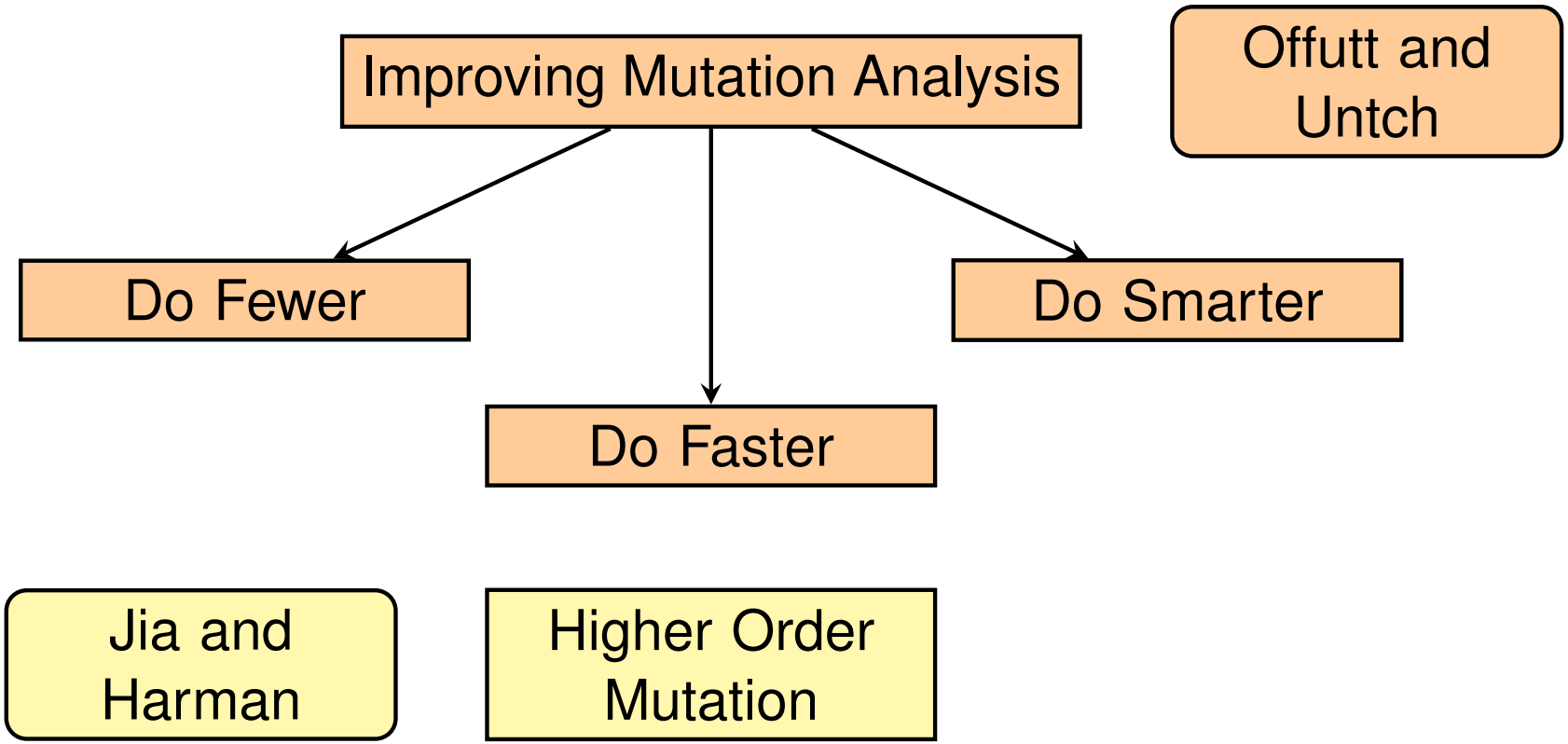

Conditional Mutation

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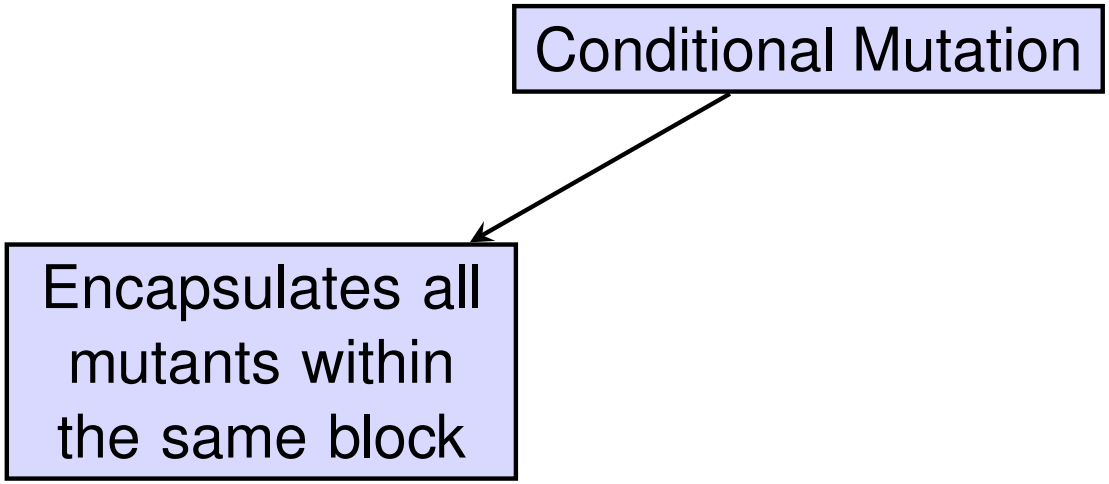

