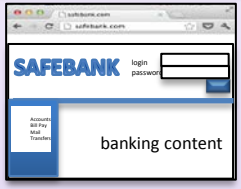
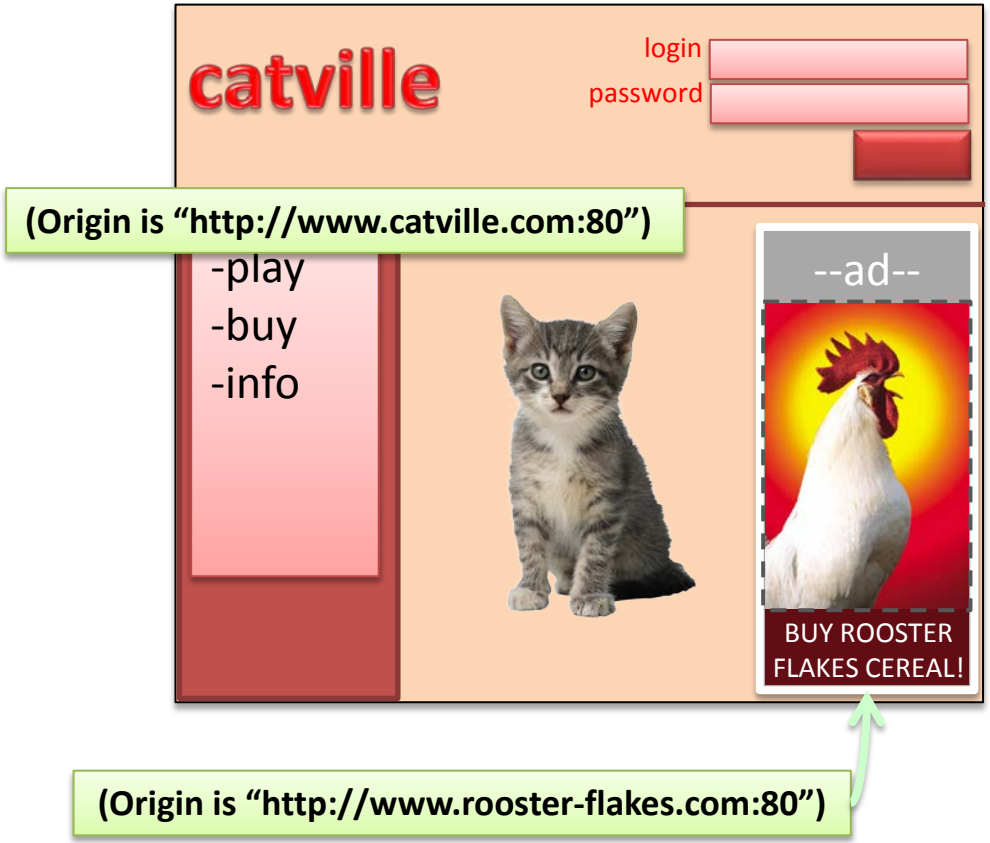
Web Security: Vulnerabilities & Attacks

Operating system	Web Browser
	
Primitives:	
– Processes – System calls – File system	– Frames – Content (including JavaScript, …) – Document object model, cookies, localStorage
Principals:	
Users – Discretionary access control	“Origins” – Mandatory access control
Vulnerabilities:	
– Buffer overflow – Root exploit	– Cross-site scripting – Cross-site request forgery – Cache history attacks

Browser security mechanism

- Each frame of a page has an origin
  - Origin = protocol://host:port
- Frame can access its own origin
  - Network access, Read/write DOM, Storage (cookies)
- Frame cannot access data associated with a different origin



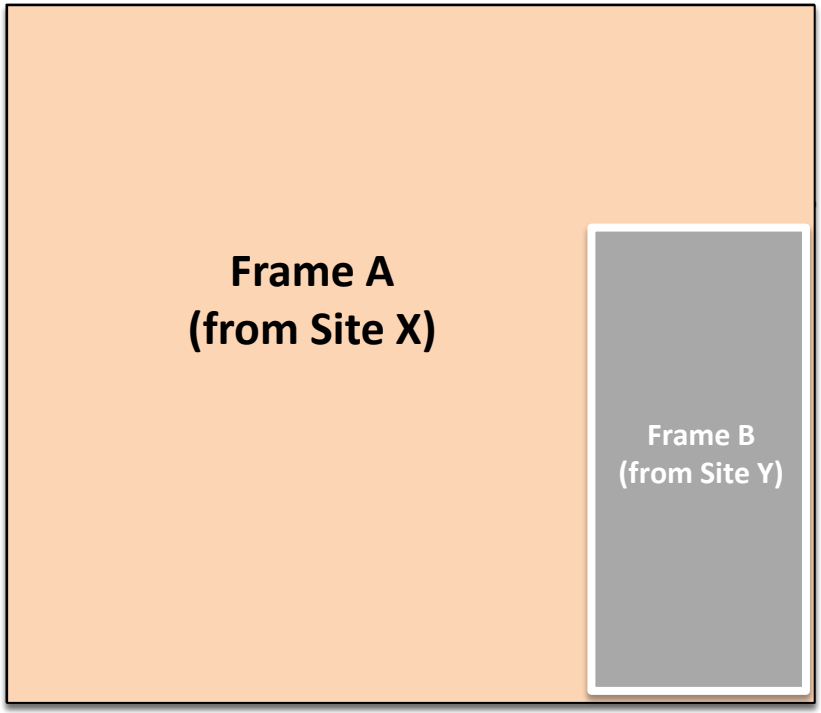
Components of browser security policy

Frame-Frame relationships

- *canScript(A,B)*
  - Can **Frame A** execute a script that manipulates arbitrary/nontrivial DOM elements of **Frame B**?
- *canNavigate(A,B)*
  - Can **Frame A** change the origin of content for **Frame B**?

Frame-principal relationships

- *readCookie(A,S), writeCookie(A,S)*
  - Can **Frame A** read/write cookies from **Site Y**?



