Large Scale Generation of Complex and Faulty PHP Test Cases

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http://samate.nist.gov

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*"If **debugging** is the process of removing software bugs, then **programming** must be the process of putting them in"*

E. Dijkstra

NIST - SAMATE - SARD

- NIST - National Institute of Standards and Technology
  - Part of the US Department Of Commerce
  - Promote U.S. Innovation and Industrial Competitiveness

- SAMATE - Software Assurance Metrics And Tool Evaluation
  - Improve Software Assurance by:
    - developing materials, specifications, and methods
    - testing tools and techniques and measure their effectiveness

- SARD - Software Assurance Reference Dataset
  - Provide database of known security flaws
  - C/C++, JAVA, PHP, C#
  - 148,903 Test cases / 665,481 Files

Outline

1. Software Testing

Outline

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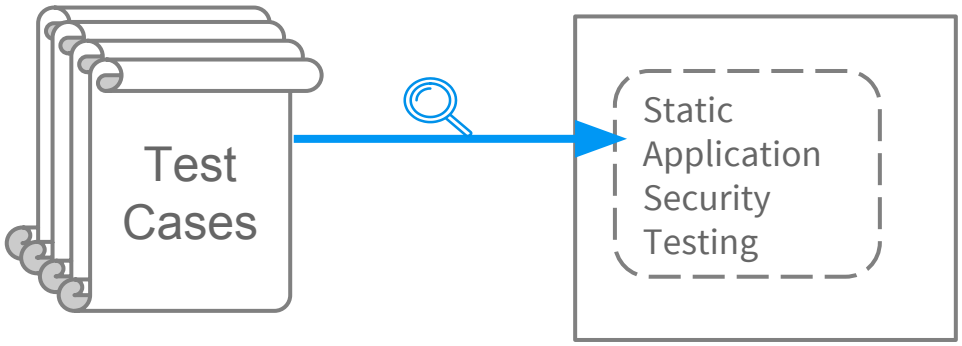
Outline

2. Design of Test Cases

1. Software Testing



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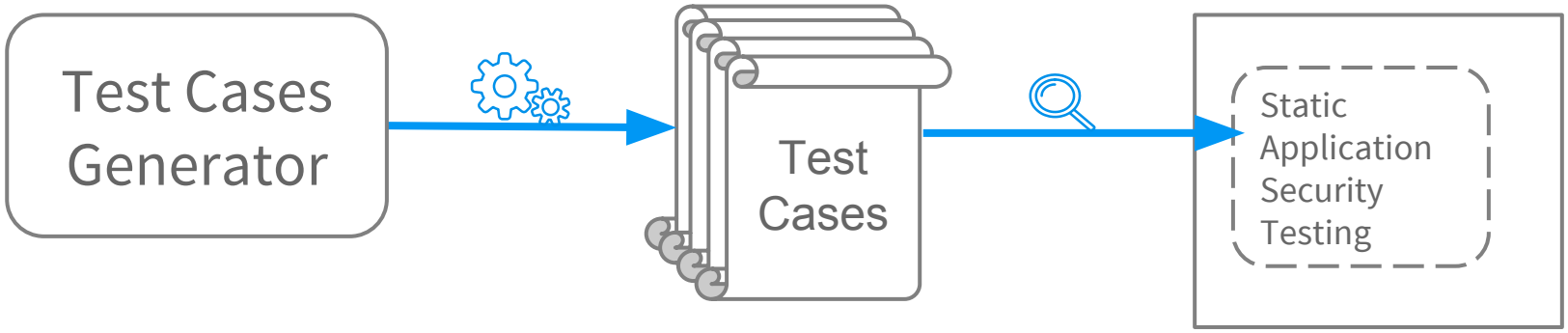
3. PHP Vulnerability Test Cases Generator

2. Design of Test Cases

1. Software Testing



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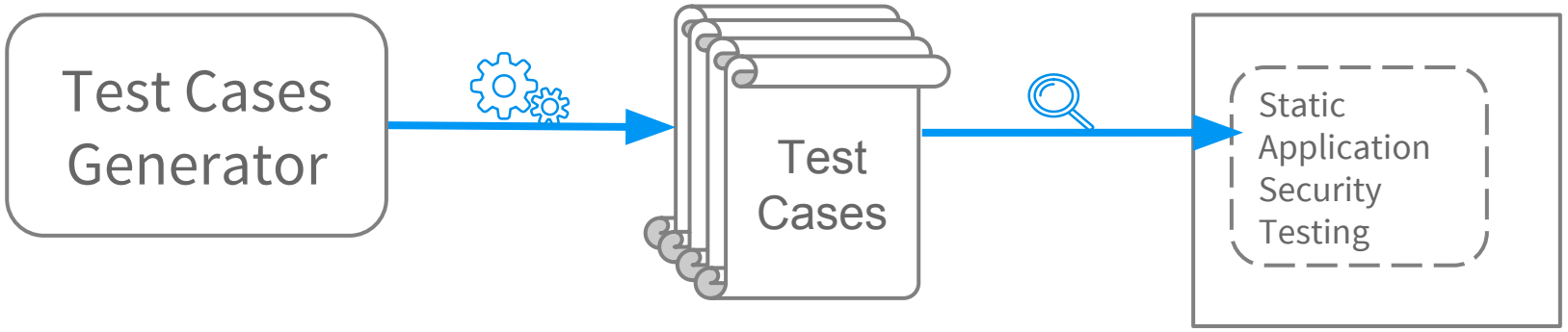