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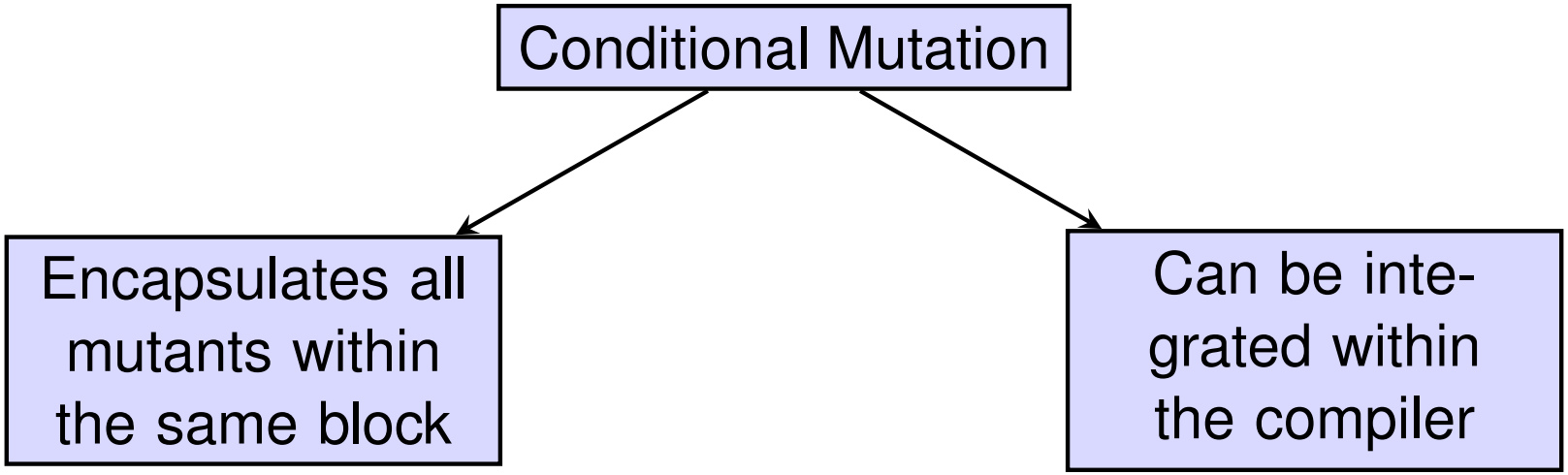

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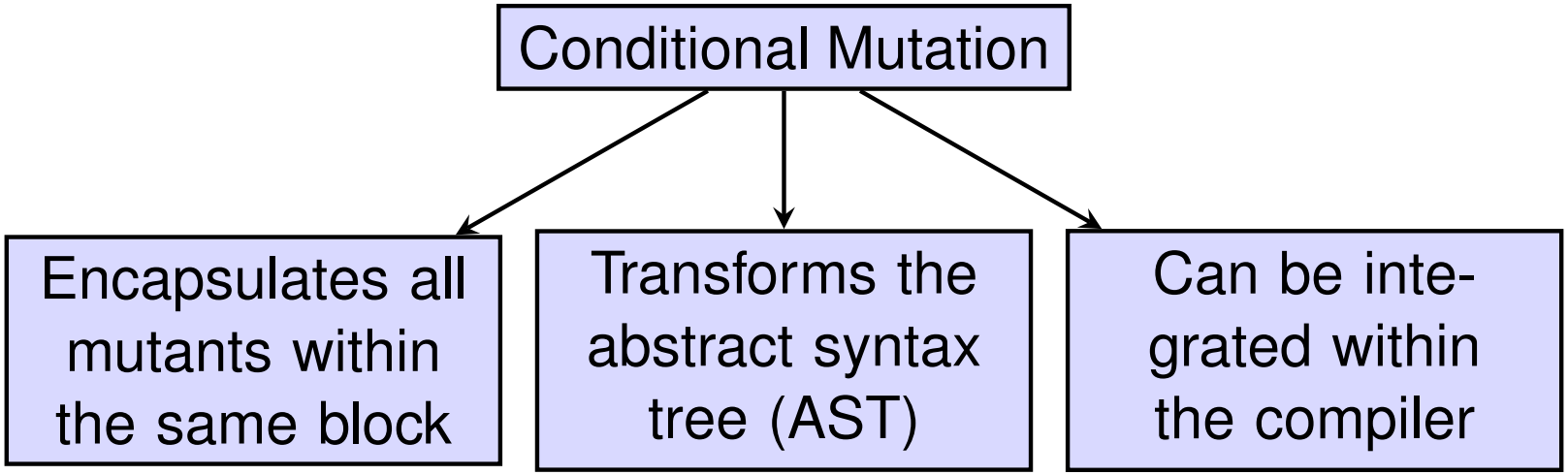

