Detecting Malicious JavaScript in PDFs

Using Conservative Abstract Interpretation

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Safe Harbor Statement

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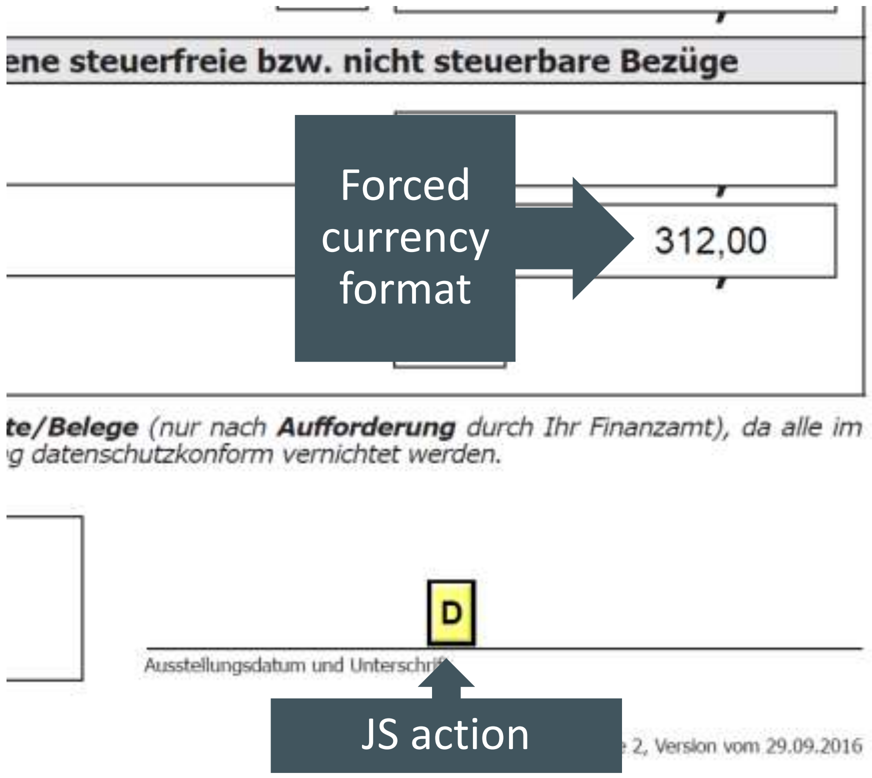
Motivation

"What is JavaScript doing in my PDFs?"


ene steuerfreie bzw. nicht steuerbare Bezüge

312,00

te/Belege (nur nach **Aufforderung** durch Ihr Finanzamt), da alle im
g datenschutzkonform vernichtet werden.

Ausstellungsdatum und Unterschri

2, Version vom 29.09.2016

- Form validation/completion
- Automation, utility functions
  - email
  - printing
- And more…
  - control embedded media
  - connect to a SQL database

Exploit Examples

CVE Id	Vulnerable Target Application	Exploit
2003-0284	Adobe Acrobat 5	Unchecked access to file-system
2007-5659	Adobe Reader, Acrobat 8.1.1	Buffer overflow (arbitrary code execution)
2008-0667	Adobe Reader, Acrobat 8.1.1	Denial-of-service (printing API)
2008-0726	Adobe Reader, Acrobat < 8.1.2	Integer overflow (arbitrary code exection)
2008-1104	Foxit Reader < 2.3	Buffer overflow (arbitrary code execution)

Current Defenses

Static

- Malware detection based on
  - signature
  - patterns
  - structure
  - machine learning

Dynamic

- Malware detection during sandboxed execution
- Runtime protection (requires modified reader application)

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Defeated by obfuscation!

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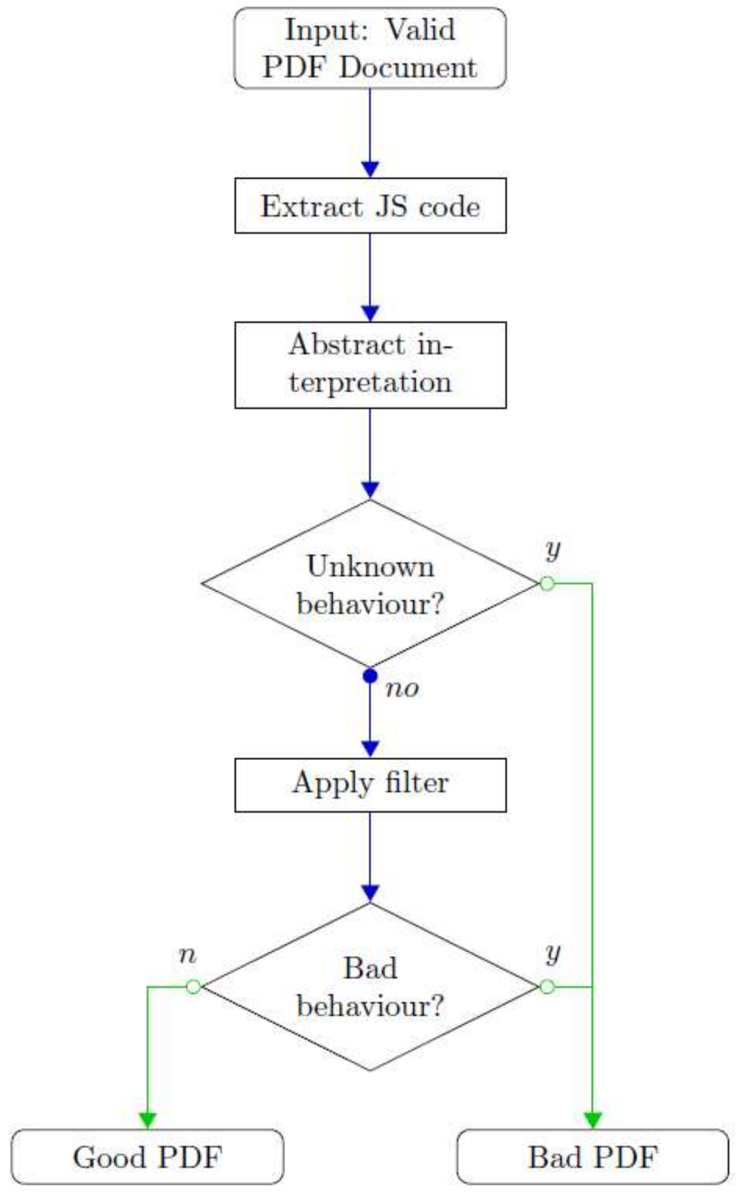
How to execute all paths?