4. Live Demo

1.
Software Testing

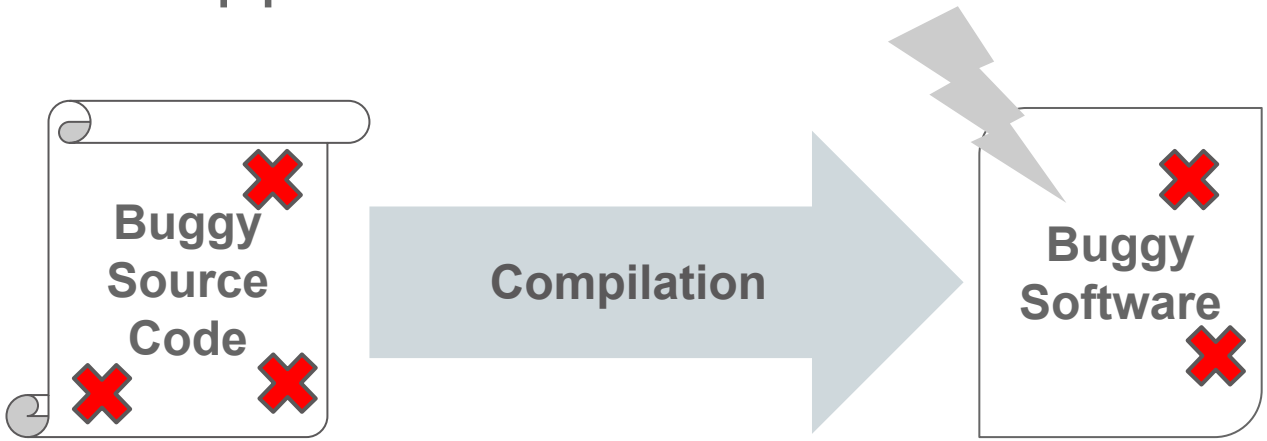
Introduction to Static Analysis

Static Analysis

- Automated analysis of large software
- Defect detection and remediation
- Use different approaches:
  - Syntax checking
  - Heuristics
  - Formal methods

Static Analysis

- Automated analysis of large software
- Defect detection and remediation
- Use different approaches



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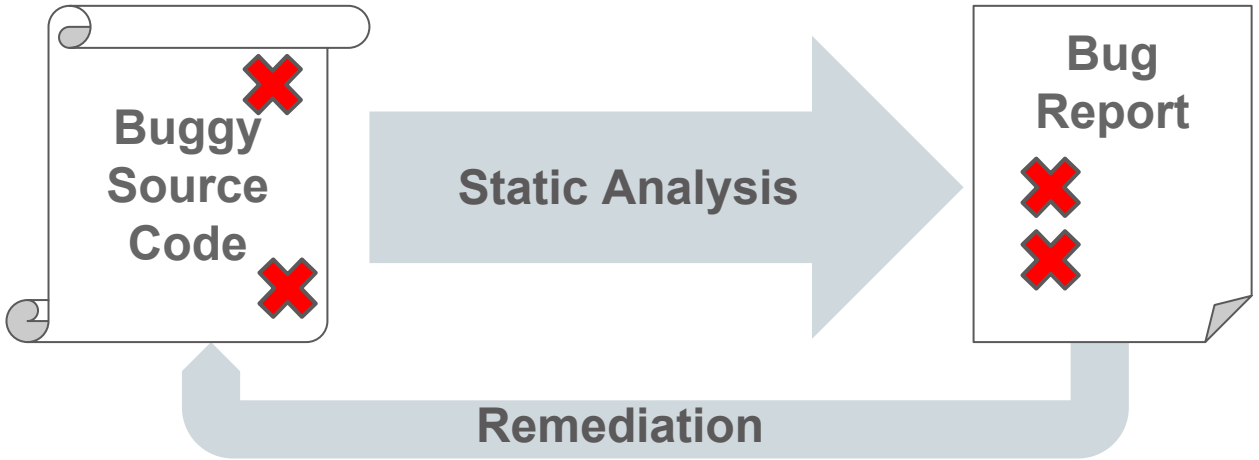
- Use different approaches