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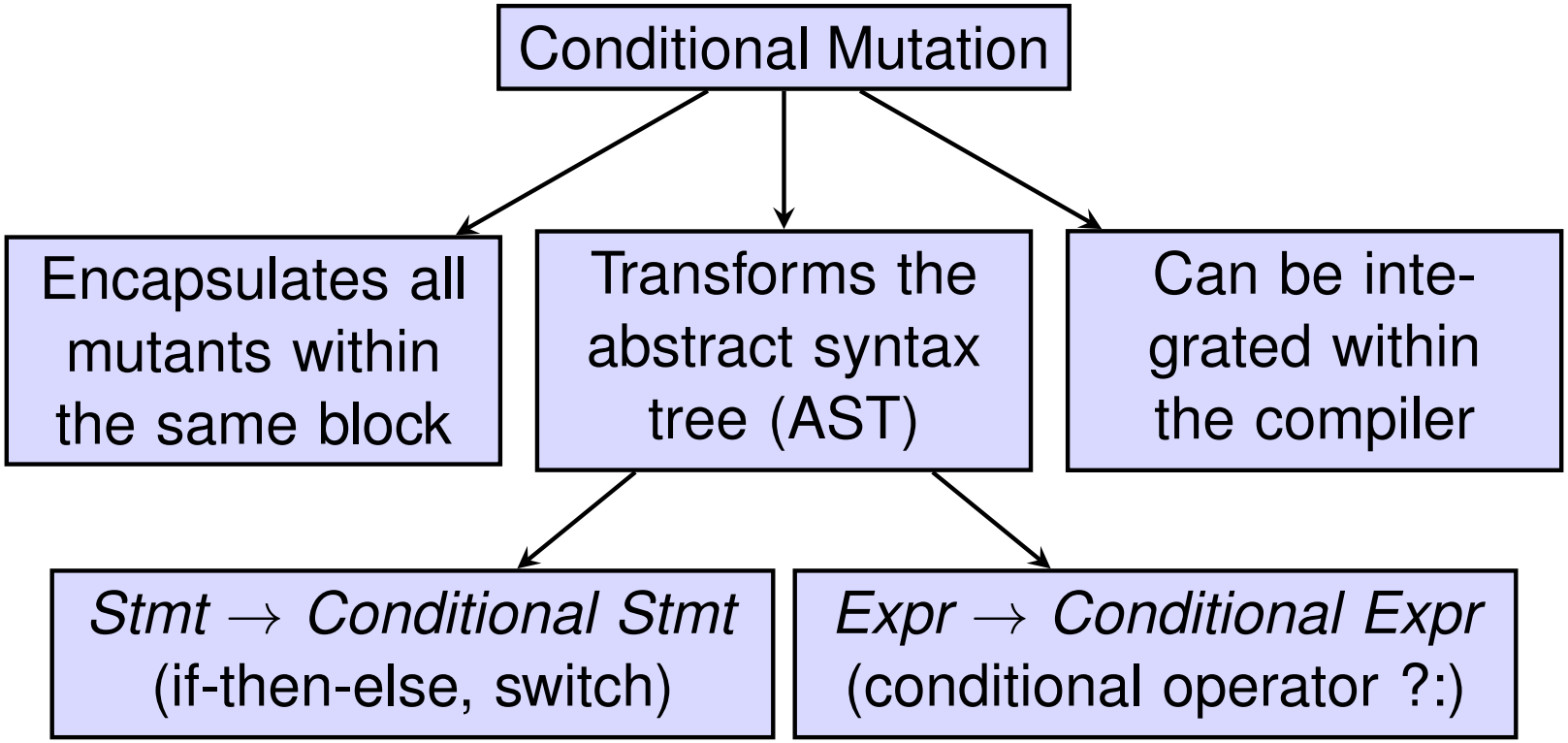

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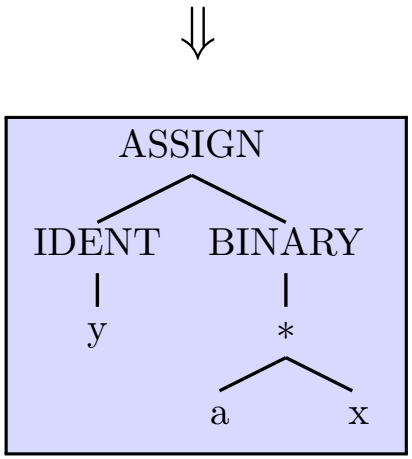

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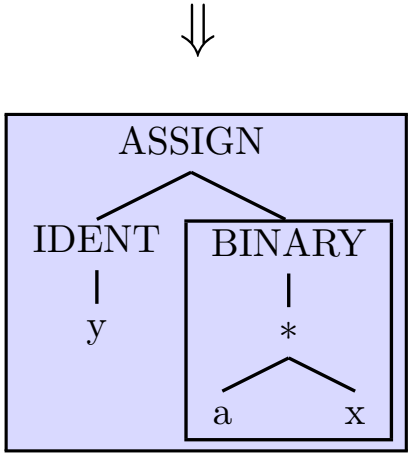

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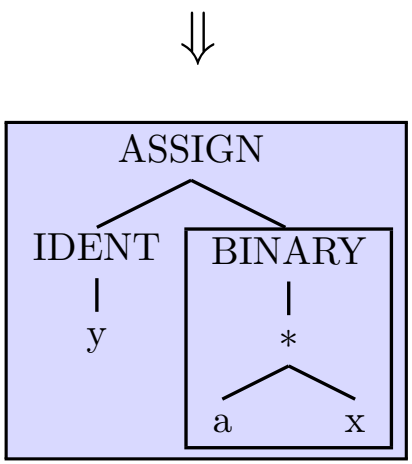

