

This time

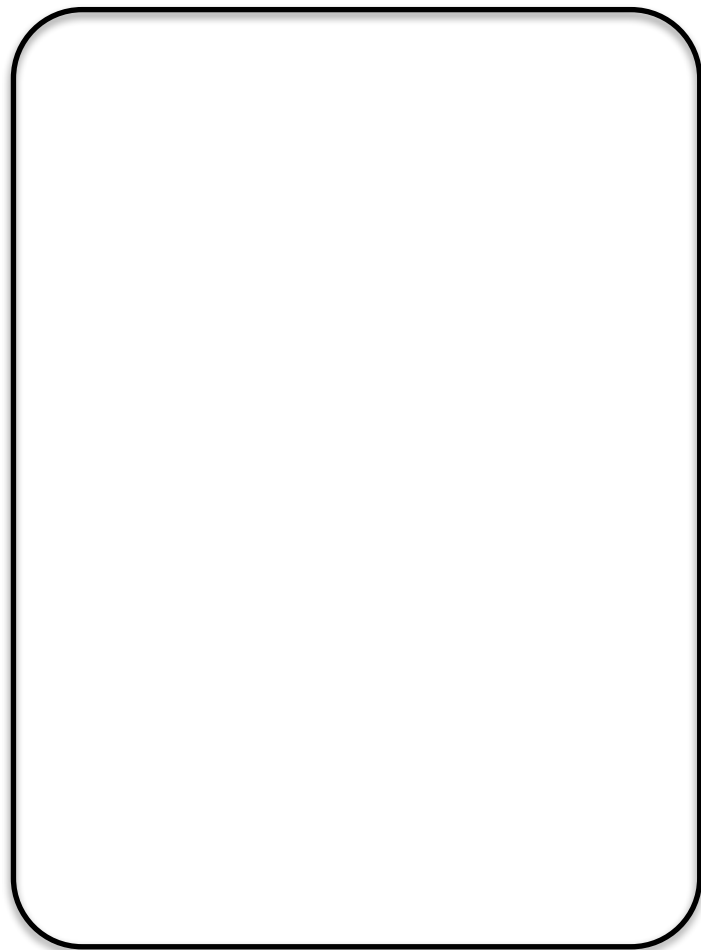
Continuing with
**Software
Security**

Getting insane with
**I n p u t
sanitization');
drop table slides**

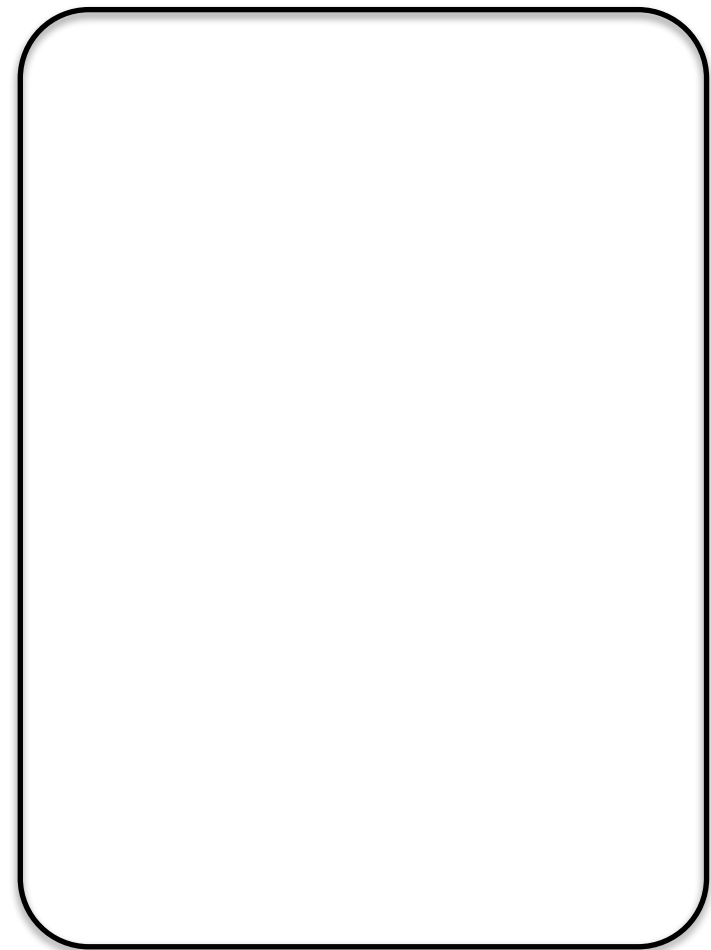
- New attacks and countermeasures:
 - SQL injection
 - Background on web architectures