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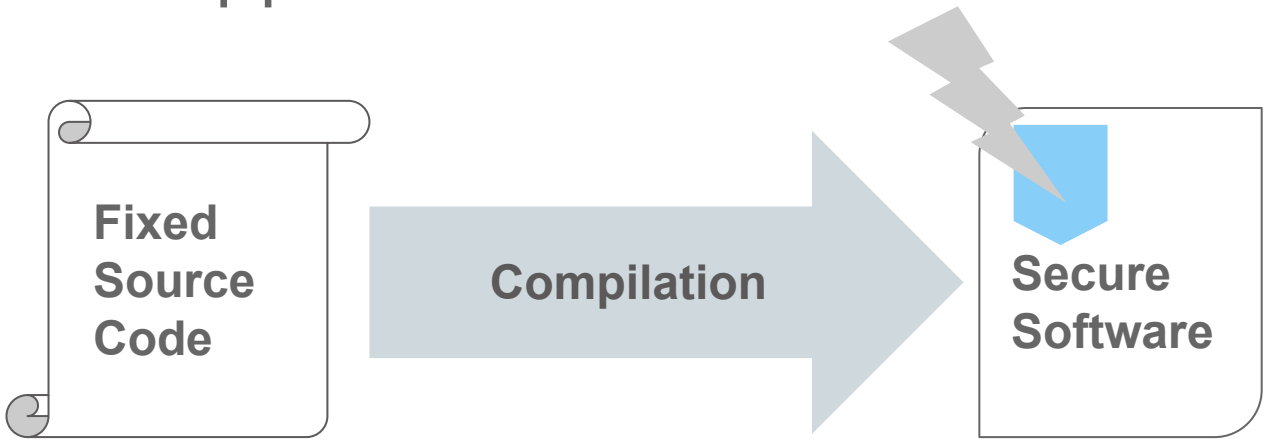

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Static Analysis Testing

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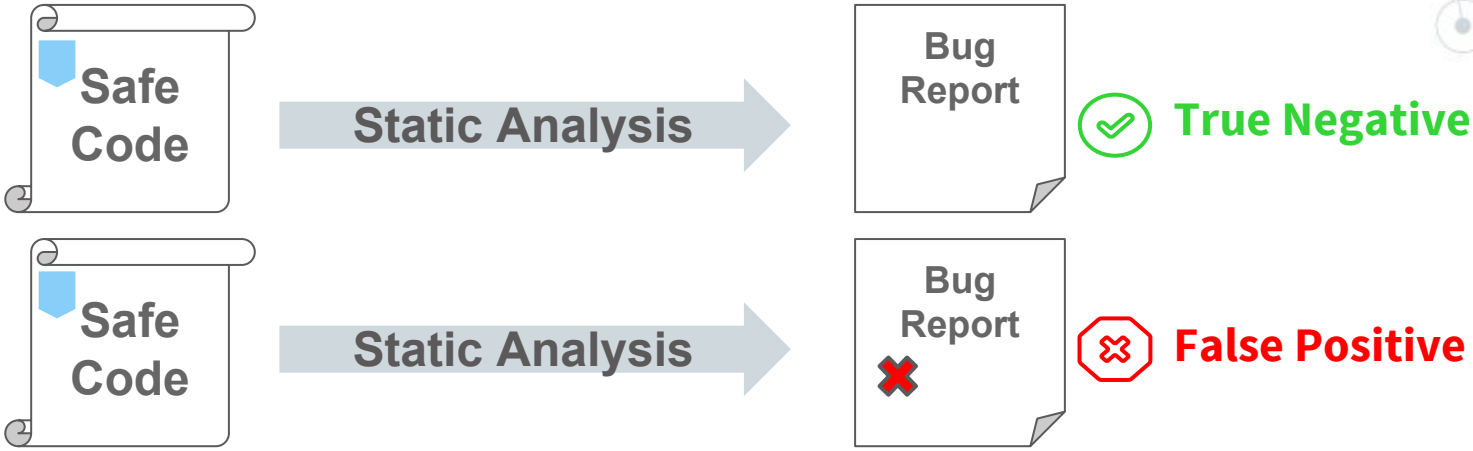
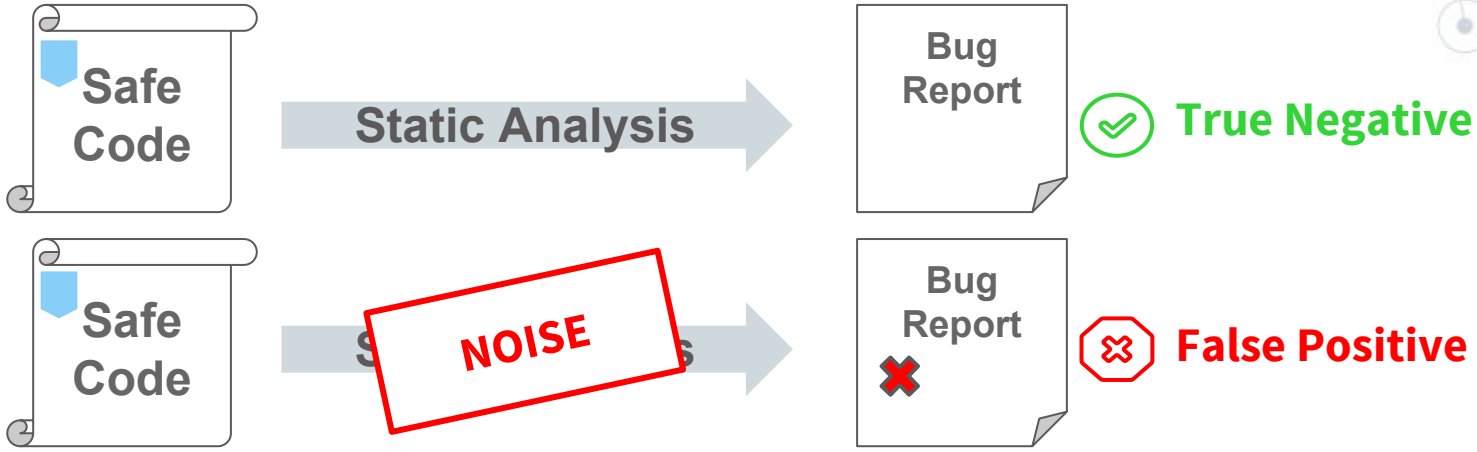


