72nd
IFIPWG 10.4
Meeting

Detection of Vulnerabilities broken by Circular Dependencies in Static Analysis

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The security of web applications continues to be a challenging problem

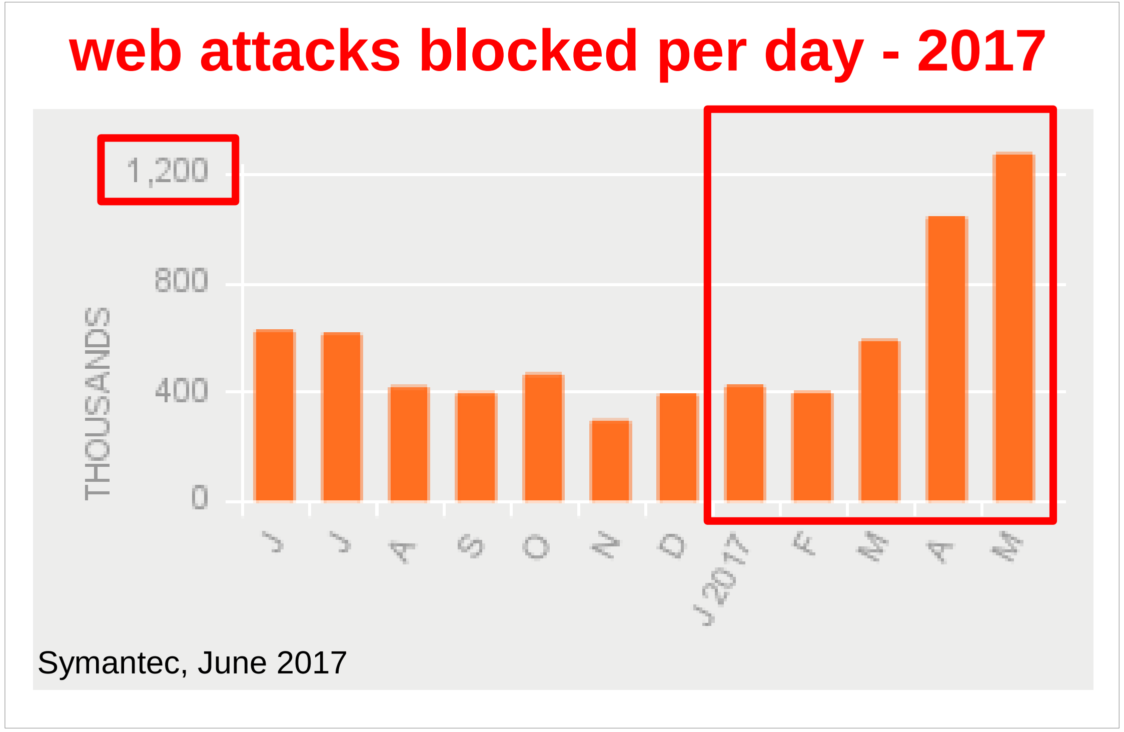
vulnerabilities

left in the source code by

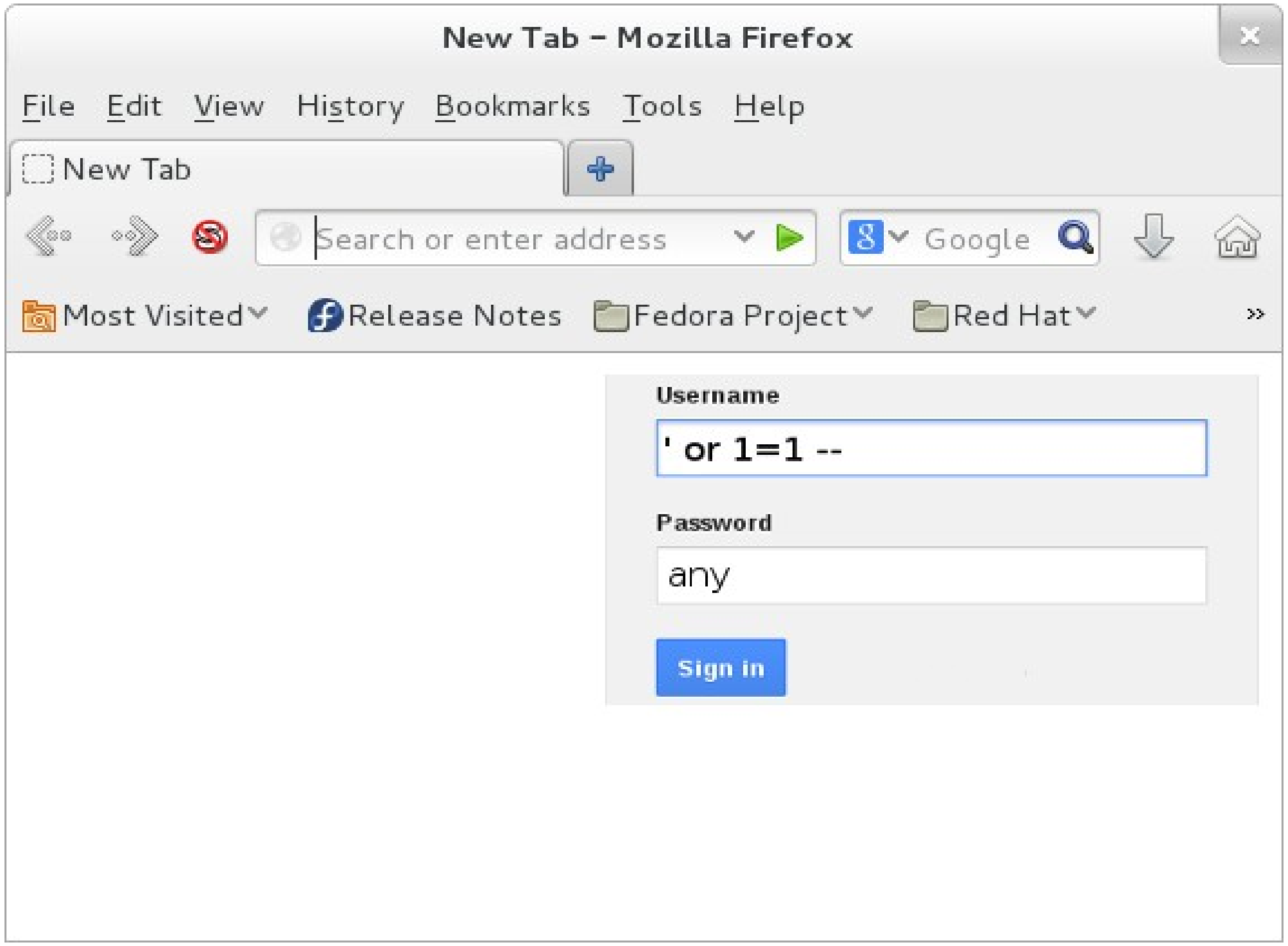
developers that make mistakes

attacks

SQL injection
XSS
RFI
...