Origin of Browser Primitives

Cookies

Setting Cookies:

Default origin is **domain** and **path** of setting URL

Javascript

Imported **in** a page or frame:

Has the **same origin** as **that** page or frame

Embedded **in** a page or frame:

Has the **same origin** as **that** page or frame

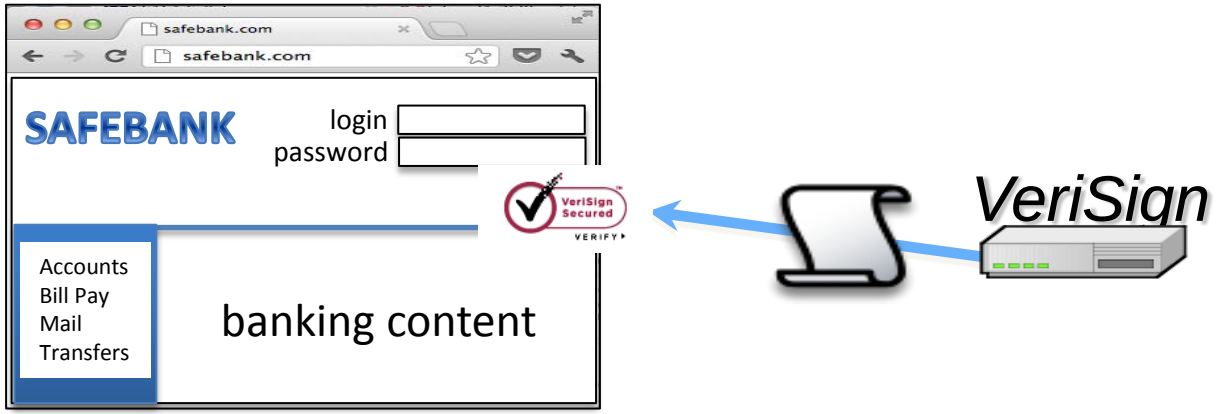
DOM

Each frame of a page:

Origin is **protocol**://**host**:**port**

Library import

```
<script
   src=https://seal.verisign.com/getseal?host_name=safebank.com>
</script>
```



- Script has privileges of imported page, NOT source server.
- Can script other pages in this origin, load more scripts
- Other forms of importing

Same-origin policy

Goal: To isolate content retrieved by different parties

Same-origin policy for Javascript/DOM

Two documents have the same origin if:

- Same **protocol** (https, http, ftp, etc)
- Same **domain** (safebank.com, etc)
- Same **port** (80, 23, 8080, etc)

Results of same-origin checks against
"http://cards.safebank.com/c1/info.html"

Same origin:
"http://cards.safebank.com/c2/edit.html"

Different origin:
"http://www.cards.safebank.com"
"http://catville.com"
"https://cards.safebank.com"
"http://cards.safebank:8080"

* any domain-suffix or URL-hostname, except Top Level Domain

Results of same-origin checks against
"http://cards.safebank.com/c1/info.html"

Same origin:
example: host="cards.safebank.com"
"http://cards.safebank.com/c2/edit.html"

allowed domains:
cards.safebank.com
.safebank.com

disallowed domains:
tos.safebank.com
catville.com
.com

Different origin:
"http://www.cards.safebank.com" (another domai
"http://catville.com" (another domain)
"https://cards.safebank.com" (another protocol)
"http://cards.safebank:8080" (another port)

** however, cookies can be accessed across different paths via the DOM

There are some exceptions to this rule.
(for example, a document can change its domain to be any suffix of its domain, evil.catville.com -> catville.com)

Same-origin policy for Cookies

Two documents have the same origin if:

- Same **protocol** (optional) (https, http, ftp, etc)
- Same **domain *** (safebank.com, etc)
- Same **Path **** (/, /c1/, etc)

There is no single same-origin policy

Same-origin policy

Goal: To isolate content retrieved by different parties

Same-origin policy for Javascript/DOM

Two documents have the same origin if:

- Same **protocol** (https, http, ftp, etc)
- Same **domain** (safebank.com, etc)
- Same **port** (80, 23, 8080, etc)

Results of same-origin checks against "http://cards.safebank.com/c1/info.html"

Same origin:
"http://cards.safebank.com/c2/edit.html"

Different origin:
"http://www.cards.safebank.com"
"http://catville.com"
"https://cards.safebank.com"
"http://cards.safebank:8080"

Same-origin policy for Cookies

Two documents have the same origin if: (optional)

- Same **protocol** (https, http, ftp, etc)
- Same **domain *** (safebank.com, etc)
- Same **Path **** (/, /c1/, etc)

host="cards.safebank.com"

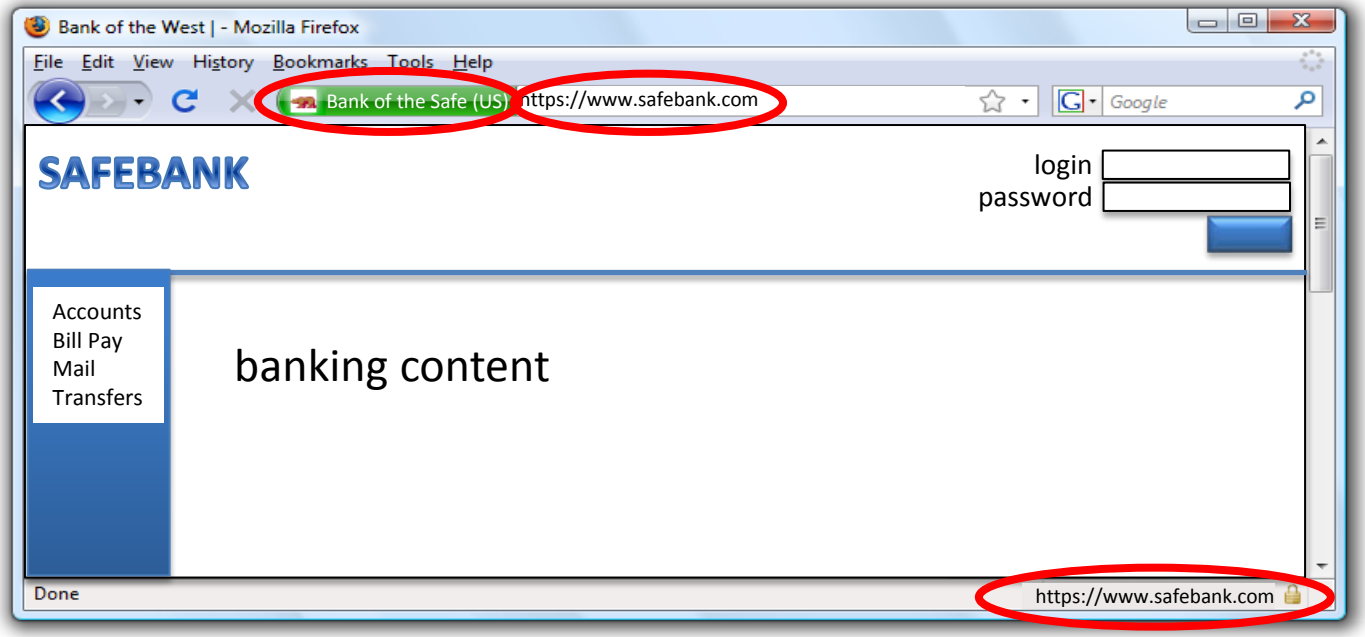
allowed domains:	**disallowed domains:**
cards.safebank.com	tos.safebank.com
.safebank.com	catville.com
	.com

