ZigZag

against Client-side Validation Attacks

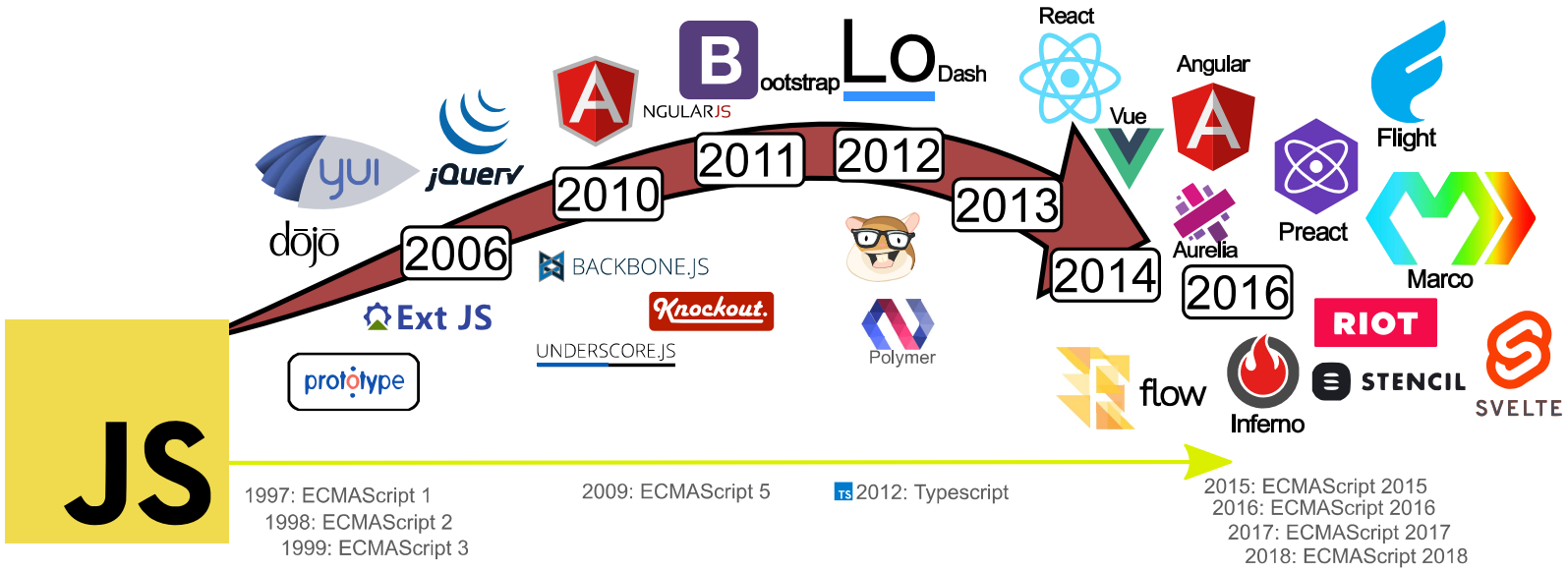
What is Client-side Validation (CSV)?