Vulnerability SQL Injection example



Username

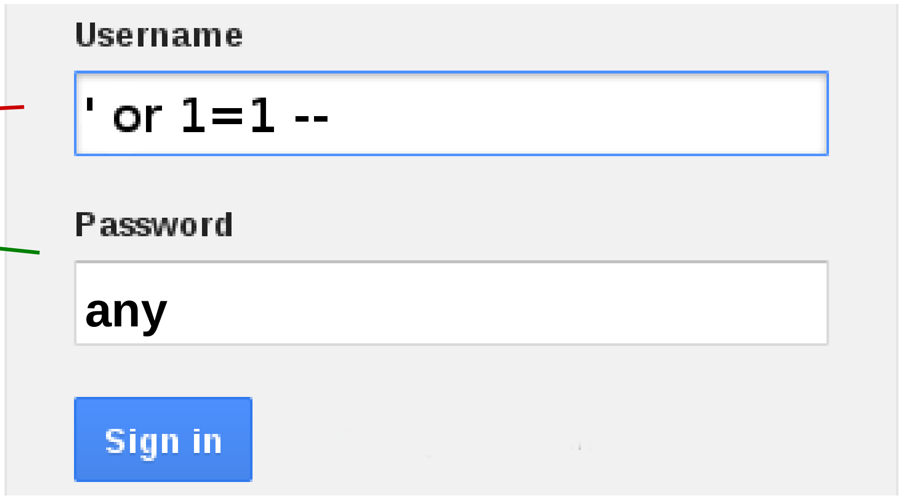
' or 1=1 --

Password

any

Motivation | Vulnerability SQL Injection example

```
$u = $_POST['user'];
$p = $_POST['password'];
$q = “SELECT * FROM users
        WHERE user='$u' AND pass='$p'”;
$r = mysql_query($q);
```



Username

' or 1=1 --

Password

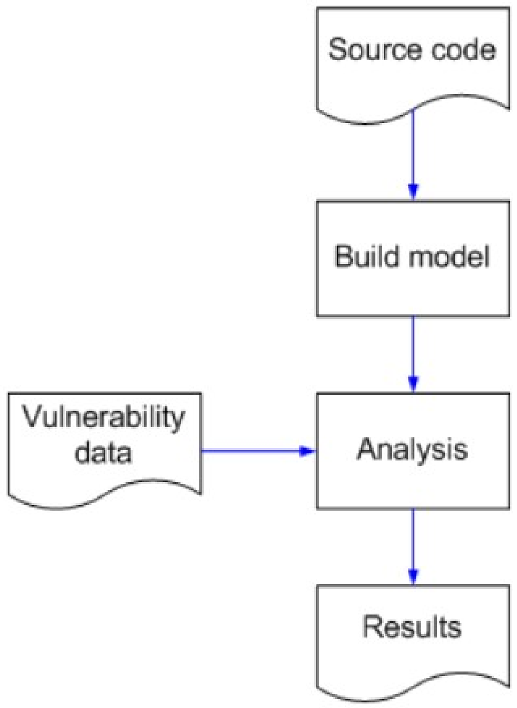
any

```
$u = ' or 1=1 -- ;
$p = any;
$q = “SELECT * FROM users WHERE user='' or 1=1;-- ' AND pass='any'”;
$r = mysql_query($q);
```

SQL injection vulnerability exploited !!