A very basic web architecture

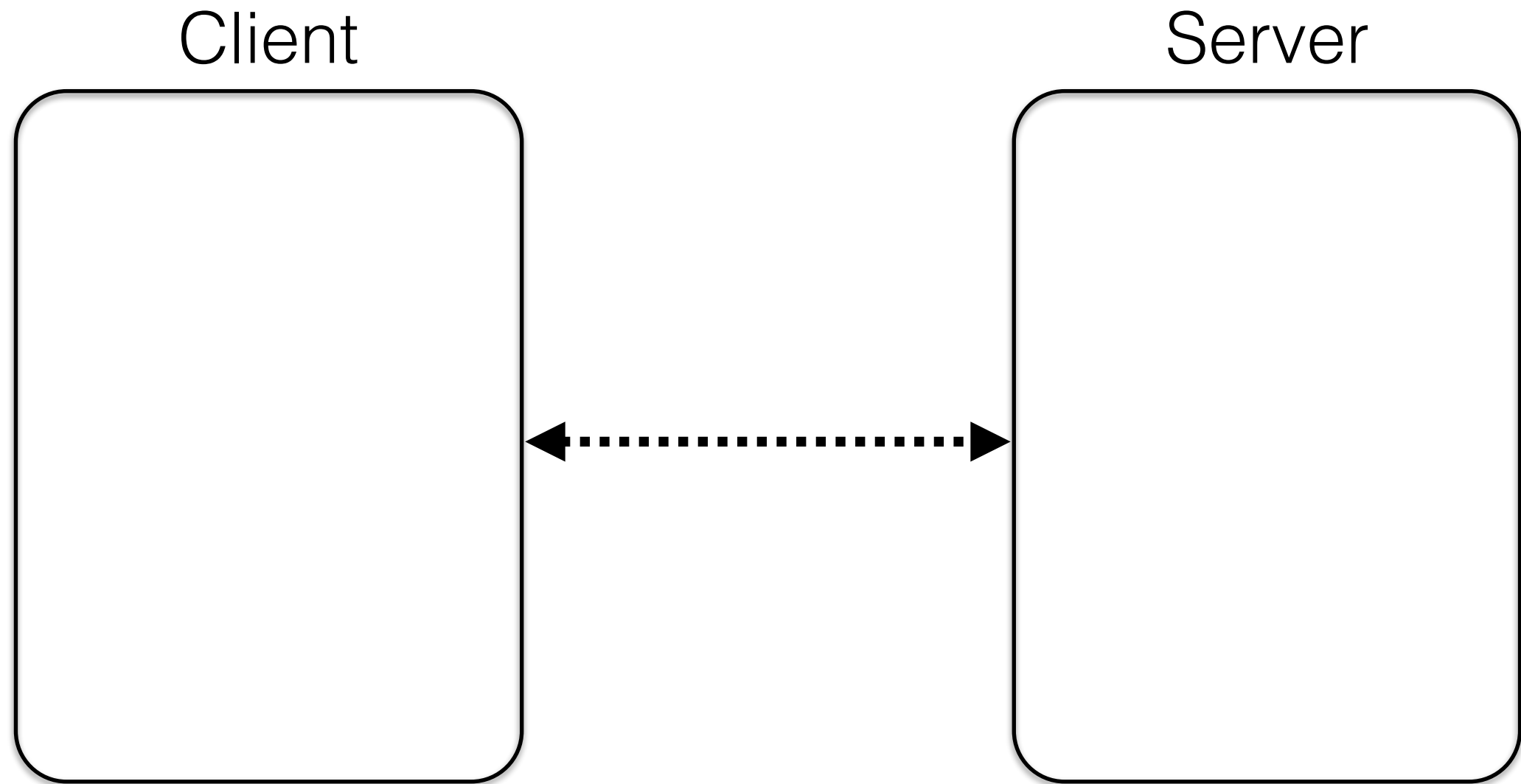
Client



Server

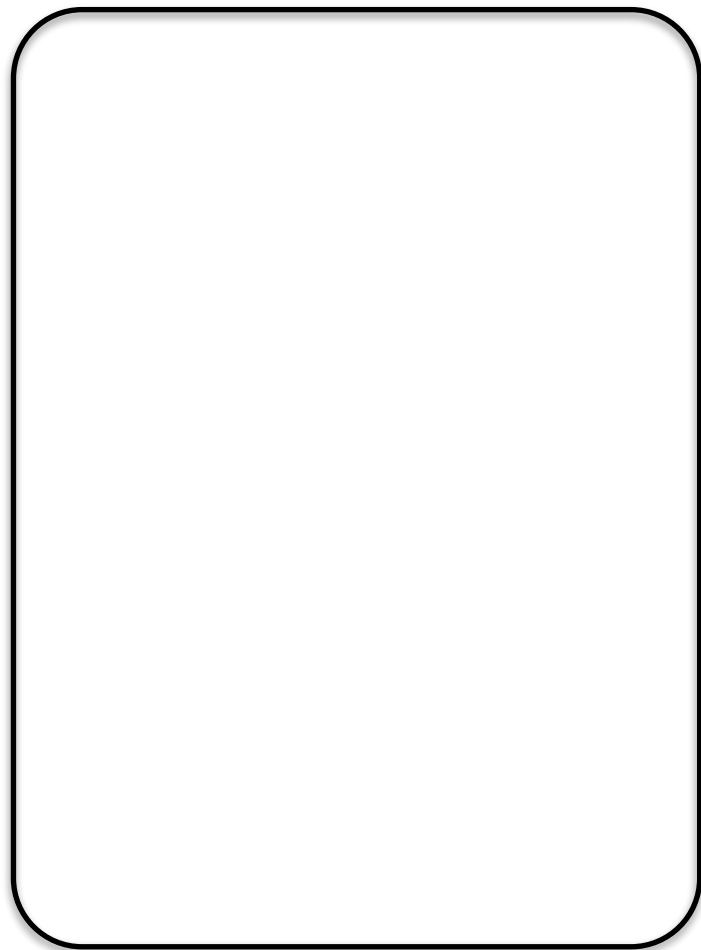


A very basic web architecture

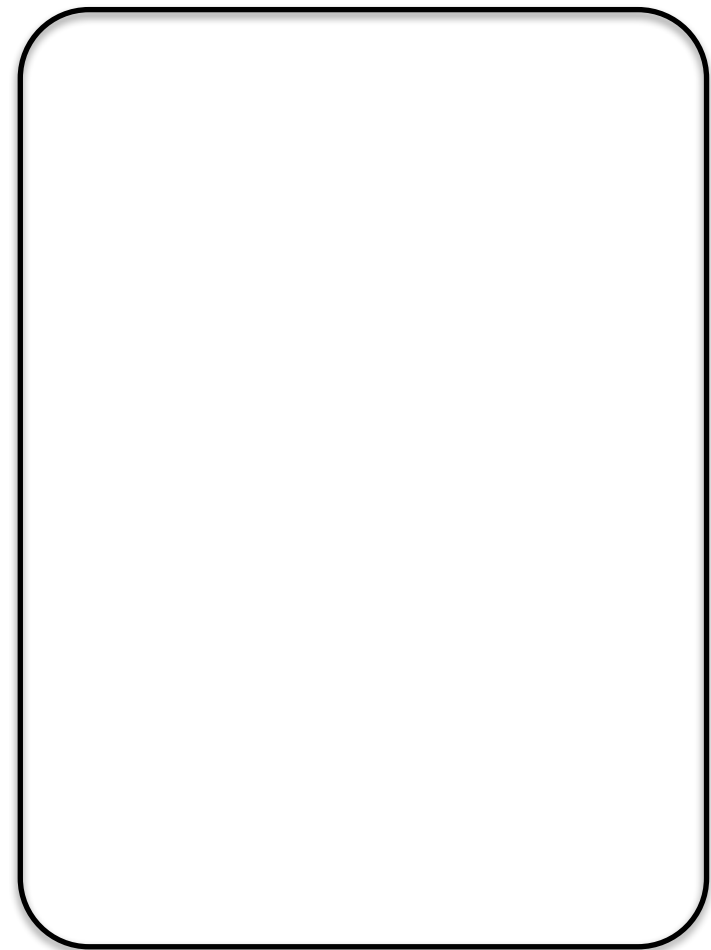


A very basic web architecture

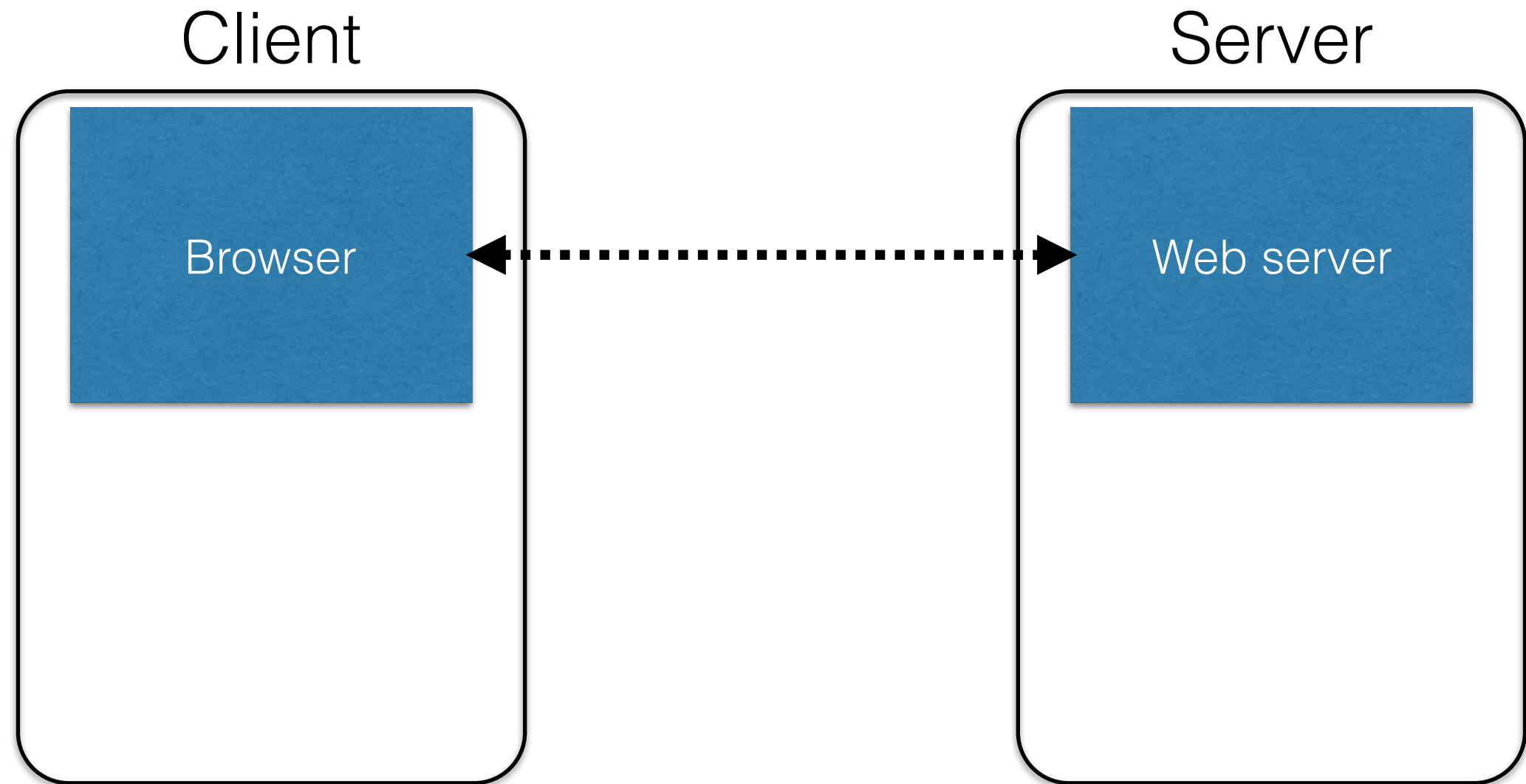
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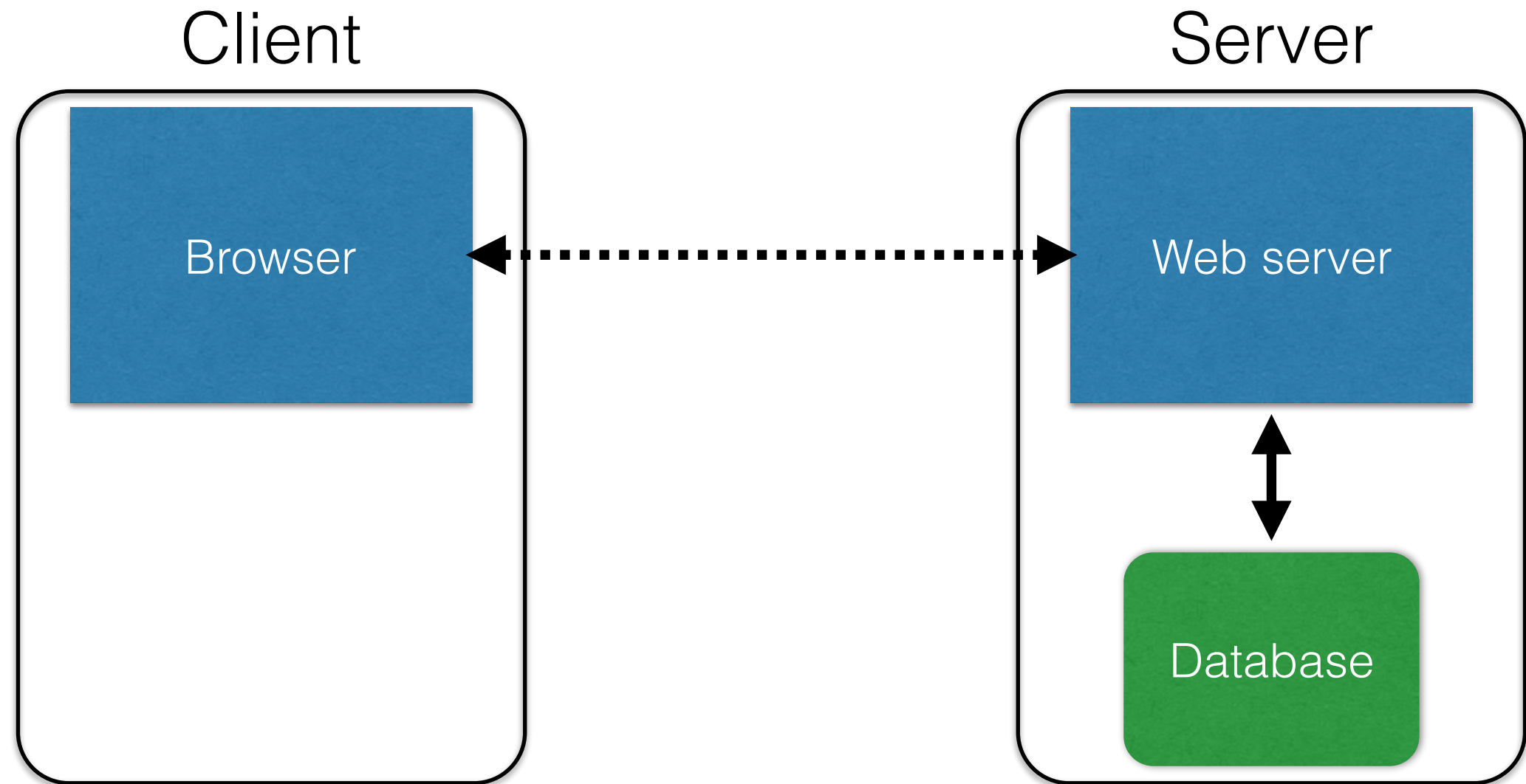
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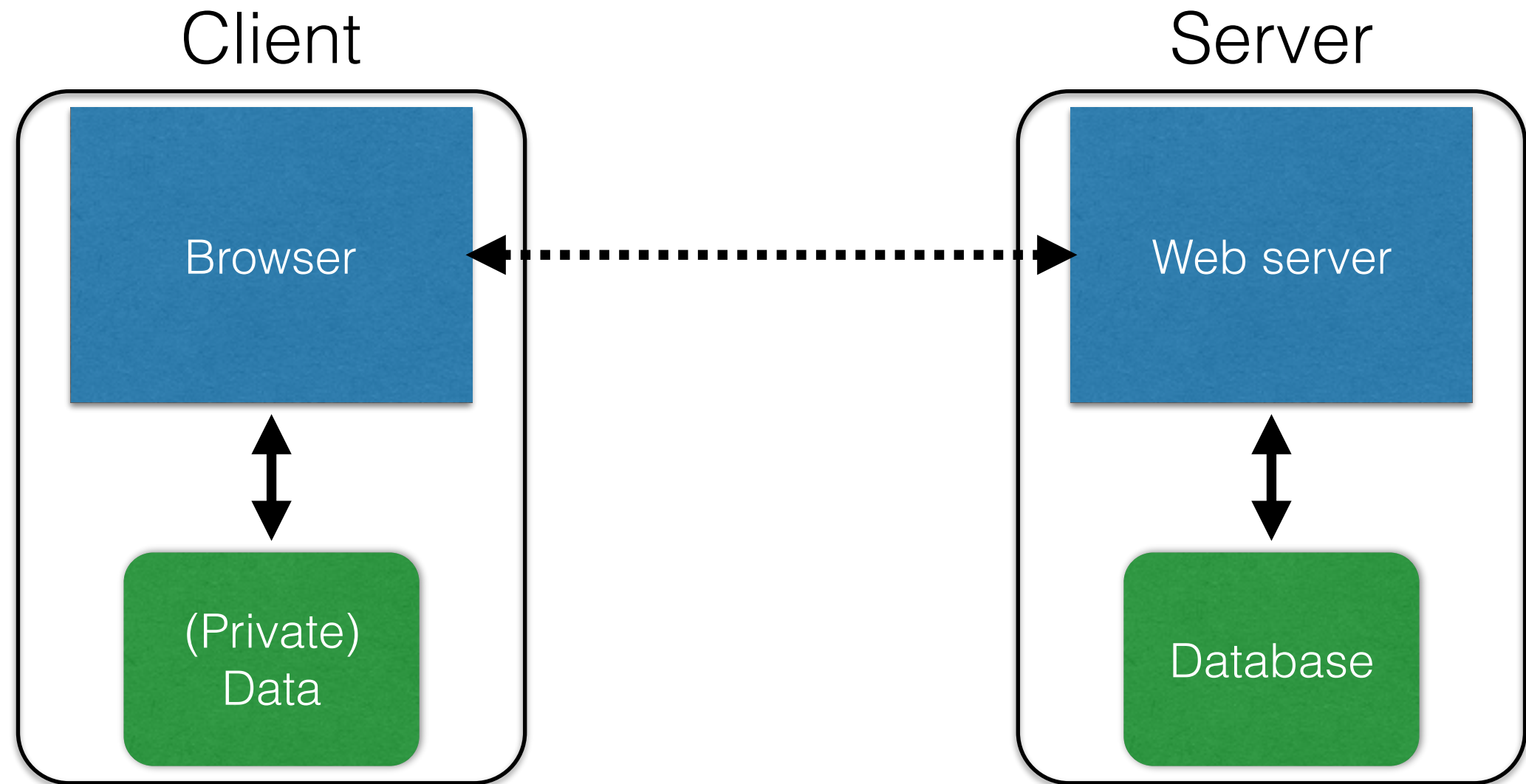
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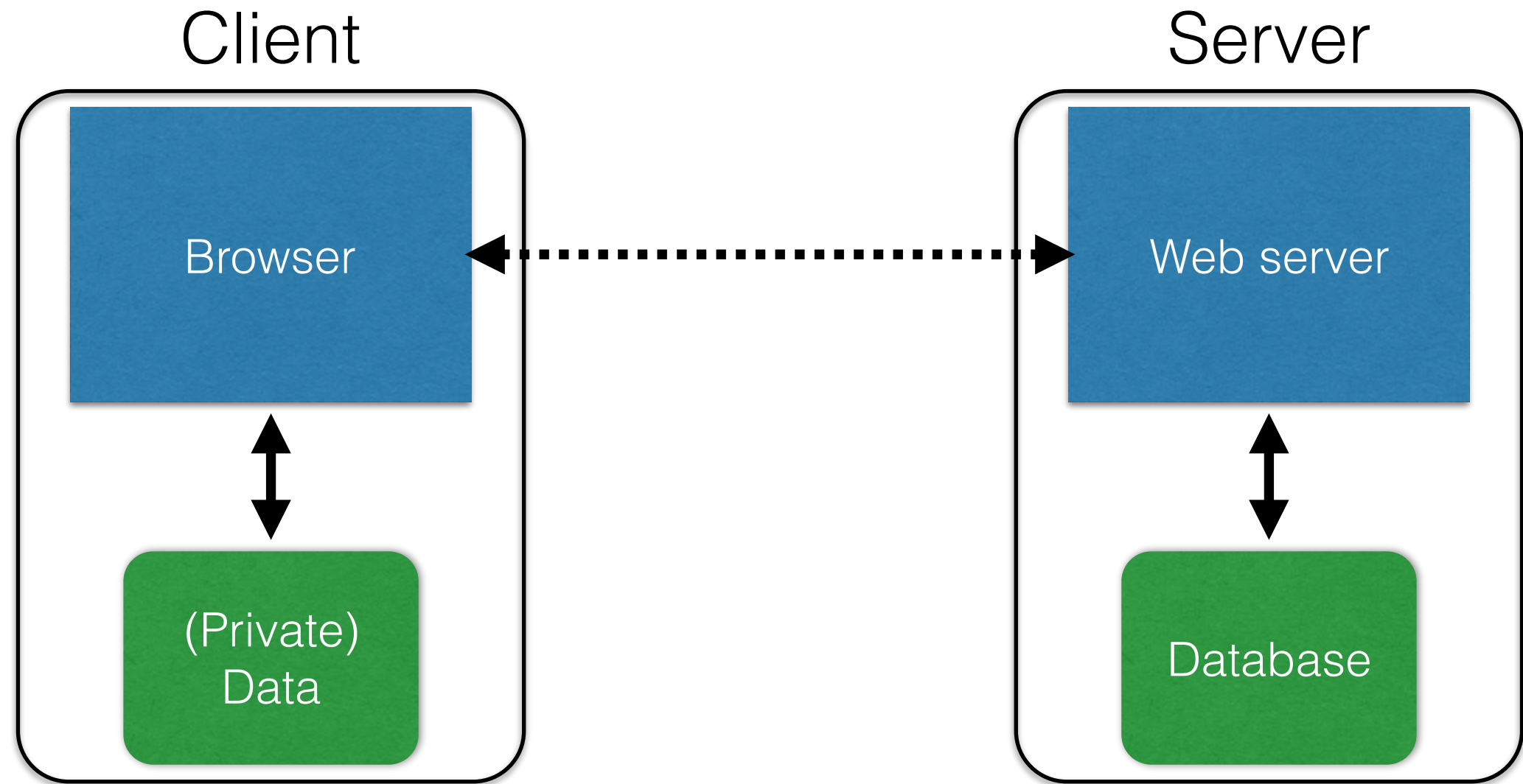
A very basic web architecture