** however, cookies can be accessed across different paths via the DOM

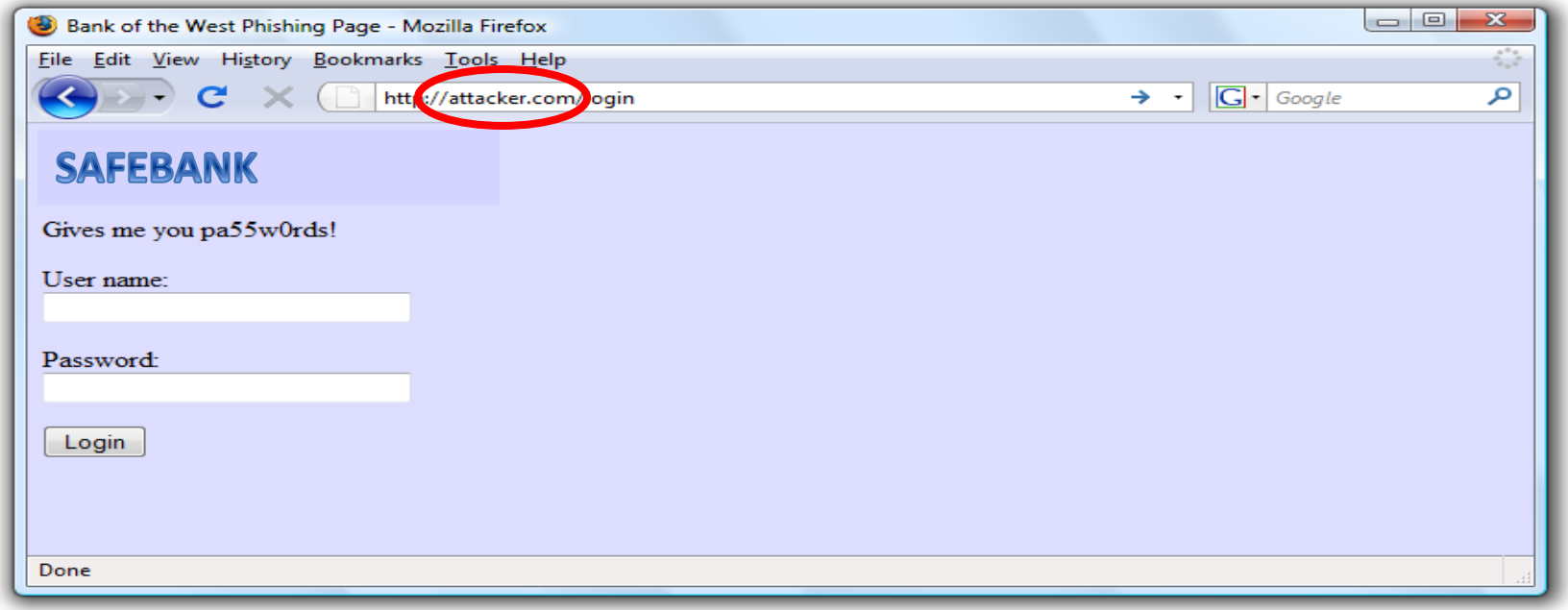
There is no single same-origin policy

Security User Interface

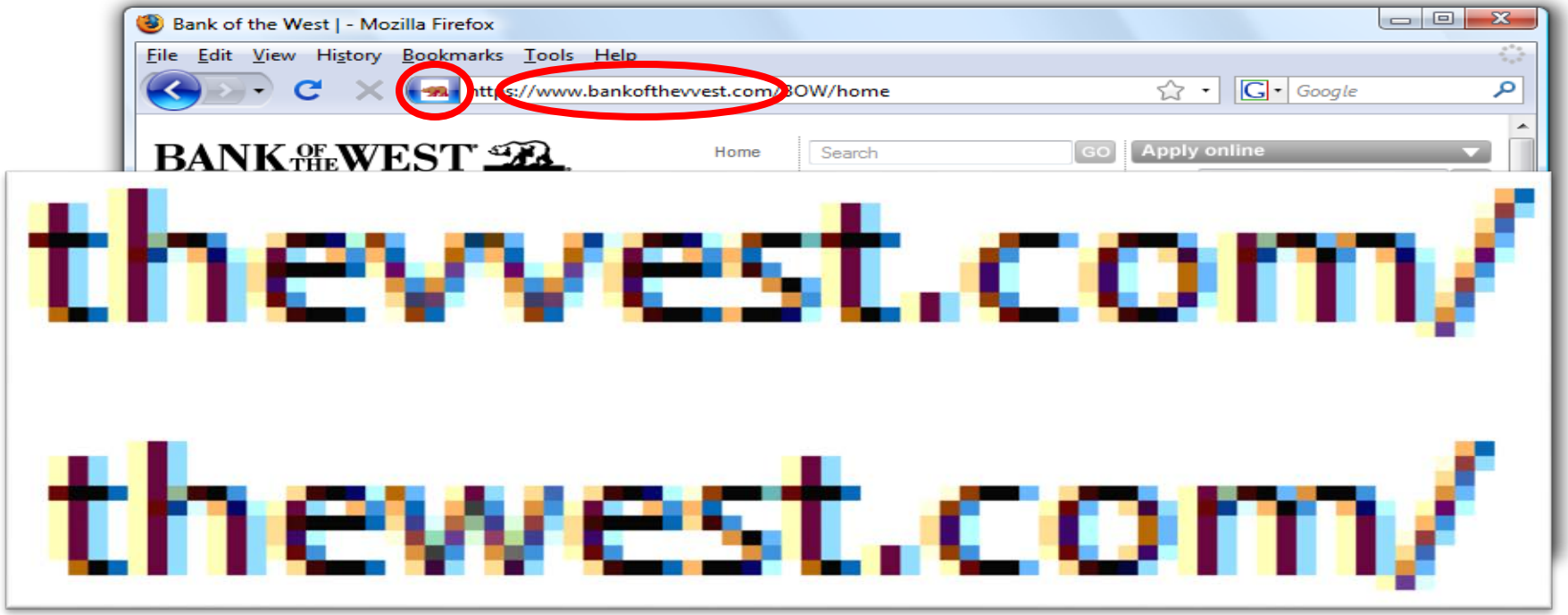
Safe to type your password?



