State of The Art: Automated Black Box Web Application Vulnerability Testing

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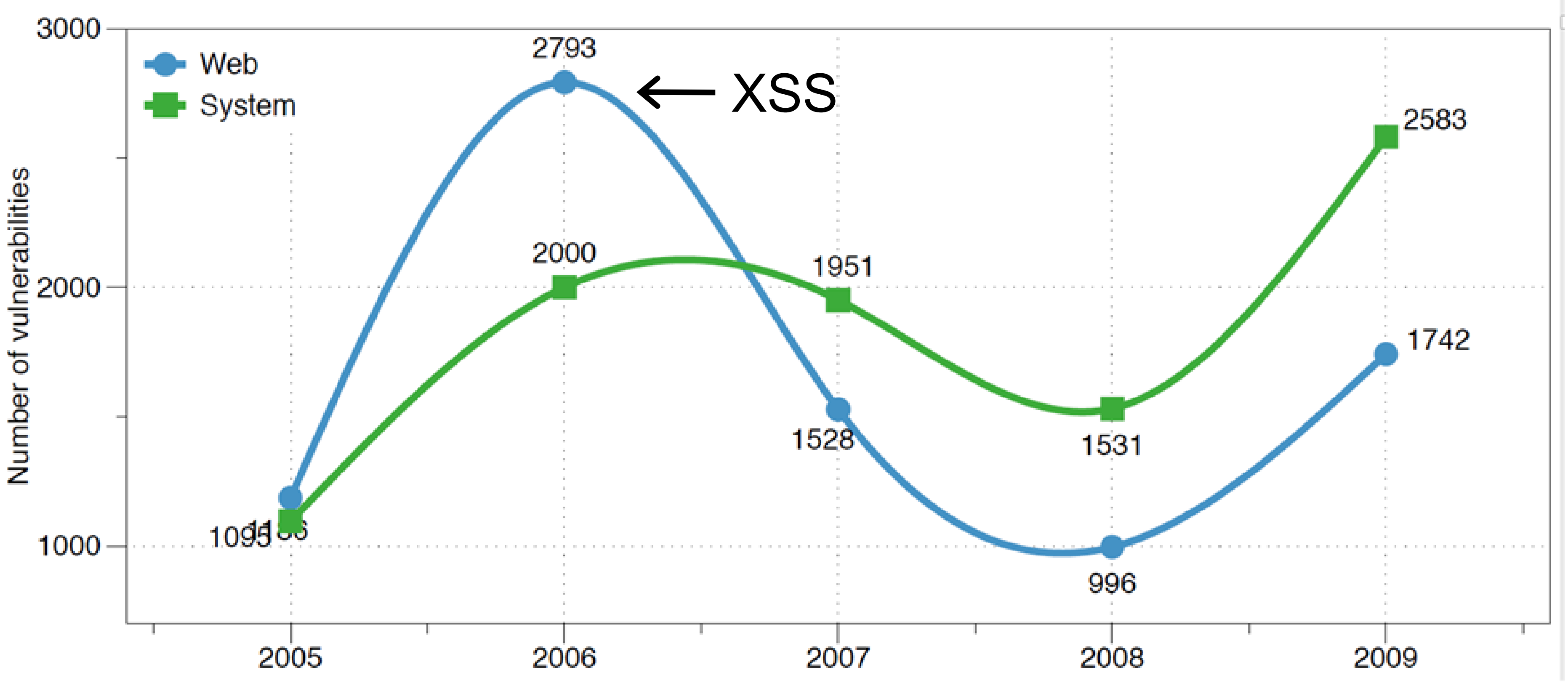
Background

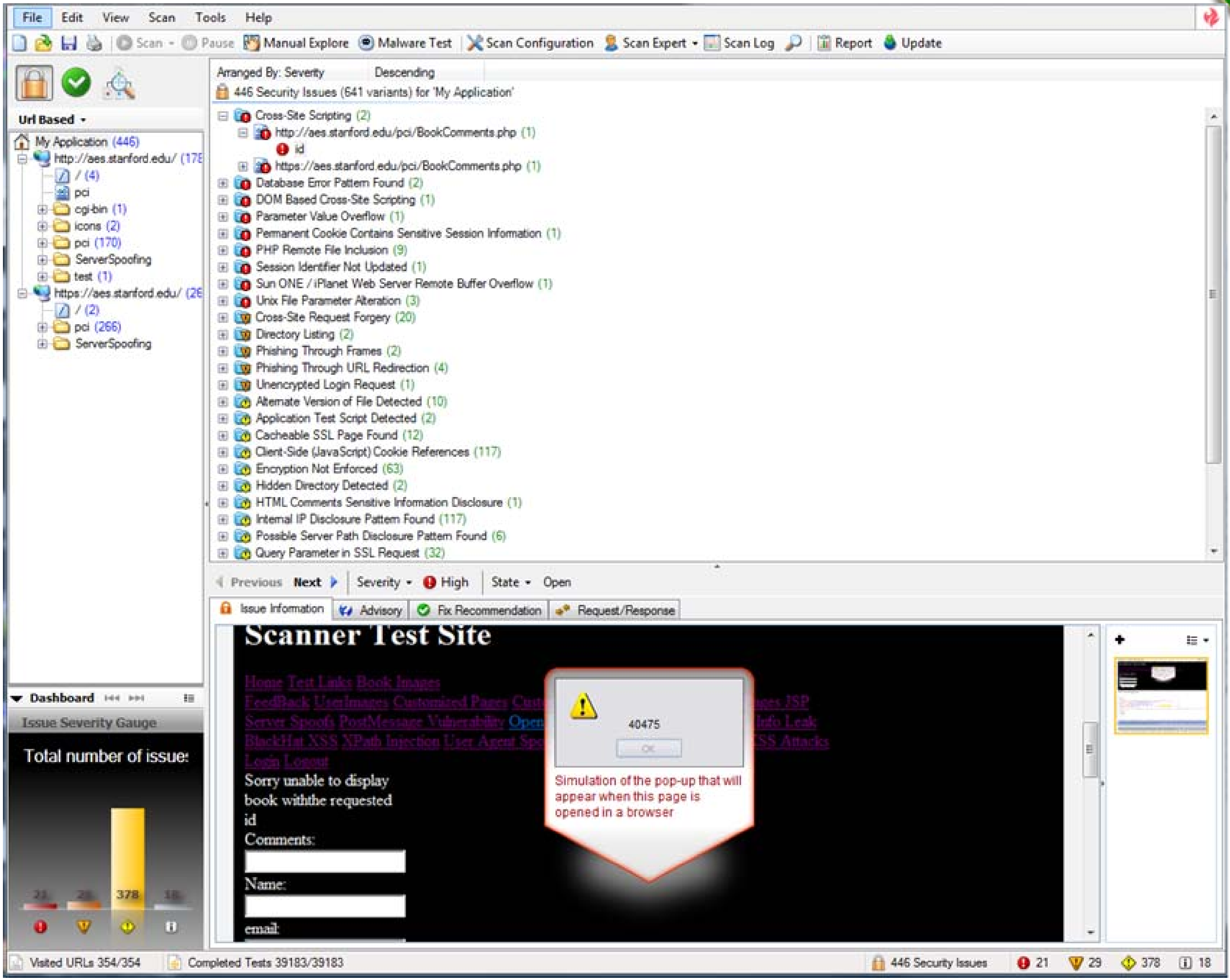
- Web Application Vulnerability Protection
  - High incidence vulnerabilities (XSS, SQLI, …)
  - Required for standards compliance (e.g PCI)



Security Tools for Apps

- Vulnerability Detection Techniques:
  - Manual vs. Automated
  - White-Box vs. Black-Box
  - Code review, Static analysis, Pen testing
  - **Automated Black Box Testing**
    - Cheaper? Less intrusive to workflow?