A very basic web architecture



A very basic web architecture



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

SQL security

Databases

- Provide data **storage** & data **manipulation**
- Database designer lays out the data into tables
- Programmers query the database
- **Database Management Systems (DBMSes)** provide
 - semantics for how to organize data
 - transactions for manipulating data sanely
 - a **language** for creating & querying data
 - and APIs to interoperate with other languages
 - management via users & permissions

Databases: basics

Users

Name	Gender	Age	Email	Password
Dee	F	28	<u>dee@pp.com</u>	j3i8g8ha
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Databases: basics

Table

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Users **Table name**

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Column

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**Row
(Record)**

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Database transactions

Transactions are the unit of work on a database

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“Give me everyone in the User table who is listed as taking CMSC414 in the Classes table”

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2 writes

- Typically want **ACID** transactions
 - **Atomicity**: Transactions complete entirely or not at all
 - **Consistency**: The database is always in a *valid* state (but not necessarily *correct*)
 - **Isolation**: Results from a transaction aren't visible until it is complete
 - **Durability**: Once a transaction is committed, it remains, despite, e.g., power failures

SQL (Standard Query Language)

Users

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```
SELECT Age FROM Users WHERE Name='Dee' ;
```

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SELECT Age FROM Users WHERE Name='Dee'; **28**

UPDATE Users SET email='readgood@pp.com'
WHERE Age=32; *-- this is a comment*

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INSERT INTO Users Values('Frank', 'M', 57, ...);

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DROP TABLE Users;

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SELECT Age FROM Users WHERE Name='Dee';      28
UPDATE Users SET email='readgood@pp.com'
WHERE Age=32; -- this is a comment
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DROP TABLE Users;
```

Server-side code

Website



Username: Password: Log me on automatically each visit ☐

“Login code” (php)

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

Suppose you successfully log in as \$user
if this query returns any rows whatsoever

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Suppose you successfully log in as \$user
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How could you exploit this?

SQL injection

Username: Password: Log me on automatically each visit ☐

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    where(name=' $user' and password=' $pass' );");
```

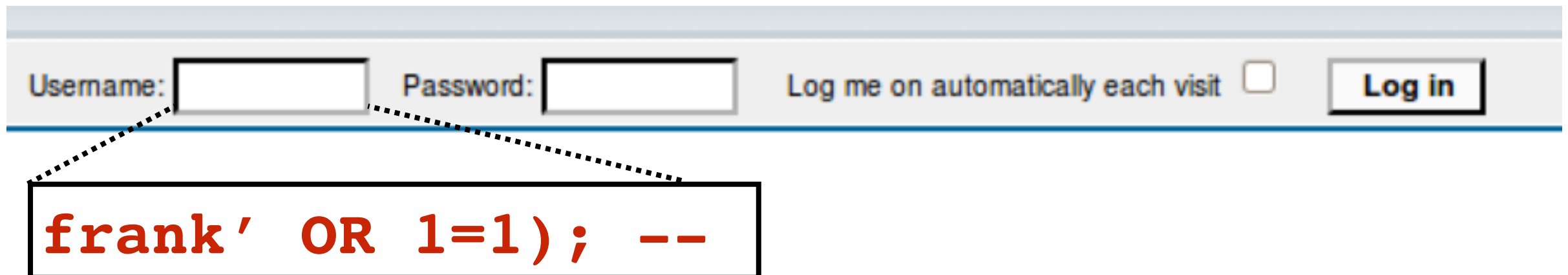
SQL injection

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frank' OR 1=1); --

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SQL injection



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$result = mysql_query("select * from Users  
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```

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

SQL injection

Username: Password: Log me on automatically each visit ☐

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

```
$result = mysql_query("select * from Users  
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**Can chain together statements with semicolon:
STATEMENT 1 ; STATEMENT 2**

SQL injection



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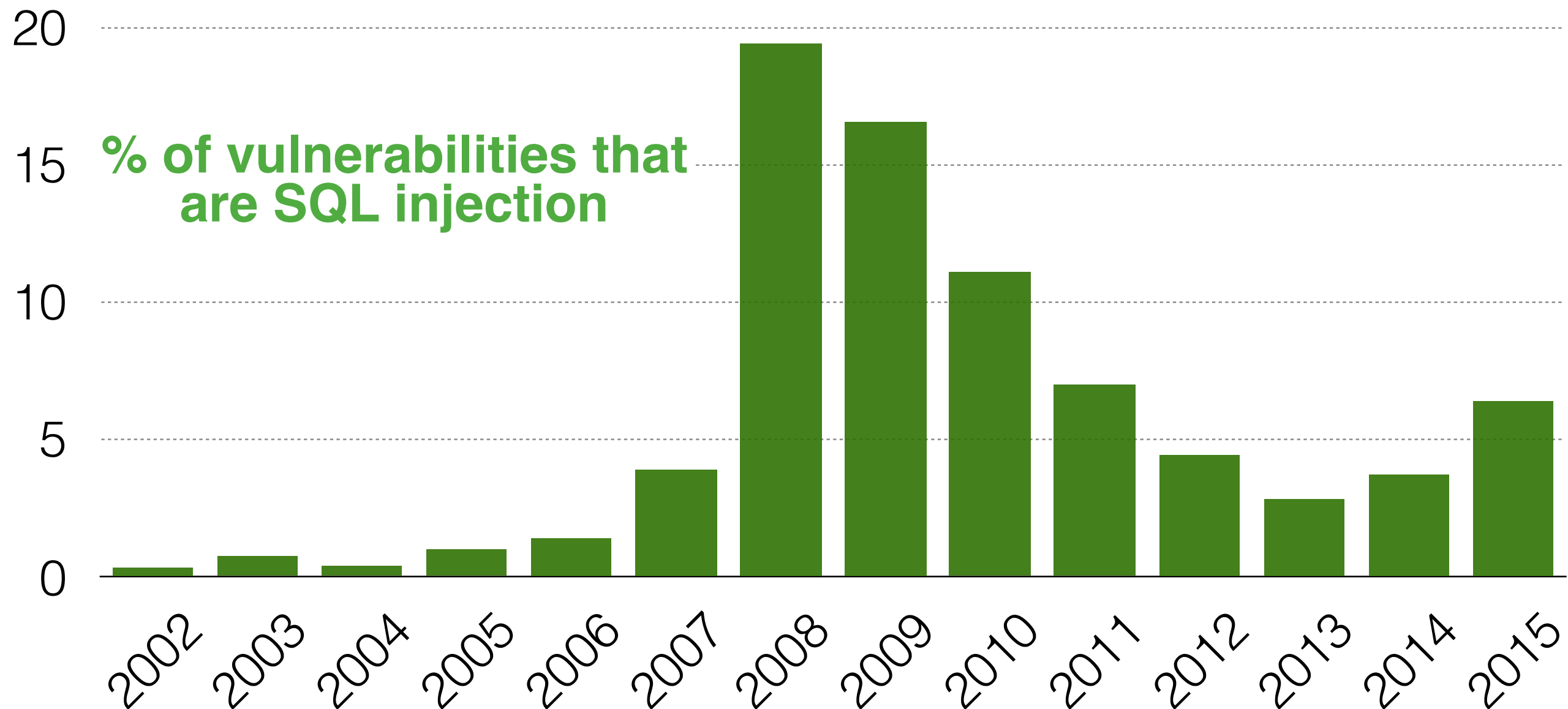
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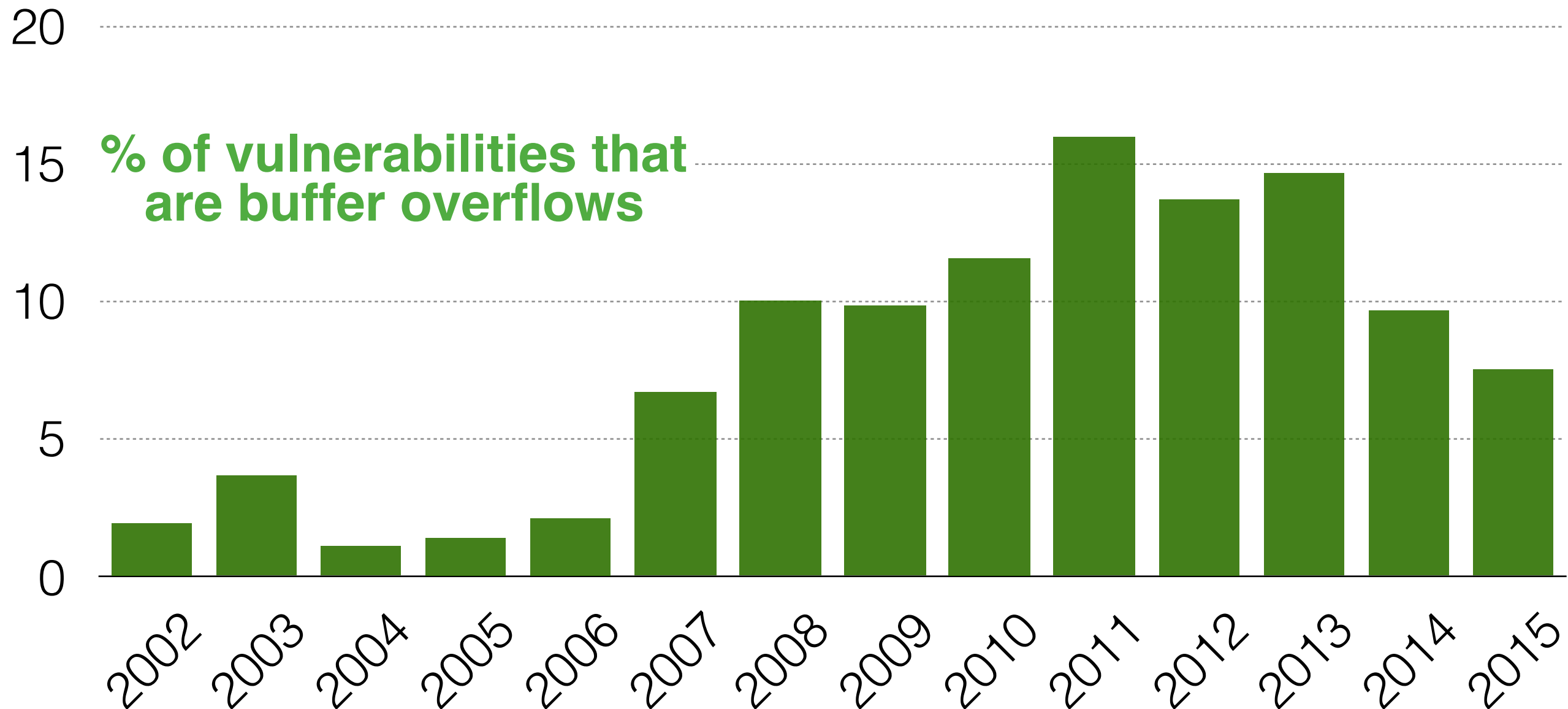
Can chain together statements with semicolon:
STATEMENT 1 ; STATEMENT 2

SQL injection attacks are prevalent



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

Buffer overflow attacks are prevalent



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

HI, THIS IS
YOUR SON'S SCHOOL.
WE'RE HAVING SOME
COMPUTER TROUBLE.



