Lab 6

Cross-Site Request Forgery (CSRF)

Web Basics

The Web, Basically

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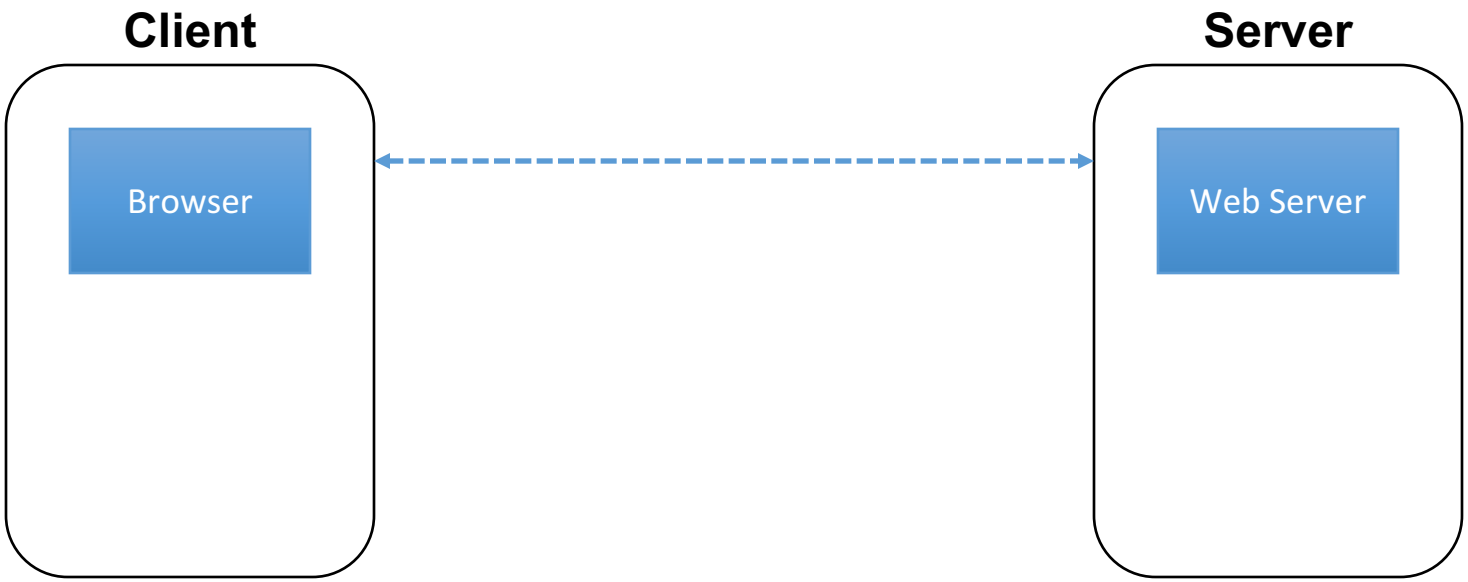
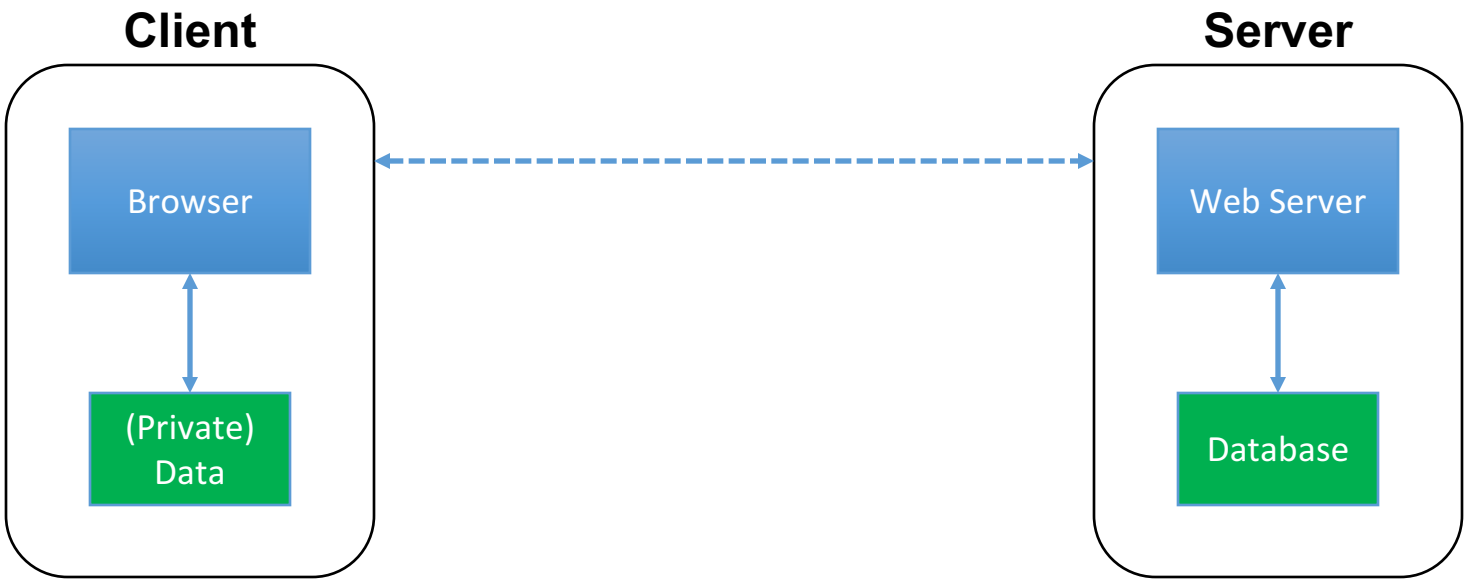


The Web, Basically



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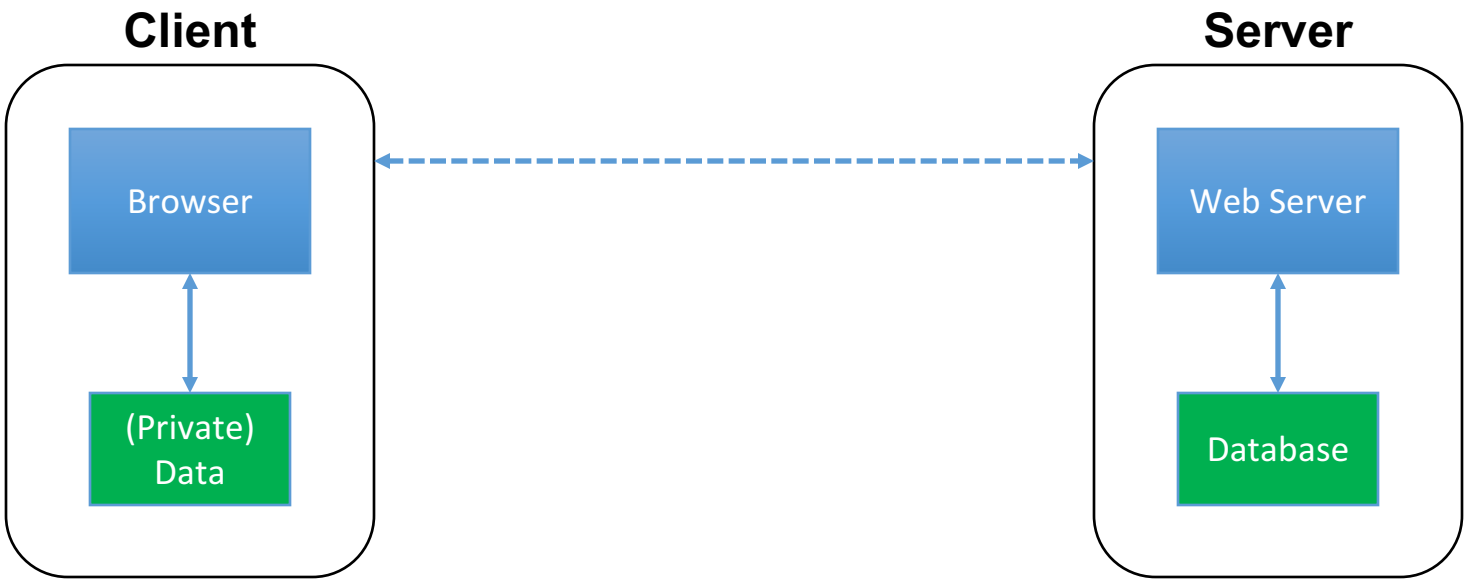