Scanner 1



My Application (446)
http://aes.stanford.edu/ (178
/ (4)
pci
cgi-bin (1)
icons (2)
pci (170)
ServerSpoofing
test (1)
https://aes.stanford.edu/ (26
/ (2)
pci (266)
ServerSpoofing

Arranged By: Severity   Descending

446 Security Issues (641 variants) for 'My Application'

- Cross-Site Scripting (2)
  - http://aes.stanford.edu/pci/BookComments.php (1)
    - id
  - https://aes.stanford.edu/pci/BookComments.php (1)
- Database Error Pattern Found (2)
- DOM Based Cross-Site Scripting (1)
- Parameter Value Overflow (1)
- Permanent Cookie Contains Sensitive Session Information (1)
- PHP Remote File Inclusion (9)
- Session Identifier Not Updated (1)
- Sun ONE / iPlanet Web Server Remote Buffer Overflow (1)
- Unix File Parameter Alteration (3)
- Cross-Site Request Forgery (20)
- Directory Listing (2)
- Phishing Through Frames (2)
- Phishing Through URL Redirection (4)
- Unencrypted Login Request (1)
- Alternate Version of File Detected (10)
- Application Test Script Detected (2)
- Cacheable SSL Page Found (12)
- Client-Side (JavaScript) Cookie References (117)
- Encryption Not Enforced (63)
- Hidden Directory Detected (2)
- HTML Comments Sensitive Information Disclosure (1)
- Internal IP Disclosure Pattern Found (117)
- Possible Server Path Disclosure Pattern Found (6)
- Query Parameter in SSL Request (32)

Scanner Test Site

Home Test Links Book Images
FeedBack UserImages Customized Pages Cust ges JSP
Server Spoofs PostMessage Vulnerability Open Info Leak
BlackHat XSS XPath Injection User Agent Spo SS Attacks
Login Logout

Sorry unable to display book withthe requested id

Comments:

Name:

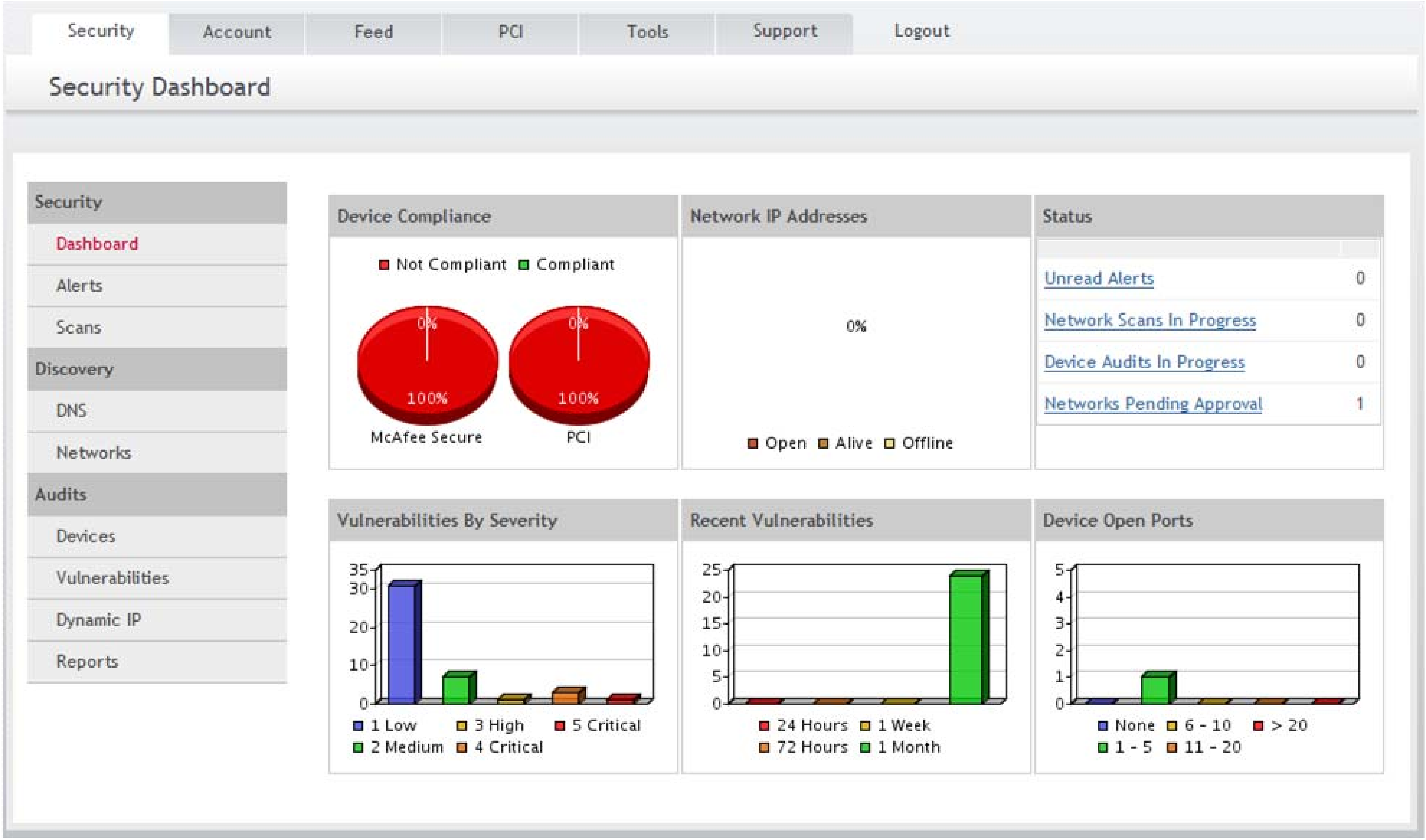
email:

40475

Simulation of the pop-up that will appear when this page is opened in a browser

Visited URLs 354/354   Completed Tests 39183/39183   446 Security Issues   21   29   378   18

Scanner 2



Status

Unread Alerts	0
Network Scans In Progress	0
Device Audits In Progress	0
Networks Pending Approval	1

Goals of Study

- What vulnerabilities are tested by scanners?
- How representative are scanner tests of in-the-wild vulnerabilities
- What can user expect from scanner?
- What is hard and needs more human review?

Non-Goals

- Not a product ranking
- Not a benchmark of particular tools

Take Aways

- How to take advantage of scanner
- How (If) to combine it with human audit
- What to expect as improvement

Outline

- Vulnerability categories tested by scanners
- How prevalent are these in the wild?
- Common application results
- Custom testbed design
- Custom testbed results
  - Coverage
  - Detection
  - False Positives