Static Analysis Testing



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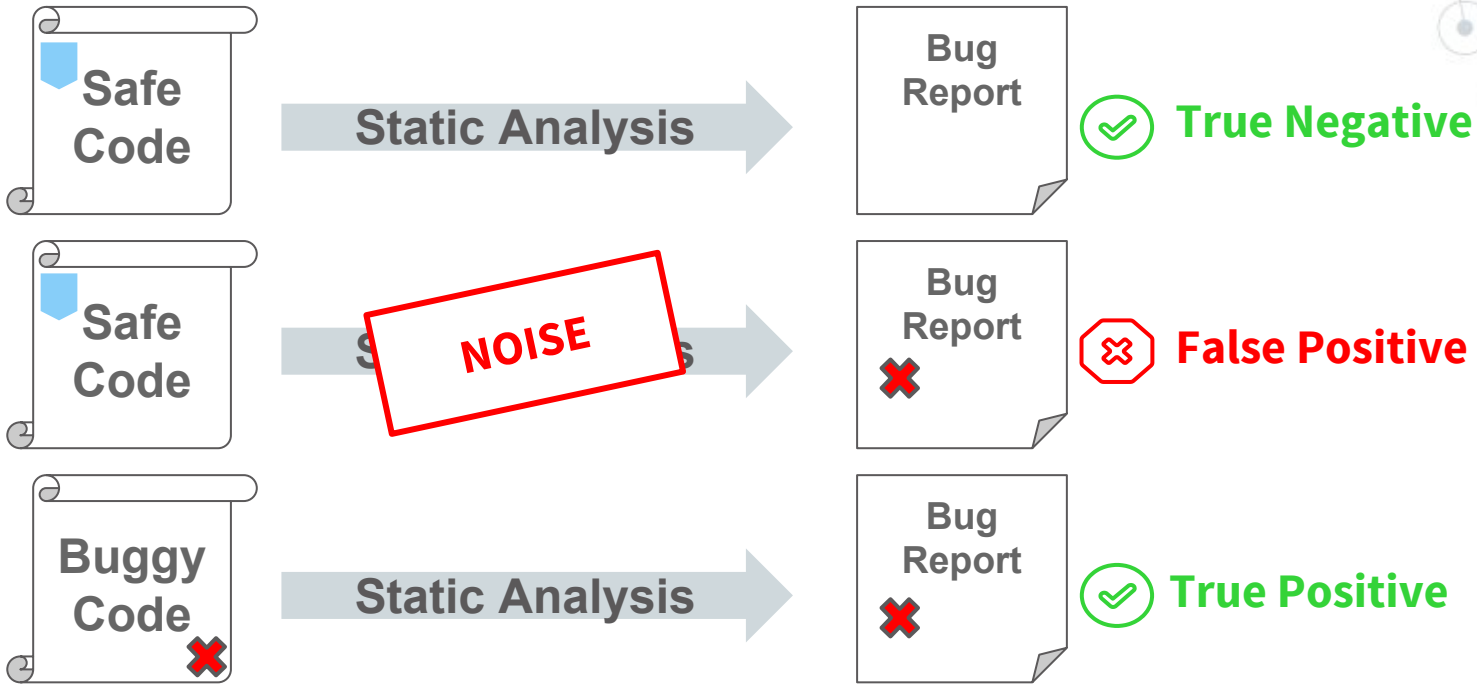
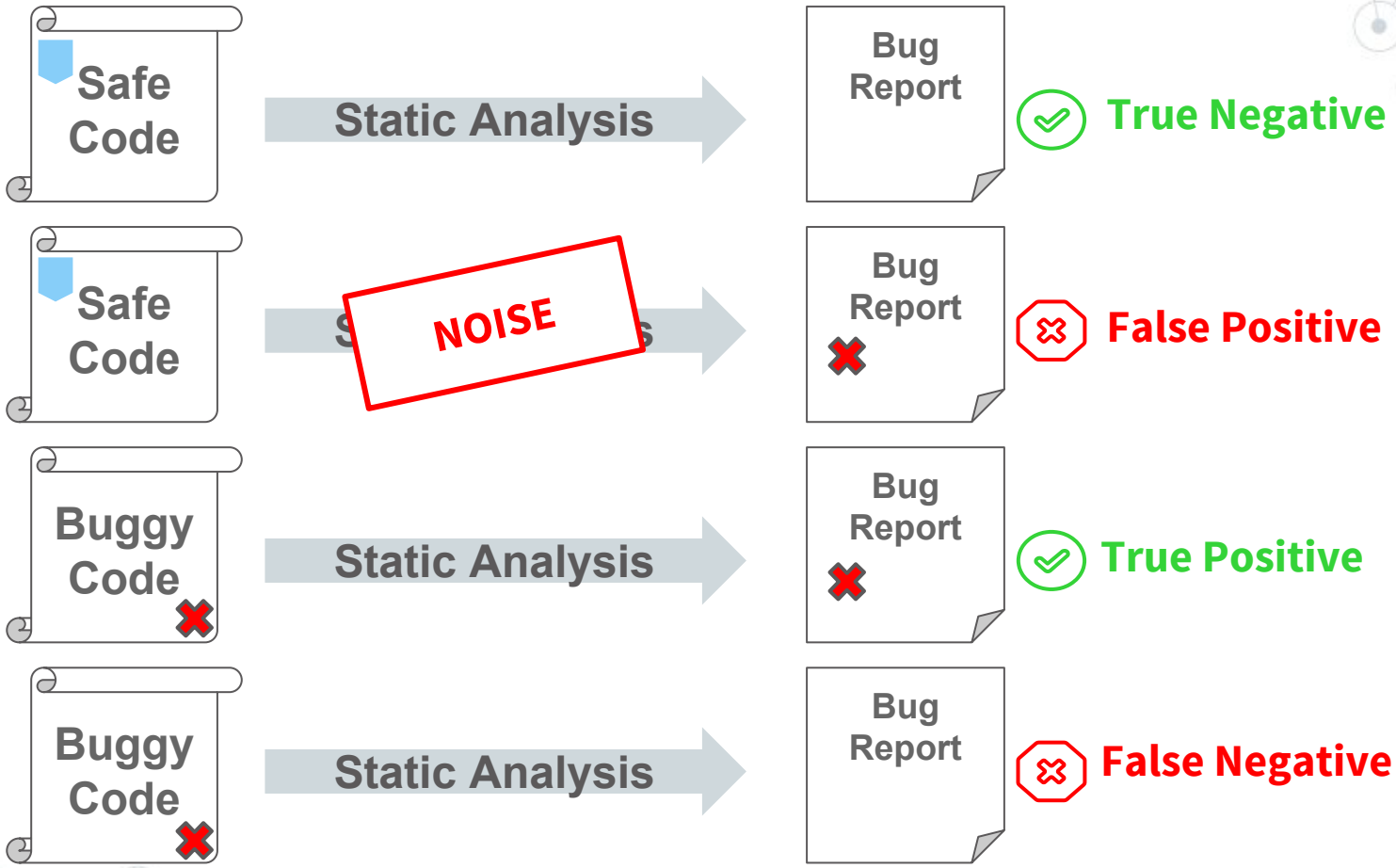