DB is a separate entity,
Logically (and often physically)

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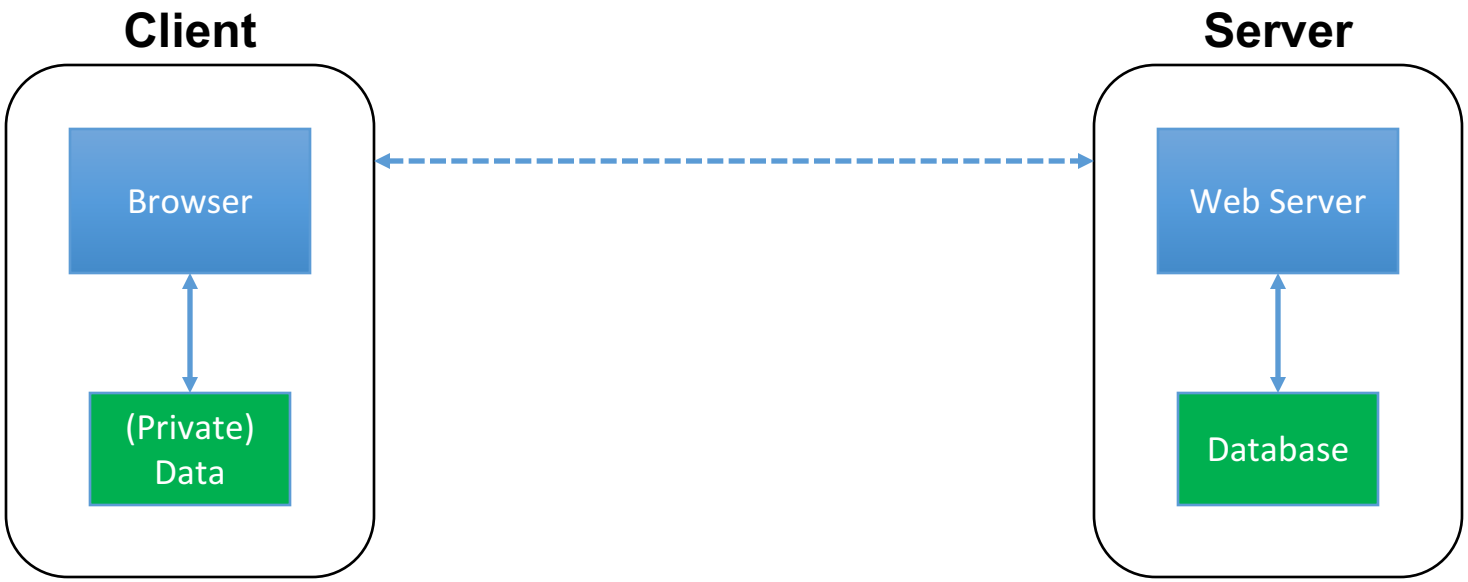

(Much) user data is part of the browser

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

Interacting with web servers

Resources which are identified by a URL

(Universal Resource Locator)

http://pages.erau.edu/~yuanj/index.html

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Protocol

ftp

https

Interacting with web servers

Resources which are identified by a URL

(Universal Resource Locator)

http://pages.erau.edu/~yuanj/index.html

Hostname/server

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

Interacting with web servers

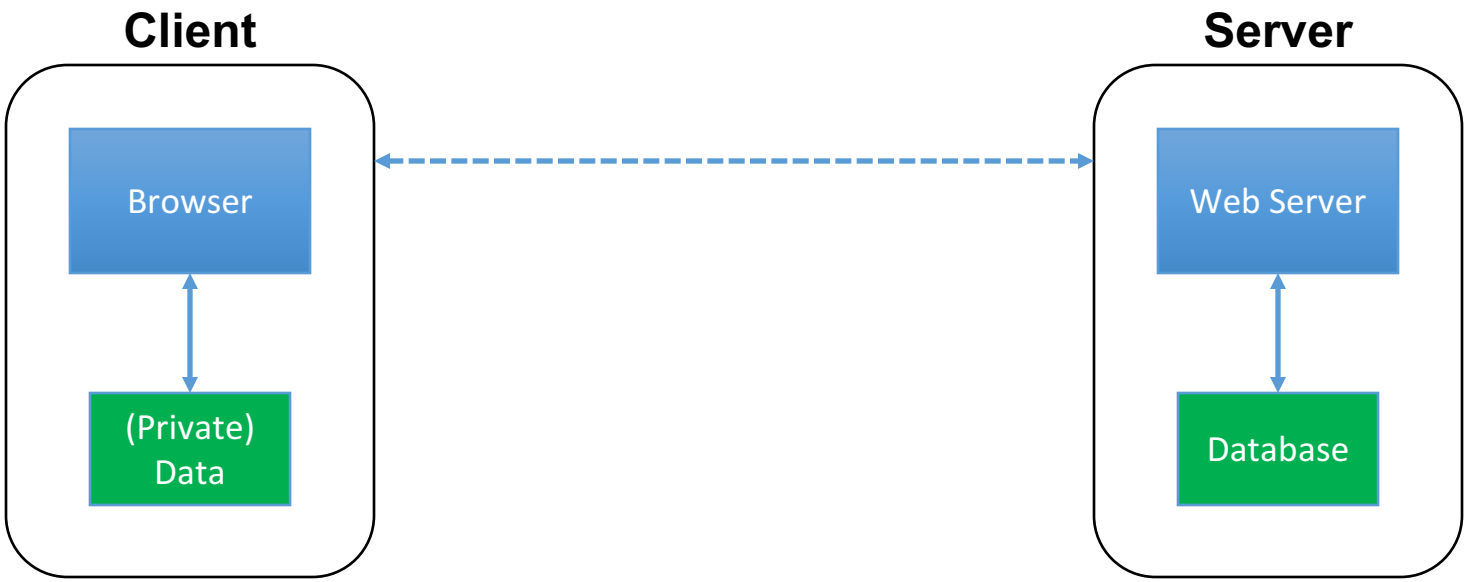
Resources which are identified by a URL

(Universal Resource Locator)

