xJS

Practical XSS Prevention for Web Application Development

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This talk is about

xJS

A practical framework for defending against Cross-Site Scripting attacks

Yet Another anti-XSS framework?

xJS Design Choices

- Web developer friendly
- Low computational overhead
- Backward compatibility in deployment
- DOM indepedend
- Cope with most of XSS
- Return-to-JavaScript attacks

Contributions

- Return-to JavaScript attacks
- xJS

Return-to JavaScript attacks

JavaScript Whitelisting

- Identify all JavaScript generated by the web application
- Mark all JavaScript as trusted (whitelist)
- Communicate the whitelist to the web browser
- The web browser executes only whitelisted scripts

BEEP

- For every trusted script keep a cryptographic hash (SHA1) in the whitelist
- The web browser executes only scripts, which their hash is found in the whitelist

Whitelisting is vulnerable to return-to-JavaScript attacks

Return Oriented Programming

Return-to Libc	Return-to JavaScript
Code injection does not contain code	Code injection does not contain foreign code
Code injection transfers execution to another place in the program's code	Code injection is based on whitelisted code from the web application
Usually execution is transferred to `libc`	Code injection alters the web application logic

Example 1

```
<html>
<head> <title> Blog! </title> <head>
<body>
<a href onclick="logout();">Logout</a>
<div class="blog_comments">
  {...}
</div>
</body>
</html>
```

Annoyance

```
<html>
<head> <title> Blog! </title> <head>
<body>
<a href onclick="logout();">Logout</a>
<div class="blog_comments">
<img onload="logout();" src="logo.gif">
</div>
</body>
</html>
```

Example 2

```
<html>
<head> <title> Blog! </title> <head>
<body>
<div class="blog_entry" id="123">
  {...}
<input type="button" onclick="delete(123);">
</div>
<div class="blog_comments">
  {...}
</div>
</body>
</html>
```

Data Loss

```
<html>
<head> <title> Blog! </title> <head>
<body>
<div class="blog_entry" id="123">
   {...}
<input type="button" onclick="delete(123);">
</div>
<div class="blog_comments">
 <img onload="delete(123);">
</div>
</body>
</html>
```

Complete Takeover

xJS Architecture

Basic Components

- Isolation operators
- Action Based Policies

Isolation Operators

- Inspired by Instruction Set Randomization (ISR)
- Applied to portions of source (e.g. JavaScript)
- Source isolation

XOR

- Fast, available as a hardware operation in most modern platforms
- No need for a JavaScript engine at the server side