Survey of Leading Products

Local

acunetix

IBM

RAPID7

N-Stalker

hp

CENZIC

Remote

McAfee SECURE
TESTED 02-FEB

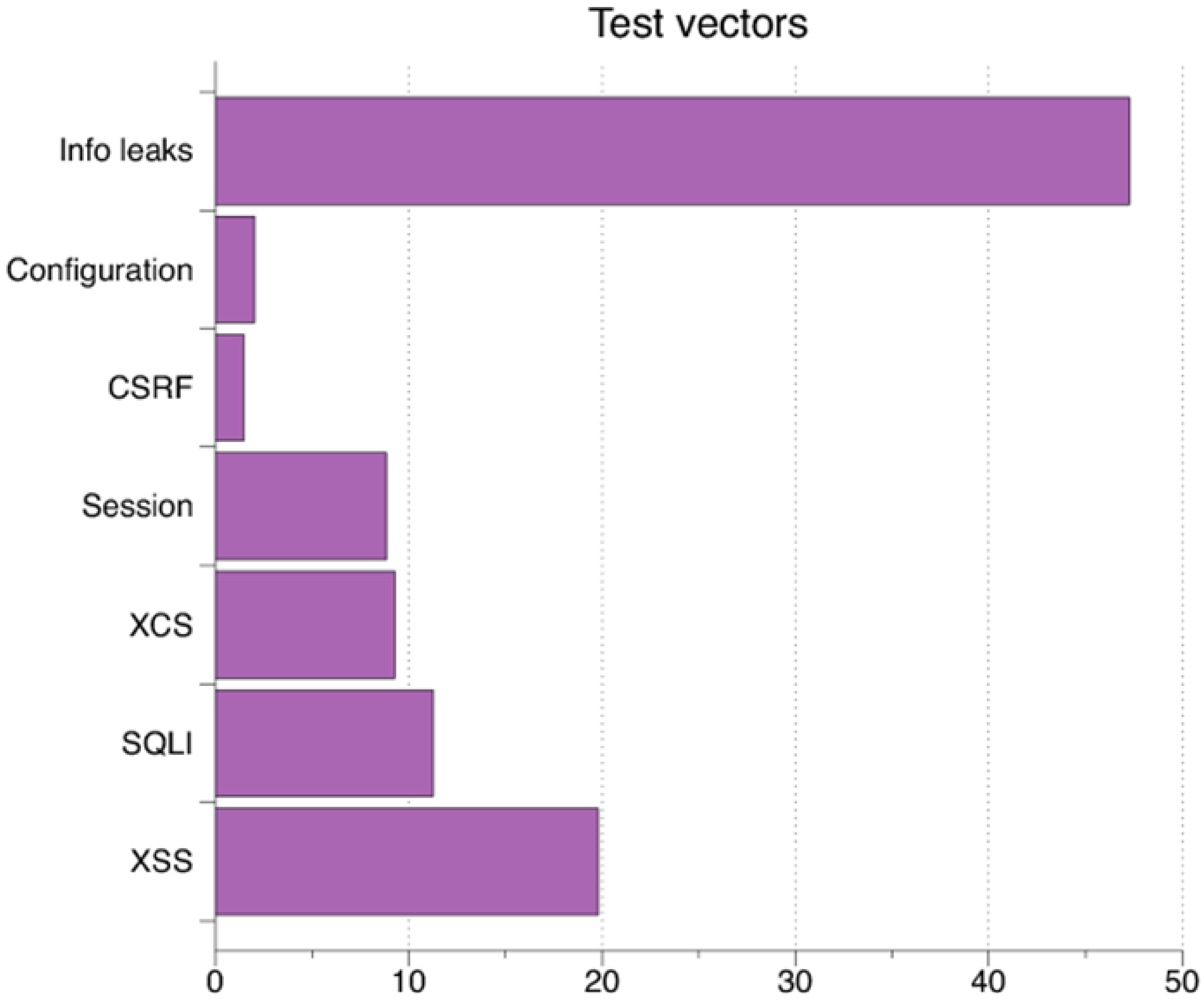
QUALYS

>$100K total retail price

Vuln Categories From Scanners

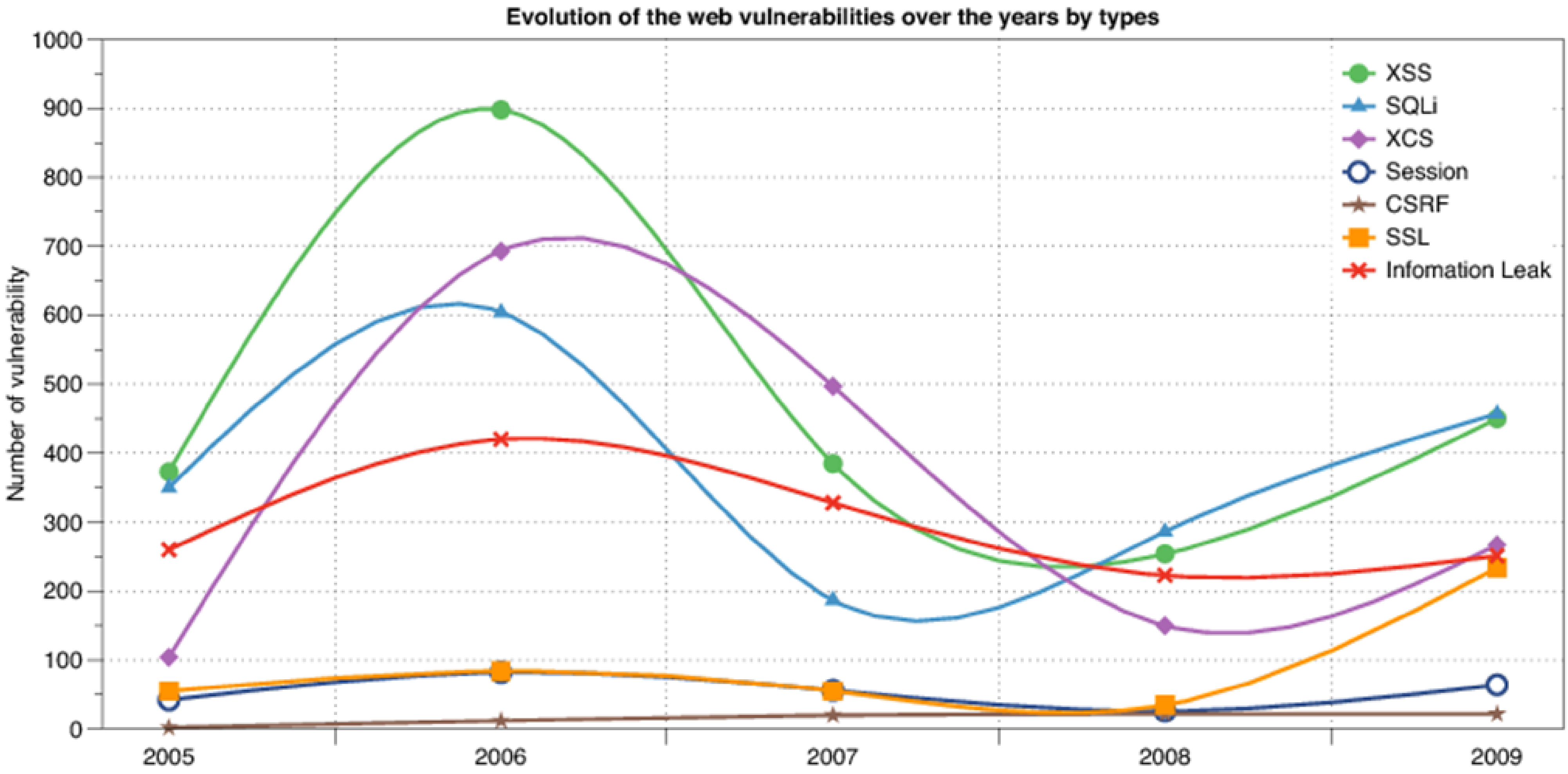
Category	Example Vulnerabilities
Cross Site Scripting	XSS
SQL Injection	SQLI
Cross Channel Scripting (Other forms of injection)	Arbitrary File Upload Remote File Inclusion OS command Injection
Session Management	Session Fixation and Prediction Authentication Bypass
Cross-Site Request Forgery	CSRF
SSL/Server Config	Self-Signed Cert, HTTP Trace
Info Leakage	Temp file access, path traversal Error message disclosure

Test Vectors By Category



Test Vector Percentage Distribution

Reported Vulnerabilities "In the Wild"



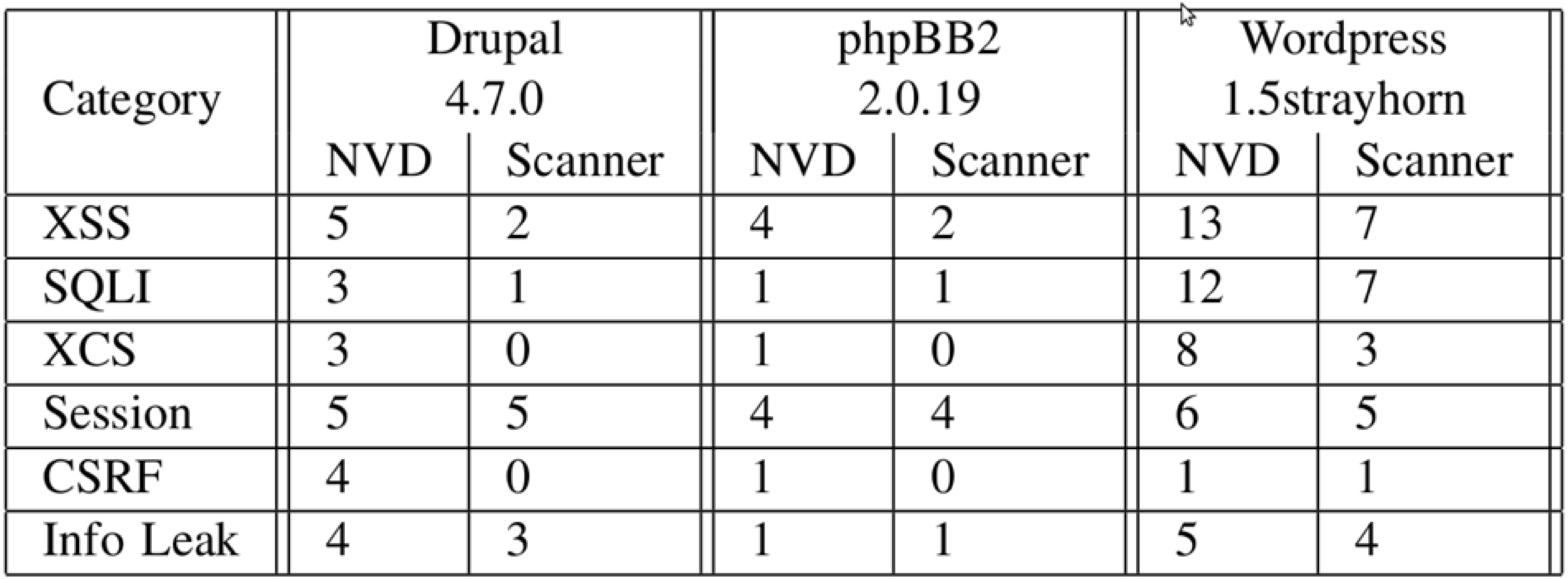
Data from aggregator and validator of NVD-reported vulnerabilities

Scanners vs. In-the-Wild

- Top 4 for both:
  - XSS
  - SQLI
  - XCS
  - Info Leak
- Scanners have many more info leak vectors
  - Easier to write?