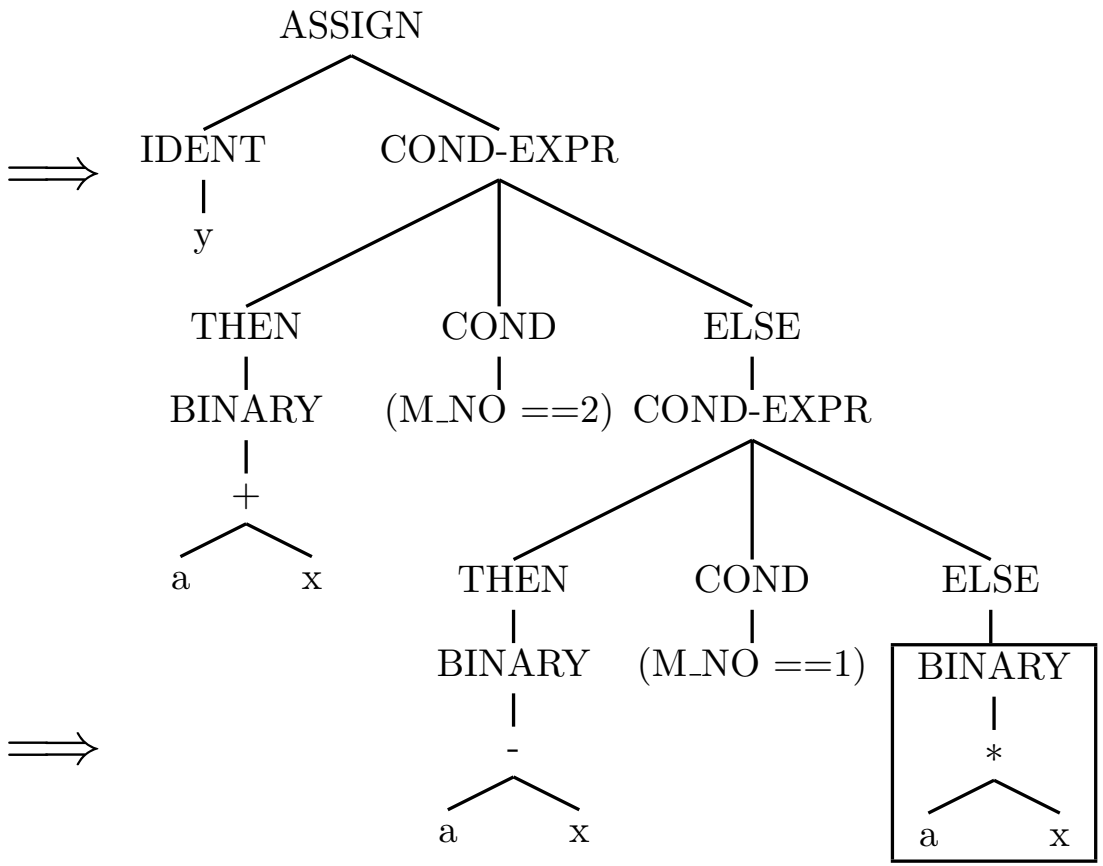

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1. Define mutation operators
   $MOP(x * y) = \{x - y, x + y, x/y\}$
2. Determine whether current expression or statement is affected by mutation
3. Apply mutation operators

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public int eval(int x){
    int a=3, b=1, y;

    y = (M_NO==1)? a - x :
                   a * x;

    y += b;
    return y;
}
```

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Conditional Mutation Algorithm

```
public int eval(int x){
    int a=3, b=1, y;

    y = (M_NO==2)? a + x :
        (M_NO==1)? a - x :
                   a * x;

    y += b;
    return y;
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- Versatile approach, can be combined with prior solutions
- Formal description and implementation details in the paper

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Mutation Coverage

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Mutants not executed cannot be killed

Mutation Coverage

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        (M_NO==0 &&
         COVERED(1,3))?
            a * x : a * x;

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```

Mutants not executed cannot be killed

Determine covered mutants with additional instrumentation

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            a * x : a * x;