http://pages.erau.edu/~yuanj/index.html

Path to a resource

Basic structure of web traffic



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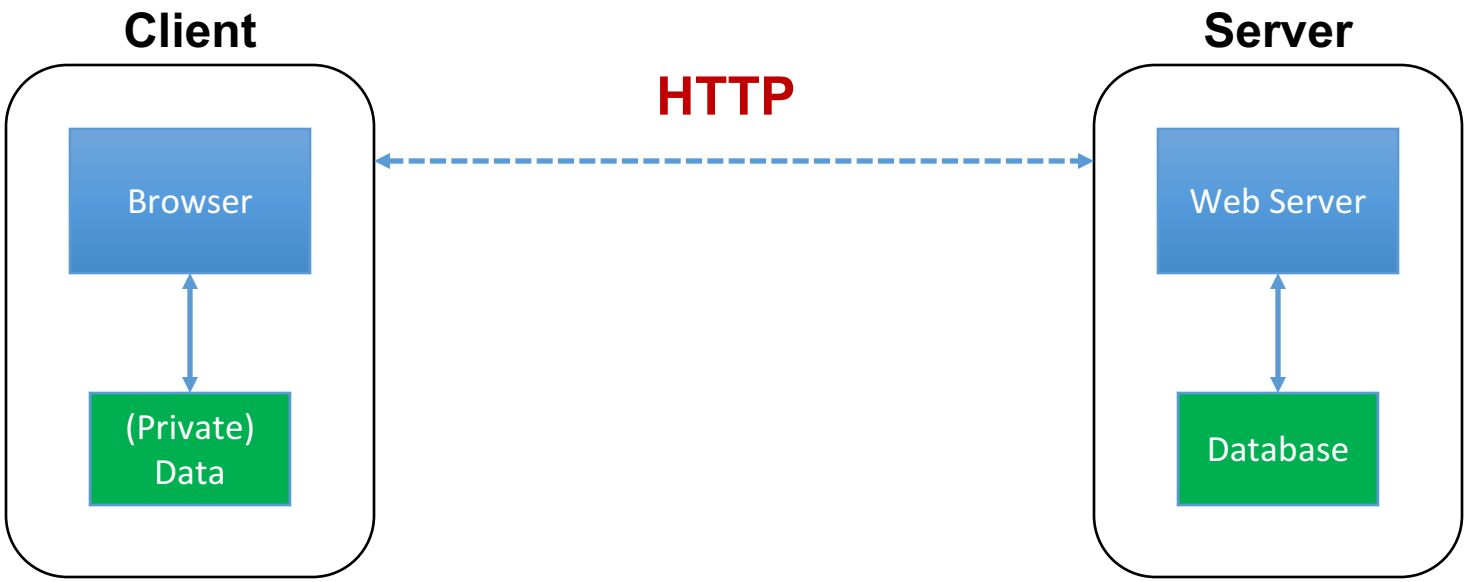

HyperText Transfer Protocol (HTTP)

Basic structure of web traffic

User clicks

Basic structure of web traffic

User clicks

Basic structure of web traffic

- **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 (no server side effects)
  - **POST**: includes the data as separate fields (can have side effects)

HTTP Get Request

http://www.reddit.com/r/security

HTTP Headers

```
http://www.reddit.com/r/security

GET /r/security HTTP/1.1
Host: www.reddit.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: 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
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 115
Connection: keep-alive
Cookie: __utma=55650728.562667657.1392711472.1392711472.1392711472.1; __utmb=55650728.1.10.1392711472; __utmc=55650...
```

HTTP Get Request

http://www.reddit.com/r/security

HTTP Headers

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Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
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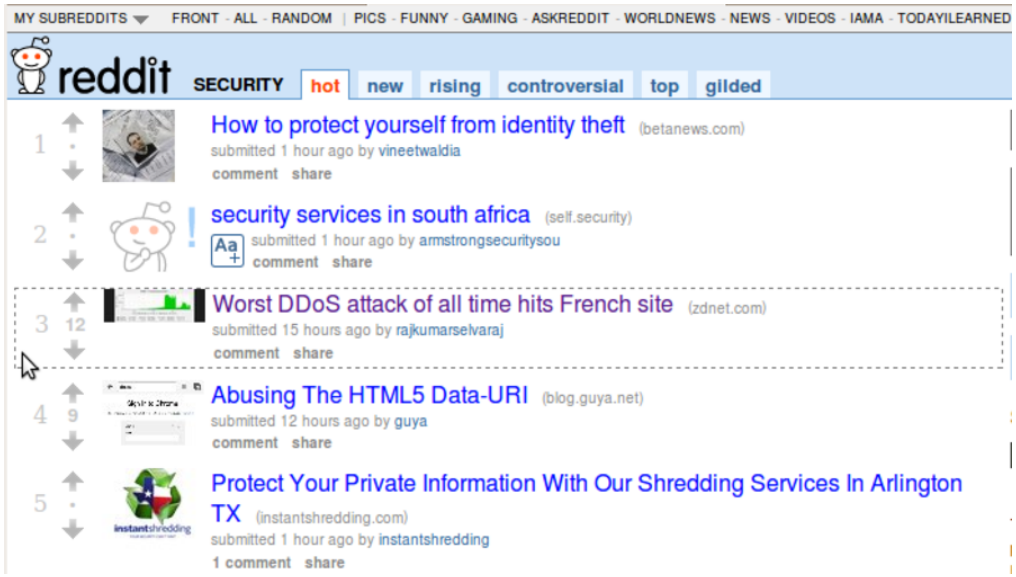
Cookie: __utma=55650728.562667657.1392711472.1392711472.1392711472.1; __utmb=55650728.1.10.1392711472; __utmc=55650...
```

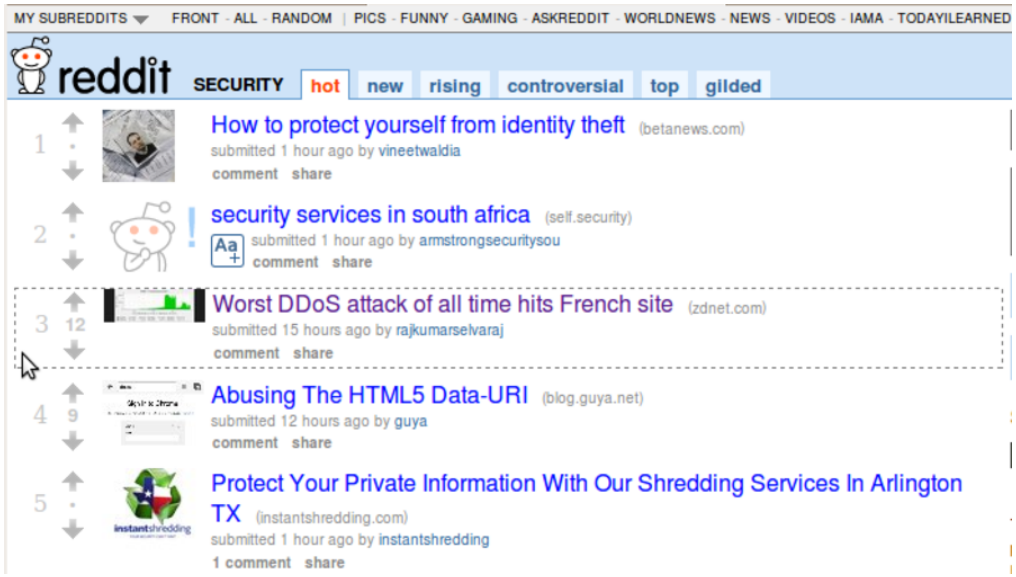
User-Agent is typically a **browser**

But it can be wget, JDK, etc

HTTP Get Request



HTTP Get Request



HTTP Headers

http://www.zdnet.com/worst-ddos-attack-of-all-time-hits-french-site-7000026330/

```
GET /worst-ddos-attack-of-all-time-hits-french-site-7000026330/ HTTP/1.1
Host: www.zdnet.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: 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
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 115
Connection: keep-alive
Referer: http://www.reddit.com/r/security
```

Referrer URL: the site from which this request was issued

HTTP Post Request

Posting on a website “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 ...
```

HTTP Post Request

Posting on a website “piazza”

HTTP Headers

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

HTTP Post Request

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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 ...