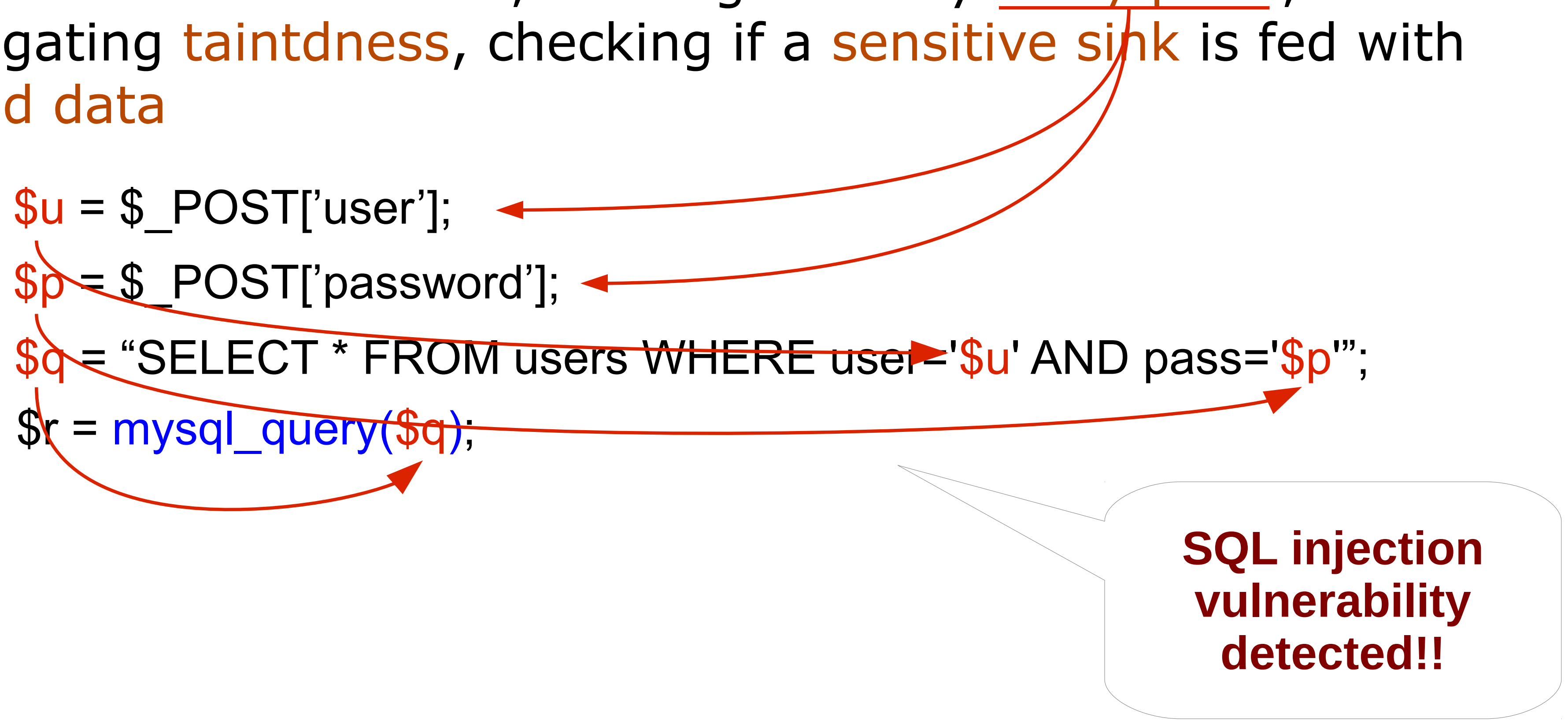
Source Code Static Analysis

- Objective: to find vulnerabilities in the applications' (source) code automatically
  - Similar to compiler's error checking but for vulnerabilities
  - Similar to manual code reviewing but automatically
- Static: because the code is not executed



Taint Analysis

Analyses the source code, starting at every entry point, propagating taintdness, checking if a sensitive sink is fed with tainted data



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$u = $_POST['user'];
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$q = "SELECT * FROM users WHERE user='$u' AND pass='$p'";
$r = mysql_query($q);
```

SQL injection vulnerability detected!!

Web Application Protection

Taint Analysis

Analyses the source code, starting at every entry point, propagating taintdness, checking if a sensitive sink is fed with tainted data

```
$u = $_POST['user'];
$p = $_POST['password'];
$q = "SELECT * FROM users WHERE user='$u' AN
$r = mysql_query($q);
```

SQL injection vulnerability detected!!