Static Analysis Testing



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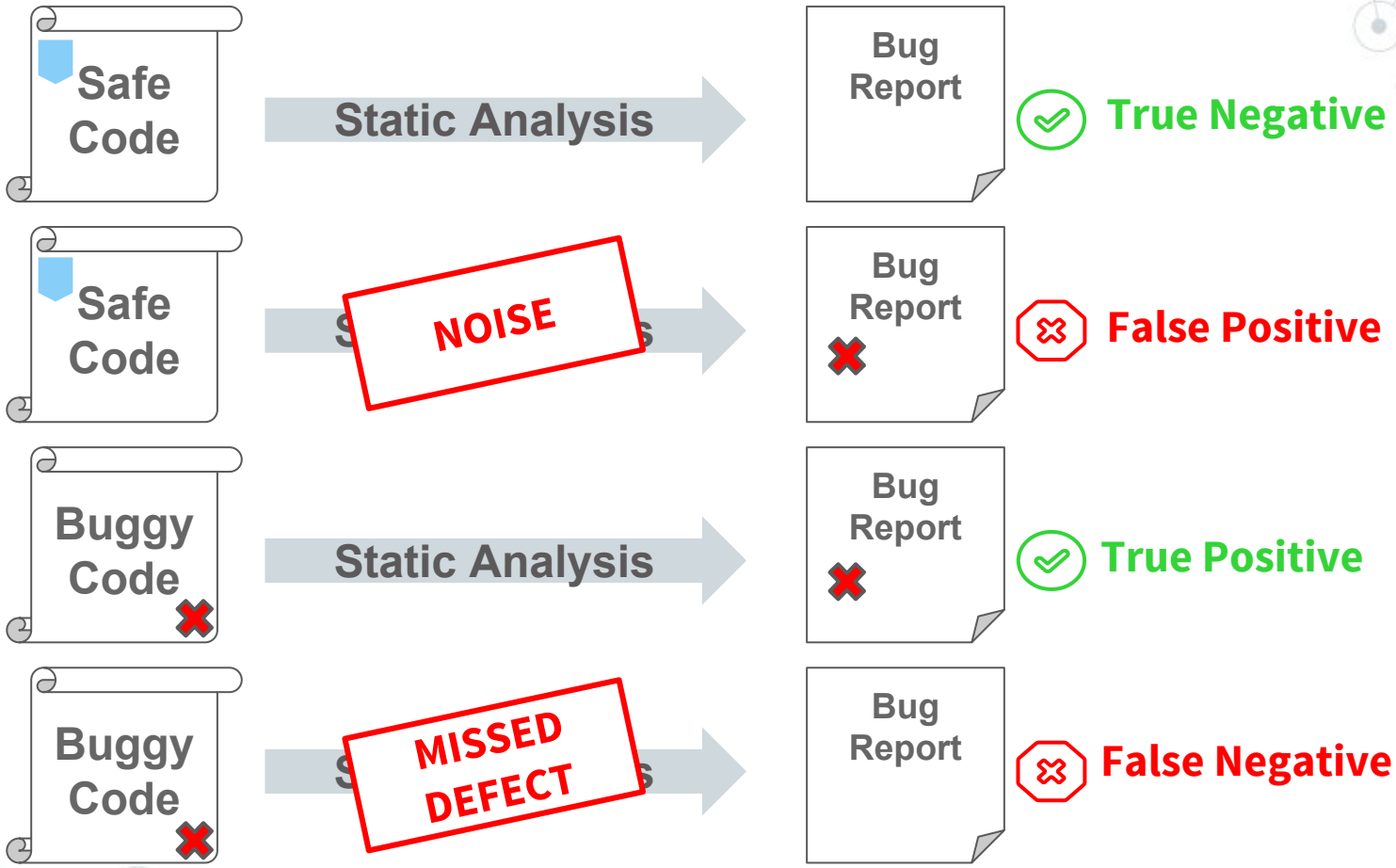


