# Precise client-side protection against DOM-based Cross-Site Scripting

USENIX Security 2014, San Diego

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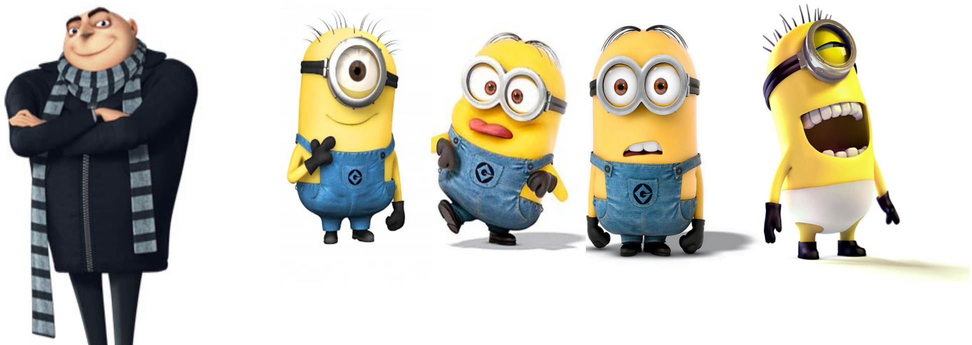

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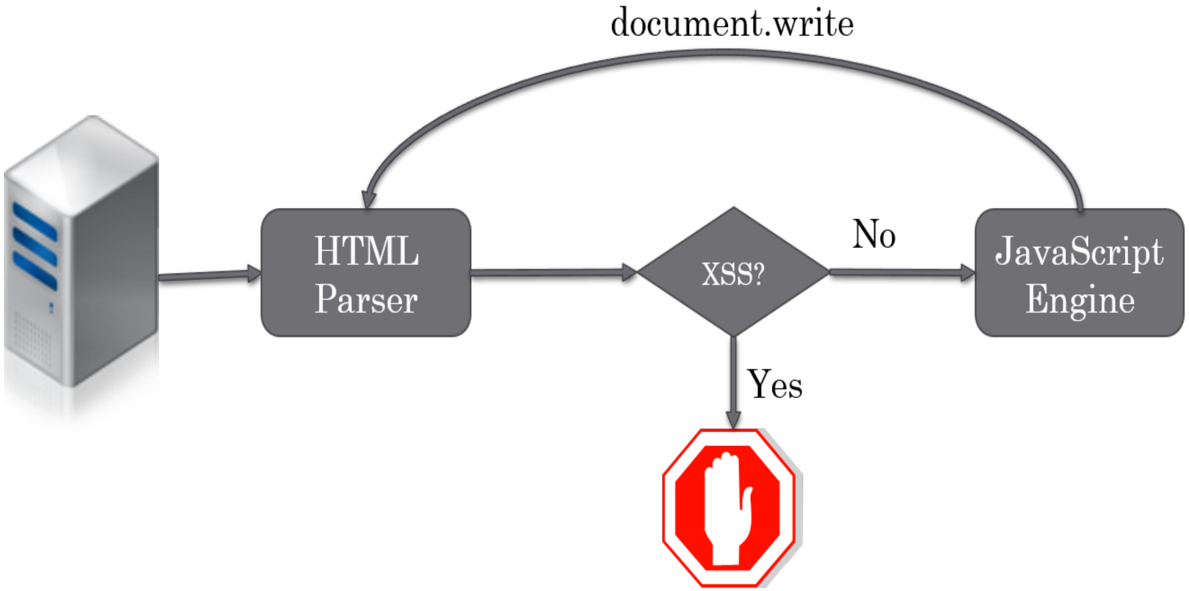
# DOM-based Cross-Site Scripting

- All kinds of XSS vulnerabilities that are purely inside client-side code
  - both "reflected" (e.g. extracting part of the URL)
  - ... and stored (e.g. localStorage)

Source: http://blogs.sfweekly.com/thesnitch/cookie_monster.jpg

# SotA in XSS filtering: XSSAuditor

- Deployed in all WebKit/Blink-based browsers
- Located inside the HTML parser
  - whenever dangerous element/attribute is found, search for "payload" in request



# DOM-based XSS in the wild and effectiveness of countermeasures

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# Finding DOMXSS at scale (CCS 2013)