```
$u = $_POST['user'];
$p = $_POST['password'];
$uu = mysql_real_escape_string($u);
$pp = mysql_real_escape_string($p);
$q = "SELECT * FROM users WHERE user='$uu' AND pass='$pp'";
$r = mysql_query($q);
```

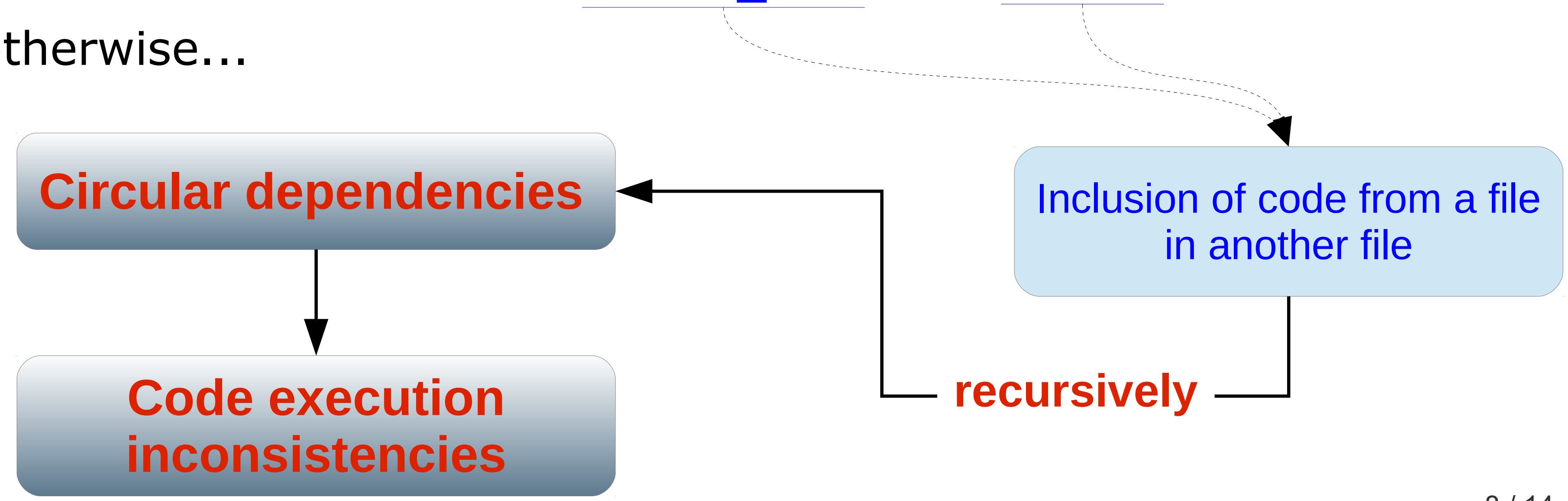
some functions sanitize, so "untaint", the data flow

SECURE APPLICATTIONS

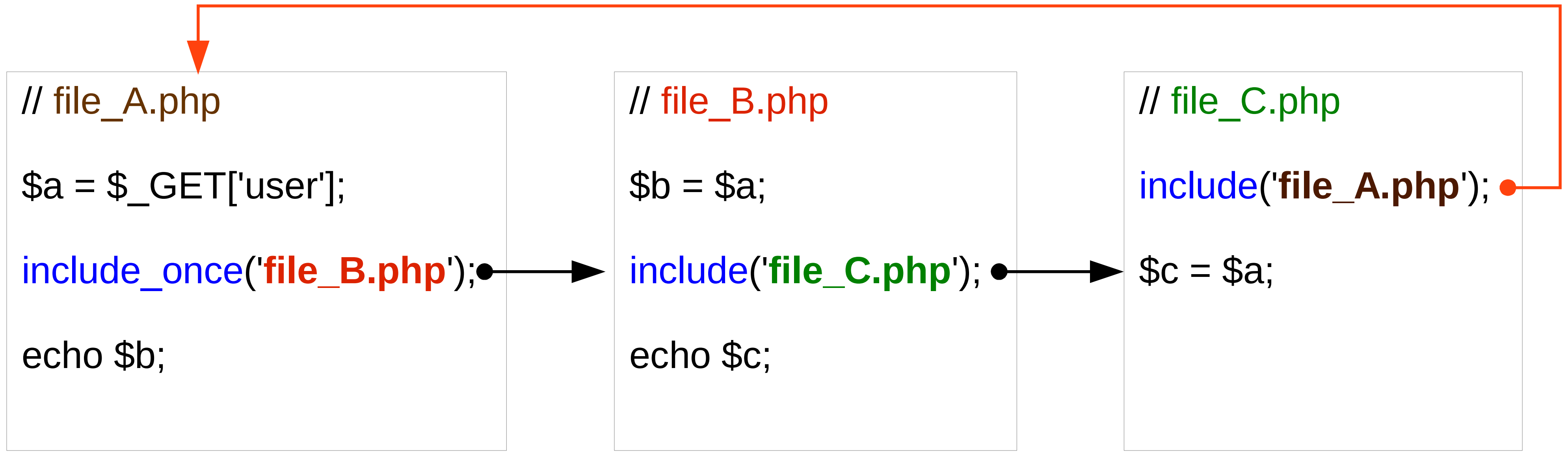
- Create secure applications is an important factor
- Knowledge about how to build secure code is required
  - sanitize and/or validate entry points
  - otherwise, vulnerabilities are left in the code

On-going work

Correct use of the functionalities of the programming language
  - differentiate when to use include_once and include functions
  - otherwise...


Circular dependencies
Code execution inconsistencies
Inclusion of code from a file in another file
recursively

Circular Dependencies