OH, DEAR - DID HE
BREAK SOMETHING?
IN A WAY -)



DID YOU REALLY
NAME YOUR SON
Robert'); DROP
TABLE Students;-- ?



OH, YES. LITTLE
BOBBY TABLES,
WE CALL HIM.

WELL, WE'VE LOST THIS
YEAR'S STUDENT RECORDS.
I HOPE YOU'RE HAPPY.



AND I HOPE
YOU'VE LEARNED
TO SANITIZE YOUR
DATABASE INPUTS.



SQL injection countermeasures

- **Blacklisting**: Delete the characters you don't want
 - '
 - --
 - ;
- Downside: "Peter O'Connor"
 - You want these characters sometimes!
 - How do you know if/when the characters are bad?

SQL injection countermeasures

1. Whitelisting

- Check that the user-provided input is in some set of values known to be safe
 - Integer within the right range
- Given an invalid input, better to reject than to fix
 - “Fixes” may introduce vulnerabilities
 - *Principle of fail-safe defaults*
- Downside:
 - Um.. Names come from a well-known dictionary?

SQL injection countermeasures

2. Escape characters

- Escape characters that could alter control
 - ' $\Rightarrow$ \'
 - ; $\Rightarrow$ \;
 - - $\Rightarrow$ \-
 - \ $\Rightarrow$ \\
- Hard by hand, but there are many libs & methods
 - magic_quotes_gpc = On
 - mysql_real_escape_string()
- Downside: Sometimes you want these in your SQL!

The underlying issue

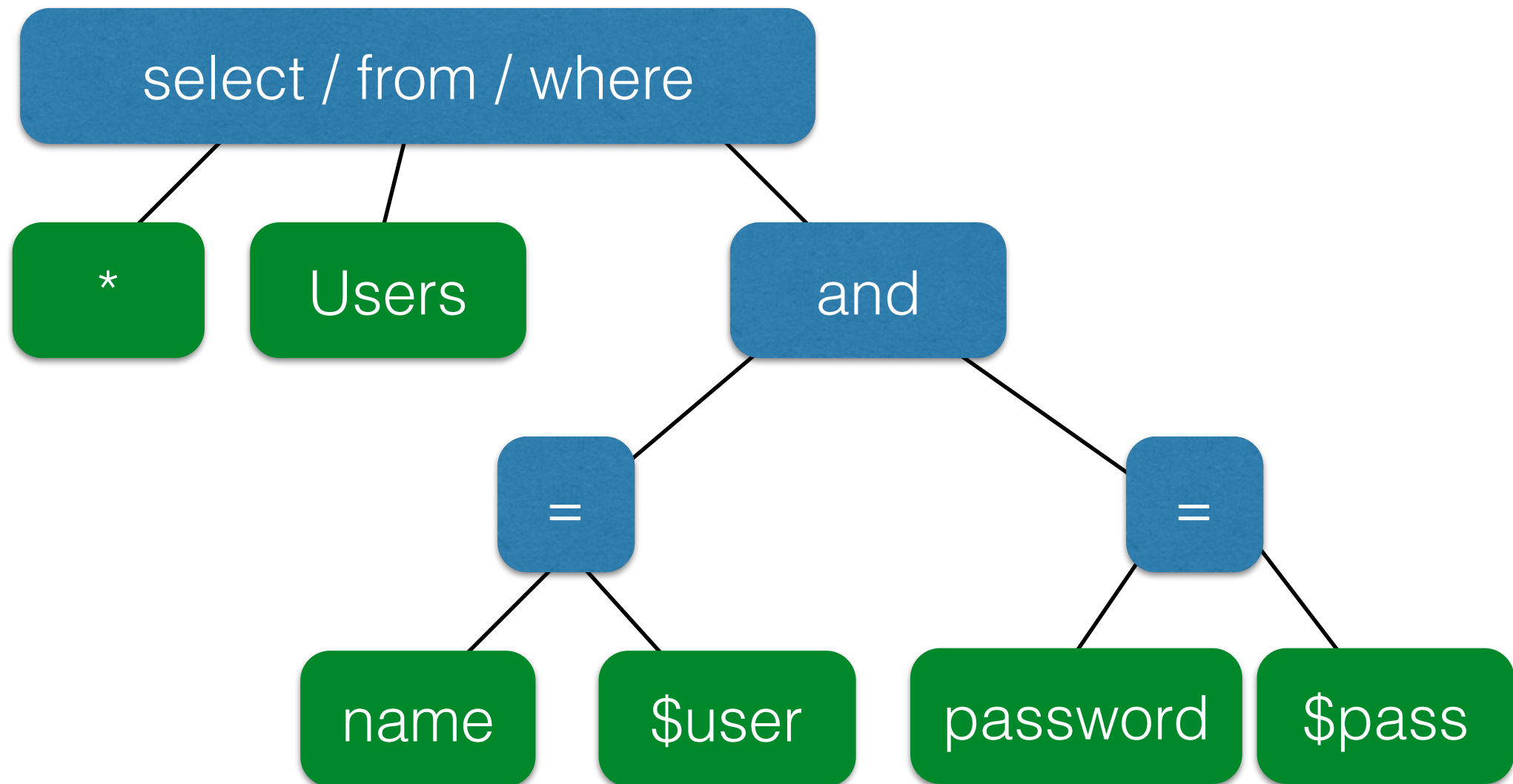
```
$result = mysql_query("select * from Users  
                        where(name=' $user' and password=' $pass' );");
```

- 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**

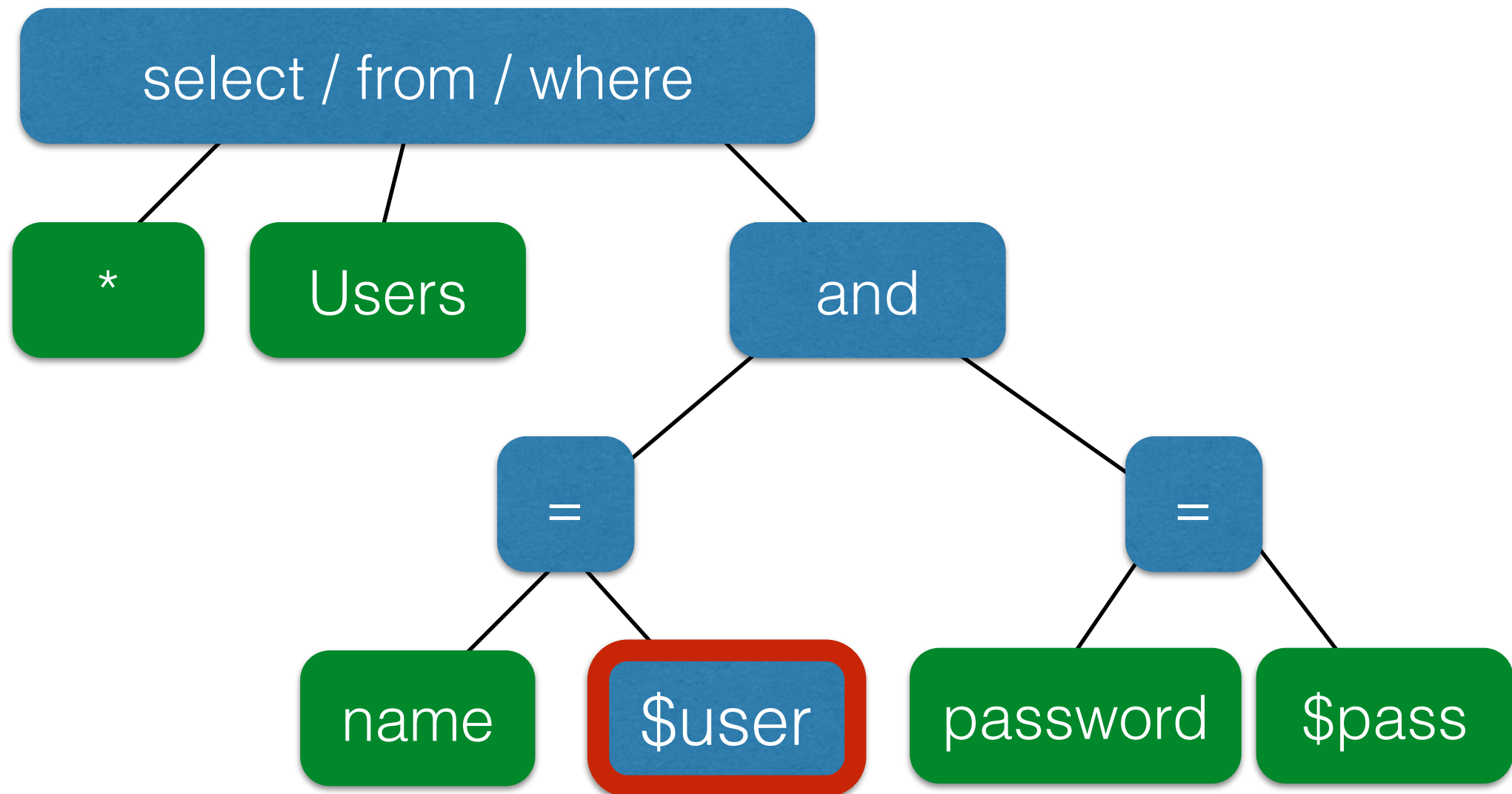
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SQL injection countermeasures

3. Prepared statements & bind variables

Key idea: *Decouple* the code and the data

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Key idea: *Decouple* the code and the data

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$result = mysql_query("select * from Users  
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```