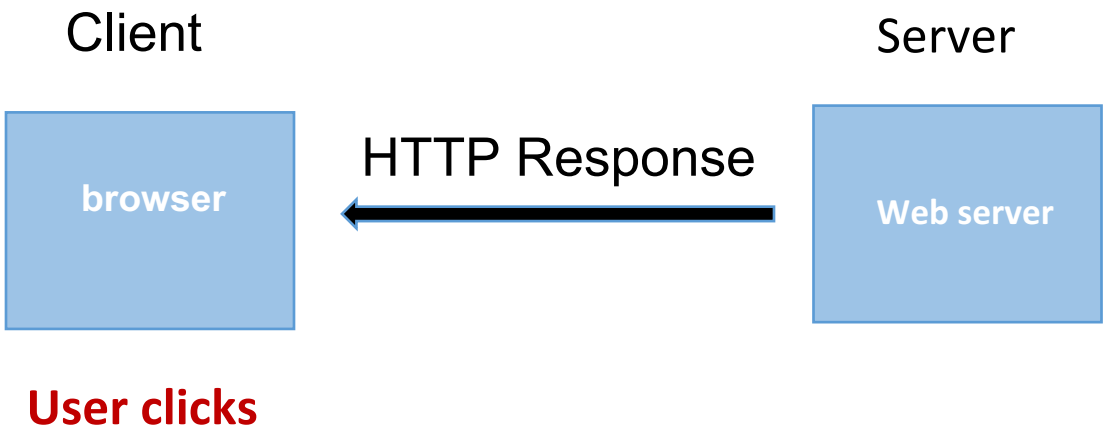
Implicitly includes data as a part of the URL

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

Basic structure of web traffic

User clicks

Basic structure of web traffic



Responses contain**:**

- **Status** code
- **Headers** describing what the server provides
- **Data**
- **Cookies**: Represent state the server would like the browser to store on its behalf

HTTP Response

HTTP version

Status code

Reason phrase

Headers

Data

```
HTTP/1.1 200 OK
Date: Tue, 18 Feb 2014 08:20:34 GMT
Server: Apache
Set-Cookie: session-zdnet-production=6bhqca1i0cbciagu11sisac2p3; 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>
```

Web-based State using Hidden Fields and Cookies

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

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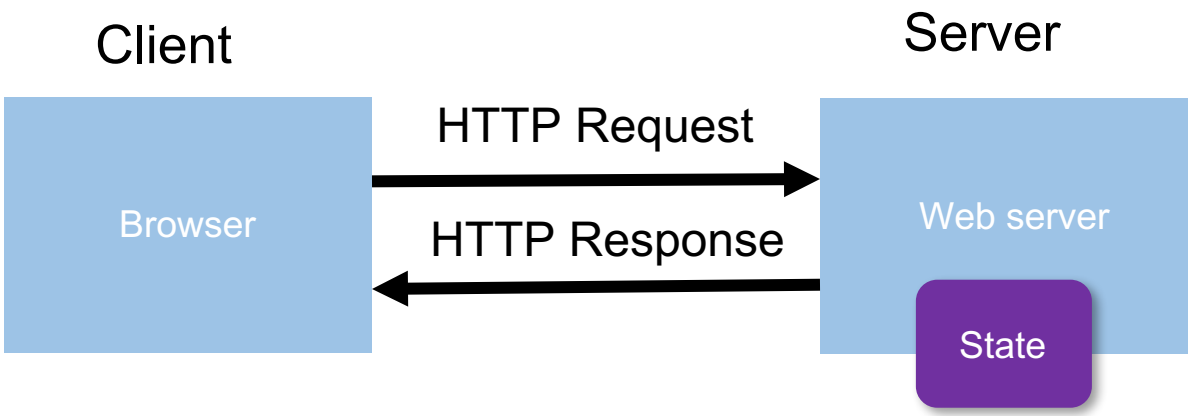
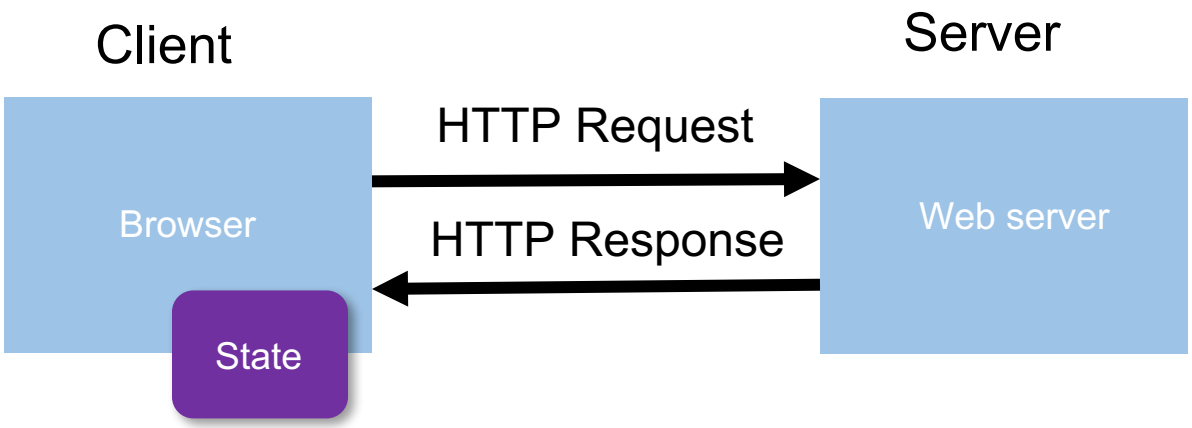
- HTTP has no means of noting “oh this is the same client from that previous session”

Maintaining State



- Web application maintains *ephemeral* state
  - Server processing often produces intermediate results
    - Not ACID, long-lived state

Maintaining State



- Web application maintains *ephemeral* state
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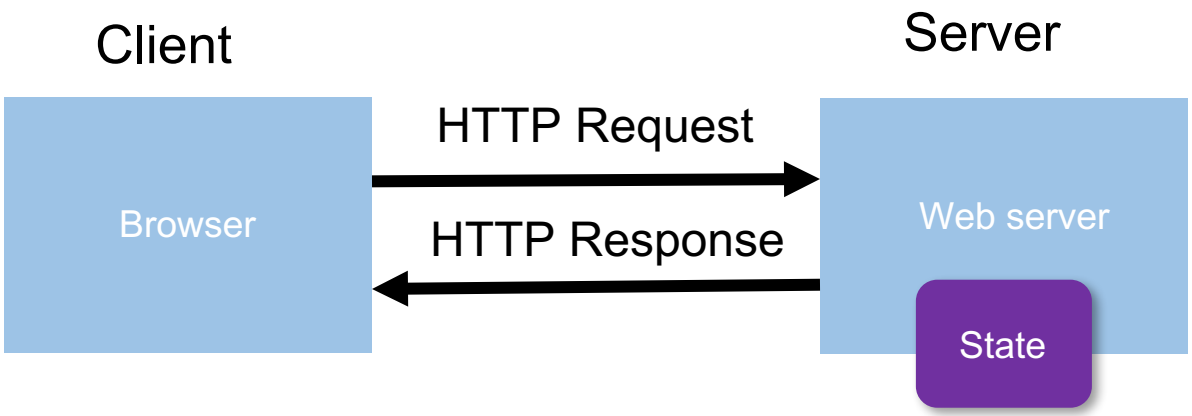
  - **Send** such **state to the client**

Maintaining State



- Web application maintains *ephemeral* state
  - Server processing often produces intermediate results
    - Not ACID, long-lived state
  - **Send** such **state to the client**
  - Client **returns the state** in subsequent **requests**

  - Two kinds of state: hidden fields, and cookies

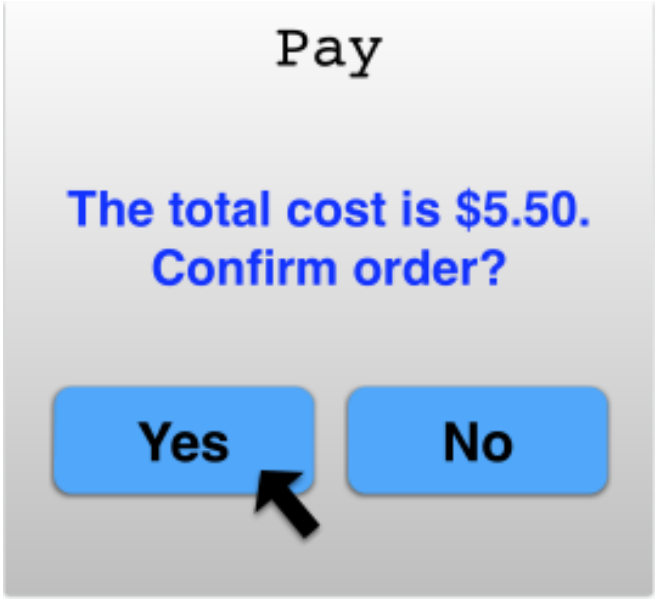
Ex: Online ordering

socks.com/order.php

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();
```

Ex: Online ordering

What's presented to the user

```
<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

What's presented to the user

```
<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>
```

Client can change the value!