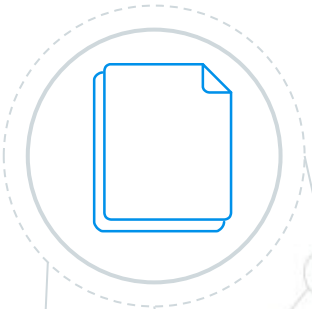
Pros and Cons

- Improves software assurance
- Saves time and money
- Takes customized rule sets

- False positive (noise)
- False negative (missed defects)
- Limited scope

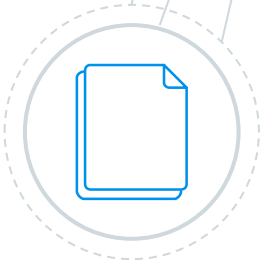
2.
Design of Test Cases

Test cases features



Test Cases Design

- Cover the most vulnerabilities possible
- Various complexities
- Statistically significant
- Ground truth
- Paired safe and flawed test cases
- Representative of production code



PHP Test Case Example

```php
<?php

    $input = $_POST['UserData'];


    $tainted = mysql_real_escape_string($input);


    $query = "SELECT * FROM student where id=". $tainted . "";

    $conn = mysql_connect('localhost', 'mysql_user', 'mysql_password');
    mysql_select_db('dbname') ;
    echo "query : ". $query ."<br /><br />" ;

    $res = mysql_query($query); //flaw

    while($data = mysql_fetch_array($res)){
        print_r($data) ;
        echo "<br />" ;
    }

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PHP Test Case Example

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PHP Test Case Example

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    $tainted = mysql_real_escape_string($input);    FILTERING

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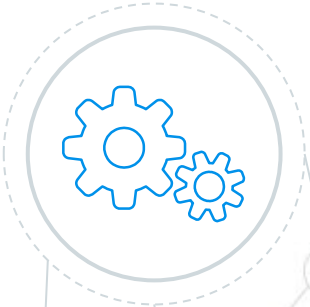