Detecting Known Vulnerabilities

Vulnerabilities for
previous versions of Drupal, phpBB2, and WordPress



Category	Drupal 4.7.0		phpBB2 2.0.19		Wordpress 1.5strayhorn	
	NVD	Scanner	NVD	Scanner	NVD	Scanner
XSS	5	2	4	2	13	7
SQLI	3	1	1	1	12	7
XCS	3	0	1	0	8	3
Session	5	5	4	4	6	5
CSRF	4	0	1	0	1	1
Info Leak	4	3	1	1	5	4

Good: Info leak, Session (Anecdote from re-test)
Decent: XSS/SQLI
Poor: XCS, CSRF (low vector count?)

Our Custom Testbed

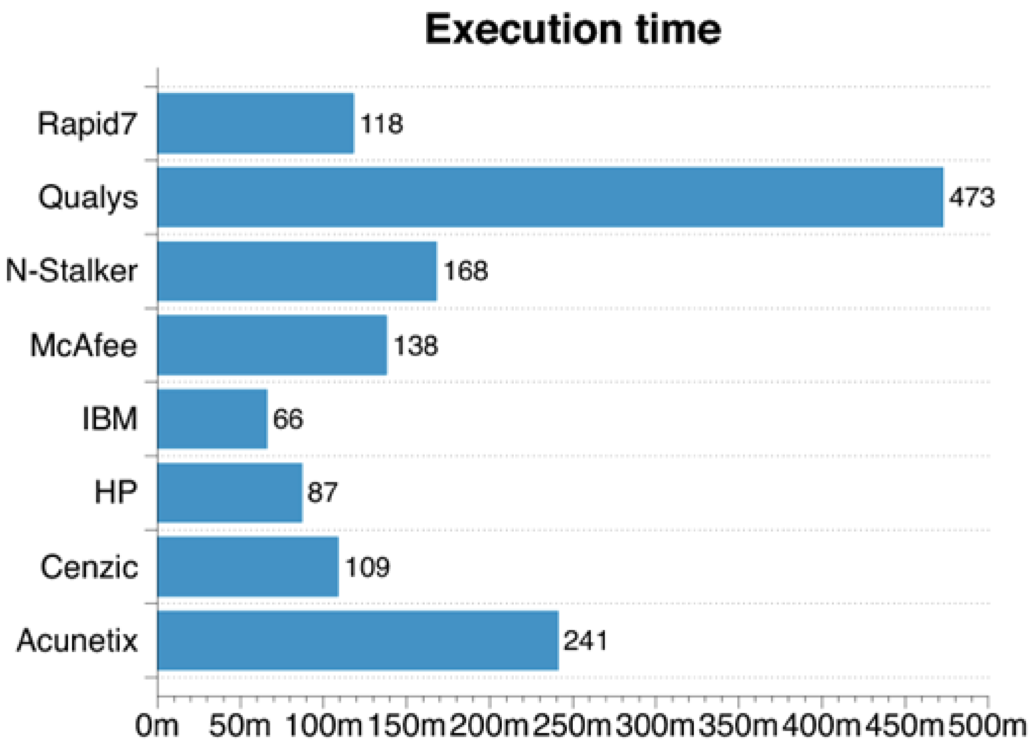
- Mainly built over summer by 1 undergrad in PHP

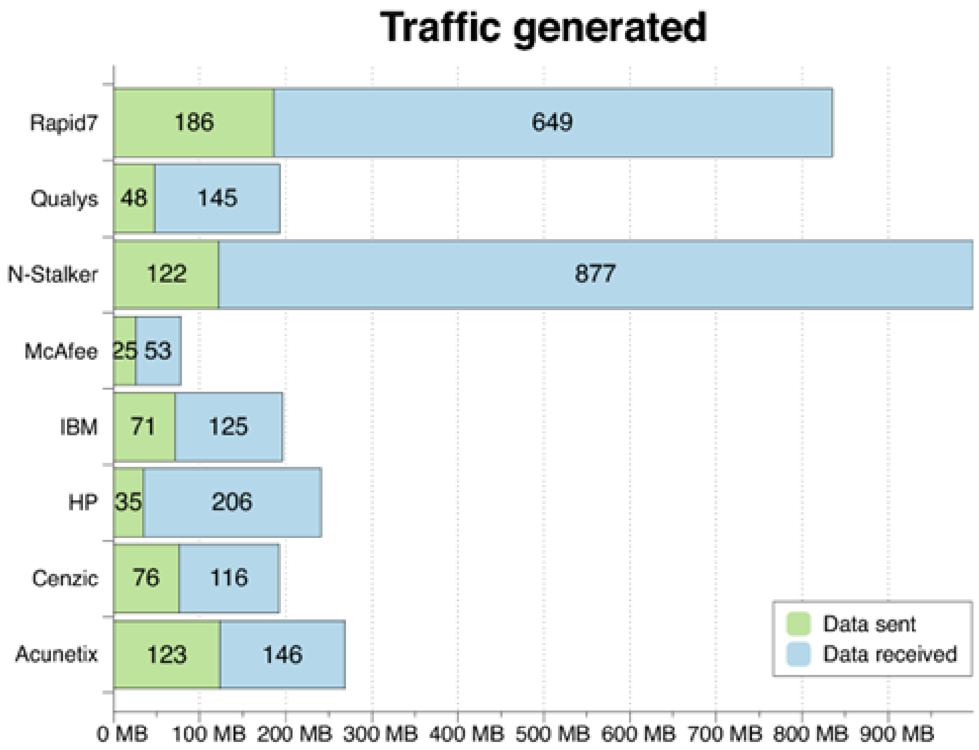
- Measure Performance
  - Test Duration / Network Traffic

- Measure Coverage
  - Links coded in various technologies (Flash, SilverLight, ...)
  - Can scanner follow link?

- Measure Vulnerability Detection Rate
  - XSS (Type 1, Type 2, Advanced)
  - SQLI (Type 1, Type 2)
  - Cross Channel Scripting
  - CSRF
  - Session Management
  - Server/Crypto Config
  - Information Leak
  - Malware