Solution: Capabilities

- **Server maintains *trusted* state** (while client maintains the rest)
  - Server stores intermediate state
  - Send a capability to access that state to the client
  - Client **references the capability** in subsequent responses

- **Capabilities should be large, random numbers**, so that they are hard to guess
  - To prevent illegal access to the state

Ex: Online ordering

What's presented to the user

```
<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>
```

Using capabilities

What's presented to the user

Capability;
the system will detect a change and abort

```
<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();
```

Using capabilities

The corresponding backend processing

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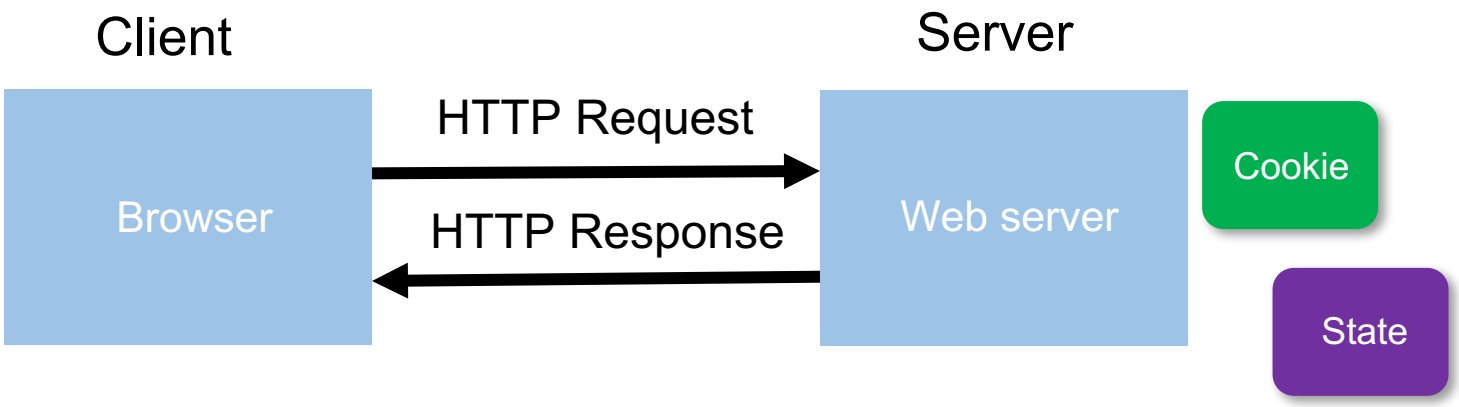
else
  display_transaction_cancelled_page();
```

But: we don't want to pass hidden fields around all the time

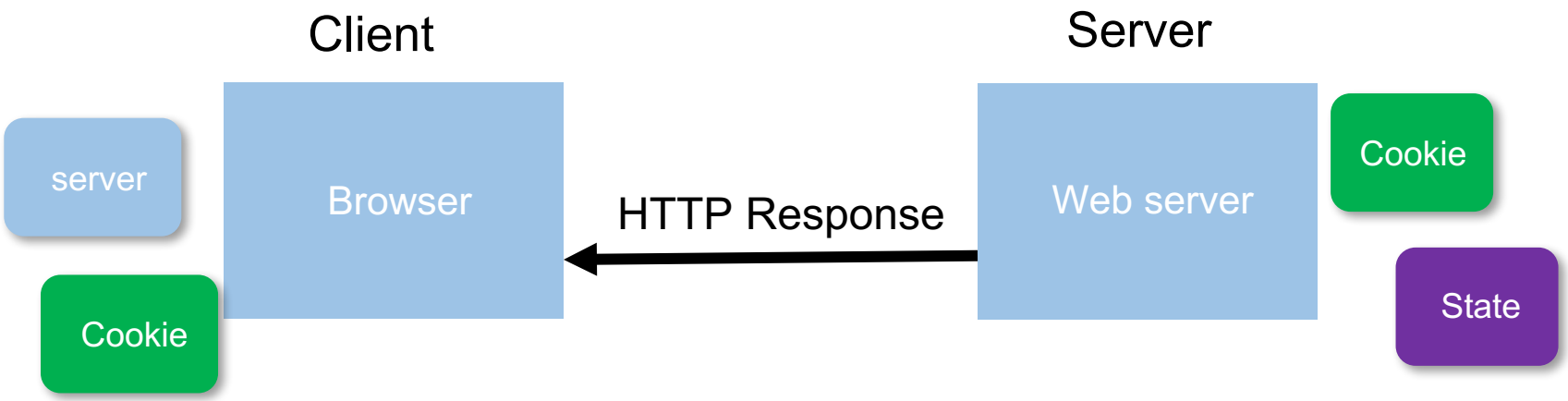
- Tedious to add/maintain on all the different pages
- Have to start all over on a return visit (after closing browser window)

Statefulness with Cookies



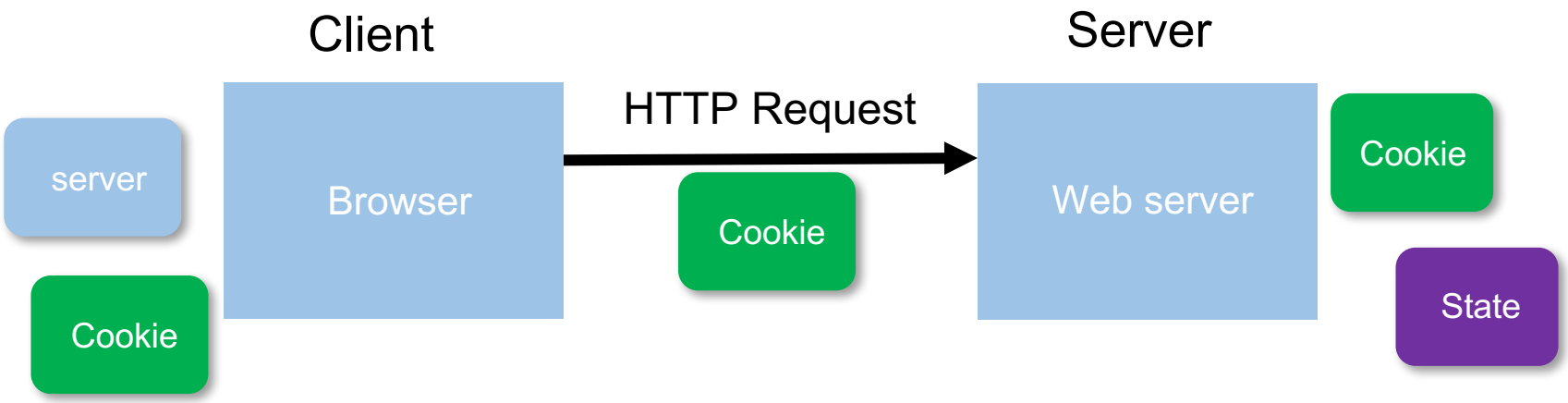
- Server **maintains trusted state**
  - Server Server indexes/denotes state with a **cookie**

Statefulness with Cookies



- Server **maintains trusted state**
  - Server Server indexes/denotes state with a **cookie**
  - Sends cookie to the client, which stores it

Statefulness with Cookies



- Server **maintains trusted state**
  - Server Server indexes/denotes state with a **cookie**
  - Sends cookie to the client, which stores it
  - Client returns it with subsequent queries to that same server

Ex: Online ordering

Set-Cookie:key=value; options; ….

Headers

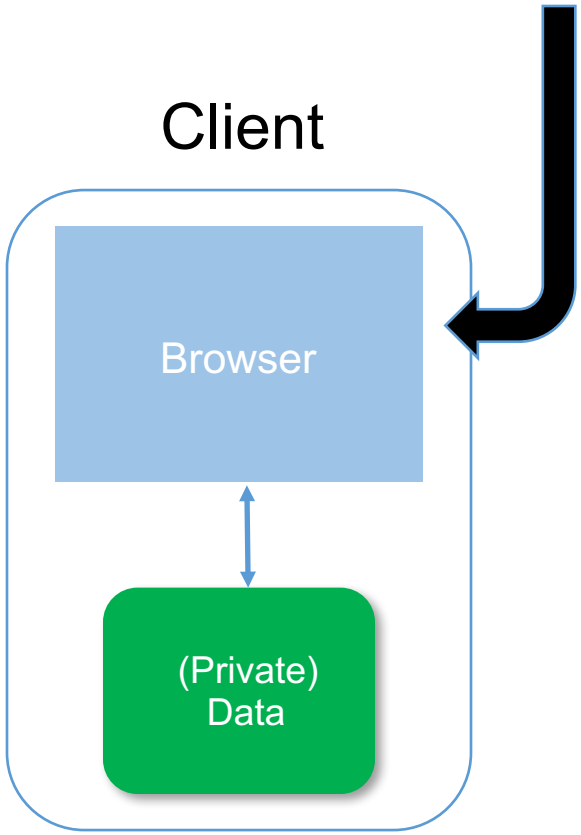
```
HTTP/1.1 200 OK
Date: Tue, 18 Feb 2014 08:20:34 GMT
Server: Apache
Set-Cookie: session-zdnet-production=6bhqca1i0cbciagu11sisac2p3; path=/; domain=zdnet.com
Set-Cookie: zdregion=MTI5LjIuMTI5LjE1Mzp1czp1czpjZDJmNWY5YTdkODU1N2Q2YzM5NGU3M2Y1ZTRmN
Set-Cookie: zdregion=MTI5LjIuMTI5LjE1Mzp1czp1czpjZDJmNWY5YTdkODU1N2Q2YzM5NGU3M2Y1ZTRmN
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
```

Data