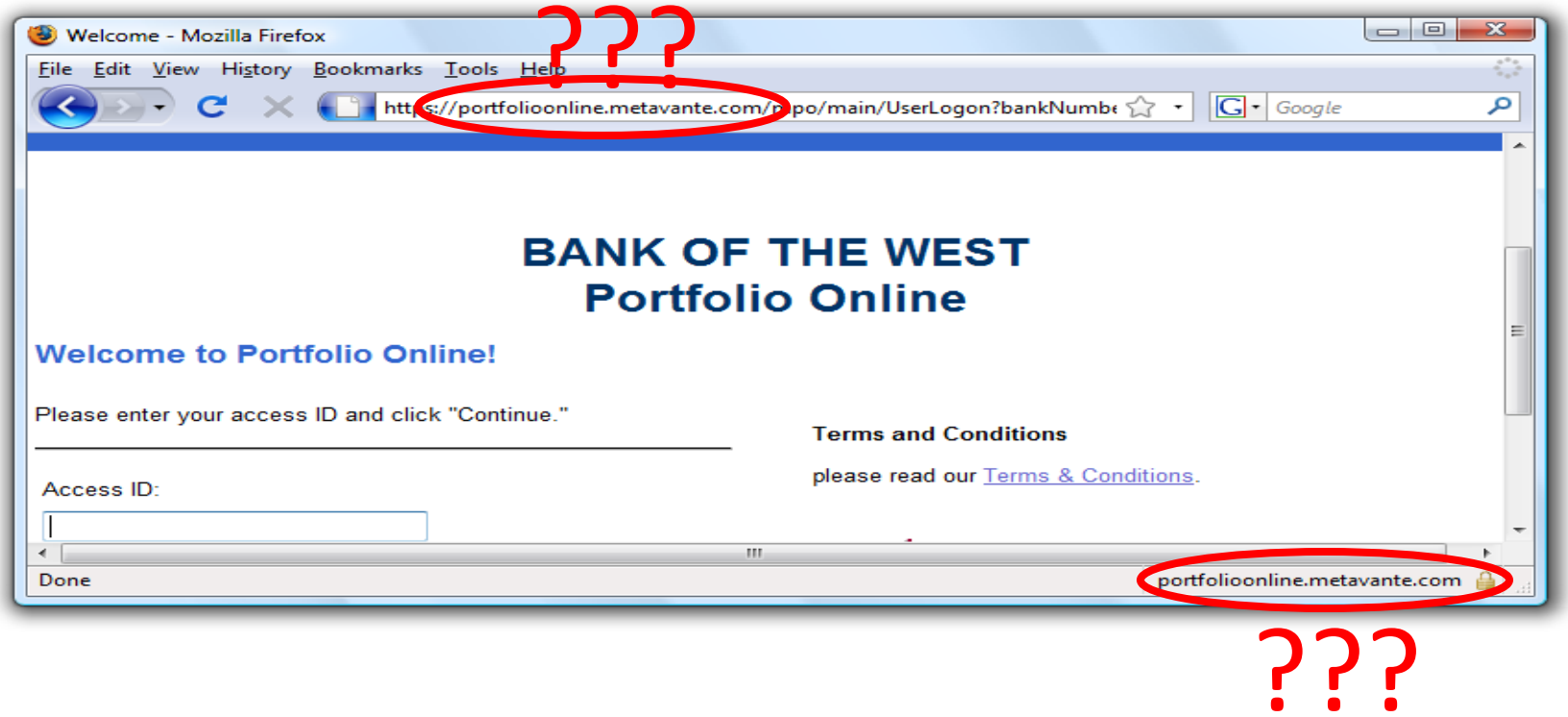
Safe to type your password?



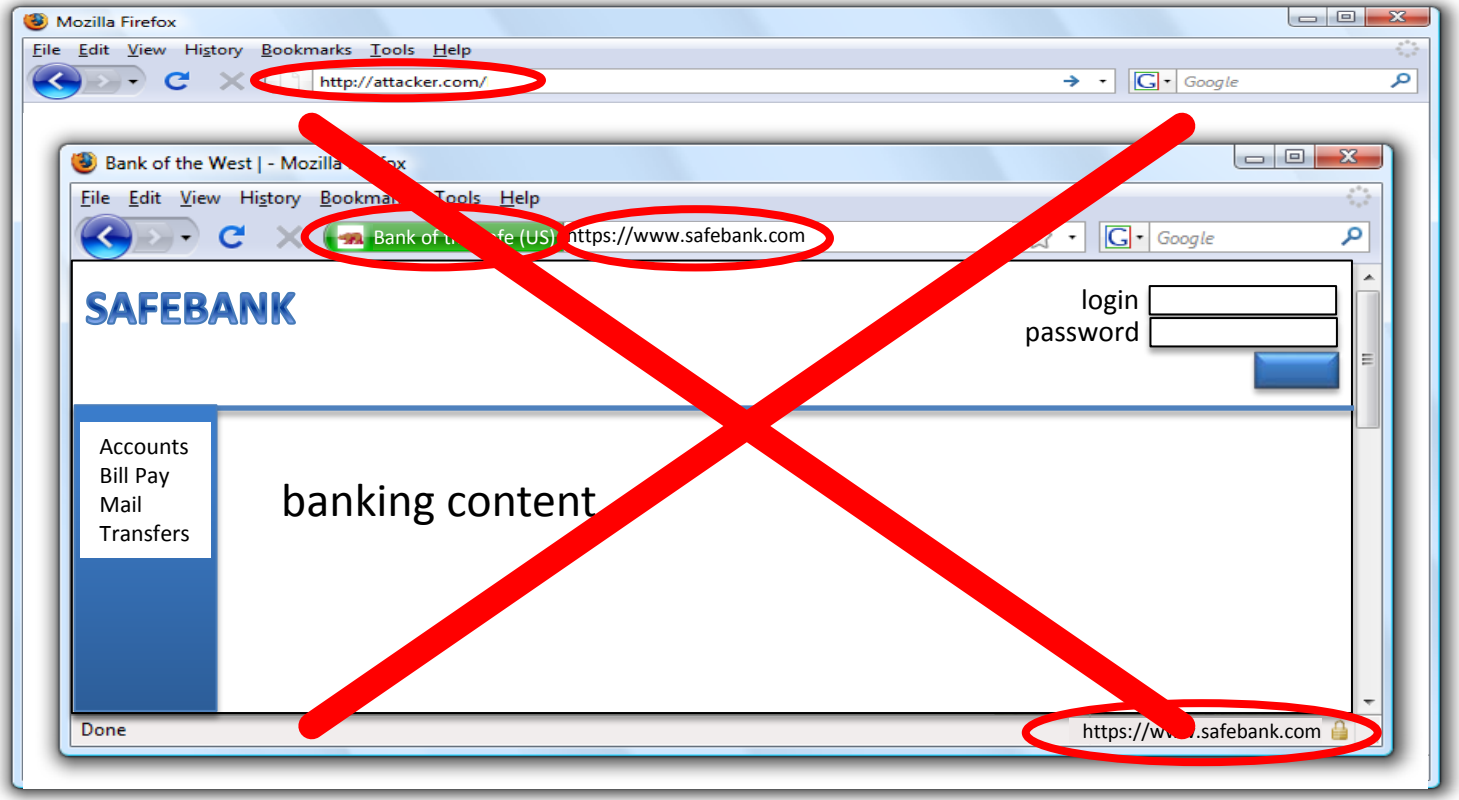
Safe to type your password?