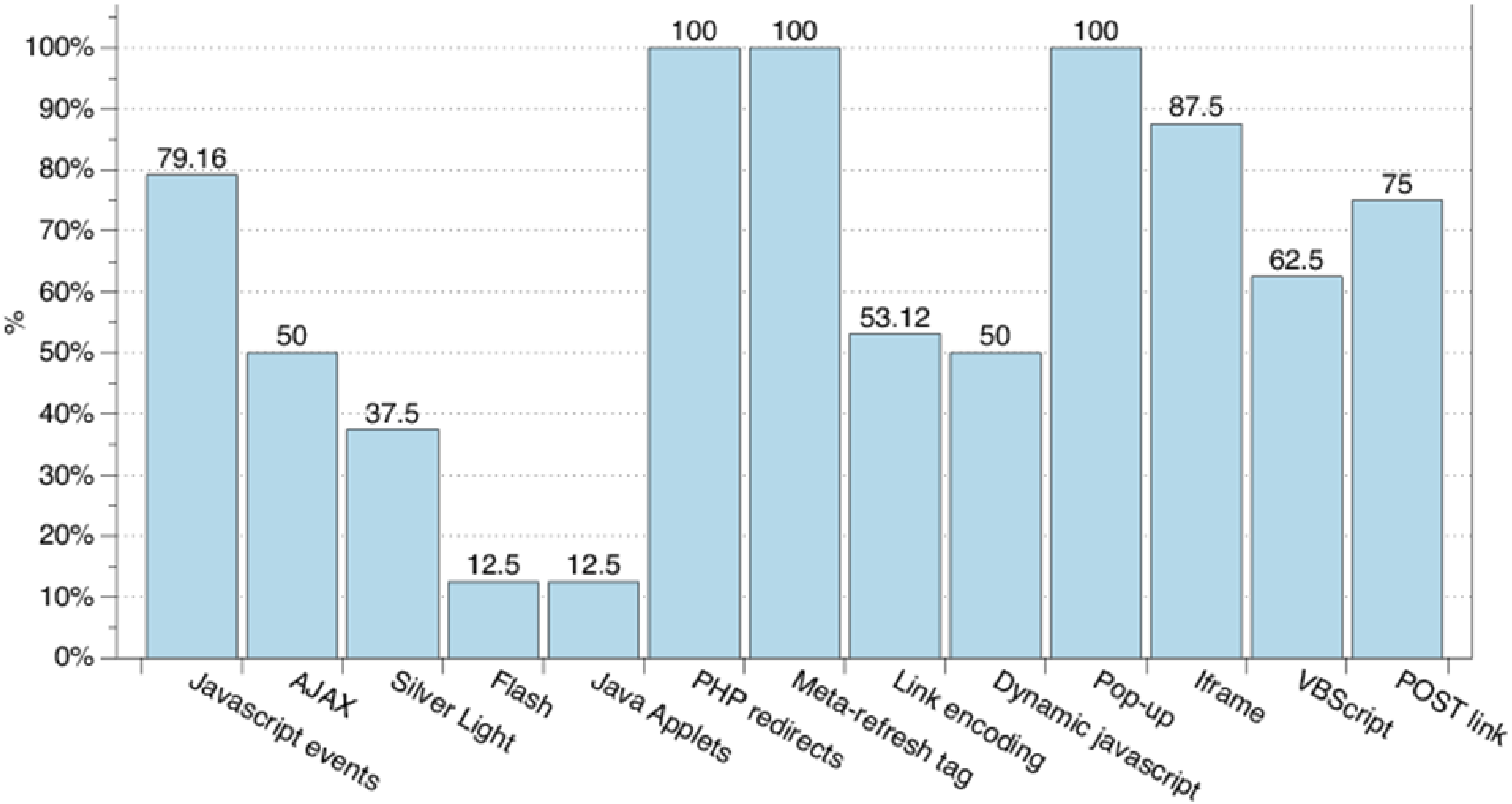
Scanner Performance





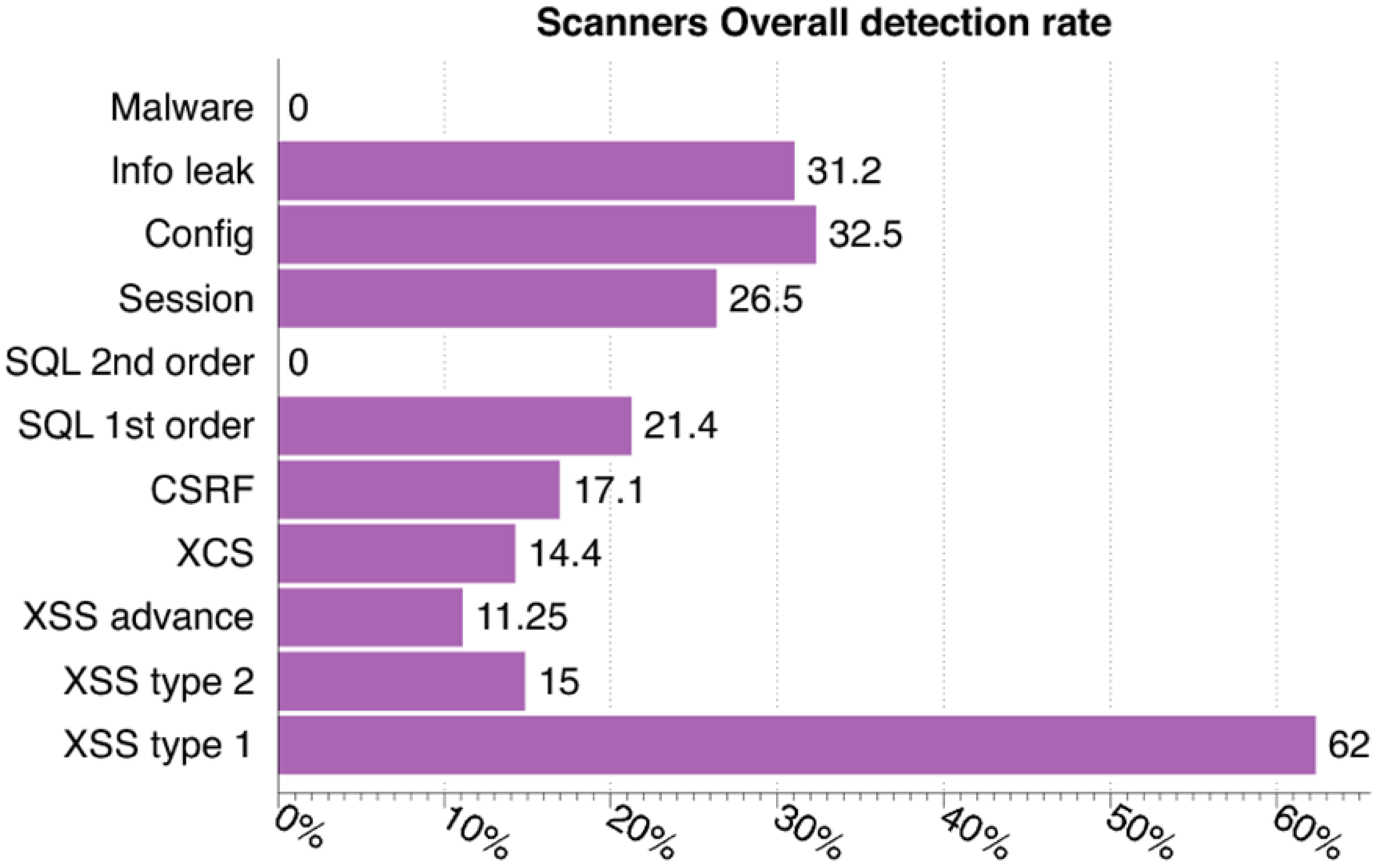
Performance did not correlate well with vulnerability detection

Scanner Page Coverage



% Successful Link Traversals By Technology, Averaged over all Scanners

Vulnerability Detection

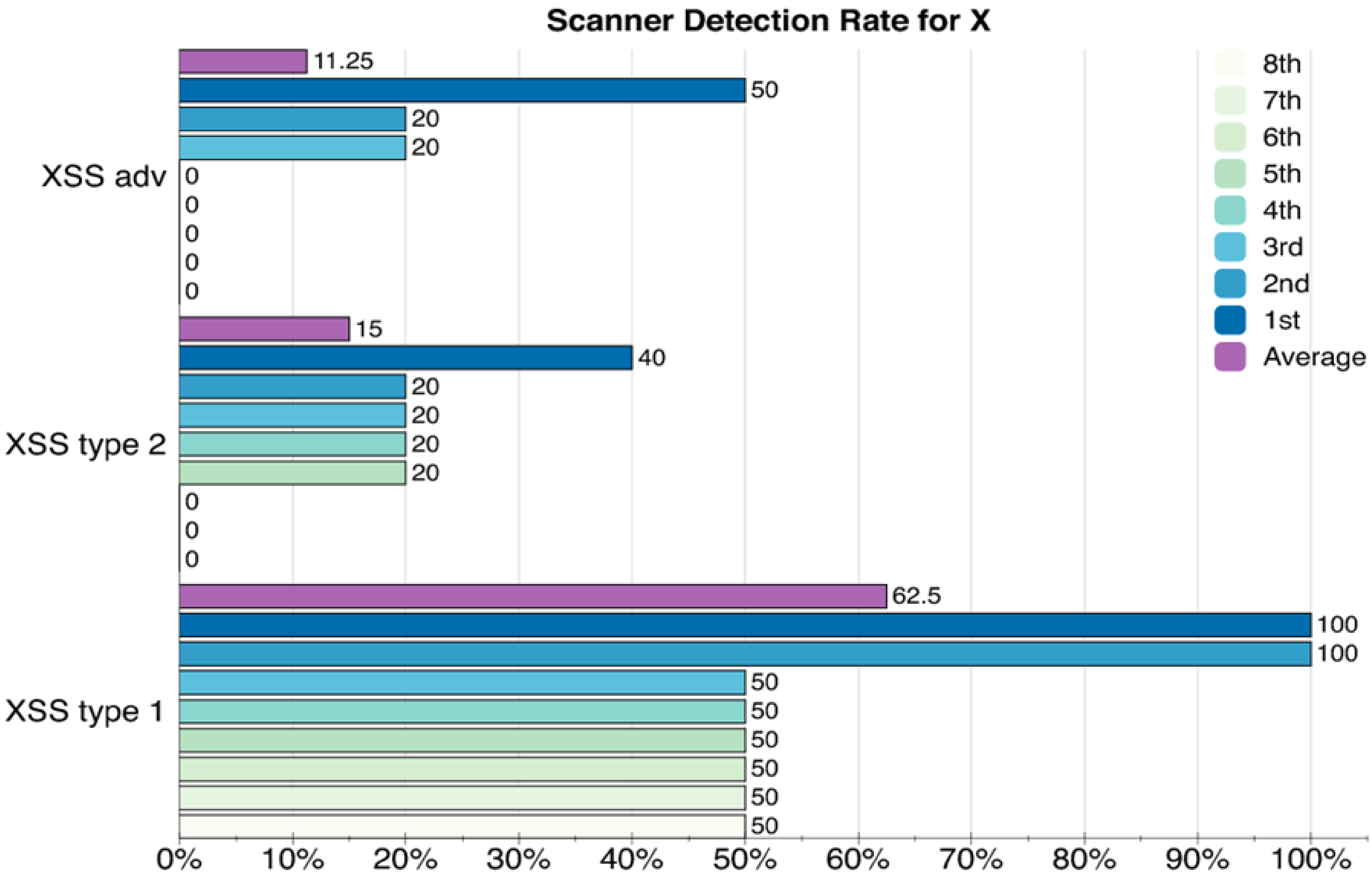


Context?