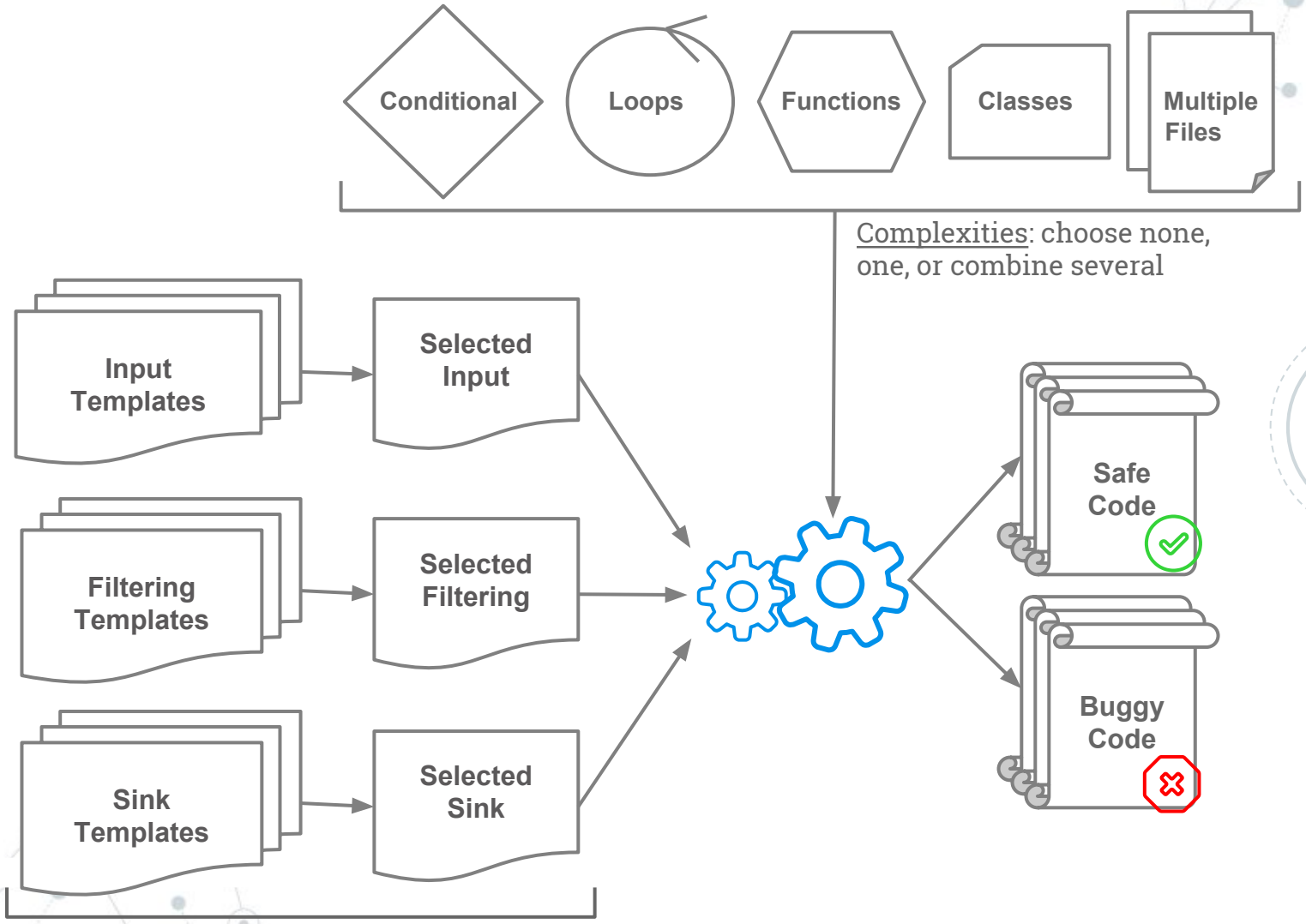
3.

PHP Vulnerability Test Cases Generator

Overview of the Test Cases generator



Test Cases Generator



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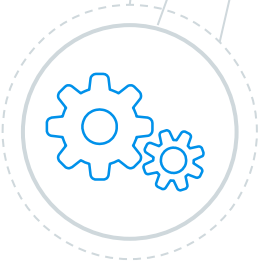
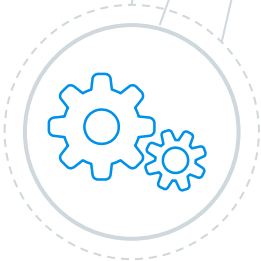


Vulnerabilities covered

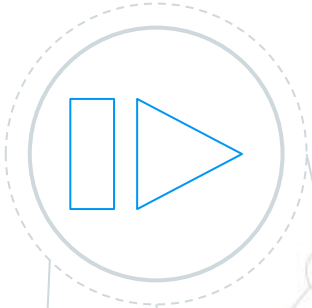
- Vulnerabilities based on OWASP Top 10 2013
  [#safe / #unsafe]
  - Injection [20912 / 5920]
  - Broken Authentication and Session Management
  - Cross Site Scripting (XSS) [5728 / 4352]
  - Insecure Direct Object References [400 / 80]
  - Security Misconfiguration [5 / 3]
  - Sensitive Data Exposure [5 / 7]
  - Missing Function Level Access Control
  - Cross-Site Request Forgery (CSRF)
  - Using Known Vulnerable Component
  - Unvalidated Redirects and Forwards [2208 / 2592]



4.

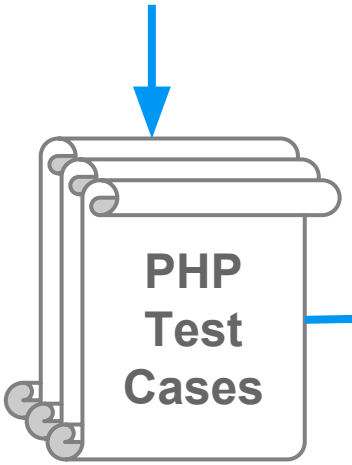
Live Demo

Generating Test Cases to Testing



Live Demo

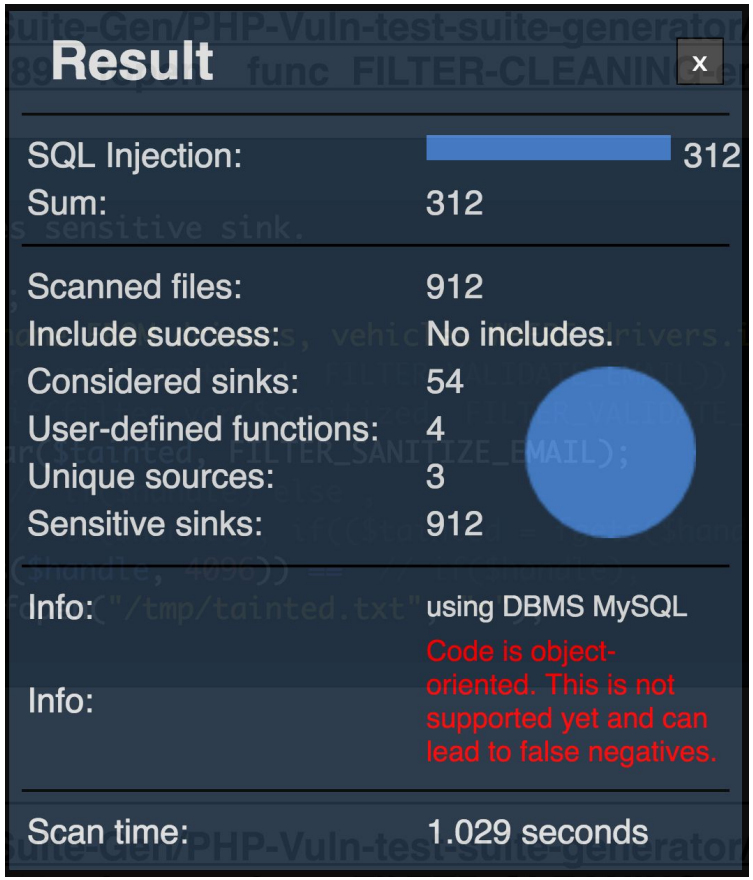
<?PHP Vulnerability Test Case Generator?>



RIPS - Metrics

Missed defects
- present : 912
- found : 312*

Recall = 312 / 912
= 34.2%



* considering all findings are True positives

RIPS - True Positive

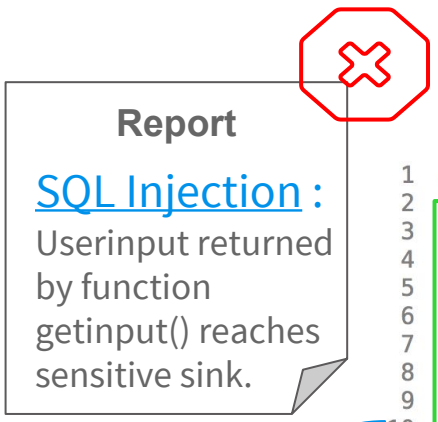
Report

SQL Injection :
Userinput reaches sensitive sink.