Action Based Policies

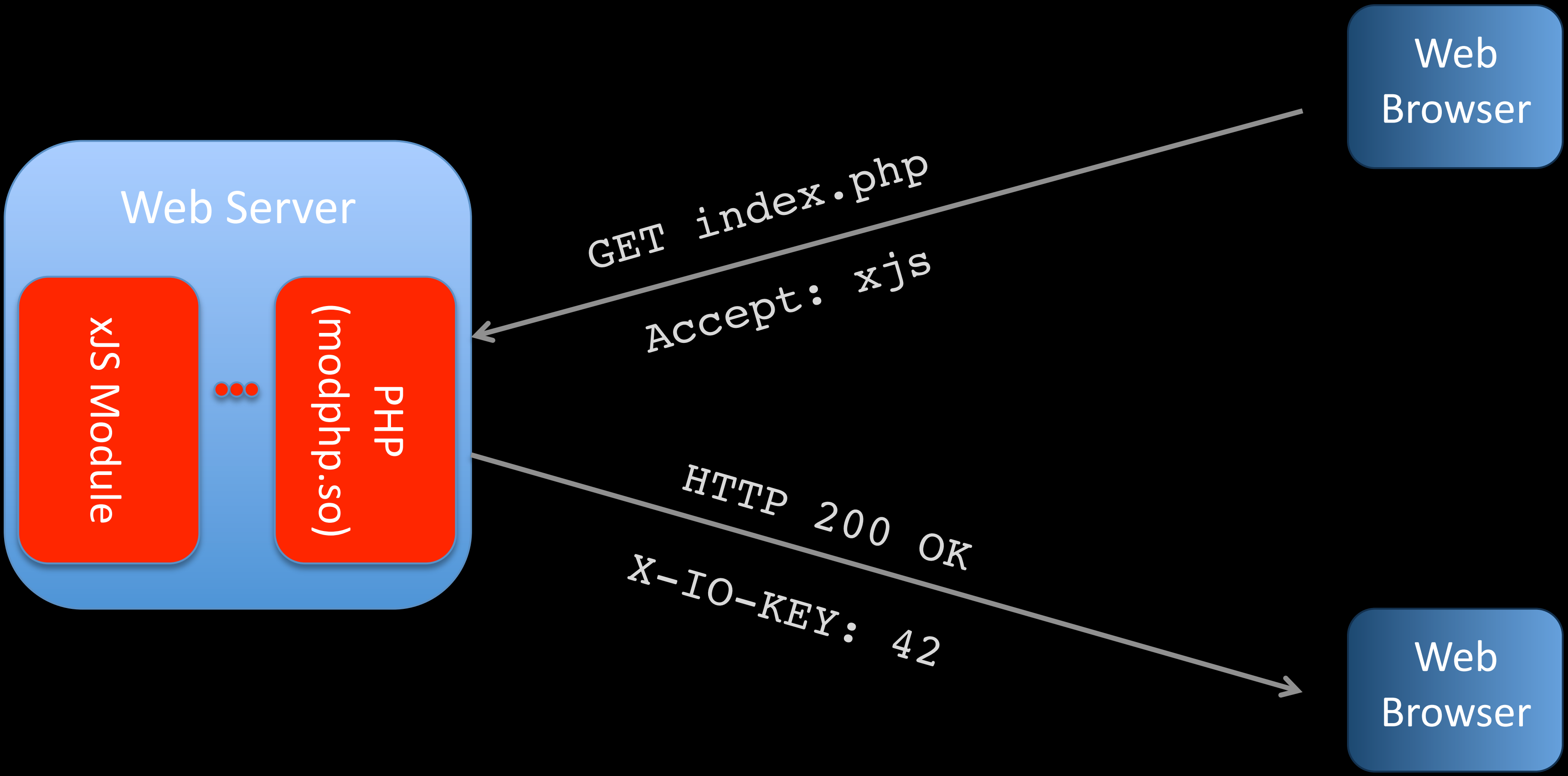
- Multiple trust levels
- Policies expressed as actions:

  De-isolate and execute

  De-isolate and execute after under user confirmation

  De-isolate with the X key and execute

xJS Session Example



Page Transformation

Original Page	xJS Page
`<div>`	`<div>`
`<img onload="render();”>`	`<img onload="AICtV...">`
`<script>`	`<script>`
`alert("Hello World");`	`vpSUJTV2NHGwJyW/NHY...`
`<script>`	`</script>`
`</div>`	`</div>`

How Trusted JavaScript is Spotted?

- All JavaScript contained in files of a web application's distribution is considered trusted
- JavaScript contained in a database is considered un-trusted