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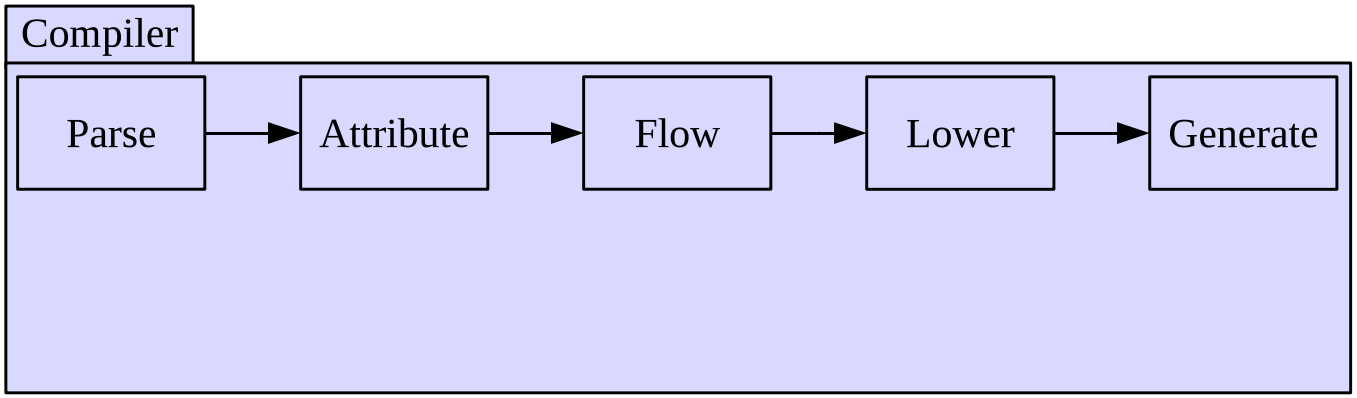
```

Mutants not executed cannot be killed

Determine covered mutants with additional instrumentation

Only execute and investigate the covered mutants

MAJOR: Mutation Analysis in a Java Compiler



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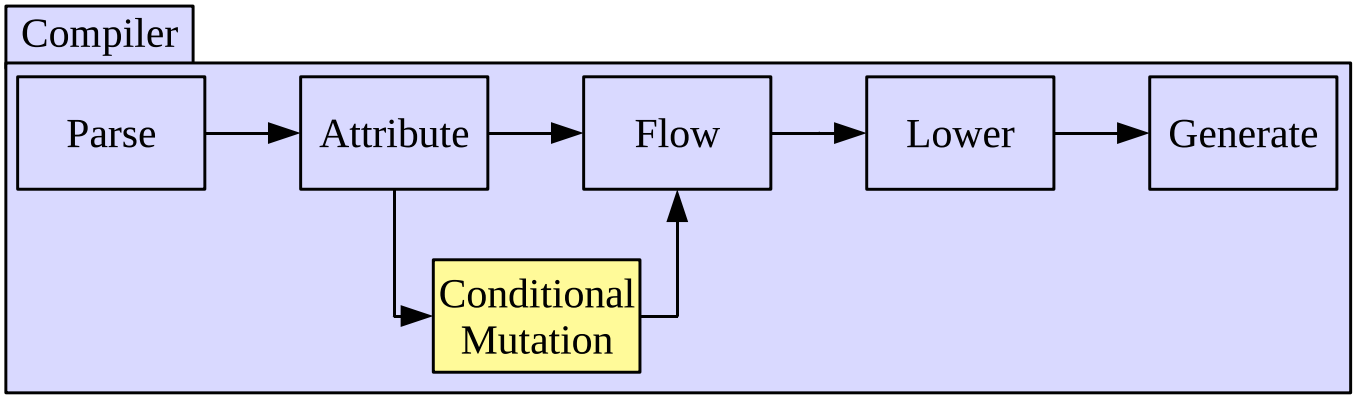

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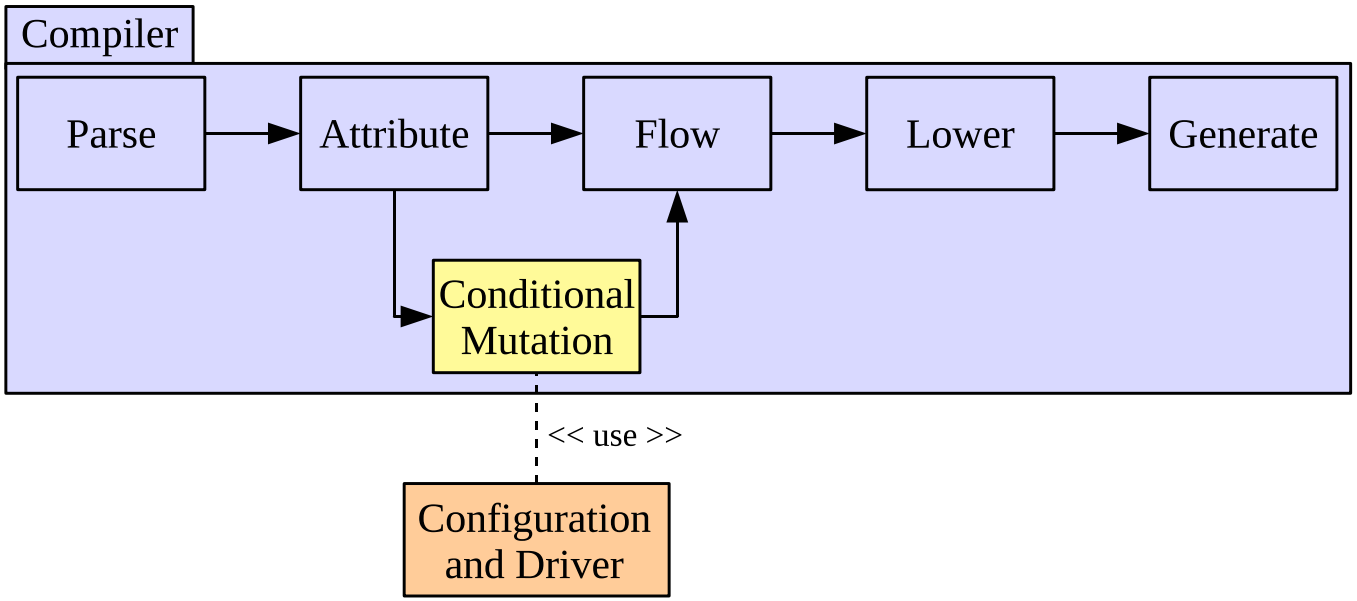

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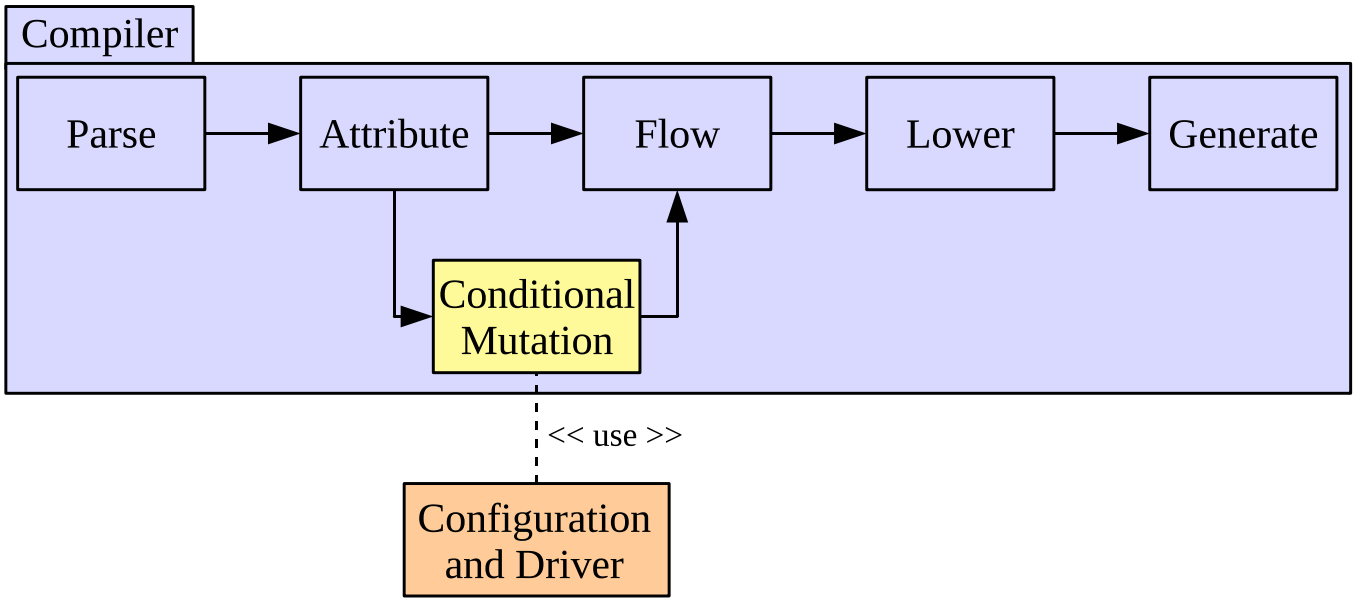
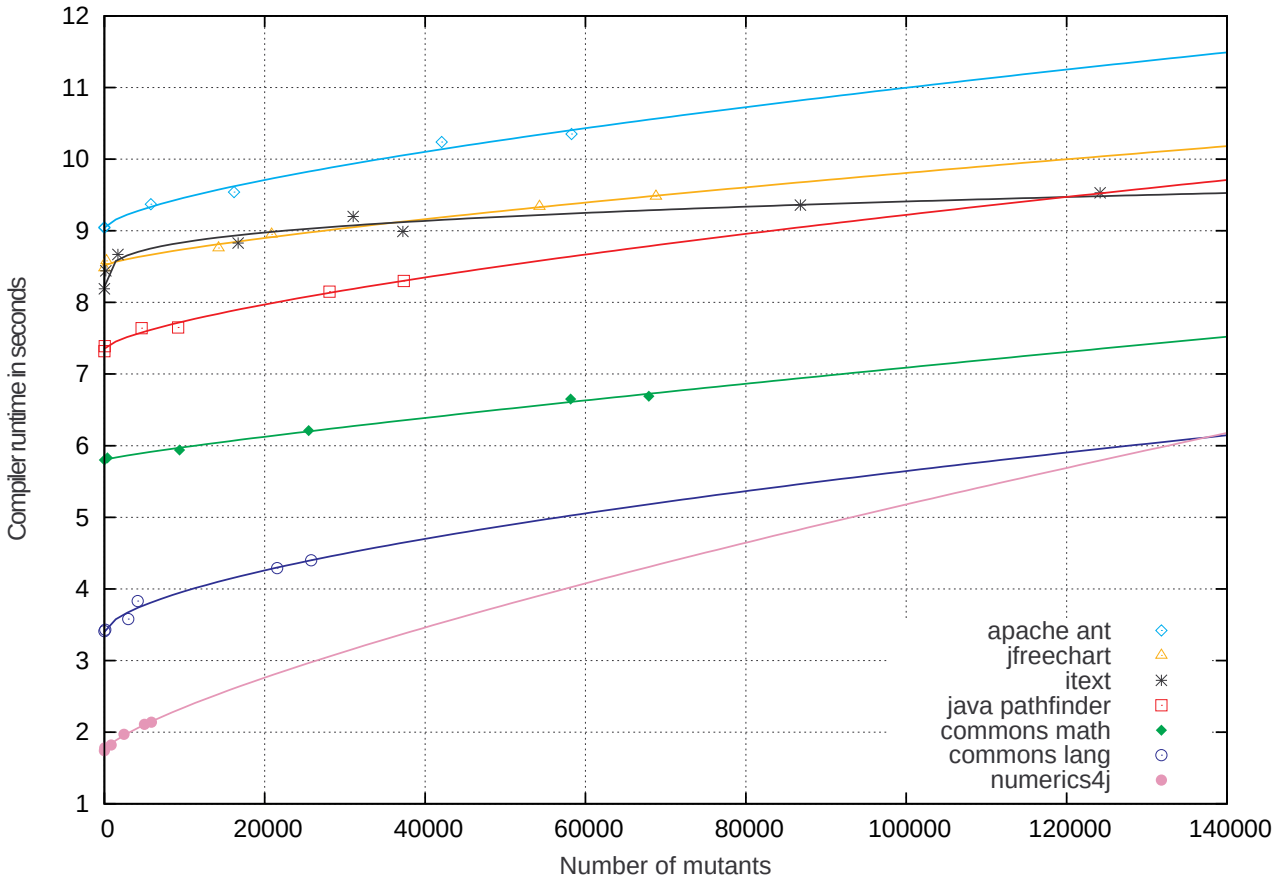


Configuration:

- Common compiler options
- Domain specific language (DSL)

http://www.mathematik.uni-ulm.de/sai/major

Performance Analysis



- Overhead for generating and compiling mutants is negligible

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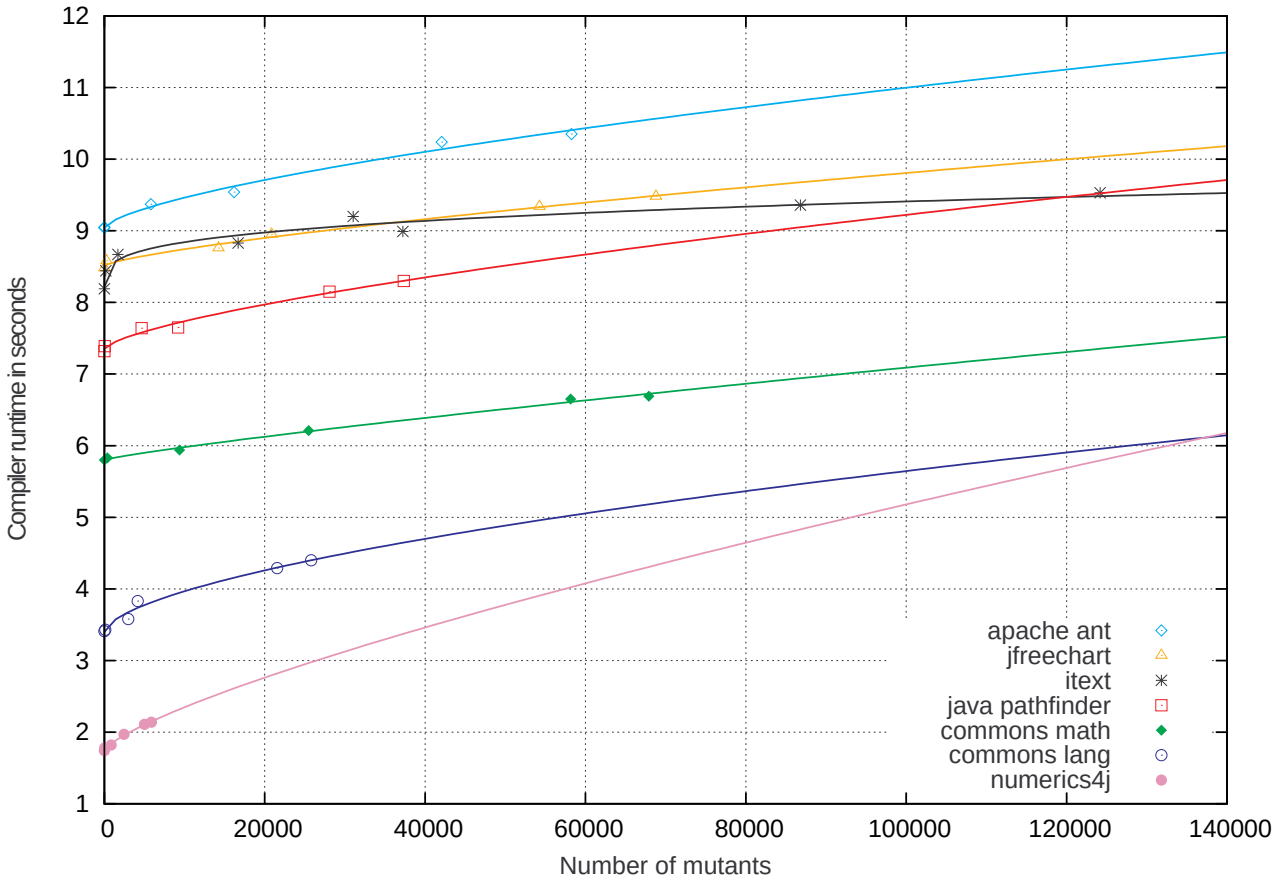

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Performance Analysis

Application	***Mutants***	***Runtime of test suite***			***Memory consumption***	
		original	*instrumented*		*original*	*instrumented*
			wcs	*wcs+cov*		
aspectj	406,382	4.3	4.8	5.0	559	813
apache ant	60,258	331.0	335.0	346.0	237	293
jfreechart	68,782	15.0	18.0	23.0	220	303
itext	124,184	5.1	5.6	6.3	217	325