```
<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 is no good as of Wed Feb 18…
- This value should only be readable by any domain ending in **.zdnet.com**
- Send the cookie with any future requests to <domain>/<path>

Requests with cookies

```
HTTP/1.1 200 OK
Date: Tue, 18 Feb 2014 08:20:34 GMT
Server: Apache
Set-Cookie: session-zdnet-production=6bhqca1i0cbciagu11sisac2p3; path=/; domain=zdnet.com
Set-Cookie: zdregion=MTI5LjIuMTI5LjE1Mzp1czp1czpjZDJmNWY5YTdkODU1N2Q2YzM5NGU3M2Y1ZTRmN
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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
```

Subsequent visit

```
HTTP Headers
  http://zdnet.com/

  GET / HTTP/1.1
  Host: zdnet.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: 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
  Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
  Keep-Alive: 115
  Connection: keep-alive
  Cookie: session-zdnet-production=59ob97fpinqe4bg6lde4dvvq11; zdregion=MTI5LjIuMTI5LjE1Mzp1czp1czpjZDJmNW
```

Session Hijacking

Cookies and web authentication

- An extremely common use of cookies is to track users who have already authenticated

- If the user already visited http://website.com/login.html?user=alice&pass=secret with the correct password, then the server associates a *"session cookie"* with the logged-in user's info

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- The idea is to be able to say "I am talking to the same browser that authenticated Alice earlier."

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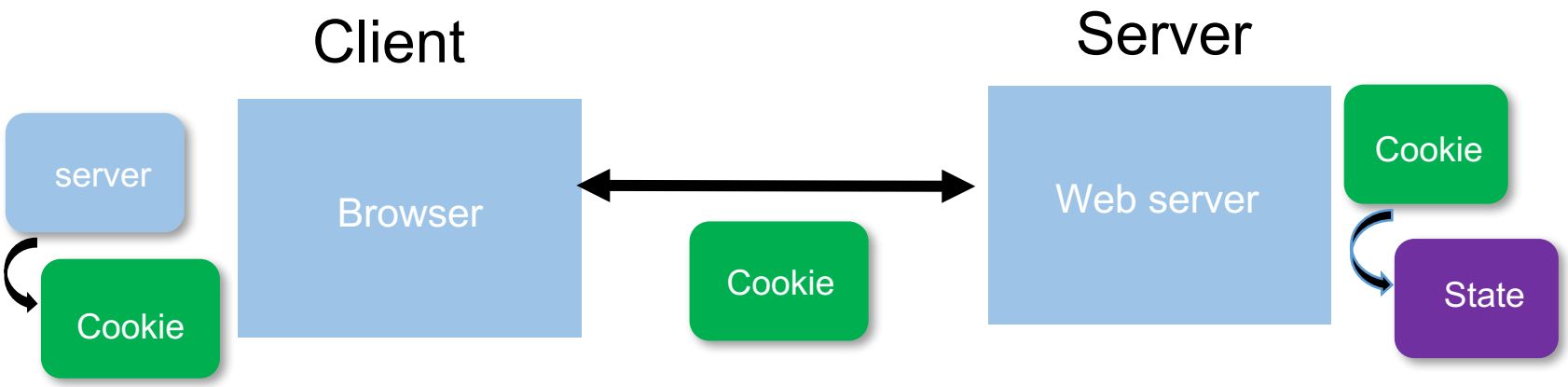
- Thus, **stealing a cookie** may allow an attacker to **impersonate a legitimate user**
  - Actions that will seem to be due to that user
  - Permitting theft or corruption of sensitive data

Stealing Session Cookies



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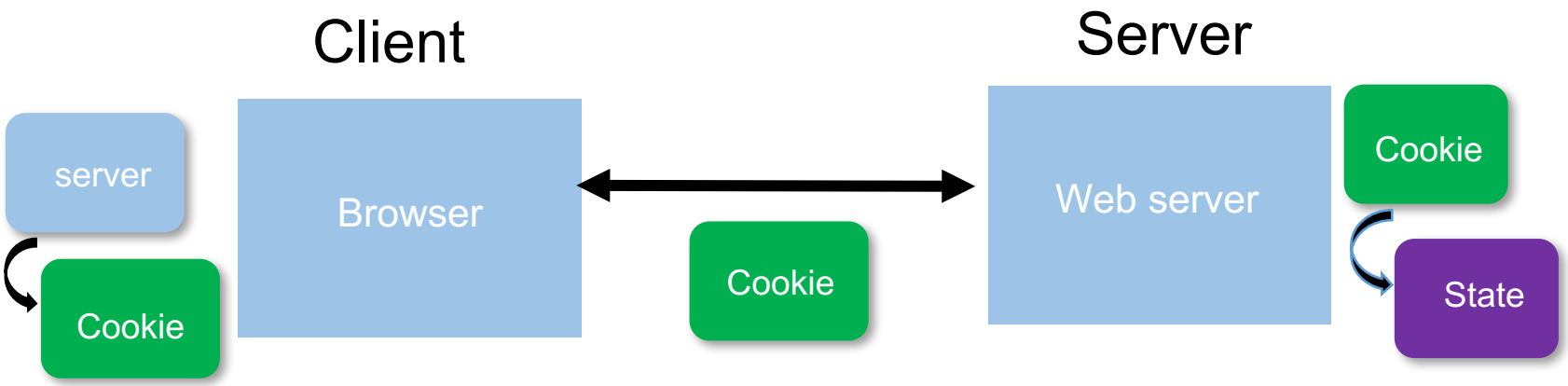