```
// file_A.php

$a = $_GET['user'];

include_once('file_B.php');

echo $b;
```

```
// file_B.php

$b = $a;

include('file_C.php');

echo $c;
```

```
// file_C.php

include('file_A.php');

$c = $a;
```

CIRCULAR DEPENDENCIES IN STATIC ANALYSIS

- Static analysis analyzes the code of include files for each time a include or include_once instruction appears
- If there are circular dependencies in the source code then they will be notice in static analysis
- Circular dependencies break static analysis process

- **A infinite loop is created**
- **Code execution inconsistency is generated**

Vulnerability detection is broken

Resolving Circular Dependencies using Static Analysis

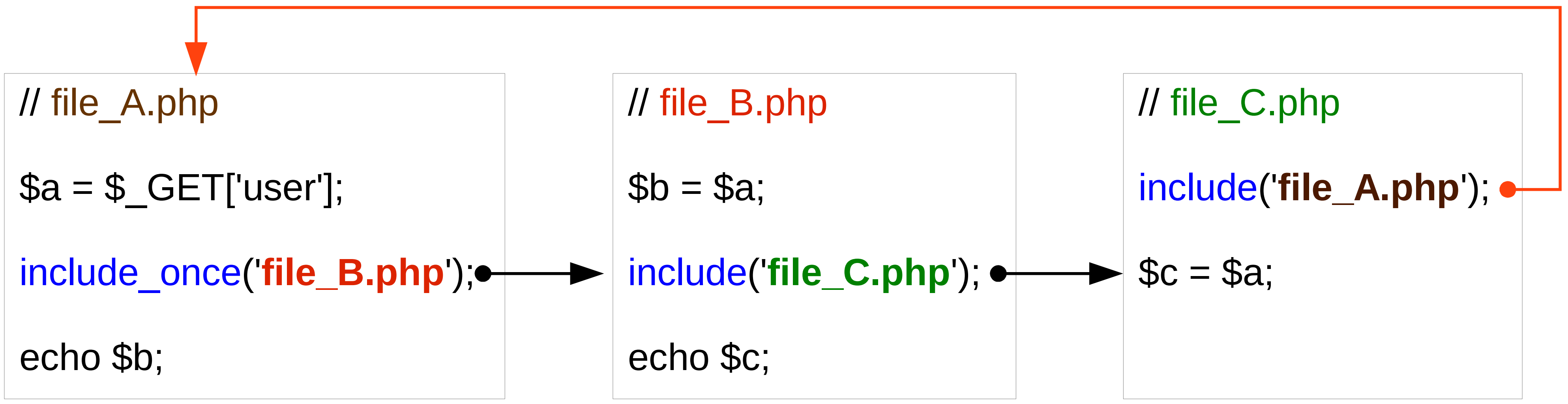
Build execution file paths

- Get for each file its include files
- Create trees to represent the execution file paths, identifying the parents and children for each tree node
- Identify the circular dependency points using the parents and children information