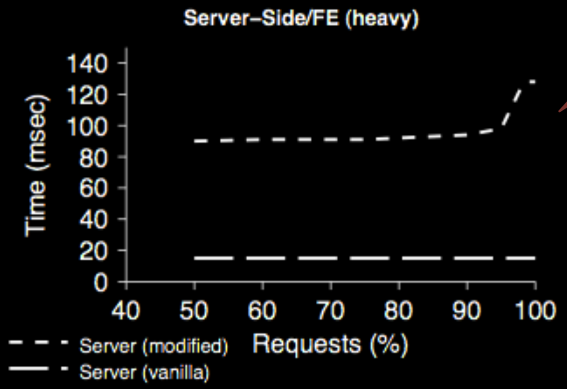
Evaluation

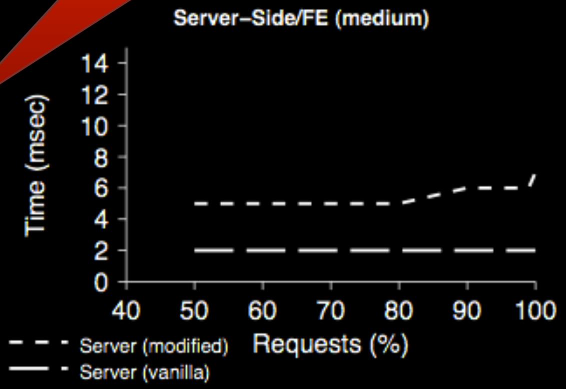
Attack Coverage

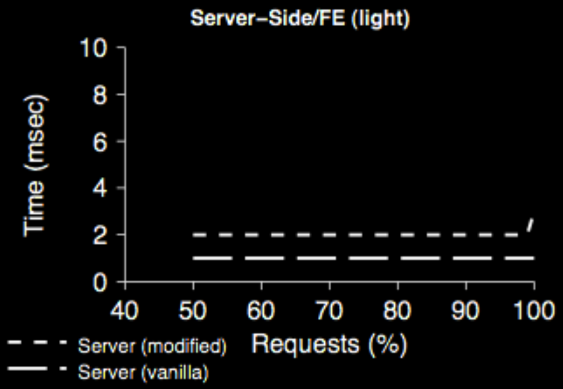
- 10,154 web pages from XSSed.com
- 1,381 still vulnerable
- Browse all 1,381 pages through a custom proxy
- All (100%) exploits were prevented

Server Side (Fast Ethernet)

Overhead of more than 60 msecs.

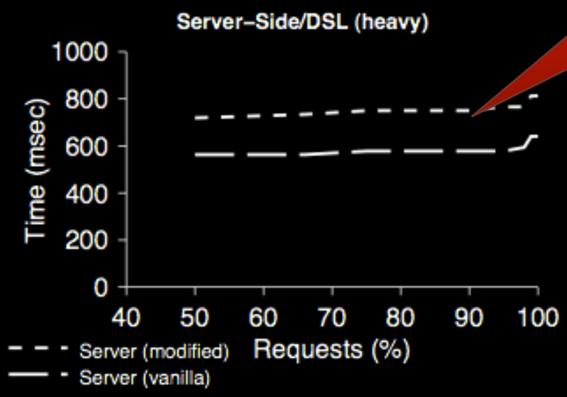


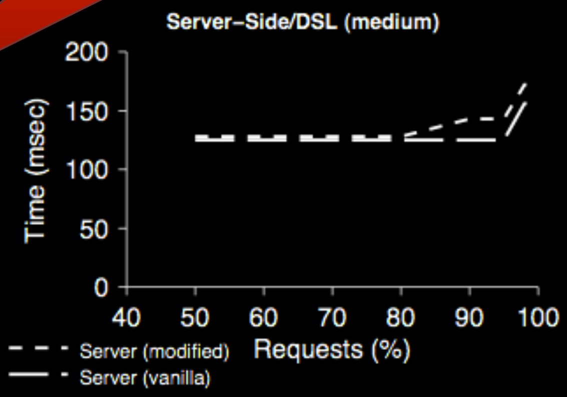


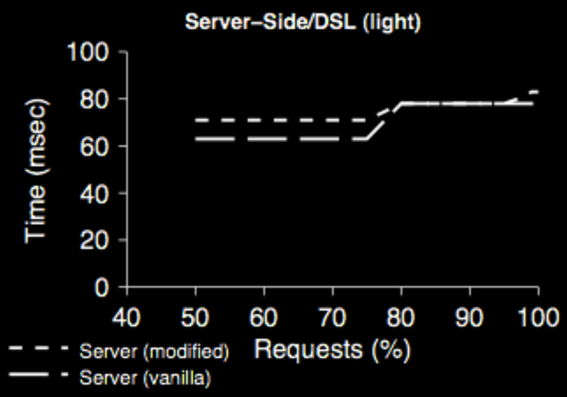


Server Side (DSL)

The overhead is fixed and less than a typical RTT of time!