Safe to type your password?



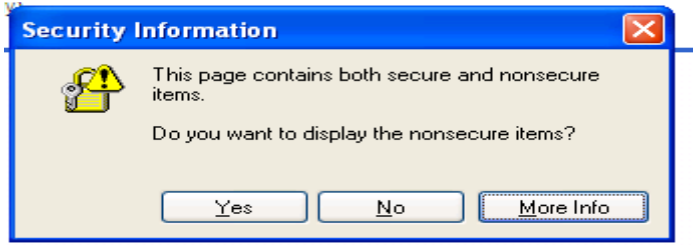
Safe to type your password?

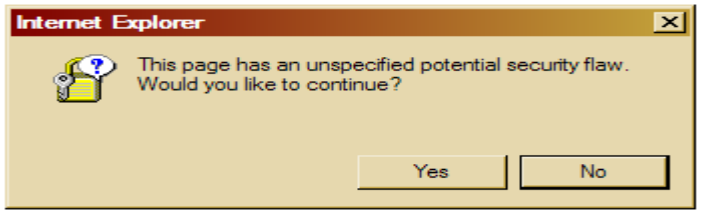


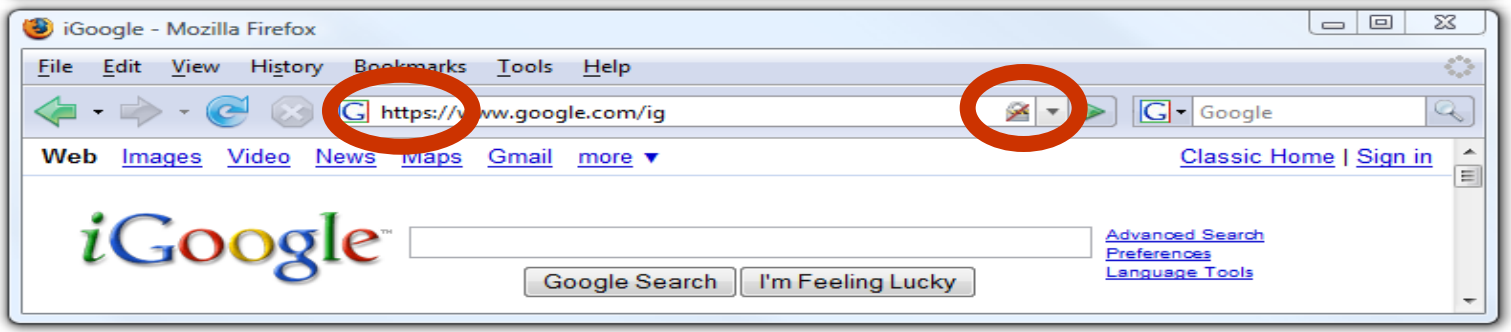
Mixed Content: HTTP and HTTPS

- Problem
  - Page loads over HTTPS, but has HTTP content
  - Network attacker can control page
- IE: displays mixed-content dialog to user
  - Flash files over HTTP loaded with no warning (!)
  - Note: Flash can script the embedding page
- Firefox: red slash over lock icon (no dialog)
  - Flash files over HTTP do not trigger the slash
- Safari: does not detect mixed content

Mixed Content: HTTP and HTTPS







Mixed content and network attacks

- banks: after login all content over HTTPS
  - Developer error: Somewhere on bank site write

```
<script src=http://www.site.com/script.js> </script>
```

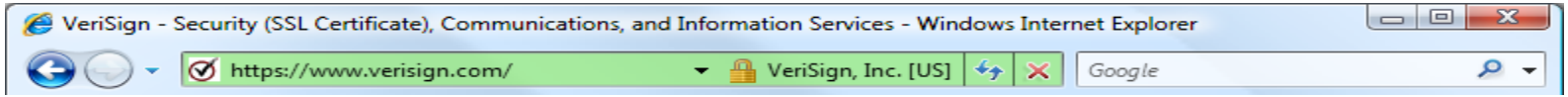
  - Active network attacker can now hijack any session
- Better way to include content:

```
<script src=//www.site.com/script.js> </script>
```

  - served over the same protocol as embedding page

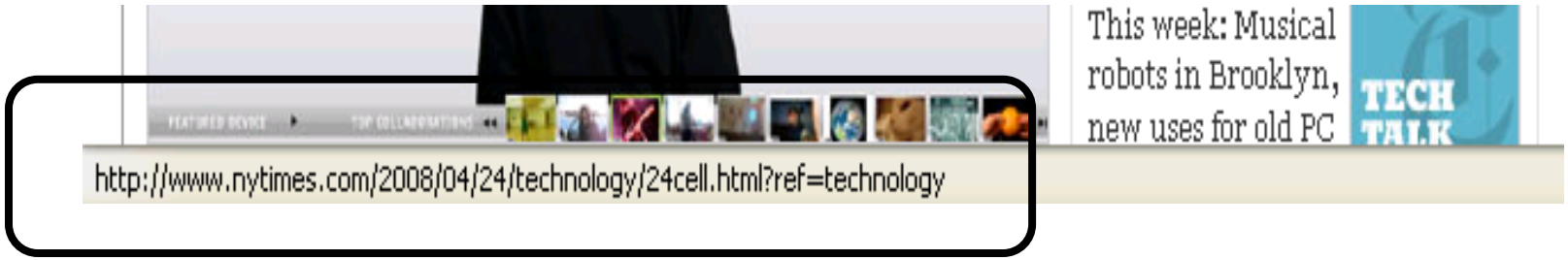
Lock Icon 2.0

- Extended validation (EV) certs



- Prominent security indicator for EV certificates
- note: EV site loading content from non-EV site does not trigger mixed content warning