XSS Testbed

- Type 1: Textbook “Reflected” Vulnerability
  - User input, http header → page w/o sanitization
- Type 2: Stored Vulnerability
  - User input → DB → Served Page
  - Some viewable only by different user
- Advanced
  - Novel Tags: e.g. <object>, <prompt>
  - Novel Channels:
    - URL → $_SERVER['PHP_SELF']
    - Filename → error msg,

XSS Results



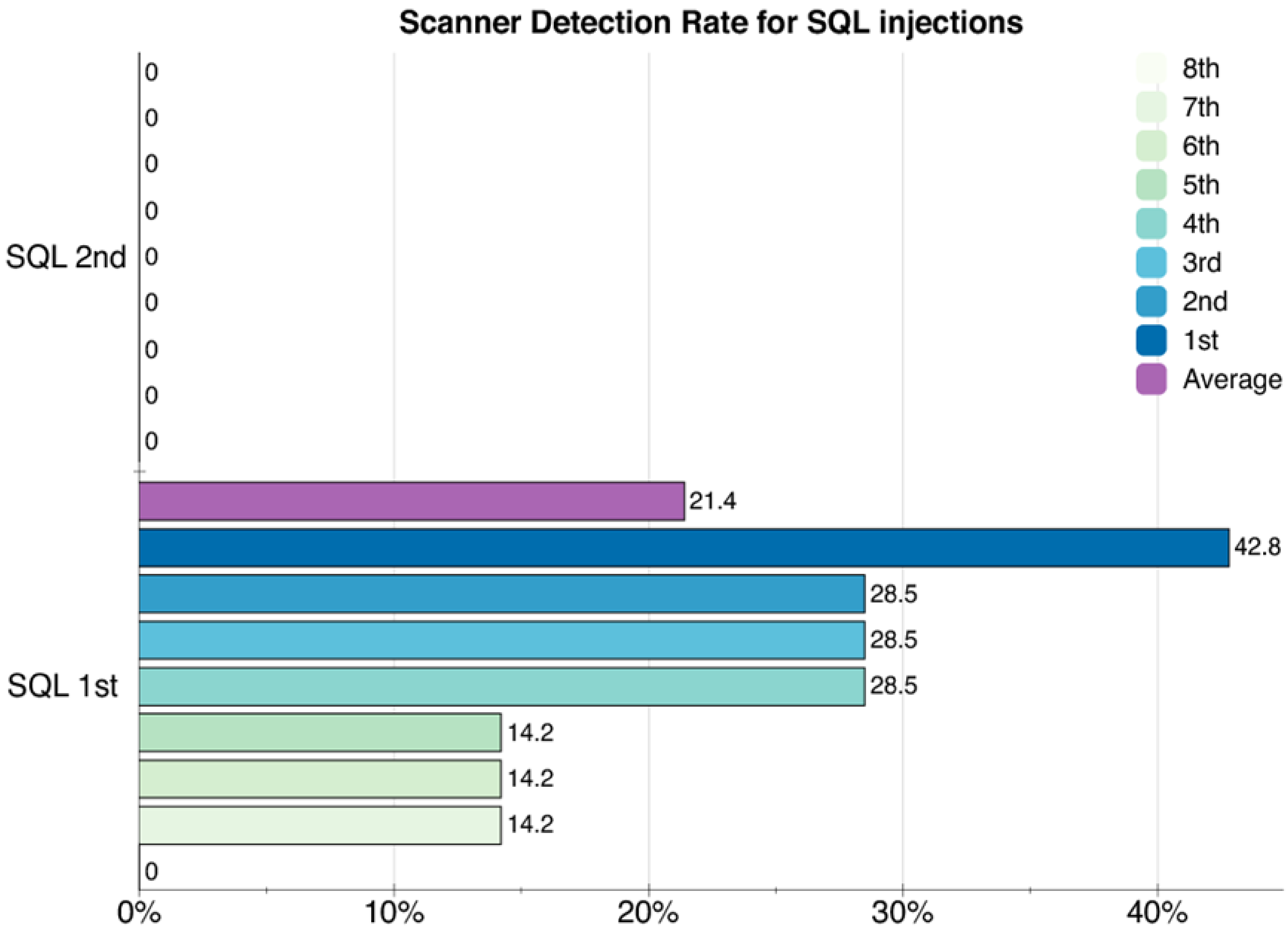
Anecdote about Type 2

SQLI Testbed

- Type 1: User input → SQLI on page generation
  - Basic: ‘ ; --
  - Advanced: “, LIKE, UNION

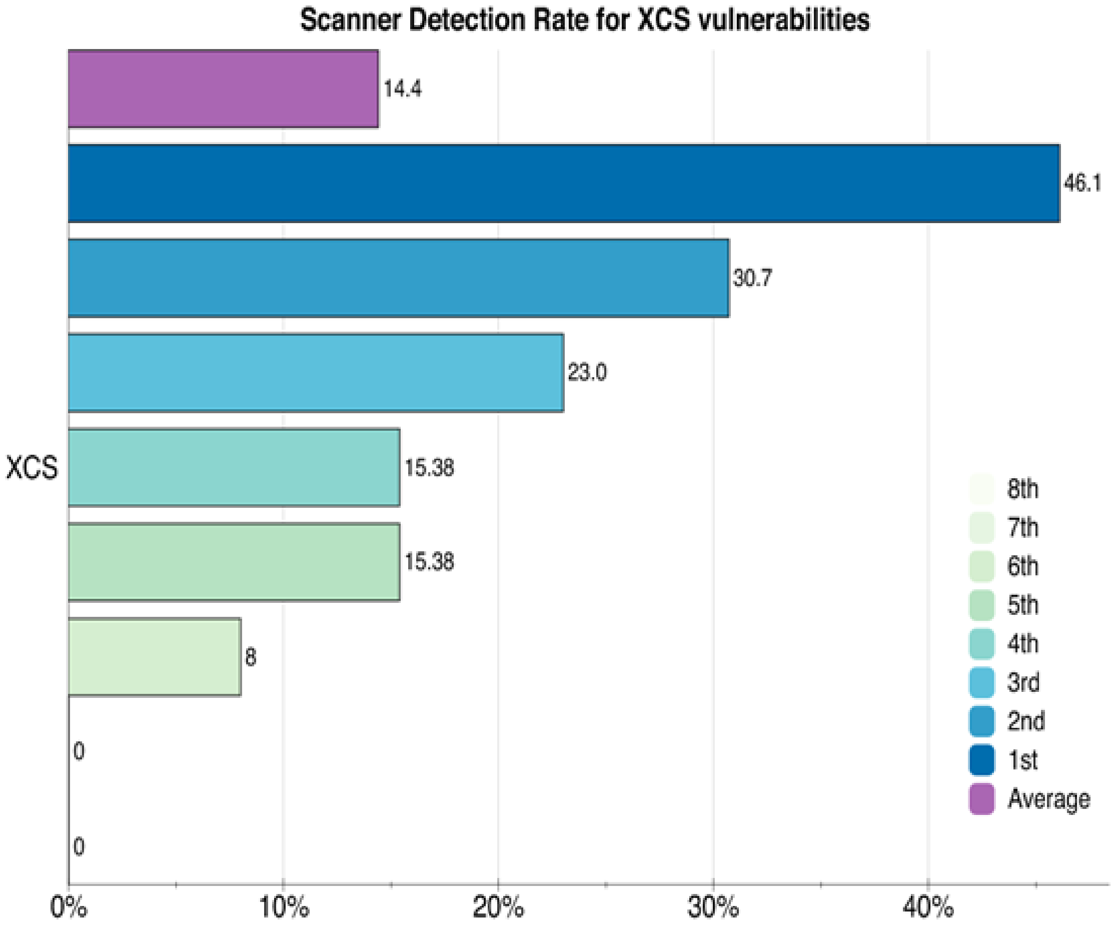
- Type 2: Input → DB → SQL Query
  - Only basic cases
  - Unsanitized form input (username) → DB, later used in SQL query