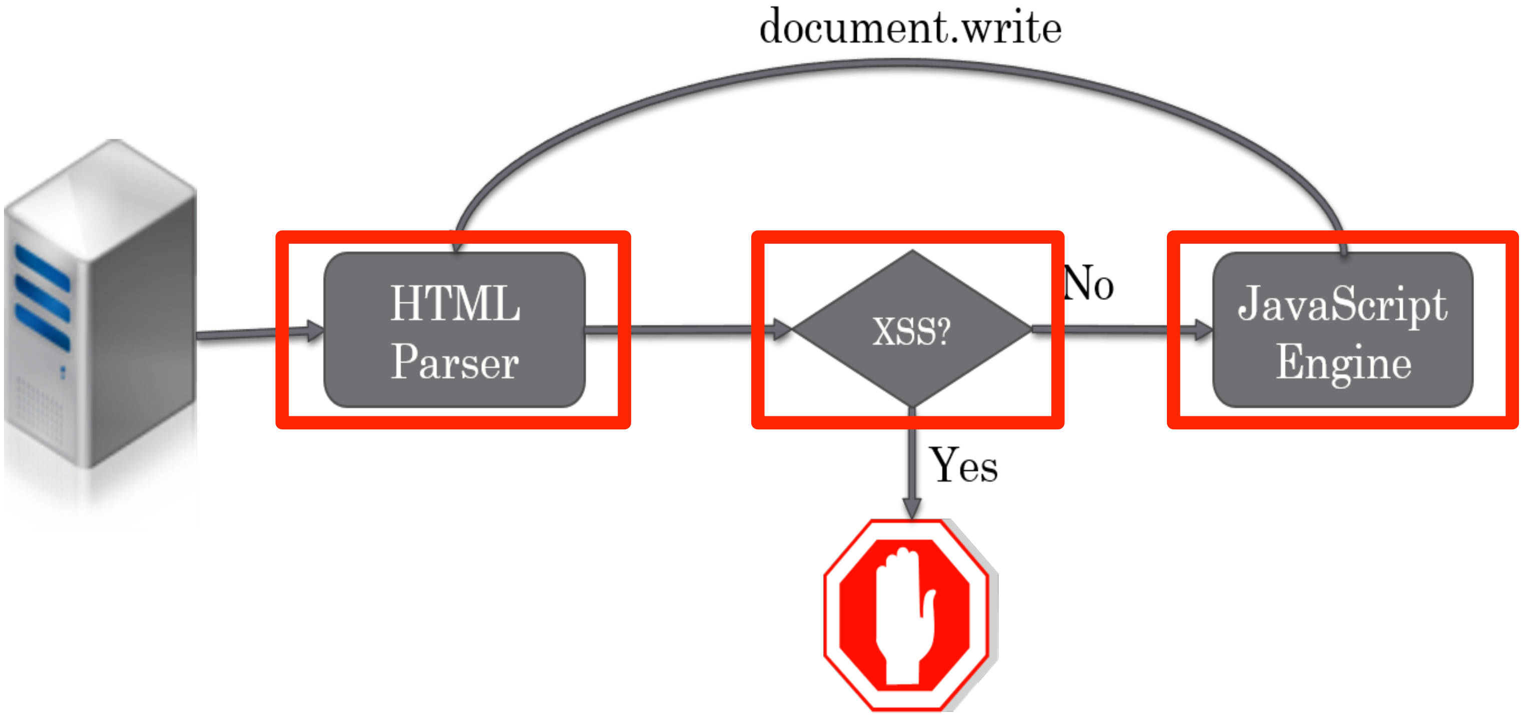
- using byte-level taint tracking in Chromium
  - precise source information for every character
  - patched sinks (e.g. document.write or eval)
- Chrome extension to crawl given set of Web sites
  - and act as interface between taint engine and backend
- and an exploit generator
  - using precise taint information
  - and HTML and JavaScript syntax rules
  - to generate exploits fully automatic

# DOMXSS in the wild

- CCS 2013
  - Alexa Top5k, one level down from homepage
  - ➔ **480** domains vulnerable

- This talk (moar crawling power)
  - Alexa Top10k, two levels down from homepage
  - ➔ **958** domains with **1,602** unique vulnerabilities
  - with disabled XSSAuditor

# Bypassing the XSSAuditor



# Bypassable exploits

- **776** out of **958** domains bypassable
- **1,169** out of **1,602** vulnerabilities bypassable