Realize taint analysis

- Perform taint analysis in each execution file path
- For circular dependencies points
  - include_once, the analysis stops there
  - include, the remaining code is analyzed

Execution File Path



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// file_A.php

$a = $_GET['user'];

include_once('file_B.php');

echo $b;
```
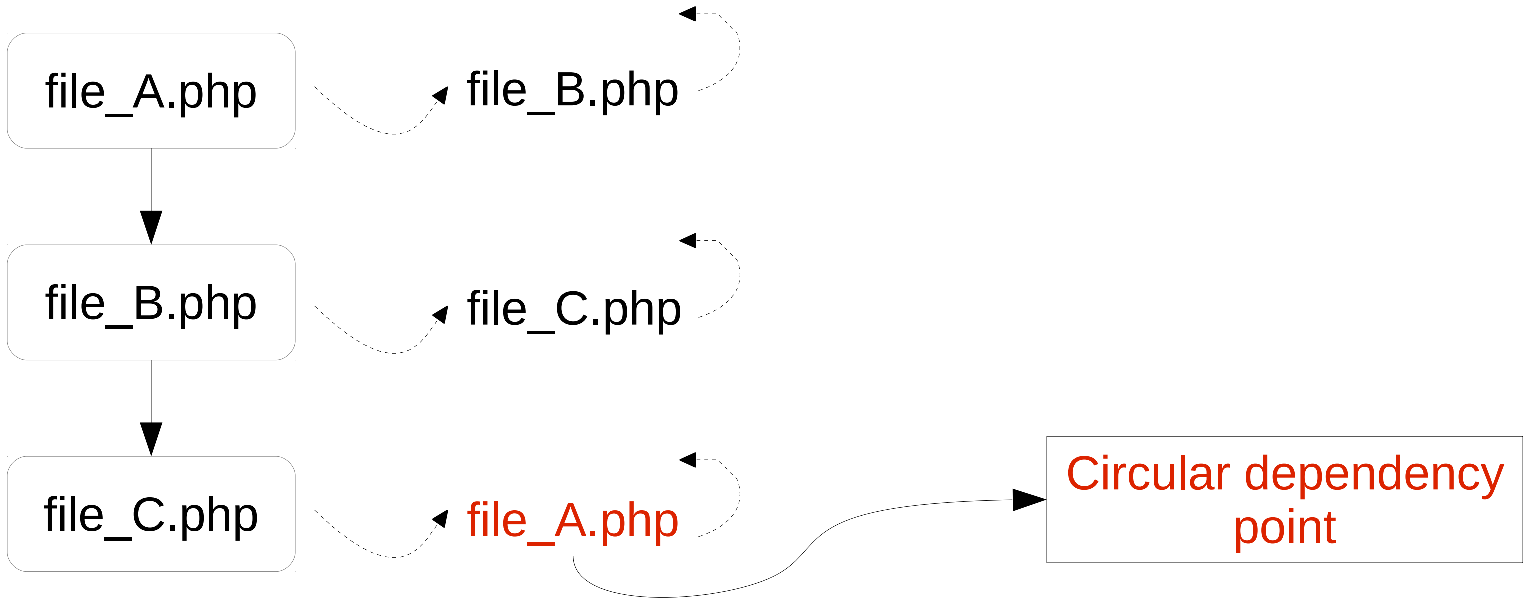

```
// file_B.php

$b = $a;

include('file_C.php');

echo $c;
```

```
// file_C.php

include('file_A.php');

$c = $a;
```



Some Results

- We evaluate 4 static analysis tools with...
  - include and include_once instructions
  - include files with code and user functions

Results with circular dependencies points

- Some tools stop analysis for include_once
- Some tools stop analysis for include, resulting false negatives
- Some tools crash with include

Circular dependencies is an effective problem in static analysis tools

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Thank you!