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

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

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

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$statement = $db->prepare("select * from Users  
where(name=? and password=?);"); Bind variables
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$statement->bind_param("ss", $user, $pass);
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```
$statement->execute(); Bind variables are typed
```

SQL injection countermeasures

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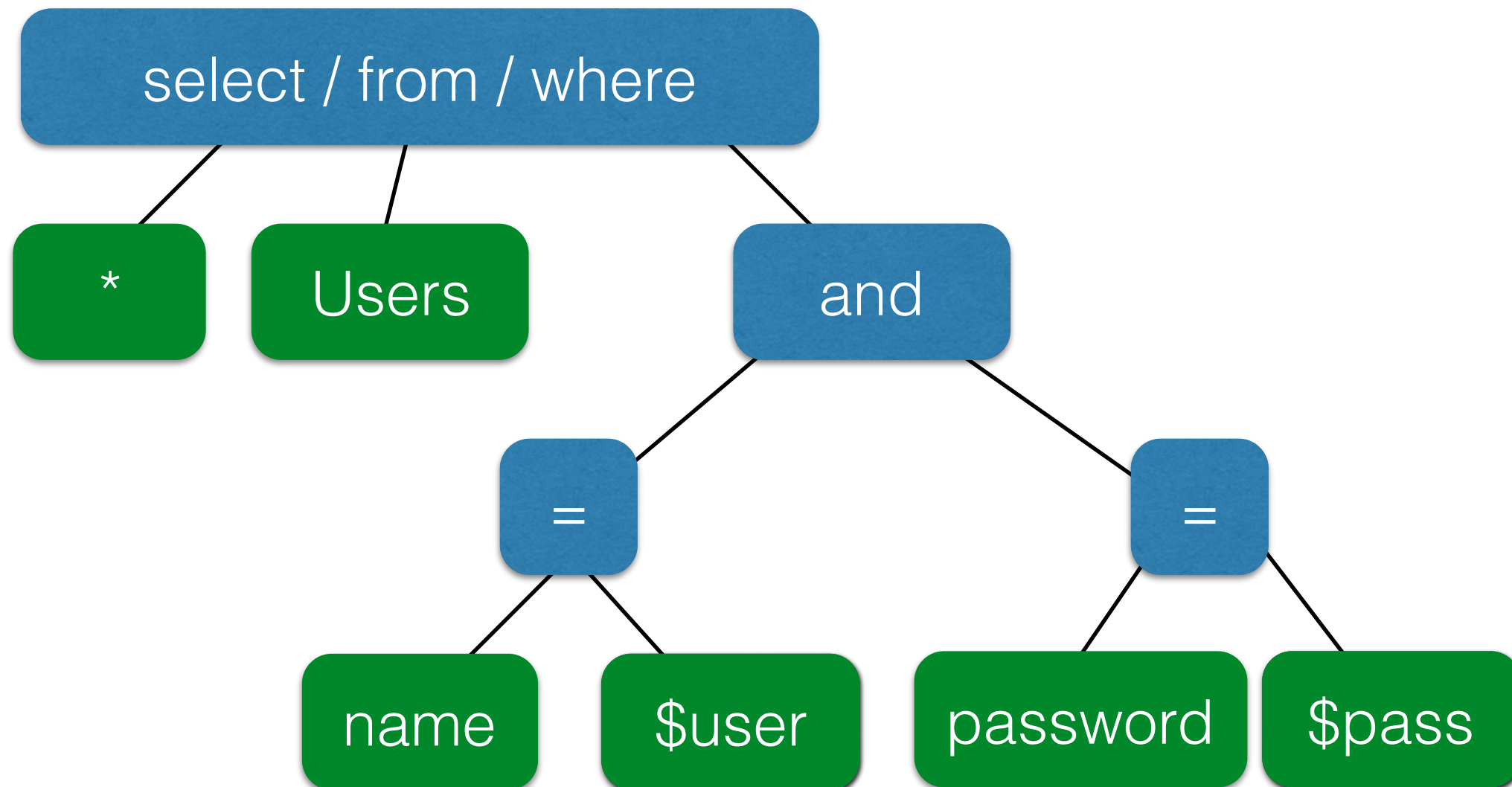
Decoupling lets us compile now, before binding the data

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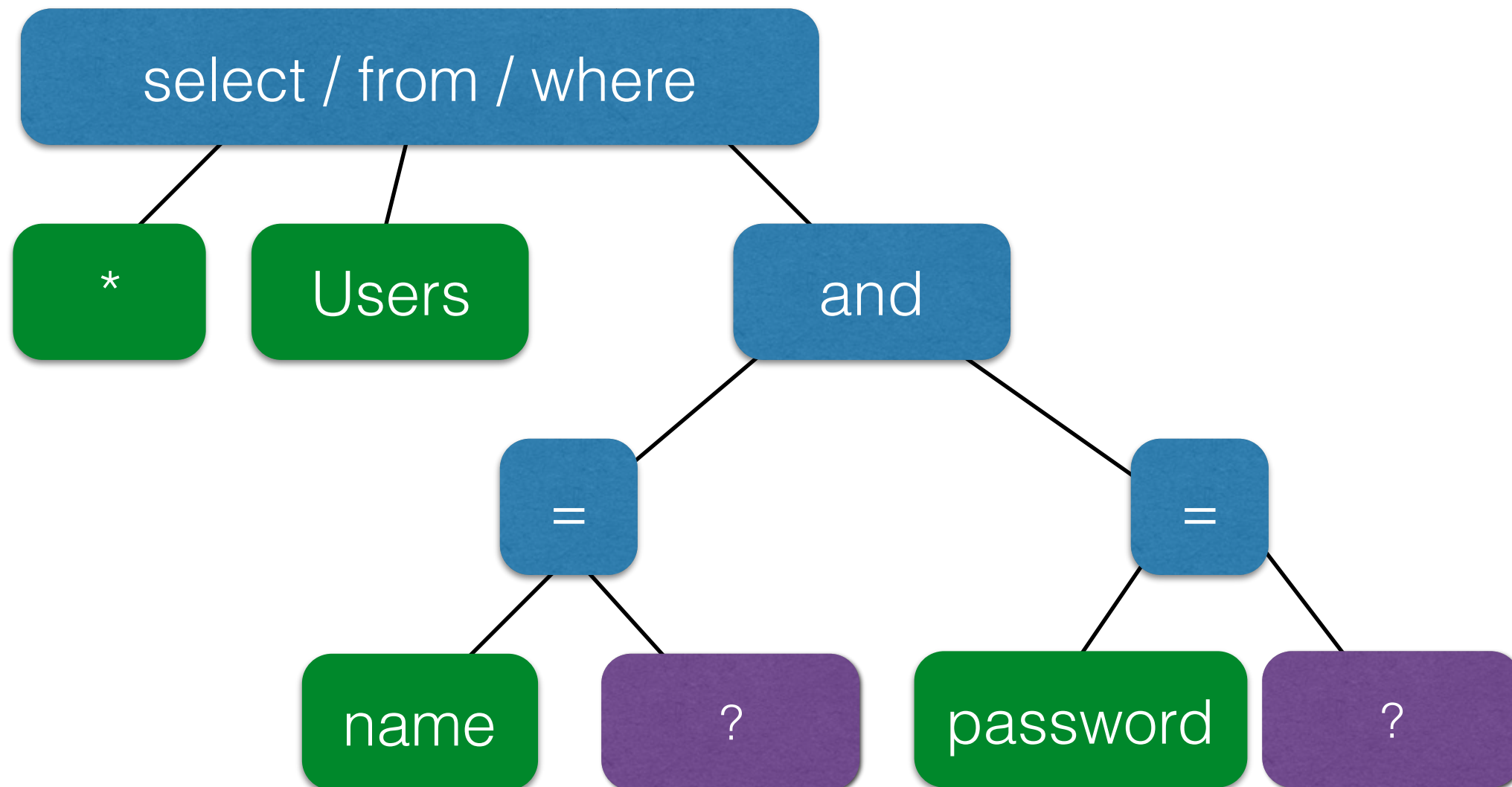

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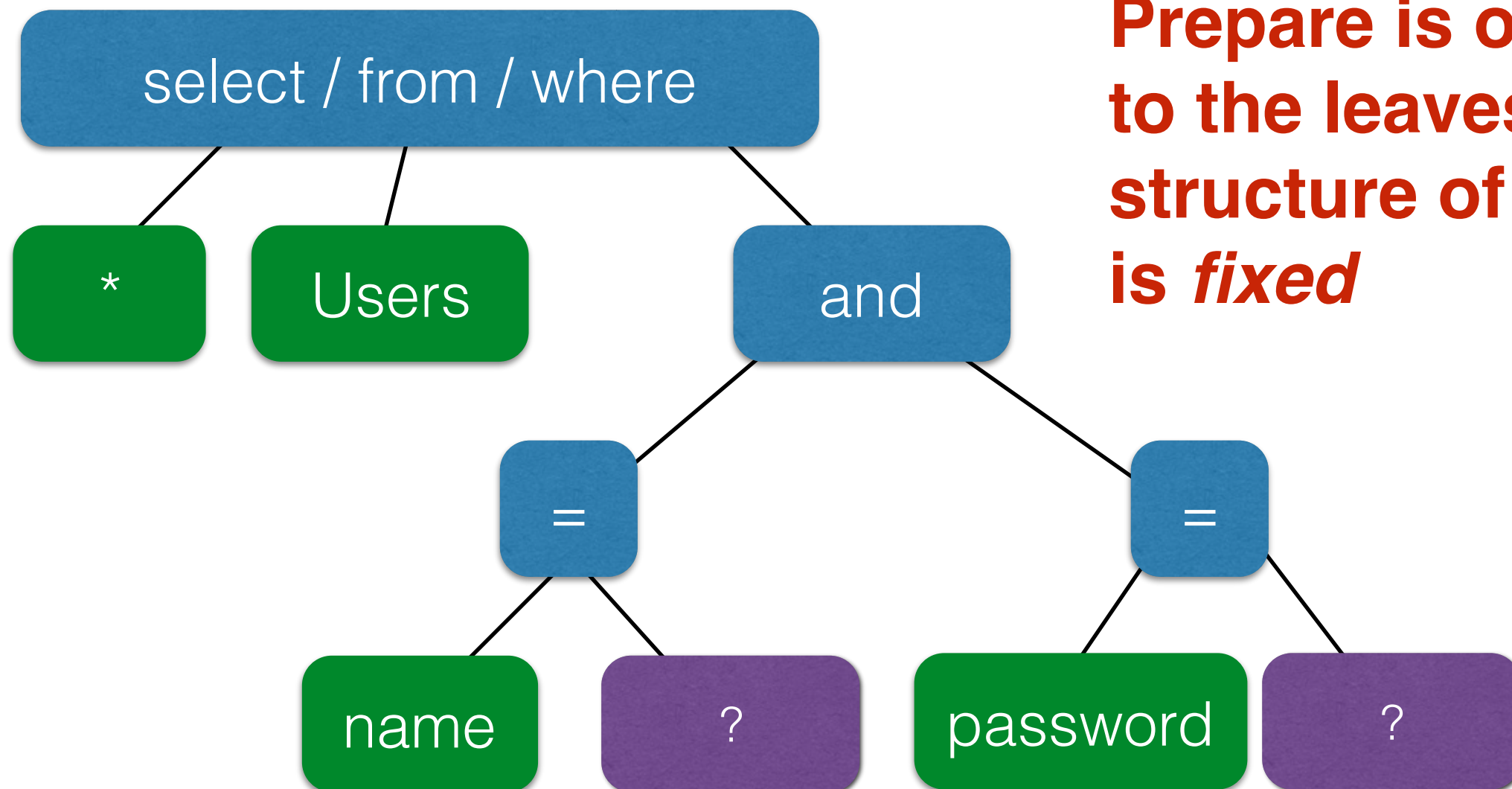
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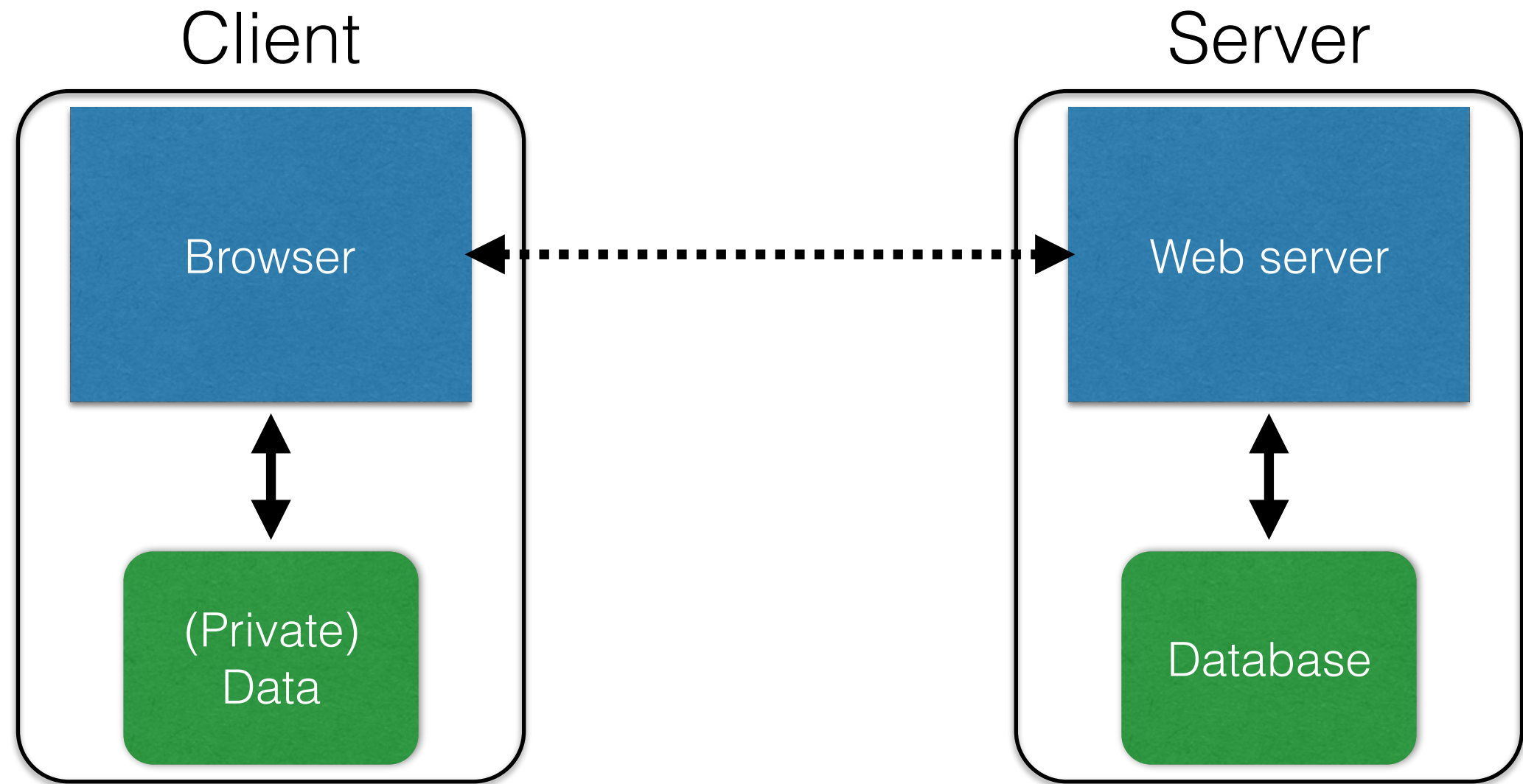
Prepare is only applied to the leaves, so the structure of the tree is *fixed*

Mitigating the impact

- Limit privileges
 - Can limit commands and/or tables a user can access
 - Allow SELECT queries on Orders_Table but not on Creditcards_Table
 - Follow the principle of least privilege
 - Incomplete fix, but helpful
- Encrypt sensitive data stored in the database
 - May not need to encrypt Orders_Table
 - But certainly encrypt Creditcards_Table.cc_numbers

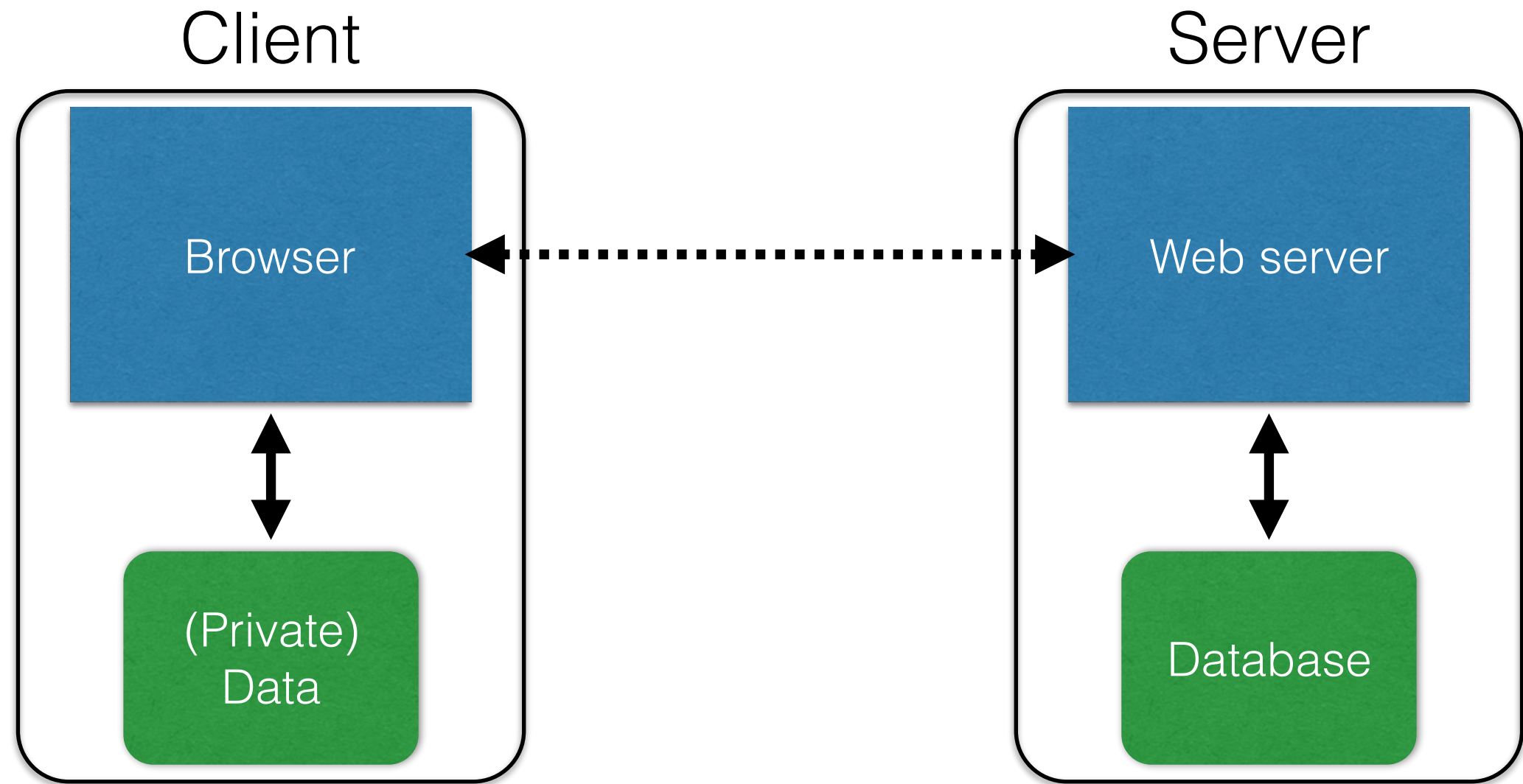
Web security

A very basic web architecture



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

A very basic web architecture



(Much) user data is part of the browser

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

Interacting with web servers

Get and put *resources* which are identified by a URL

`http://www.cs.umd.edu/~dml/home.html`

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Protocol

`ftp`

`https`

`tor`

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Get and put *resources* which are identified by a URL

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Hostname/server

Translated to an IP address by DNS
(more on this later)

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