Finally: the status Bar



- Trivially spoofable

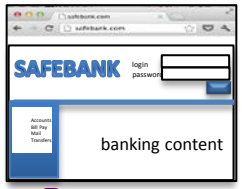
```
<a href="http://www.paypal.com/"
        onclick="this.href = 'http://www.evil.com/';">
    PayPal</a>
```

Cookies

Slides credit: John Mitchell

Cookies

- Used to store state on user's machine



Browser

POST …

HTTP Header:

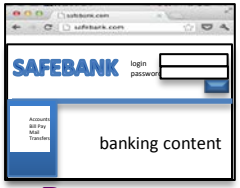
Set-cookie: NAME=VALUE ;

domain = (who can read) ;

expires = (when expires) ;

secure = (only over SSL)

If expires=NULL:
this session only



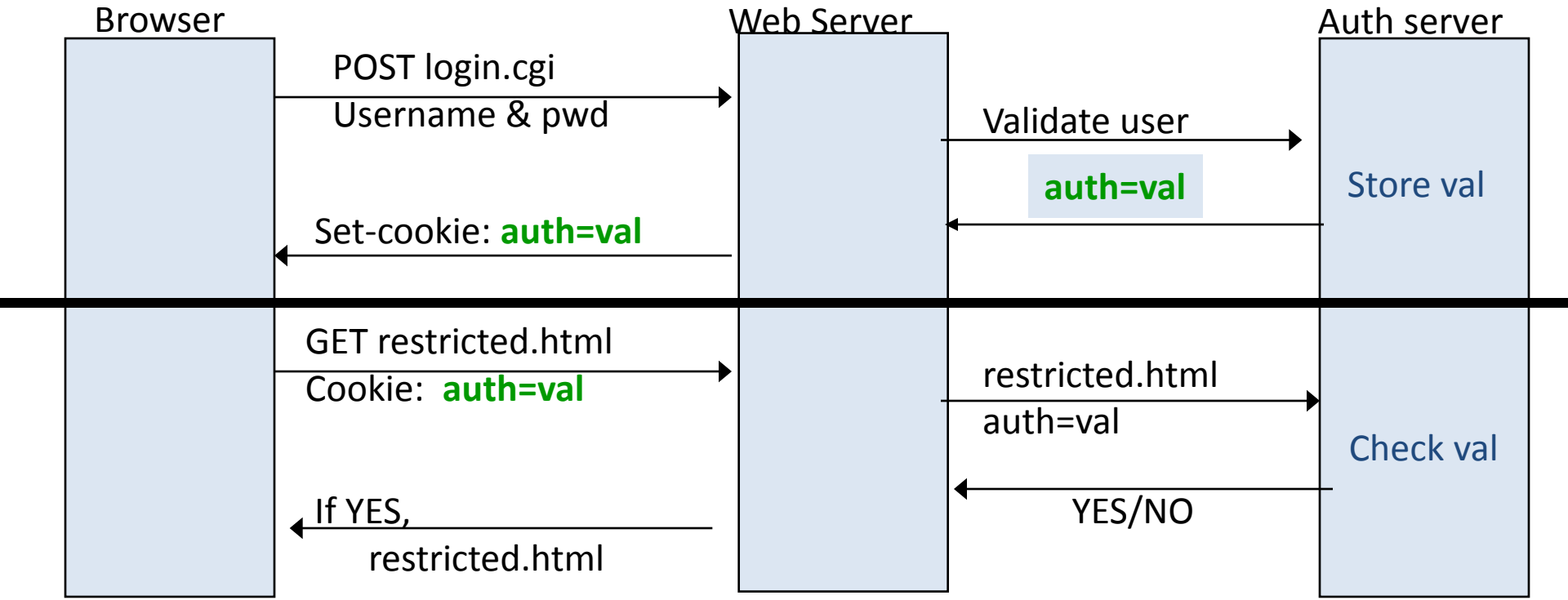
Browser

POST …

Cookie: NAME = VALUE

Important Point: HTTP is a stateless protocol; cookies add state

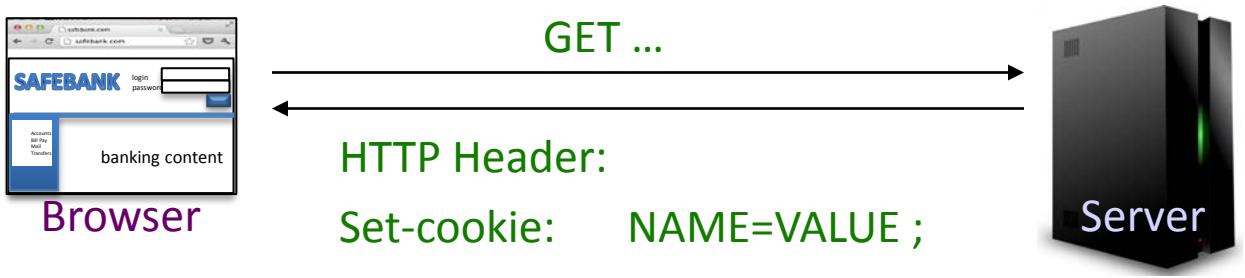
Cookie authentication



Cookie Security Policy

- Uses:
  - User authentication
  - Personalization
  - User tracking: e.g. Doubleclick (3rd party cookies)
- Browser will store:
  - At most 20 cookies/site, 3 KB / cookie
- Origin is the tuple **<domain, path>**
  - Can set cookies valid across a domain suffix