Validation of Untrusted Input

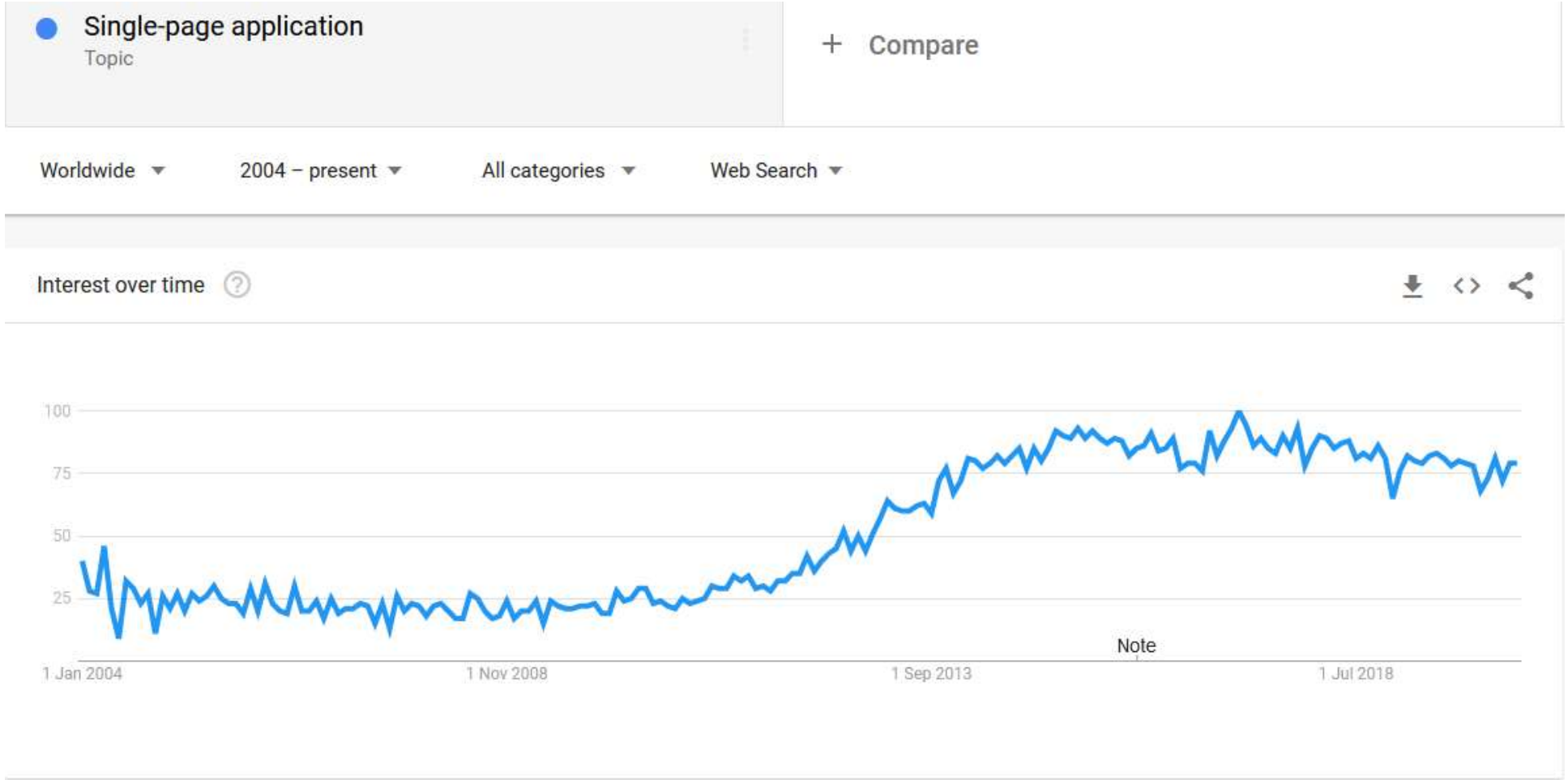
- HTTP Referrer
- Browser Information
- Cookie values
- URL parameters & fragment
- Form data
- Cross-document communication
- ...

BUT: Not all data is processed by the server!

The Rise of JavaScript



The Rise of JavaScript



How do CSV Attacks work?