```
1  <?php
2
3  $tainted = $_GET['UserData'];                                    INPUT
4
5  //no_sanitizing                                                  FILTERING
6
7  $query = "SELECT * FROM COURSE c WHERE c.id IN (SELECT idcourse FROM
       REGISTRATION WHERE idstudent= $tainted )";
8
9  $conn = mysql_connect('localhost', 'mysql_user', 'mysql_password');
10 mysql_select_db('dbname') ;
11 echo "query : ". $query ."<br /><br />" ;
12
13 $res = mysql_query($query); //execution                           SINK
14
15 while($data =mysql_fetch_array($res)){
16 print_r($data) ;
17 echo "<br />" ;
18 }
19 mysql_close($conn);
20
21 ?>
```

CWE_89__GET__no_sanitizing__multiple_select-interpretation.php

RIPS - False Positive




```php
<?php

class Input{
  public function getInput(){
    return $_GET['UserData'] ;
  }
}

$temp = new Input();
$tainted =  $temp->getInput();

if(settype($tainted, "float"))
  $tainted = $tainted ;
else
  $tainted = 0.0 ;

$query = sprintf("SELECT Trim(a.FirstName) & ' ' & Trim(a.LastName) AS employee_name, a.city, a.
    street & (' ' +a.housenum) AS address FROM Employees AS a  WHERE a.supervisor=%u", $tainted);

$conn = mysql_connect('localhost', 'mysql_user', 'mysql_password');
mysql_select_db('dbname') ;
echo "query : ". $query ."<br /><br />" ;

$res = mysql_query($query); //execution

while($data =mysql_fetch_array($res)){
print_r($data) ;
echo "<br />" ;
}
mysql_close($conn);

?>
```

INPUT

FILTERING

SINK

CWE_89__object-directGet__CAST-func_settype_float__multiple_AS-sprintf_%u.php

Conclusion

- Tools need evaluation!
- Test cases need improvement
- PHP Vulnerability Test Suite Generator:
  - Automated generation
  - Modular and expandable
  - Customizable with options
  - 42 000 PHP test cases generated

Conclusion

- Tool is available on Github:

  https://github.com/stivalet/PHP-Vuln-test-suite-generator

- Test cases are hosted in the SARD:

  https://samate.nist.gov/SARD/view.php?tsID=103

- Project is already used by researchers:
  - M. K. Gupta, et al, “Security Vulnerabilities in Web Applications", JCSSE 2015
  - M. K. Gupta, et al, "XSSDM: Towards Detection and Mitigation of Cross-Site Scripting Vulnerabilities in Web Applications", ICACCI 2015
  - SATE VI - Static Analysis Tool Exposition, NIST 2016

Thanks!

Any questions?

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