SQLI Results



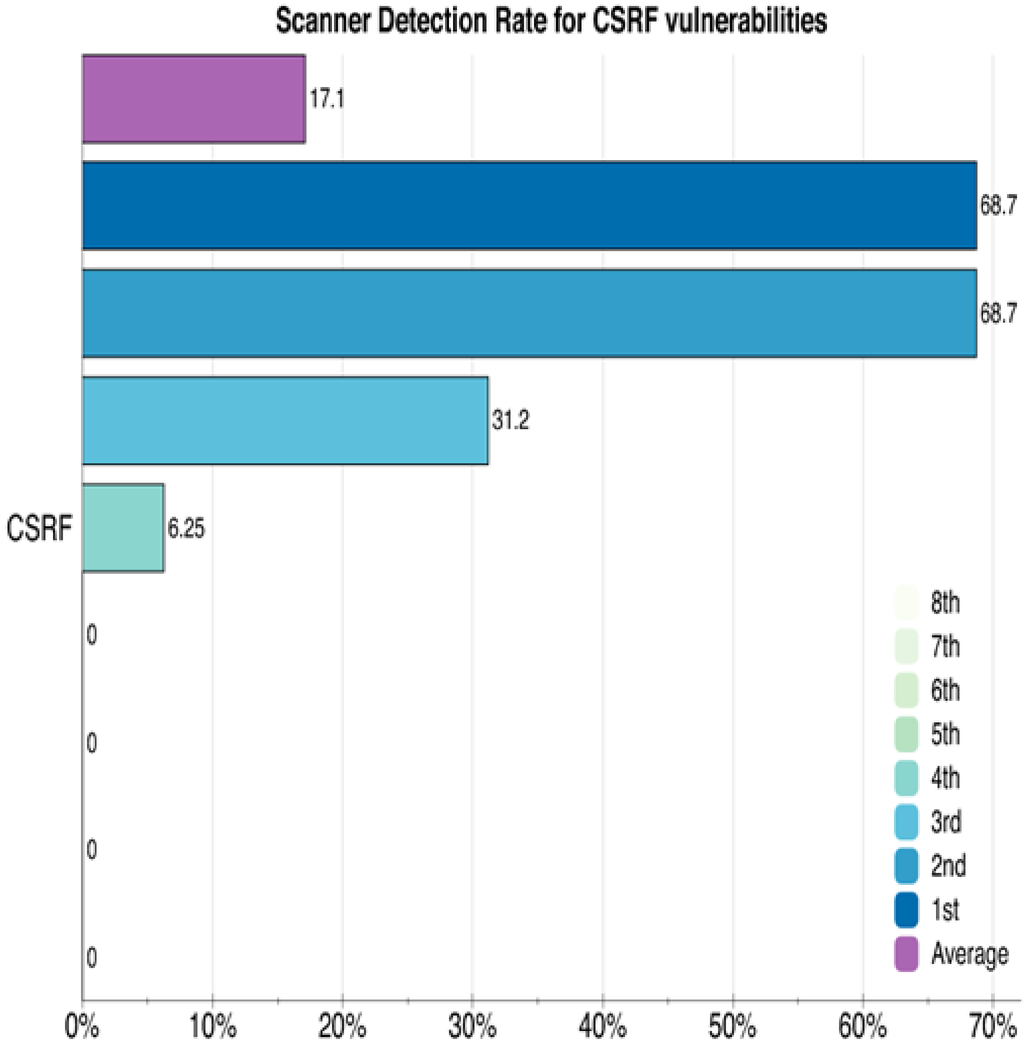
XCS Results

- Code Injection by Attacker
- Manipulate server or client browser
- Tests:
  - o XPATH injection
  - o Malicious File Upload
  - o Direct Object Ref
  - o Cross-Frame Scripting
  - o Open Redirects
  - o Server Side Includes
  - o Header Injection
  - o Flash Parameter Inject
  - o SMTP Injection



CSRF Results

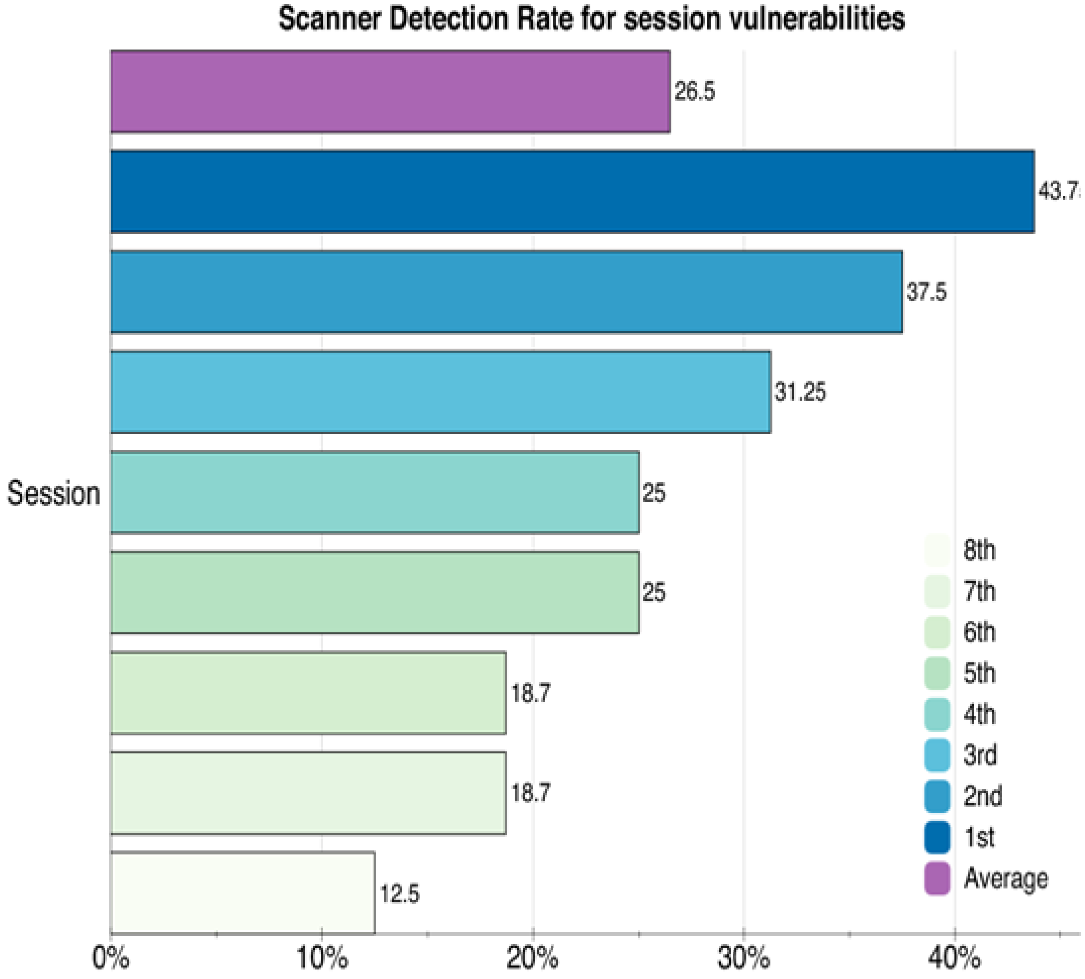
- Post-login forms
  - w/o hidden random token
  - with weak [0,9] token
  - with same token each time
- JSON Hijacking
  - No session id sent with AJAX request for sensitive data
- Anecdote: Told by one vendor CSRF not checked on purpose



Session Management

- Login / form errors
  - Login form not https
  - Reg. credentials in clear
  - Autocomplete pwd field
  - Weak pwds and pwd recovery question
  - Weak reg. page CAPTCHA