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Here, the file `home.html` is *dynamic content*
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Path to a resource

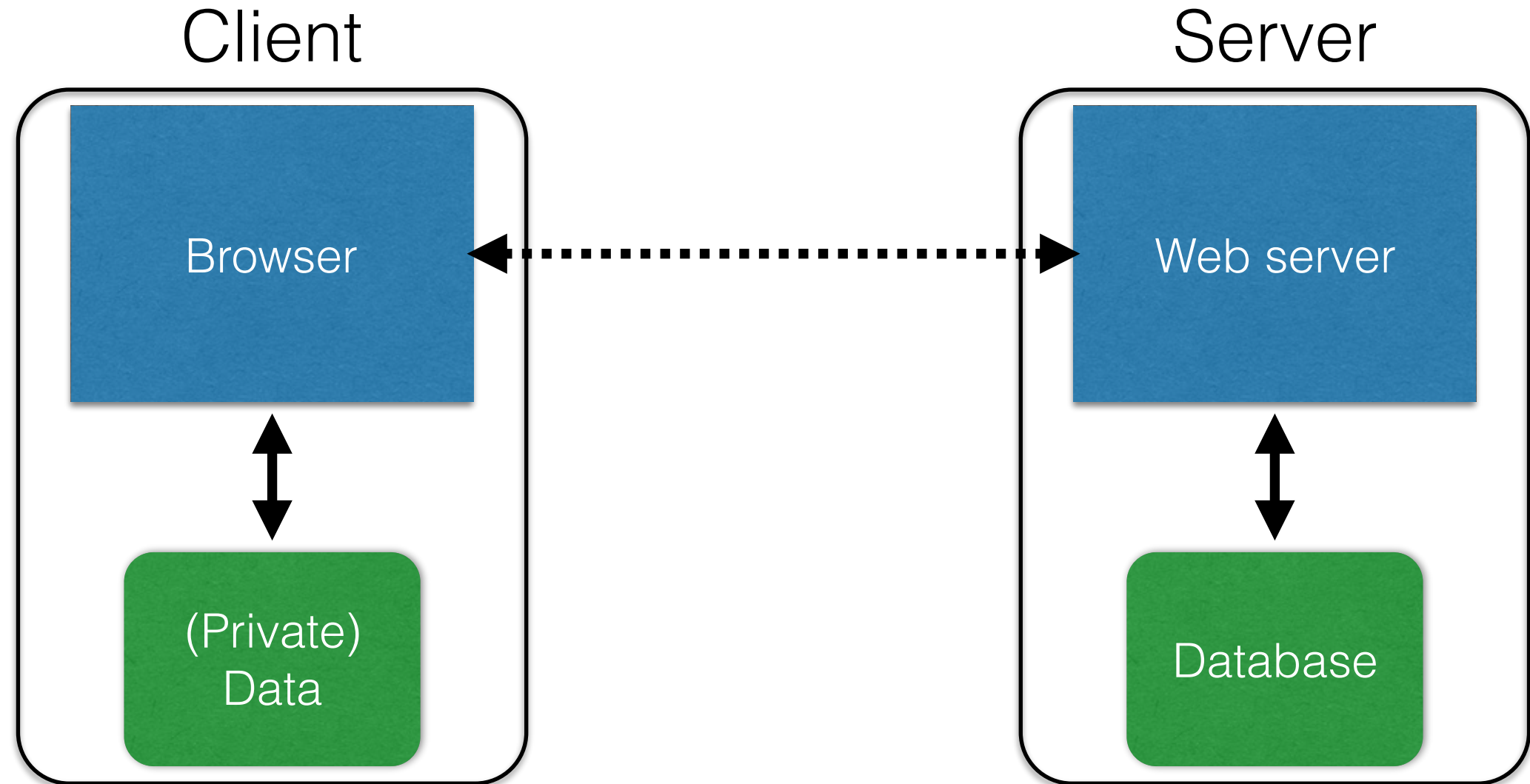
Here, the file `home.html` is *static content*
i.e., a fixed file returned by the server

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

Arguments

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

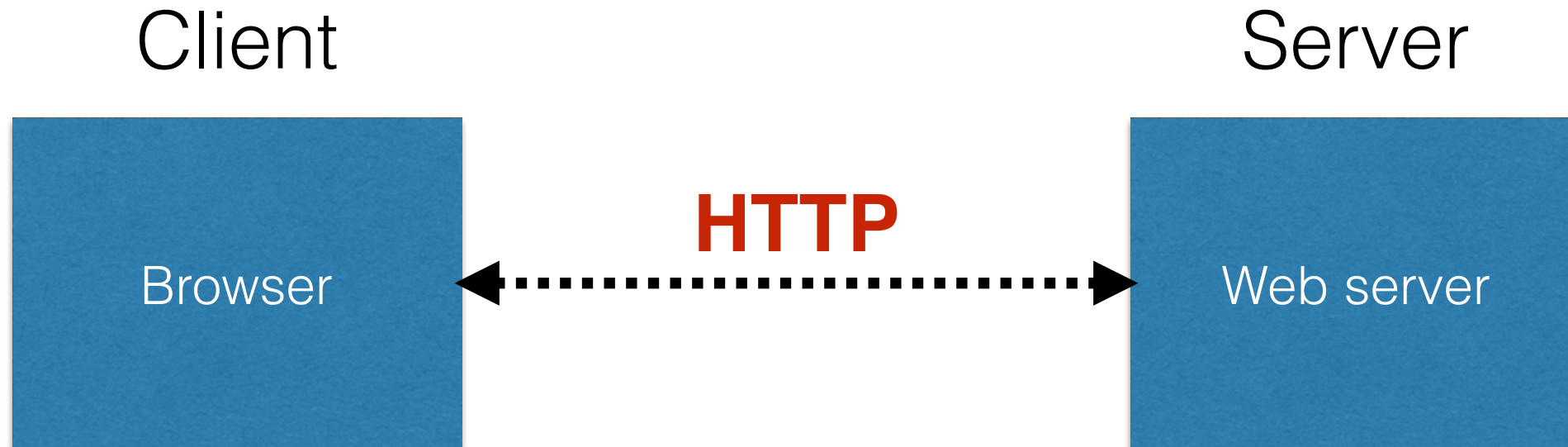
Basic structure of web traffic



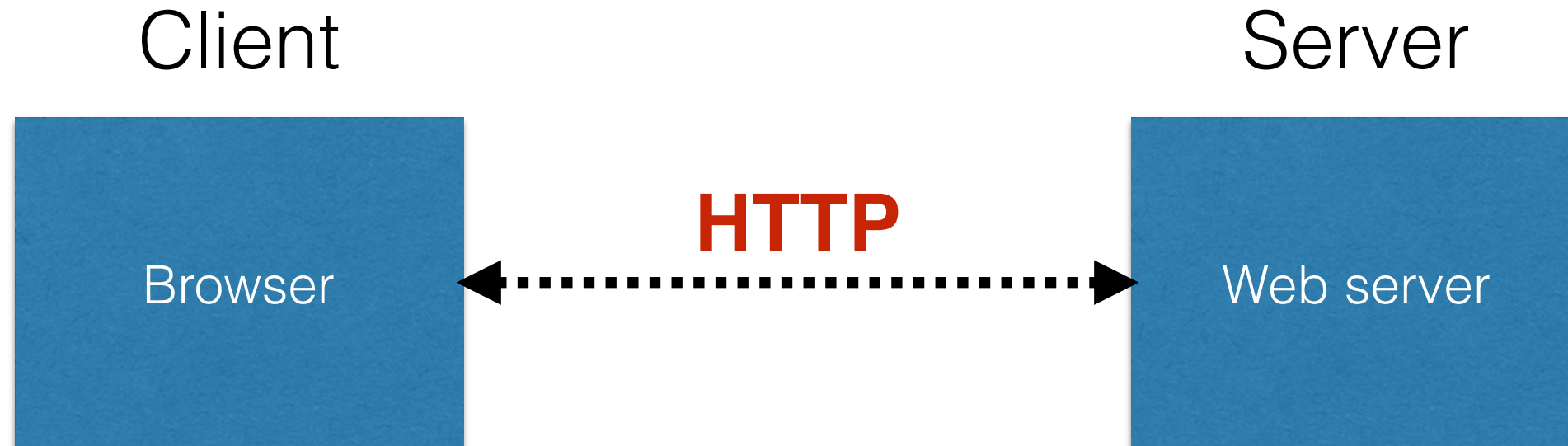
Basic structure of web traffic



Basic structure of web traffic



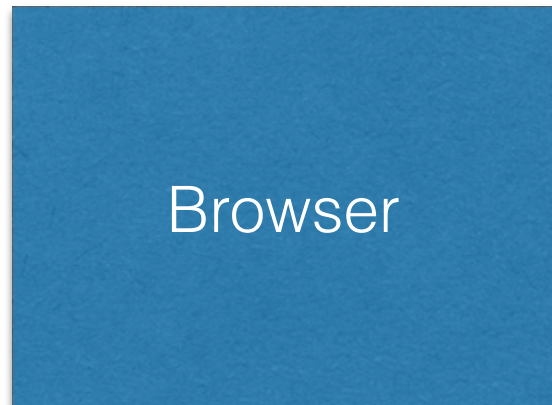
Basic structure of web traffic



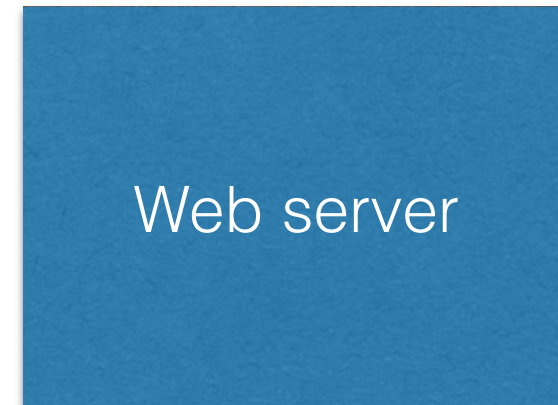
- HyperText Transfer Protocol (**HTTP**)
 - An “application-layer” protocol for exchanging collections of data

Basic structure of web traffic

Client

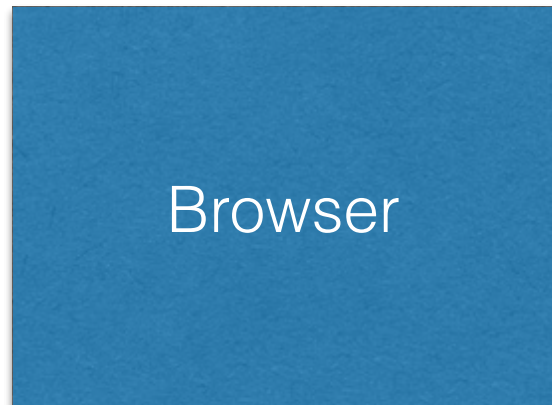


Server

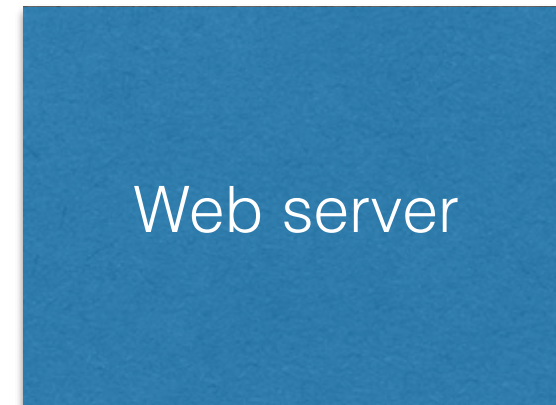


Basic structure of web traffic

Client

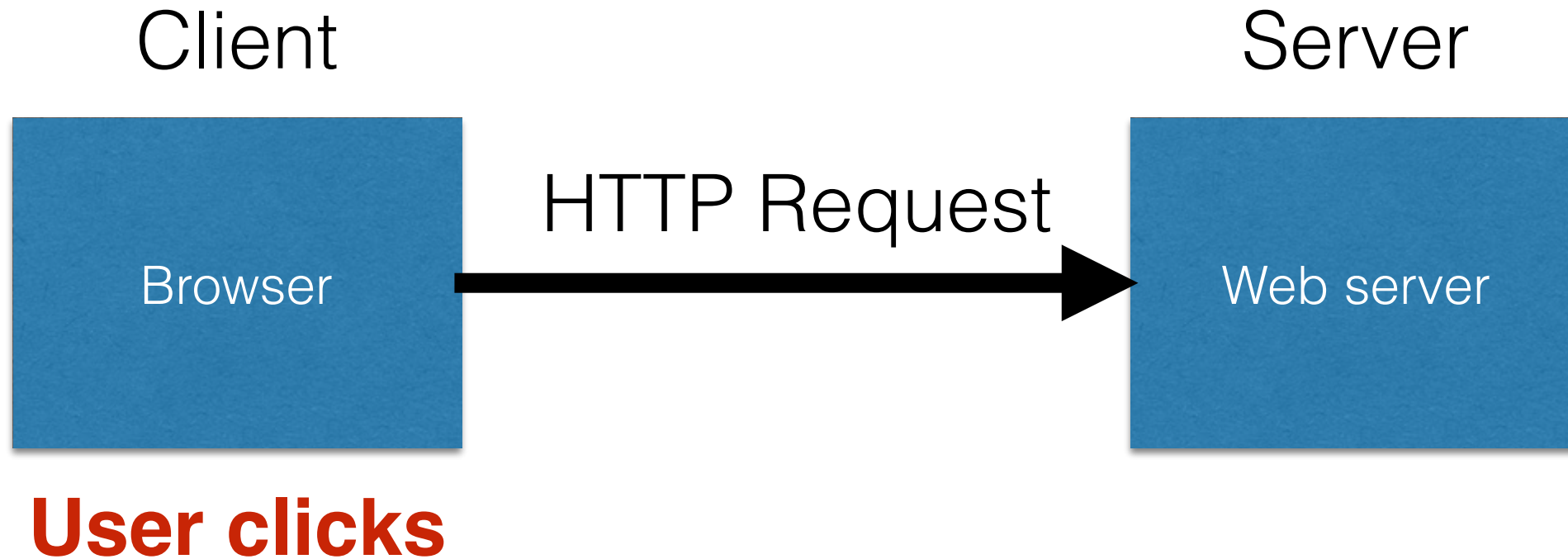


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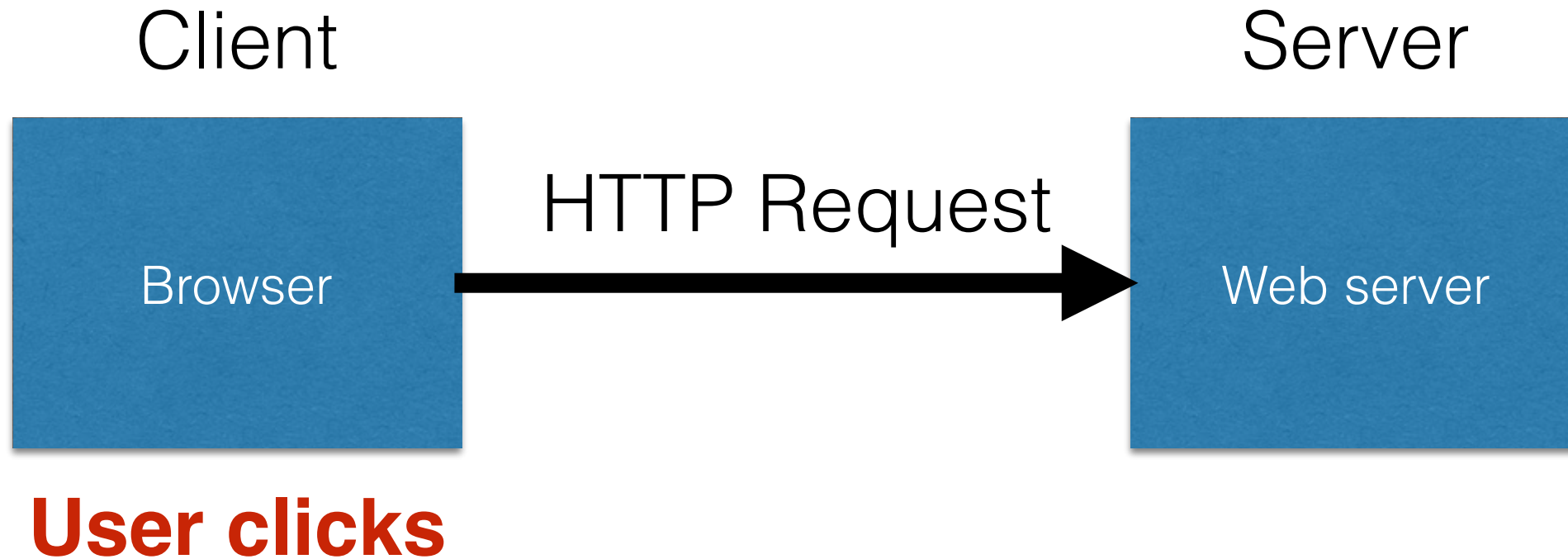


User clicks

Basic structure of web traffic



Basic structure of web traffic



- Requests contain:
 - The URL of the resource the client wishes to obtain
 - Headers describing what the browser can do
- Requests be GET or POST
 - **GET**: all data is in the URL itself (supposed to have no side-effects)
 - **POST**: includes the data as separate fields (can have side-effects)

HTTP GET requests

<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`

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`Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7`

`Keep-Alive: 115`

`Connection: keep-alive`

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Keep-Alive: 115

Connection: keep-alive

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



reddit

SECURITY

hot

new

rising

controversial

top

gilded

promoted

1

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HTTP Headers

<http://www.theverge.com/2015/2/19/8067505/lenovo-installs-adware-private-data-hackers>

GET /2015/2/19/8067505/lenovo-installs-adware-private-data-hackers HTTP/1.1