java pathfinder	37,331	17.0	22.0	29.0	182	217
commons math	67,895	67.0	83.0	98.0	153	225
commons lang	25,783	10.3	11.8	14.8	104	149
numerics4j	5,869	1.2	1.3	1.6	73	90

- Runtime overhead is application dependent
  - Larger for CPU-bound applications
  - Small for I/O-bound applications
- Even for large projects, applicable on commodity workstations

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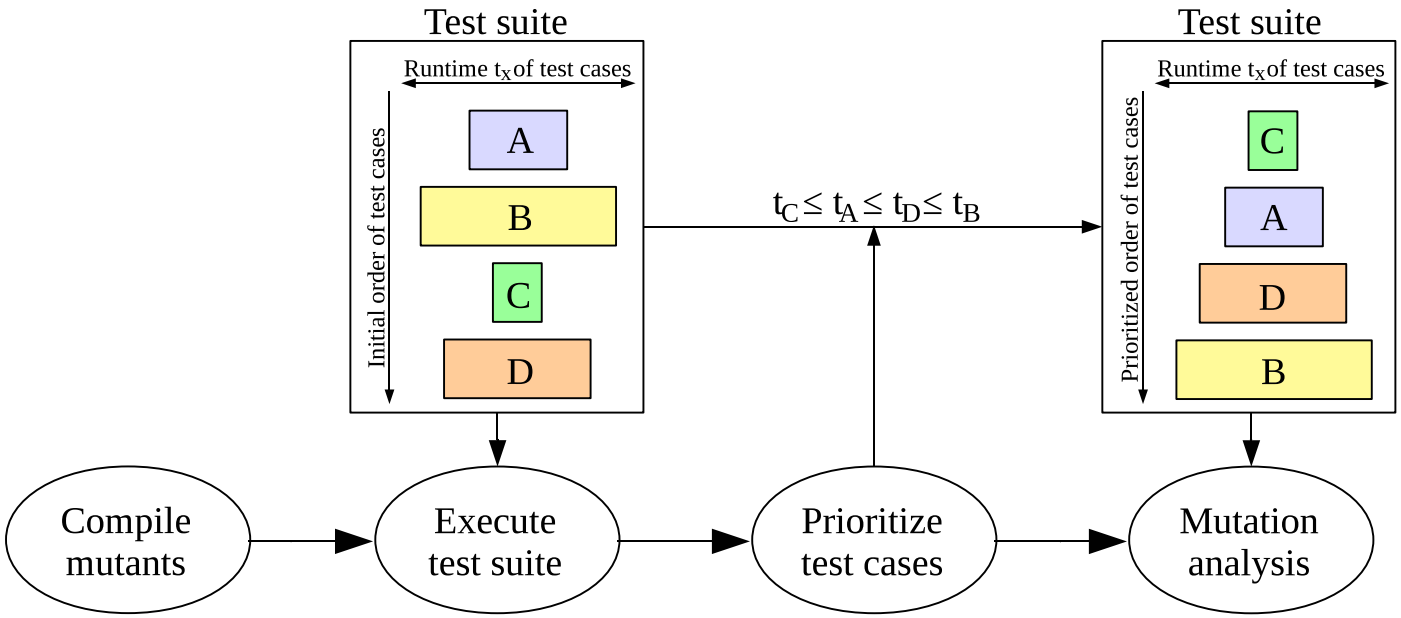
Enabling Efficient Mutation Analysis



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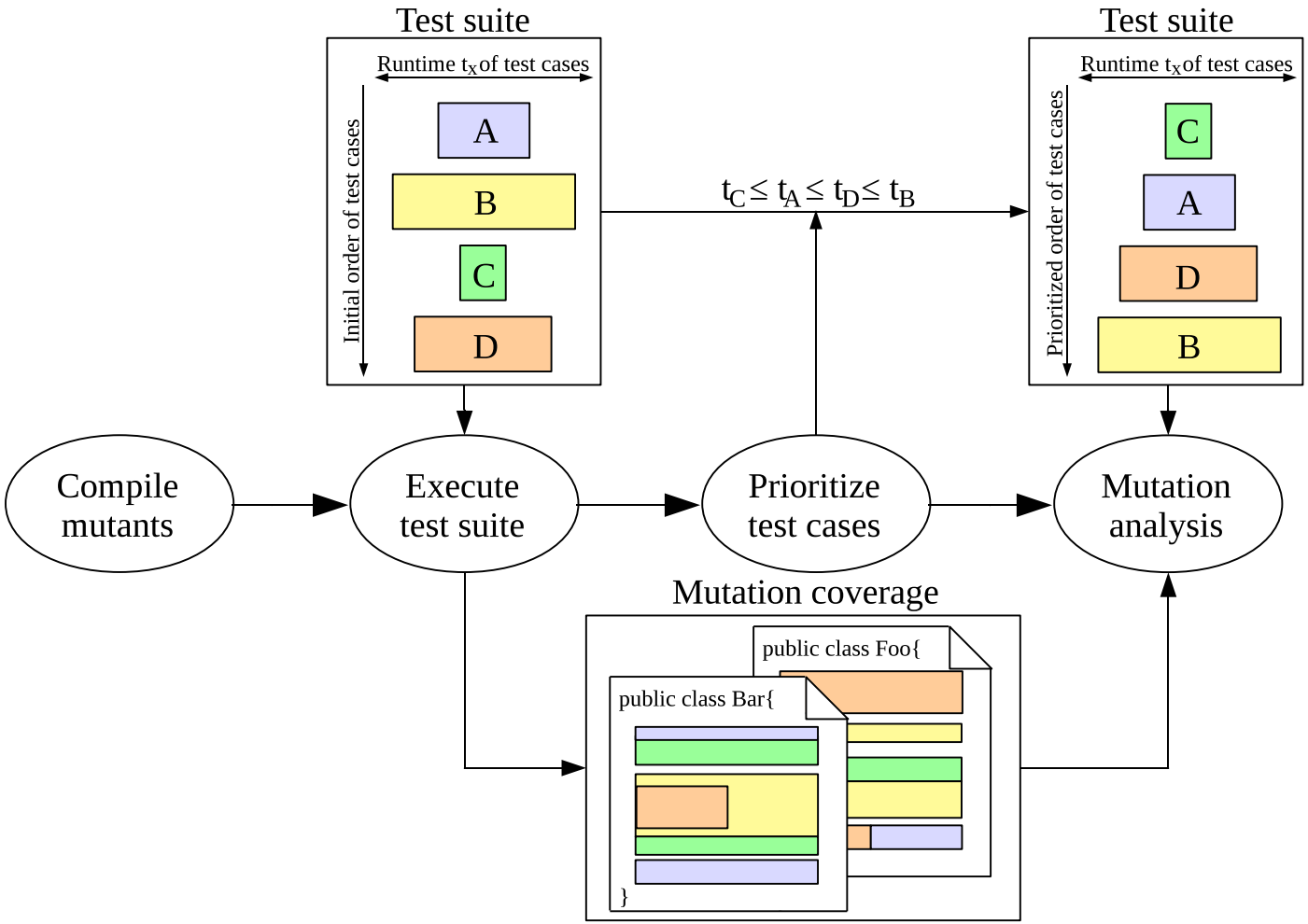

Conclusion

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- Largest empirical study of mutation analysis to date
- Mutant generation time reduced to a minimum
- Mutation coverage provides runtime optimization
- Versatilely applicable in every Java-based environment
- Arbitrary conditions enable support for higher order mutation

Future Work:

- Implement new mutation operators
- Enhance the domain specific language

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Using Conditional Mutation to Increase the Efficiency of Mutation Analysis

Thank you for your attention!

Questions?

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http://www.mathematik.uni-ulm.de/sai/major