An Approach for the Automated Detection of XSS Vulnerabilities in Web Templates

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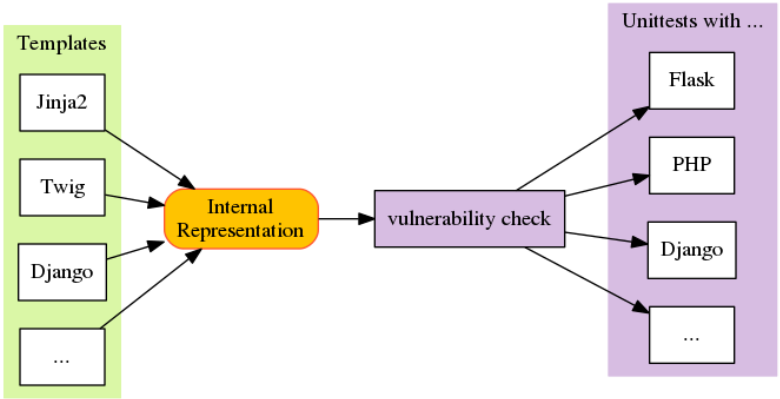
Motivation

- Web Frameworks are often predefined by the customer or already existing projects
- Templates from different Web Template Engines (WTE) look similar but don't behave completely equally
- Due to this facts, valid and secure code fragments from one WTE can lead to security risks in another WTE

Methodology

Architecture of our Approach

- Inspired by the LLVM Compiler



Source: own graphic

- Very easy to add a new Template Engine and unittest

Considered Web Template Engines

A WTE must comply with the following constraints for our approach

1. There is a restricted set of control structures (loop, condition, filter, setting and printing of variables)
2. There may be mechanisms to include other templates (inheritance, macros)
3. There is no way to write arbitrary code in the language of the backend within the template

Example of a Template

index.html

```
<!DOCTYPE html>
<html>
    <body>
        <h1>Hello world</h1>
      {% for name in usernames %}
        <p>Hello {{ name }}</p>
      {% endfor %}
    </body>
</html>
```

The Internal Representation (IR)

- The IR is represented by a two-staged intertwined abstract syntax tree (AST)
- The first stage AST is constructed by parsing the pure HTML part of the template and by marking the places where template tags are with special tokens
- The second stage AST is built by walking the first stage AST in depth-first-order and parsing the entries of the special tokens from above
- While constructing the second stage AST we collect the free variables and the output variables in a list and build a data flow graph between all used variables

First stage AST of the Example

First stage AST of `index.html`

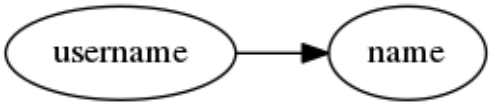
```
Declaration(raw="<!DOCTYPE html>")
StartTag(tag="html", attributes=[])
  StartTag(tag="body", attributes=[])
    StartTag(tag="h1", attributes=[])
      Data(raw="Hello world")
    EndTag(tag="h1")
    TemplateStatement(entry="for name in usernames")
    StartTag(tag="p", attributes=[])
      Data(raw="Hello ")
      TemplateExpression(entry="name")
    EndTag(tag="p")
    TemplateStatement(entry="endfor")
  EndTag(tag="body")
EndTag(tag="html")
```

Second stage AST of the Example

Second stage AST of `index.html`

```
1 Foreach(item=Variable(name="name", ref=None),
2         collection=Variable(name="usernames", ref=None),
3         ref=7)
4   Variable(name="name", ref=10)
5 EndForeach(ref=12)
```

Data flow graph of the Example



Source: own graphic

Finding vulnerabilities in templates

- Candidates are variables that reside in an expression template tag (the output variables)
- Using the data flow graph, we check if the value of this variable comes from a free variable
- Use 2nd stage AST to find all special tokens in 1st stage AST which influences the output variable
- Use the reference in 2nd stage AST to find the encapsulating html tag of the output variable in the 1st stage AST

Template for the unittest

- Generate from these nodes in the ASTs the template code and replace line 9 with it

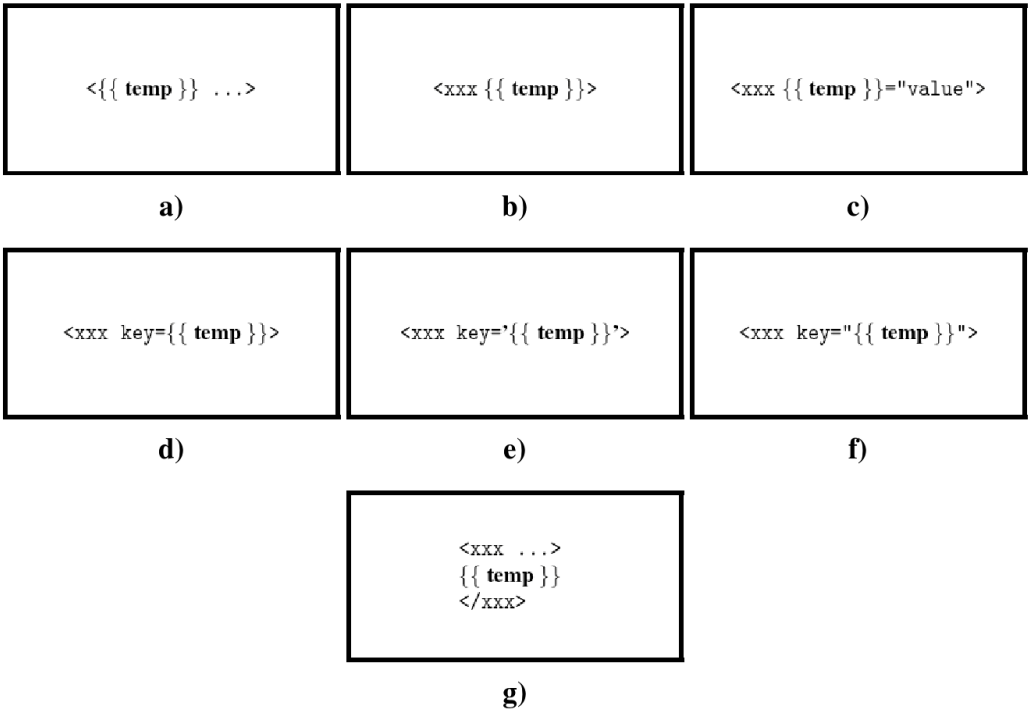
Skeleton for the template

```
1  <!DOCTYPE html>
2  <html>
3      <head>
4          <title>Unittest</title>
5          <script type="text/javascript">
6              function attack() { document.title="ATTACK"; };
7          </script>
8      <body>
9          <!-- <a onclick='attack()'>Attack</a> -->
10     </body>
11 </html>
```

- Use selenium webdriver to run the backend with this template and inject values for the free variables

Findings

Places for template tags in HTML



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Attack on case e)

```
<xxx key='{{ temp }}'>
```

There are three cases for the value of `temp`:

`xxx` is clickable and `key` is **onclick**

```
attack();
```

`xxx` is clickable and `key` is not **onclick**

```
' onclick='attack();
```

`xxx` is not clickable

```
'><a onclick="attack();">click</a><xxx key='
```

Thank you for your attention!

This was

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Questions?

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