Host: www.theverge.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

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Keep-Alive: 115

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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 requests

Posting on Piazza

HTTP Headers

`https://piazza.com/logic/api?method=content.create&aid=i6ceq3skno48`

`POST /logic/api?method=content.create&aid=i6ceq3skno48 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?nid=i55texo54nv3eh`

`Content-Length: 640`

`Cookie: piazza_session="`

Session cookie (more on this later). Not something you want to share!

`Pragma: no-cache`

`Cache-Control: no-cache`

`{"method":"content.create","params":{"nid":"i55texo54nv3eh","type":"note","subject":"Live HTTP headers","content":"<p>Starting today ...`

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Implicitly includes data
as a part of the URL

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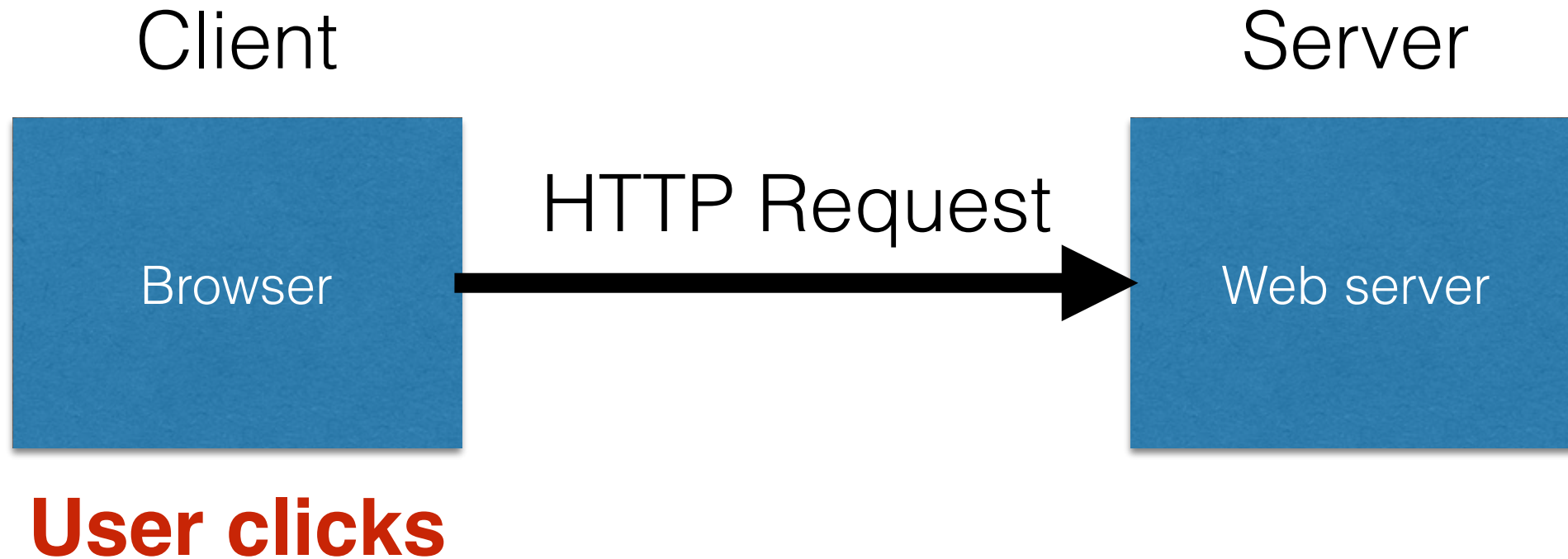
Cache-Control: no-cache

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Implicitly includes data as a part of the URL

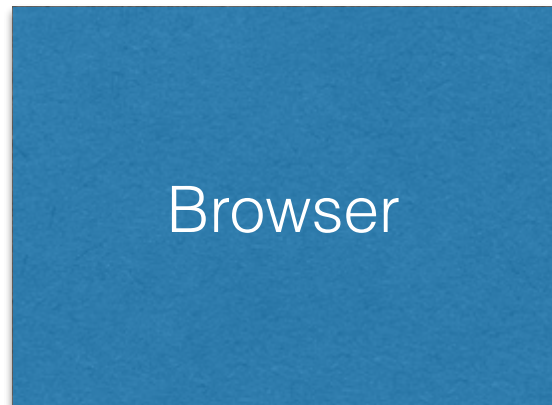
Explicitly includes data as a part of the request's content

Basic structure of web traffic

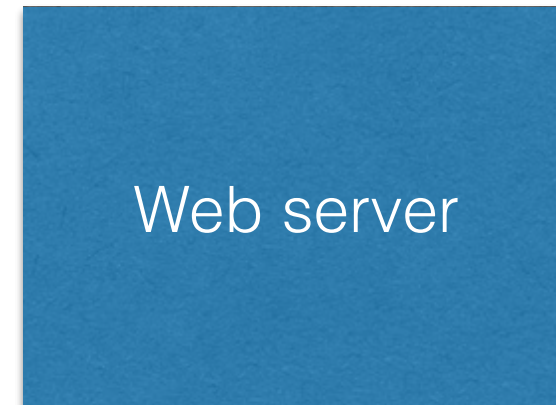


Basic structure of web traffic

Client

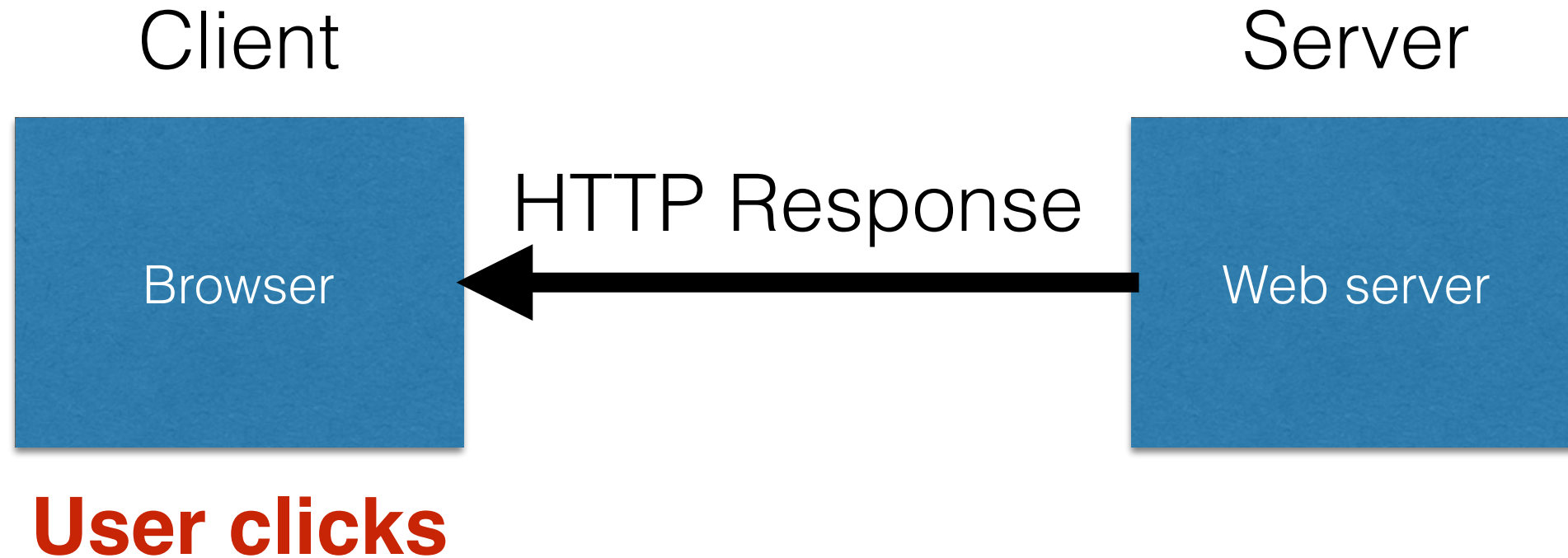


Server

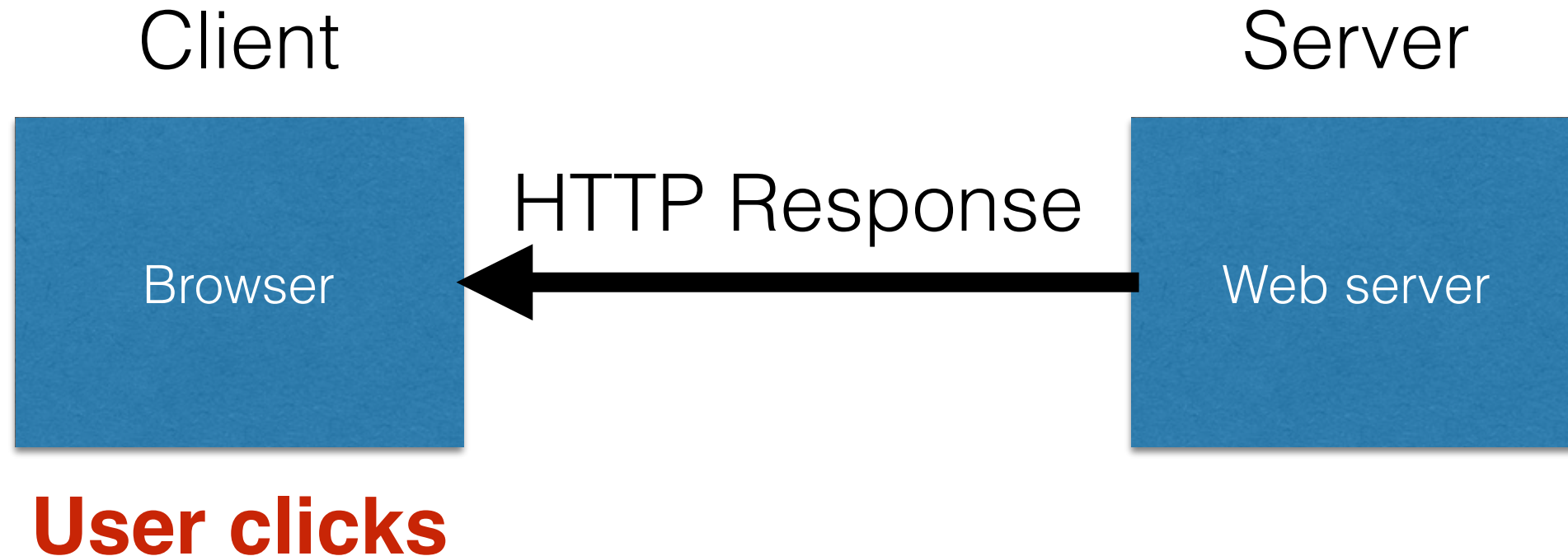


User clicks

Basic structure of web traffic



Basic structure of web traffic



- Responses contain:
 - Status code
 - Headers describing what the server provides
 - Data
 - Cookies
 - State it would like the browser to store on the site's behalf

HTTP responses

HTTP/1.1 200 OK
Date: Tue, 18 Feb 2014 08:20:34 GMT
Server: Apache
Set-Cookie: session-zdnet-production=6bhqcali0cbciagu11sisac2p3; path=/; domain=zdnet.com
Set-Cookie: zdregion=MTI5LjluMTI5LjE1Mzp1czp1czpjZDjmNWY5YTdkODU1N2Q2YzM5NGU3M2Y1ZTRmN0
Set-Cookie: zdregion=MTI5LjluMTI5LjE1Mzp1czp1czpjZDjmNWY5YTdkODU1N2Q2YzM5NGU3M2Y1ZTRmN0
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>

HTTP responses

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
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<html> ..... </html>
```