**➔ State of the Art XSS filter cannot protect against DOM-based XSS***

* was not necessarily designed that way, though

# Our proposed solution

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# The hard life of a reflected XSS filter

- XSS abstracted: user-provided **data** ends up being interpreted as **code**
  - same for SQLi, CMDi, ..
- XSS filter's problem: find this code among all the other code
  - string matching to approximate **data flow**

# Our proposal

- Approximation unnecessary imprecise for local flows
    - we can use taint tracking
- XSS boils down to being **JavaScript** execution
    - build filter into JavaScript engine
- XSS means that **data** ends up being interpreted as **code**
    - allow user-provided data only to generate Literals (Numeric, String, Boolean)
    - **never** anything else

# Our proposal exemplified

```
var userinput = location.hash.slice(1)
eval("var a='" + userinput + "';")
```

# Userinput: `userdata`

```
var a='userdata';
```

```
Declaration
   Identifier: a
   StringLiteral: 'userdata'
```

# Userinput: `userdata'; alert(1); //`

```
Declaration
   Identifier: a
   StringLiteral: 'userdata'
ExpressionStmt
   Type: CallExpression
   Callee:
      Identifier: alert
      Arguments:
         Literal: 1.0
```

```
var a='userdata';
alert(1); //'
```

# Policies

- No **tainted value** may generate anything other than a **Literal** in the JavaScript tokenizer
- No element that can reference an **external resource** may have **tainted origin**(e.g. script.src or embed.src)
    - enforced in the HTML parser and DOM bindings
    - single exception to rule: SAME origin as current page

# Evaluation

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# False negatives

- Took known vulnerabilities
  - ... with matching exploit URLs
- Disabled the XSSAuditor
  - ... to avoid interference
- Caught every exploit

# False positives

- Compatibility crawl of Alexa Top10k with policies in place
  - **981,453** URLs, **9,304,036** frames

| Blocking component | documents |
|---|---|
| JavaScript | 5,979 |
| HTML | 8,805 |
| DOM API | 182 |
| **Sum** | 14,966 (0.016%) |

# False positives

- Compatibility crawl of Alexa Top10k with policies in place
  - **981,453** URLs, **9,304,036** frames

| Blocking component | documents | domains |
|---|---|---|
| JavaScript | 5,979 | 50 |
| HTML | 8,805 | 73 |
| DOM API | 182 | 60 |
| **Sum** | 14,966 (0.016%) | 183 (1.83%) |

# False positives

- Compatibility crawl of Alexa Top10k with policies in place
  - **981,453** URLs, **9,304,036** frames

| Blocking component | documents | domains | exploitable domains |
|---|---|---|---|
| JavaScript | 5,979 | 50 | 22 |
| HTML | 8,805 | 73 | 60 |
| DOM API | 182 | 60 | 8 |
| **Sum** | 14,966 (0.016%) | 183 (1.83%) | 90 |

# Performance

- Evaluation using standard benchmarks
  - Dromaeo, Octane, Kraken, Sunspider
- Two modes (benchmarks usually don't use tainted values)
  - normal operation
  - all strings tainted
- Overhead between **7 and 17%**
  - optimization possible

# Conclusion

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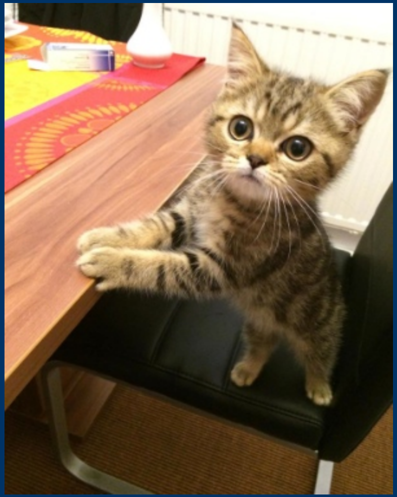
# Conclusion

- SotA filters can be bypassed for DOM-based XSS
- We propose filter inside JavaScript parser
  - using precise taint information, allowing only tainted Literals
  - **No false negatives**
  - **Low false positives**
    - "XSS by design"
    - untaint API built in
  - **performance impact exists**
    - optimizations possible
    - deployable next to the Auditor if optimized

# Thank you

# Questions?



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