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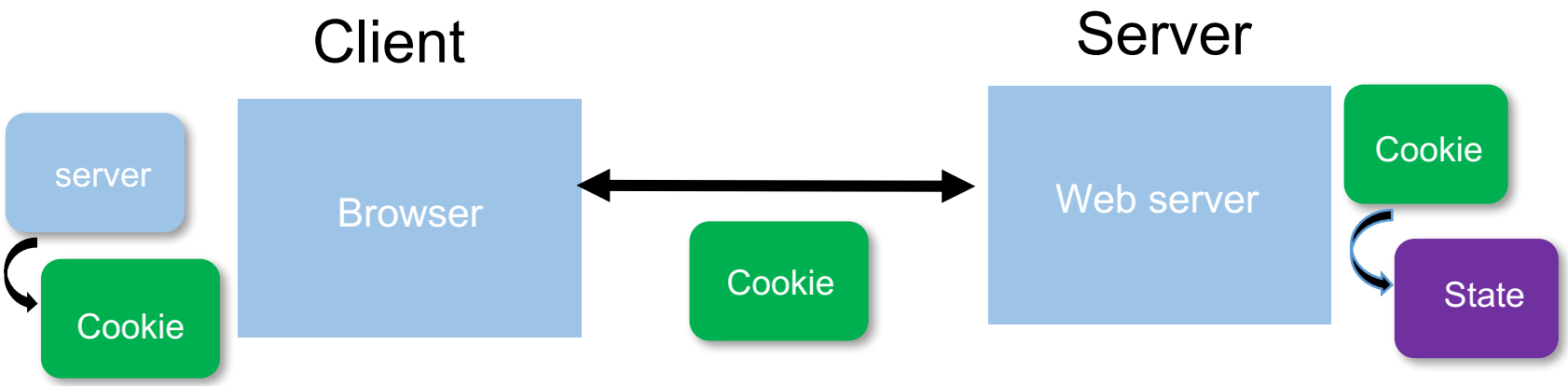

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Network-based attacks

Defense: Unpredictability

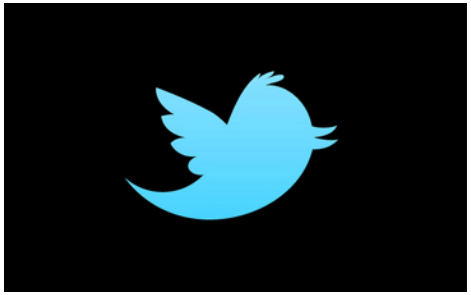
- **Avoid theft by guessing**; cookies should be
  - **Randomly** chosen,
  - Sufficiently **long**

    (Same goes with hidden field identifiers)

Mitigating Hijack

- Sad story: **Twitter**
- Uses one cookie (**auth_token**) to validate user, which is a function of
  - User name, password

Mitigating Hijack



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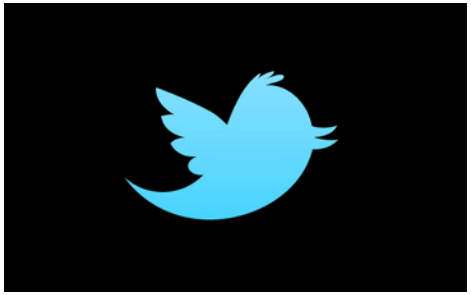

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  - Thus: **steal this cookie once**, and you can **log in as the user any time you want** (until password change)
- **Defense**: **Time out** session IDs and **delete** them once the session ends

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

Cross-Site Request Forgery (CSRF)

URLs with side effects

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

- GET requests can 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?**

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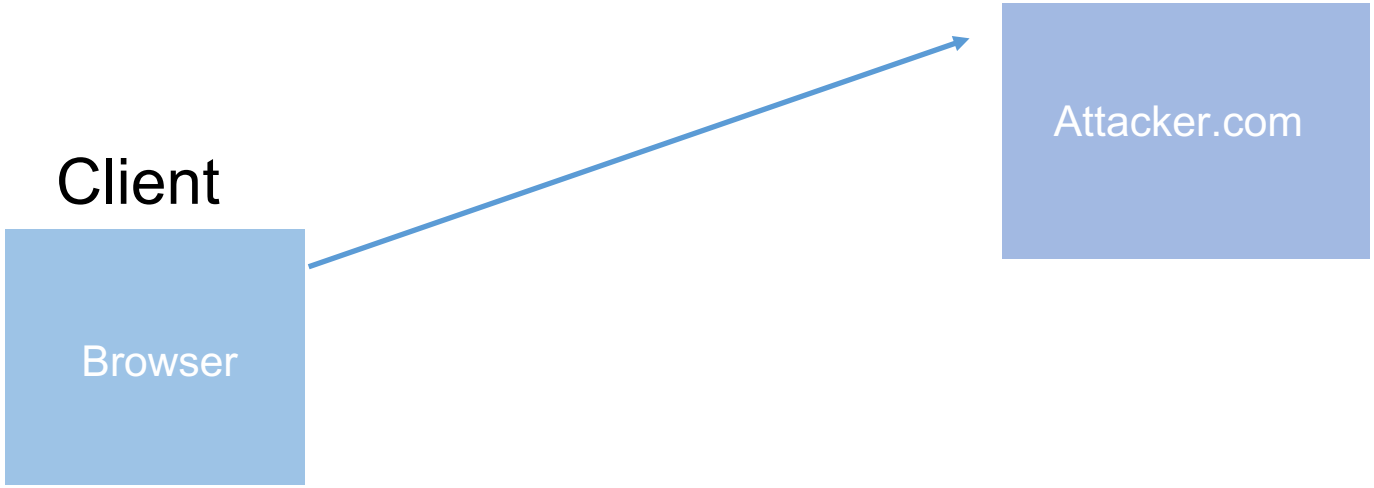
- What happens if
  - the **user is logged in** with an active session cookie
  - a **request is issued for the above link?**
- How could you get a user to visit a link?