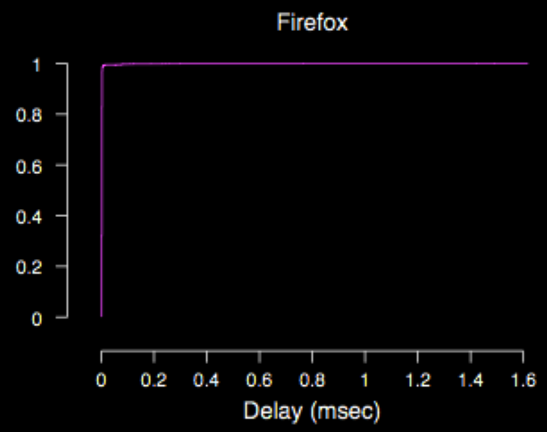


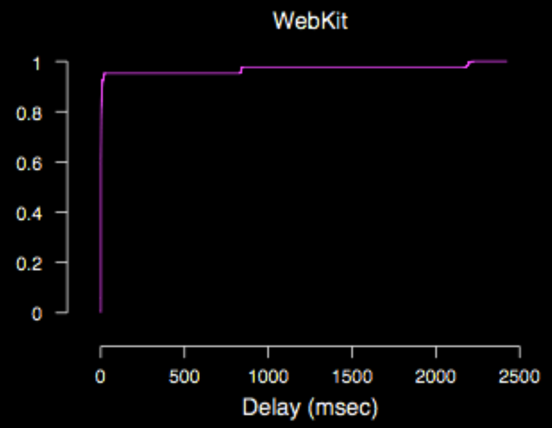
Client Side

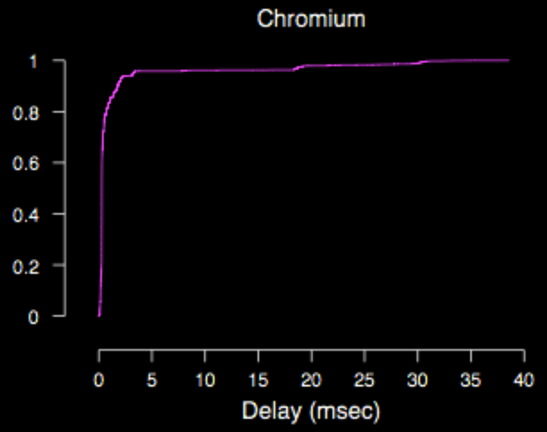
Many short calls (less than 1 msec overhead).

Fewer longer calls (less than 10 msec overhead).