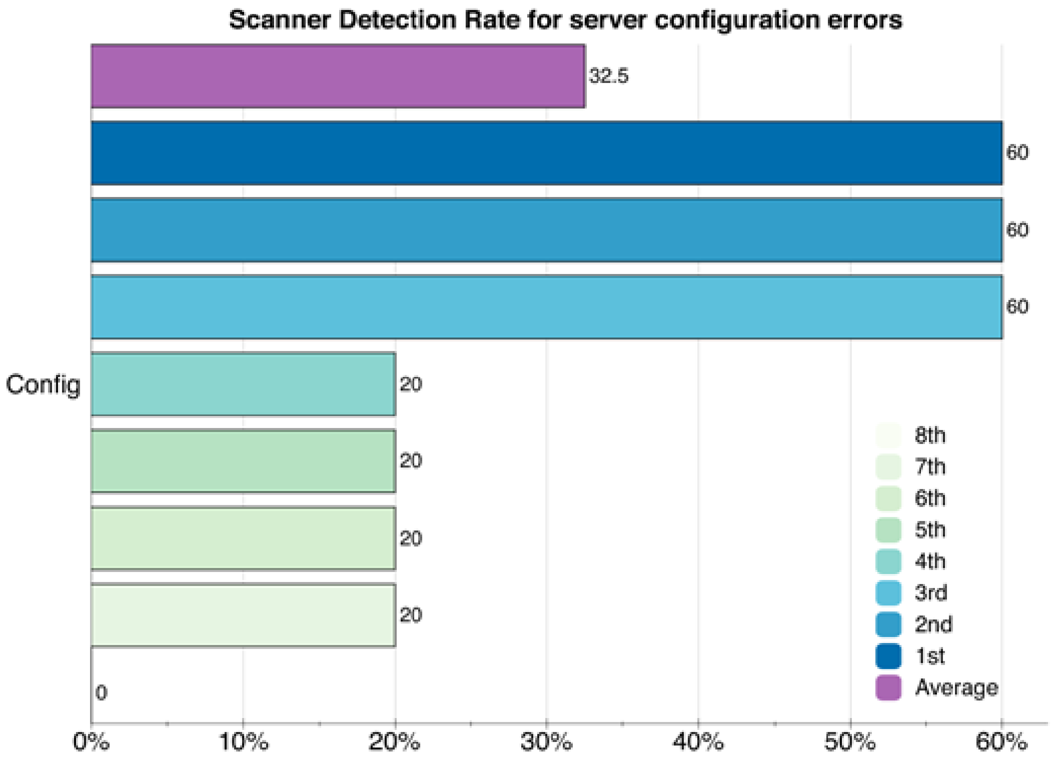
- Cookie errors
  - Not HttpOnly
  - Auth tokens not https
  - Persistent Auth token value MD5 (pwd)
  - Logout fails to clear cookie
  - Path restriction to '/'



Server/Crypto Mis-Config

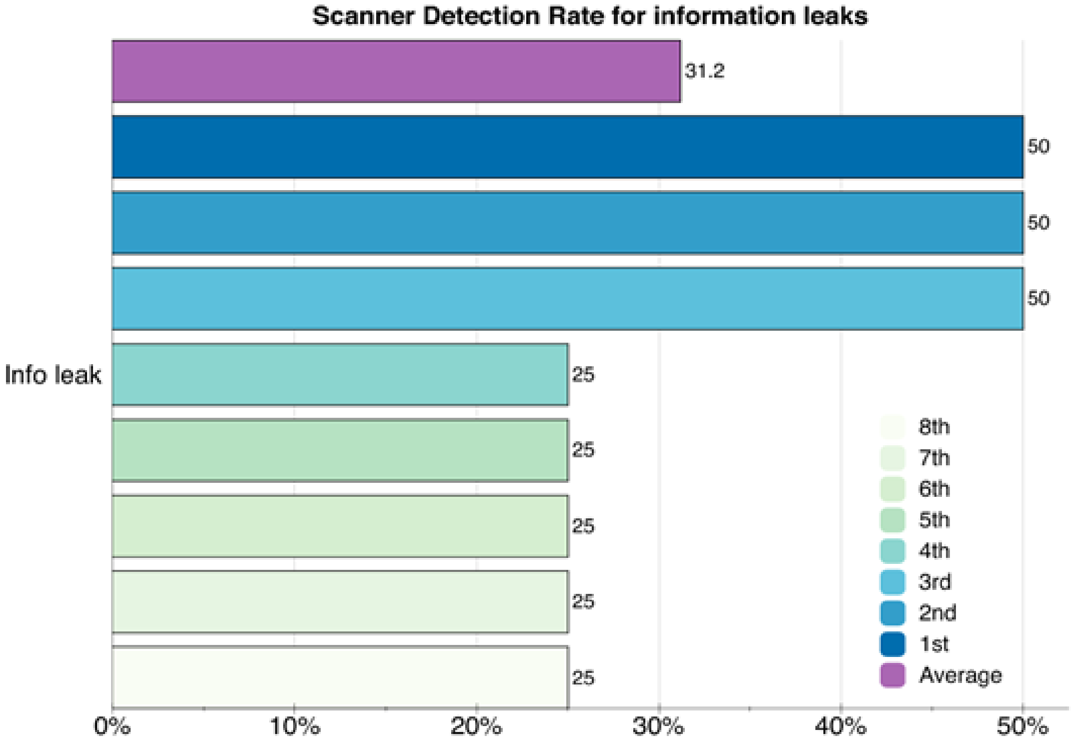
- Server Mis-Config:
  - HTTP Trace enabled
  - open_basedir not set in php
  - allow_url_fopen set in php

- Crypto Mis-Config
  - Self Signed Cert
  - Weak SSL Cipher



Info Leak

- SQL error message
- Username existence
- Backup files
- Comment/Path Disclosure
- Path Traversal
  - Inclusion of /etc/secret.txt



Scanner Detection Rate for information leaks

Malware Presence

- JavaScript key-logger on login page

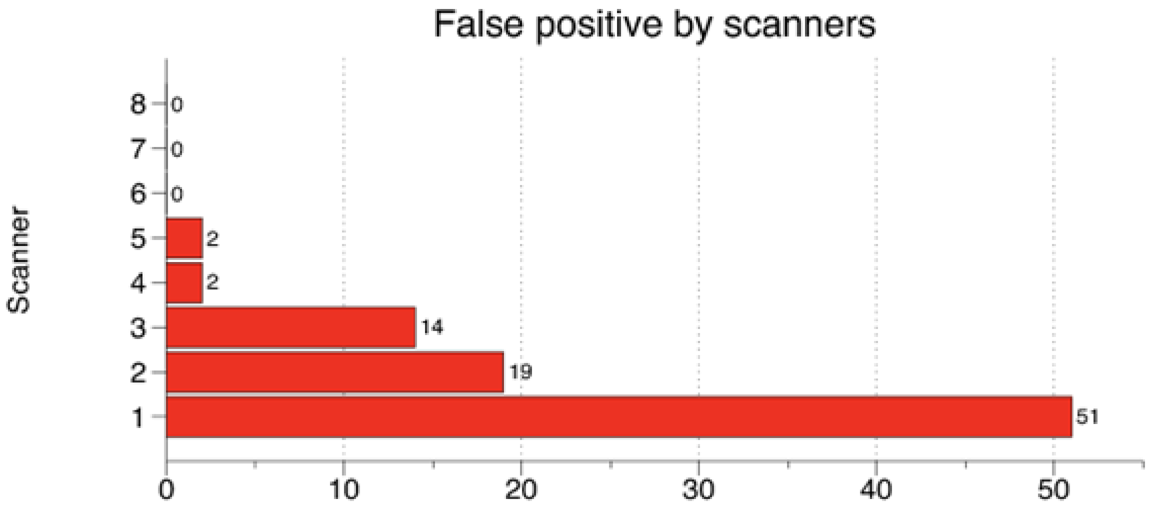
- Malicious graphic uploaded by user
  - .jpg with appended PHP
  - Directly reference-able

- No Scanner Detected
  - Because not part of PCI compliance?

False Positives

- Testbed Traps
  - alert()s as site behavior (not part of injection)
    - Scanners avoided
  - Benign (not-executed) region within <script> tags
    - Tripped 2 scanners (reported 1 and 13 times)

- On a testbed of ~90 confirmed vulnerabilities



- Some scanners with low false positive rates also had high relative detection rates

Observations

- No individual scanner tops across all categories
  - Best XSS, SQLI → Bottom 3 Session Management
  - Top 3 Session Management → Found 0 SQLI
  - Rough break along XSS/SQLI/XCS and Session/Config/Info lines

- Scanners exist :
  - High Detection Rate, Low False Positive Rate
  - Low Detection Rate, High False Positive Rate
  - Low Detection Rate, Low False Positive Rate

Conclusions 1

- XSS, SQLI, XCS, Info Leak most common “in-the-wild”
- Black Box Scanner "effort" roughly proportional to this

- Can improve coverage of technologies like Flash, SL

- Scanners relatively adept at detecting
  - Historical vulnerabilities
  - Textbook XSS and SQLI
  - Info Leak, Session, and Server/Crypto Mis-config
    - Easier test vectors to write/interpret

Conclusions 2

- Can stand improvement on
  - CSRF, Malware, XCS
    - Low test vector count → Not vendor focus?
  - Advanced (novel) forms of XSS, SQLI
    - Faster reactive process
  - Stored forms of XSS, SQLI (acknowledged by a CTO)
    - Better DB modeling