Best defense?

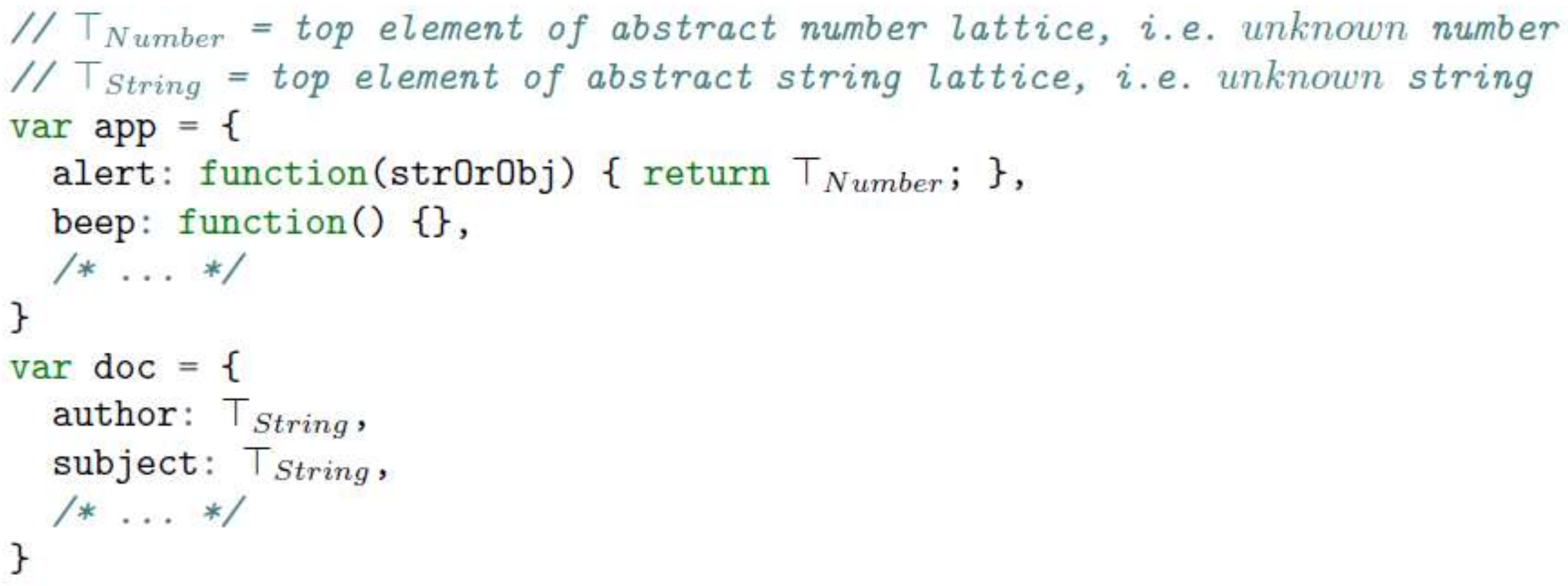
Strip all JavaScript from PDF documents.

Detection based on *conservative* abstract interpretation

- The idea
  - extracted JS code is analyzed with a model of Acrobat's JS API
- *Conservative?*
  - the model is conservative
  - unknown behavior is handled conservatively



PDF-JS Model



```
// $\top_{Number}$ = top element of abstract number lattice, i.e. unknown number
// $\top_{String}$ = top element of abstract string lattice, i.e. unknown string
var app = {
  alert: function(strOrObj) { return $\top_{Number}$; },
  beep: function() {},
  /* ... */
}
var doc = {
  author: $\top_{String}$,
  subject: $\top_{String}$,
  /* ... */
}
```

Prototype Implementation

Abstract Interpretation based on *SAFE*[1]

+

Initial PDF-JS Model (120 LoC)

1) https://github.com/sukyoung/safe

Results

Oracle-Internal Benchmark Set

Malicious

- 1323 documents
- All rejected as malicious

Non-Malicious

- 60 documents
- 22 rejected as malicious (*false positives)*
- But all 22 use unsafe JavaScript APIs

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Current Status

- ✓ Patent filed
- ❏ Paper to be submitted in July

Takeaway

Why does abstract interpretation work in this context?

1. Non-malicious JavaScript in PDF is *easy* to analyze.
2. If something is *too hard*, it is okay to reject it.
3. We can gradually refine the PDF-JS model as long as it remains conservative.

Safe Harbor Statement

Integrated Cloud

Applications & Platform Services