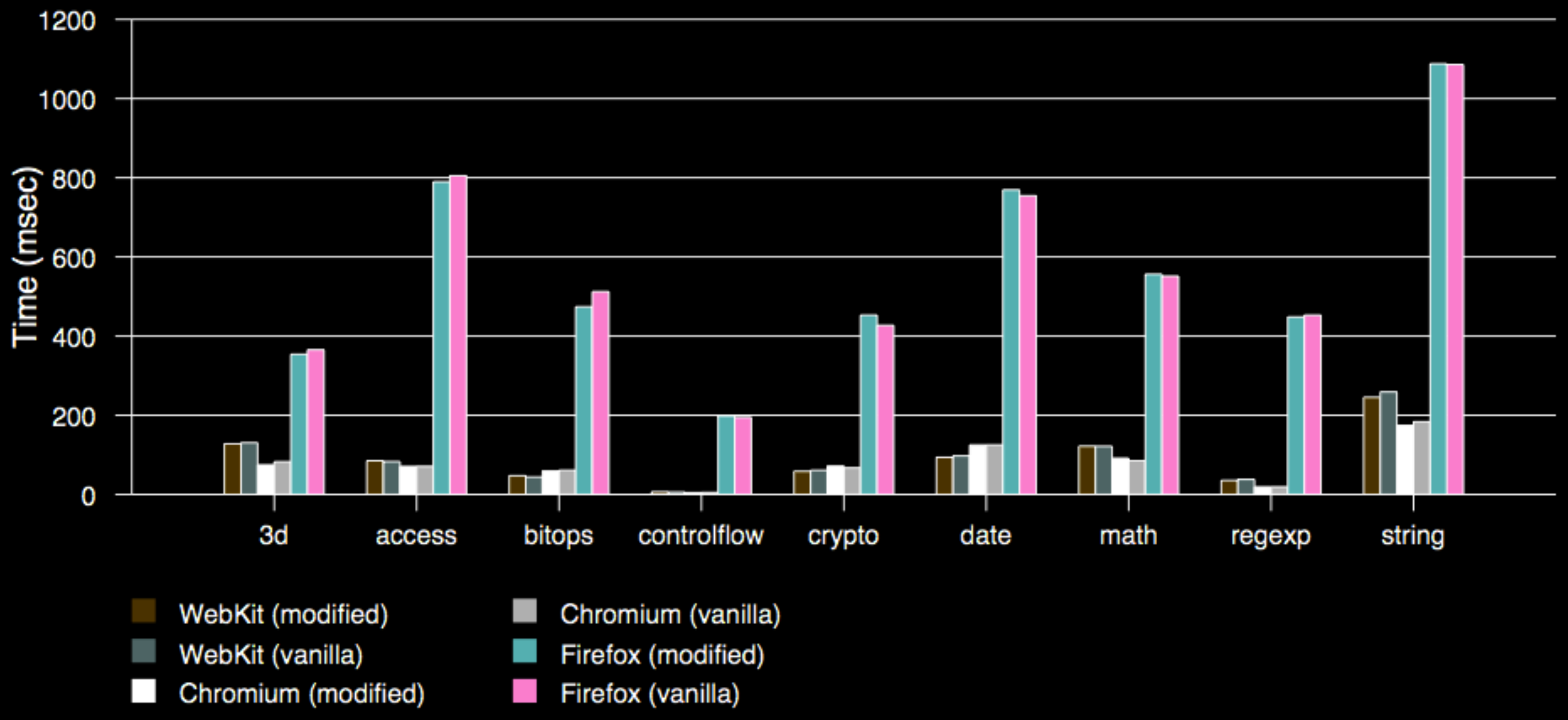
Fewer longer calls (less than 5 msec overhead).







User Experience



Limitations

`eval()` **Semantics**

- `eval()` is changed to *de-isolate and evaluate*
- `xeval()` is provided to simply evaluate

Code-Mixing

- Modern web applications mix server-side code (e.g. PHP) and JavaScript

```
<?php if (user_exists($user)) { ?>
var msg = <?php echo "Welcome” ?>;
<?php } else { ?>
var msg = "Registration Needed.";
<?php } ?>
```

Antonis Krithinakis, Elias Athanasopoulos, and Evangelos P. Markatos.

Isolating JavaScript in Dynamic Code Environments.

In Proceedings of the 1st Workshop on Analysis and Programming Languages for Web Applications and Cloud Applications (APLWACA), co-located with PLDI.

June 2010, Toronto, Canada.

Take Aways

1. JavaScript whitelisting is not sufficient
   - Return-to JavaScript attacks
2. xJS
   - Practical framework based on `XOR` for isolating legitimate JavaScript

Thank You!

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