Exploiting URLs with side-effects



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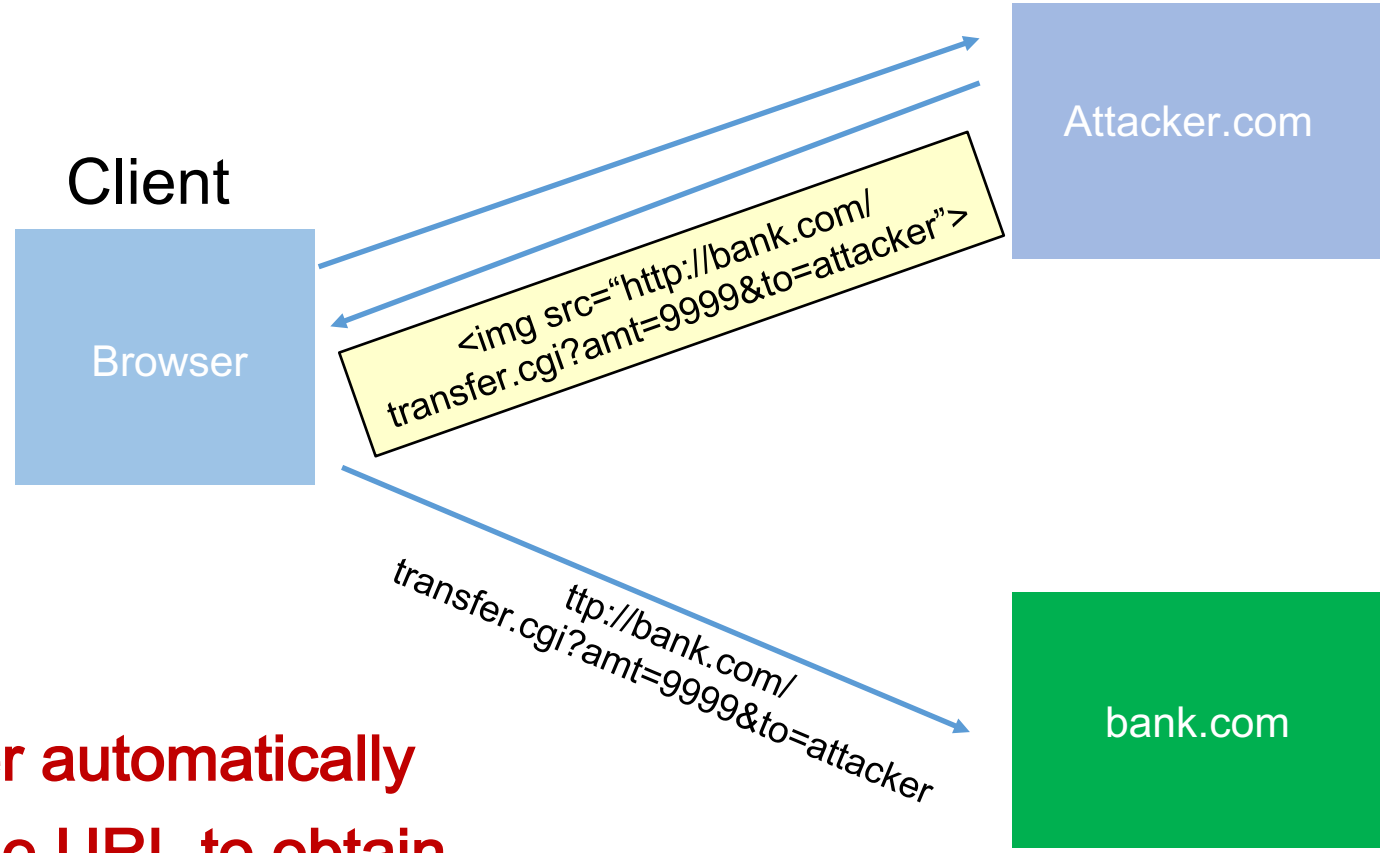

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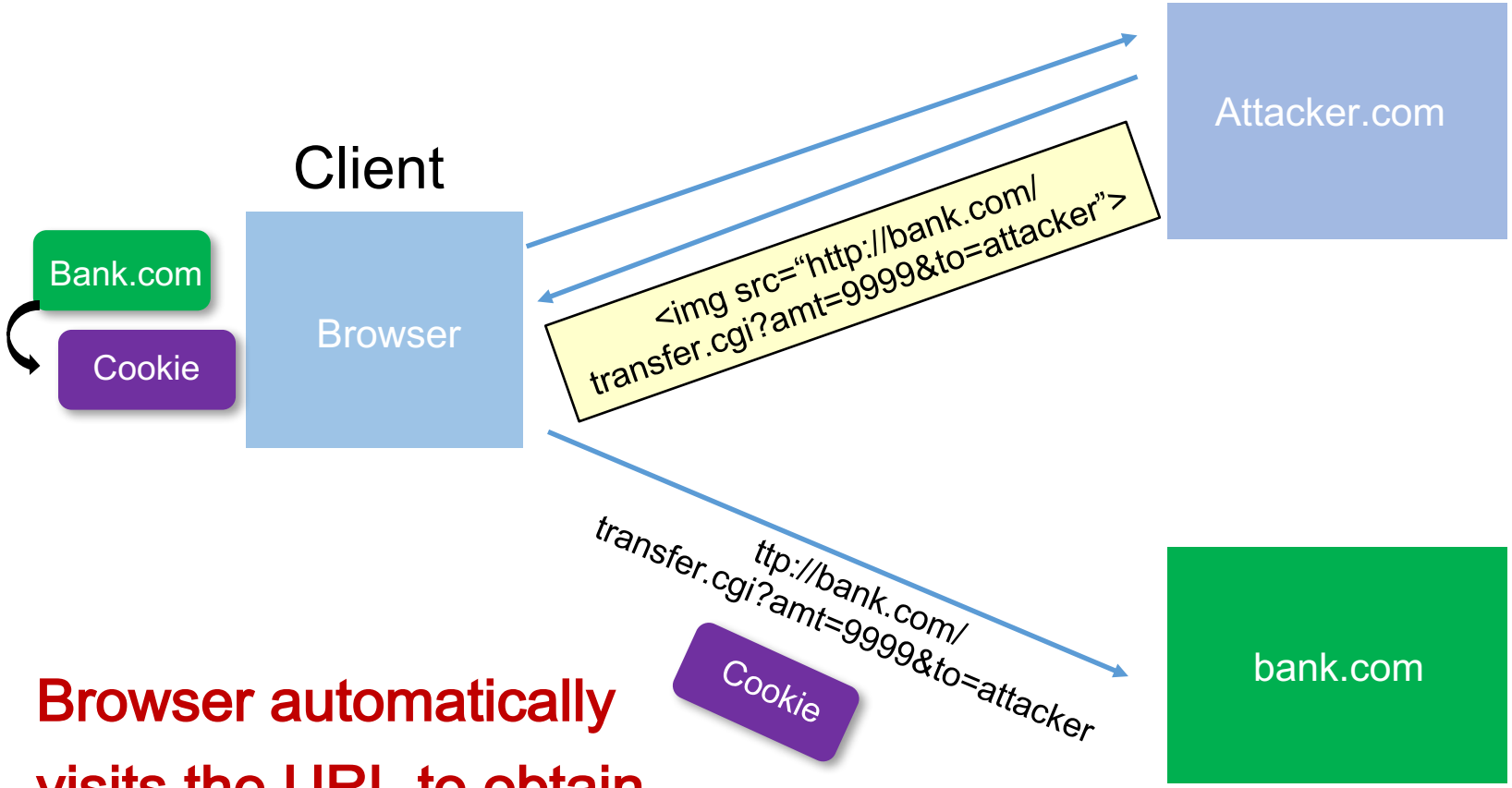

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Cross-Site Request Forger

- Target: User who has an account on a vulnerable server
- Attack goal: make requests to the server via the user's browser that look to the server like the user intended to make them
- Attacker tools: 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 of something like <img src=…> to force the victim to send it

CSRF protections: REFERER

- The browser will set the **REFERER** field to the page that hosted a clicked link

HTTP Headers

```
http://www.zdnet.com/worst-ddos-attack-of-all-time-hits-french-site-7000026330/

GET /worst-ddos-attack-of-all-time-hits-french-site-7000026330/ HTTP/1.1
Host: www.zdnet.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: 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
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 115
Connection: keep-alive
Referer: http://www.reddit.com/r/security
```

- **Trust requests from pages a user could legitimately reach**
  - From good users, if referrer header present, generally trusted
  - Defends against session hijacks too