Secure Cookies



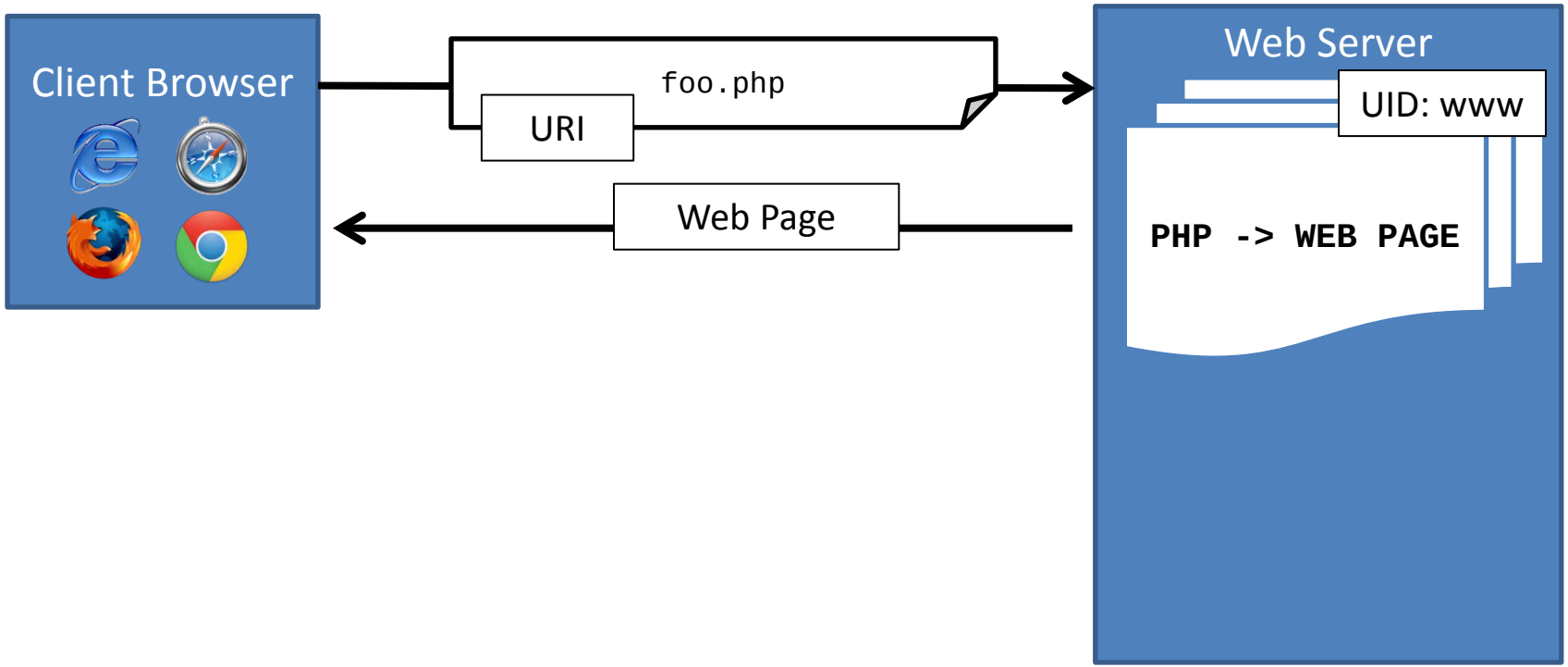
- Provides confidentiality against network attacker
  - Browser will only send cookie back over HTTPS
- … but no integrity
  - Can rewrite secure cookies over HTTP

    $\Rightarrow$ network attacker can rewrite secure cookies

    $\Rightarrow$ can log user into attacker's account

Command Injection

Background


Client Browser
foo.php
URI
Web Page
Web Server
UID: www
PHP -> WEB PAGE

Quick Background on PHP

```
display.php: <? echo system("cat ".$_GET['file']); ?>
```

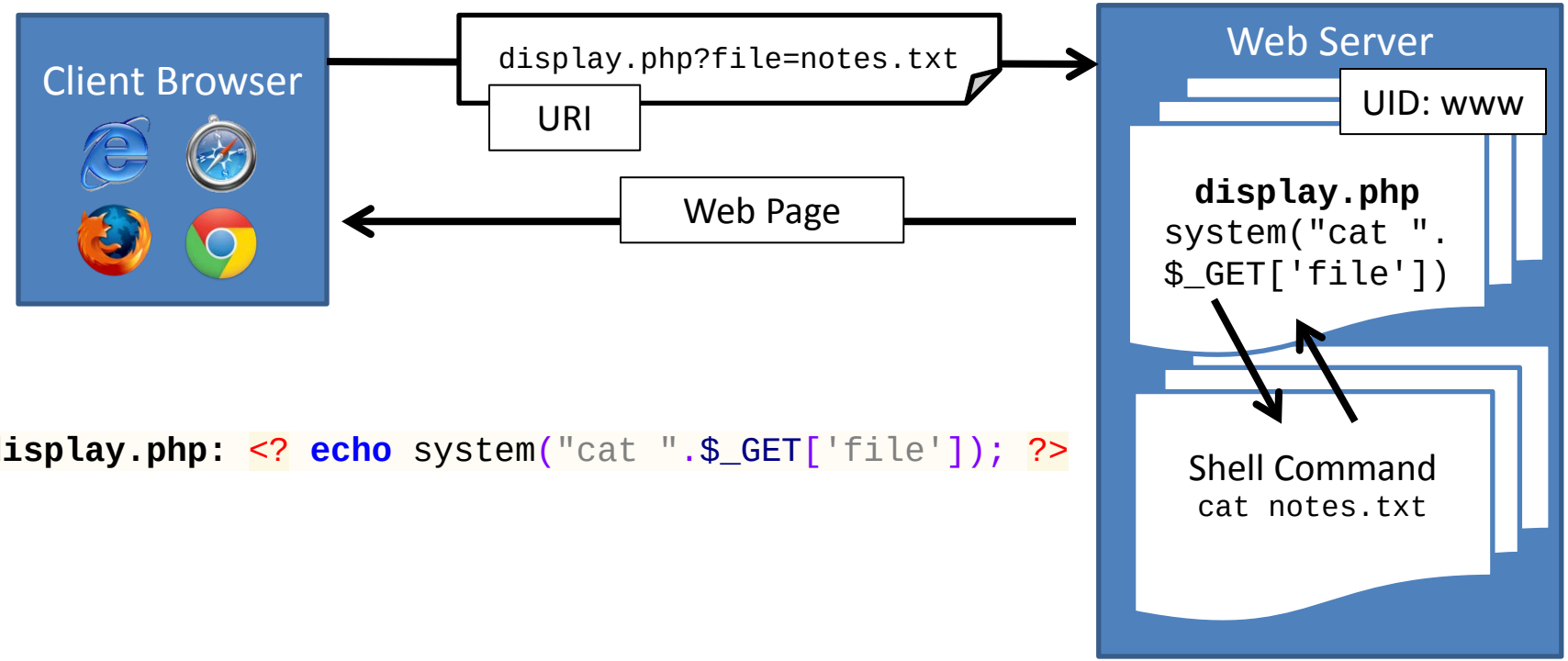
IN THIS EXAMPLE

<? *php-code* ?>	executes php-code at this point in the document
echo expr:	evaluates expr and embeds in doc
system(call, args)	performs a system call in the working directory
" ….. ", ' ….. '	String literal. Double-quotes has more possible escaped characters.
.	(dot). Concatenates strings.
_GET['key']	returns *value* corresponding to the *key/value* pair sent as extra data in the HTTP GET request