Vulnerable example

```
1  // Handle a received message
2  var receiveMessage = function(e) {
3    // Missing check on e.origin!
4    // ...
5  }
6
7  var sendMessage = function(e) {
8    // Send data to window
9    window.postMessage(data, "*");
10 }
11
12 // Register for messages
13 window.addEventListener("message", receiveMessage, false);
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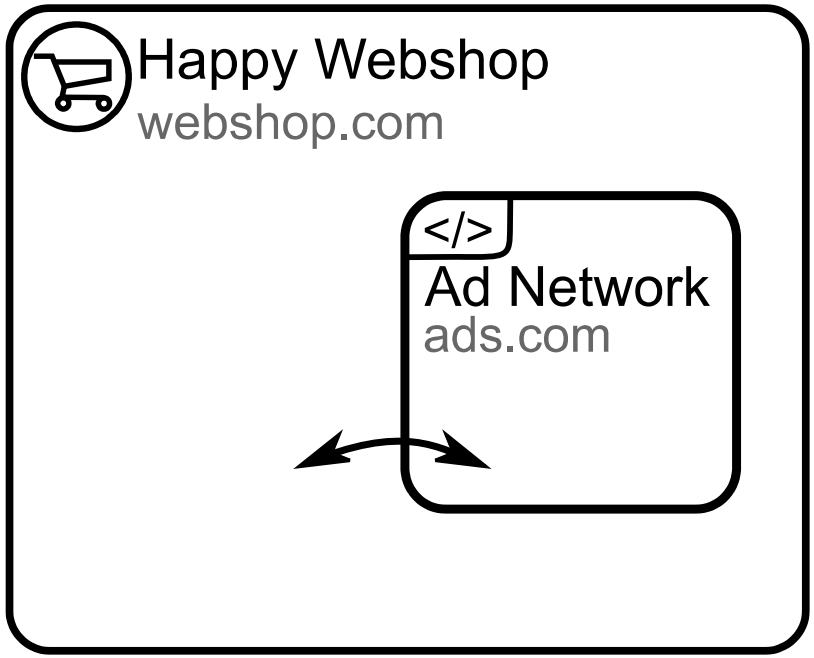
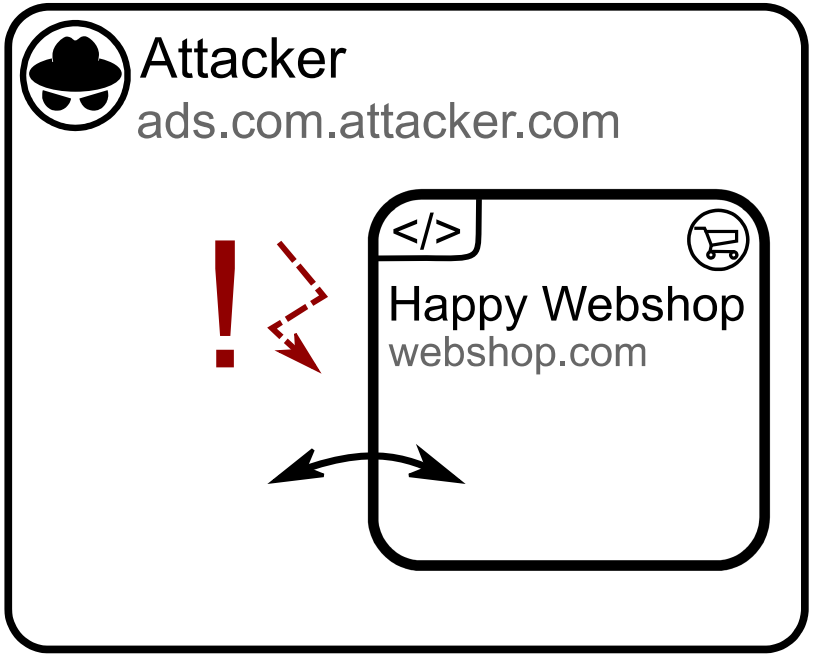

Happy Webshop
webshop.com
</>
Ad Network
ads.com


Attacker
ads.com.attacker.com
!
</>
Happy Webshop
webshop.com

Critical Effects on the Client

- Origin mis-attribution
- XML-HTTP-Requests (Command injection)
- Accessing private data (Session hijacking)
- Document manipulation (XSS)

How to prevent CSV attacks?

Previous works

- 🕵 Program analysis for finding vulnerabilities
- 🛠 Language-based protection
- 📦 Sandboxing potentially vulnerable code
- 🔑 Signature and anomaly checks

Problems

- ❌ No same origin policy
- 😵 Difficulty of training developers
- 🐾 Rapidly evolving web platform
- 🔄 Highly dynamic interaction across documents

ZigZag's approach

- Fully automatic
- No modifications to source code
- No browser modifications needed
- Dynamic reactions to changed conditions
- Deployable by website operators or third parties

How does that work?

Core Idea

Anomaly Patching

- 🔍 Find security-relevant application parts