HTTP Headers

<http://blog.lifars.com/2015/02/18/weird-security-term-of-the-week-clickjacking/>

GET /2015/02/18/weird-security-term-of-the-week-clickjacking/ HTTP/1.1

Host: blog.lifars.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>

HTTP/1.1 200 OK

Server: nginx

Date: Thu, 19 Feb 2015 17:25:28 GMT

Content-Type: text/html; charset=UTF-8

Transfer-Encoding: chunked

Connection: keep-alive

Vary: Accept-Encoding, Cookie

X-hacker: If you're reading this, you should visit automattic.com/jobs and apply to join the fun, mention this header.

X-Pingback: <http://blog.lifars.com/xmlrpc.php>

Link: <<http://wp.me/p4BZPV-iV>>; rel=shortlink

Last-Modified: Thu, 19 Feb 2015 17:25:28 GMT

Cache-Control: max-age=300, must-revalidate

X-nananana: Batcache

Content-Encoding: gzip

HTTP Headers

<http://blog.lifars.com/2015/02/18/weird-security-term-of-the-week-clickjacking/>

GET /2015/02/18/weird-security-term-of-the-week-clickjacking/ HTTP/1.1

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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
- HTTP has no means of noting “oh this is the same client from that previous session”
- *With this alone, you'd have to log in at every page load*

Next time

Continuing with
**Web
Security**



Cookies
XSS & CSRF

Required reading for next lecture:

“Web Security: Are You Part Of The Problem?”

“Cross Site Request Forgery: An Introduction...”

Optional reading for this lecture:

“SQL Injection Attacks by Example”