LATER IN THIS LECTURE

preg_match(Regex, Stiring)	Performs a regular expression match.
proc_open	Executes a command and opens file pointers for input/output.
escapeshellarg()	Adds single quotes around a sring and quotes/escapes any existing single quotes.
file_get_contents(file)	Retrieves the contents of file.

Background



display.php: `<? echo system("cat ".$_GET['file']); ?>`

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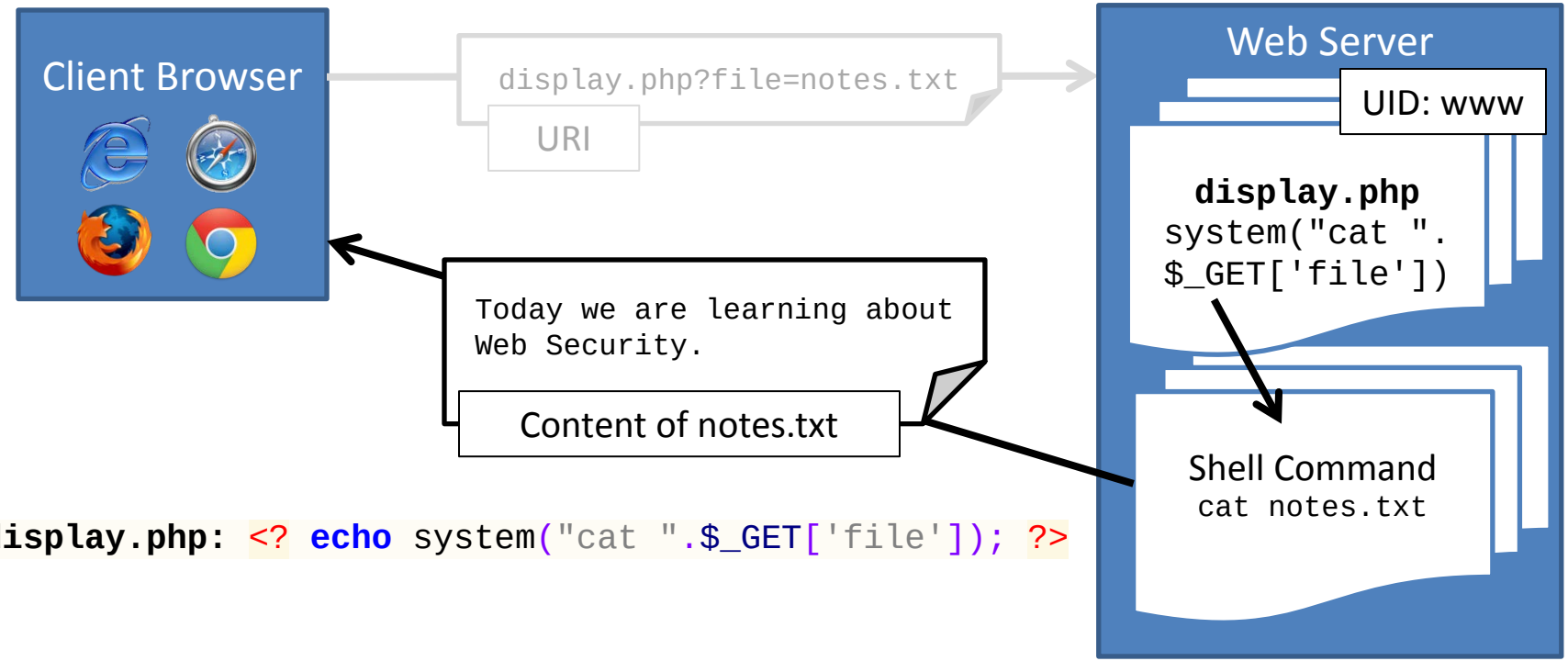

display.php: `<? echo system("cat ".$_GET['file']); ?>`

Command Injection

display.php: `<? echo system("cat ".$_GET['file']); ?>`

Q: Assuming the script we've been dealing with (reproduced above) for `http://www.example.net/display.php`. Which one of the following URIs is an attack URI?
Hint: Search for a URI Decoder to figure out values seen by the PHP code.

a. `http://www.example.net/display.php?get=rm`
b. `http://www.example.net/display.php?file=rm%20-rf%20%2F%3B`
c. `http://www.example.net/display.php?file=notes.txt%3B%20rm%20-rf%20%2F%3B%0A%0A`
d. `http://www.example.net/display.php?file=%20%20%20%20%20`

Command Injection

```
display.php: <? echo system("cat ".$_GET['file']); ?>
```

Q: Assuming the script we've been dealing with (reproduced above) for `http://www.example.net/display.php`. Which one of the following URIs is an attack URI?
Hint: Search for a URI Decoder to figure out values seen by the PHP code.

(URIs decoded)

a. `http://www.example.net/display.php?get=rm`
b. `http://www.example.net/display.php?file=rm -rf /;`
c. `http://www.example.net/display.php?file=notes.txt; rm -rf /;`
d. `http://www.example.net/display.php?file=`

Command Injection

display.php: `<? echo system("cat ".$_GET['file']); ?>`

Q: Assuming the script we've been dealing with (reproduced above) for `http://www.example.net/display.php`. Which one of the following URIs is an attack URI?
Hint: Search for a URI Decoder to figure out values seen by the PHP code.

(Resulting php)

a. `<? echo system("cat rm"); ?>`
b. `<? echo system("cat rm -rf /;"); ?>`
c. `<? echo system("cat notes.txt; rm -rf /;"); ?>`
d. `<? echo system("cat "); ?>`

Injection

- Injection is a general problem:
  - Typically, caused when data and code share the same *channel.*
  - For example, the code is "`cat`" and the filename the data.
    - But '`;`' allows attacker to start a new command.