- 📝 Trace normal execution flow
- 🤔 Deduce likely restrictions for variables
- 👮 Enforce restrictions on application calls

Find relevant functions

- 🕵 Determine checkpoints for tracing
- ✈ Use entry and exit points of callback functions
- 🔥 Use static analysis to detect relevant API sinks

Trace execution flow

Store values of...

- Function parameters
- Caller / callee pairs
- Return values

Deduce restrictions of...

...single values

- type (typeof origin === "string")
- equality (origin === "ads.com")
- length (origin.length < 8)
- isJSON, isPrintable, isEmail, isURL, ...

Deduce restrictions of...

...multiple values

- equality (x === y)
- inequality (x < y)
- also for same type, isJSON, ...

Enforce restrictions

- Repeat tracing step
- Terminate application if invalid
- Warn about violations

Any issues with this?

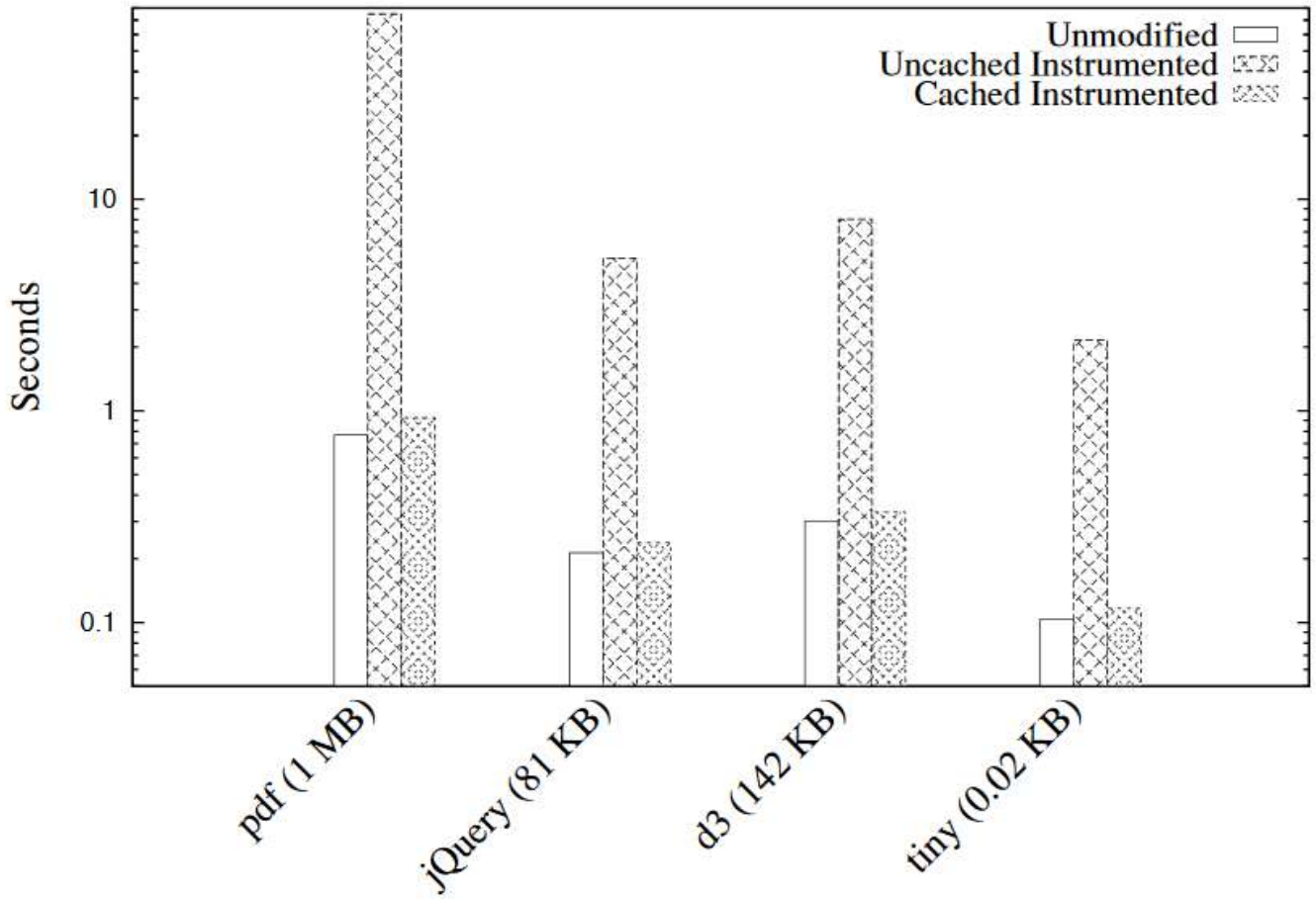
Training Process

- Requires training in order to function
- Too few test runs ⇒ false-positives
- Learning phase requires attack-free usage
- End-to-end tests as possible base

Generated Code

- Detection of dynamic code rewriting
- Detection of templated code generation
- Abstracting of restrictions for code classes

Performance



Security

- Protects against anomalies
- Does not hide itself
- No protection against other XSS attacks

Does it actually work?

- Tested on Alexa Top 50
- No false-positives
- Working on all but one page

Further questions?