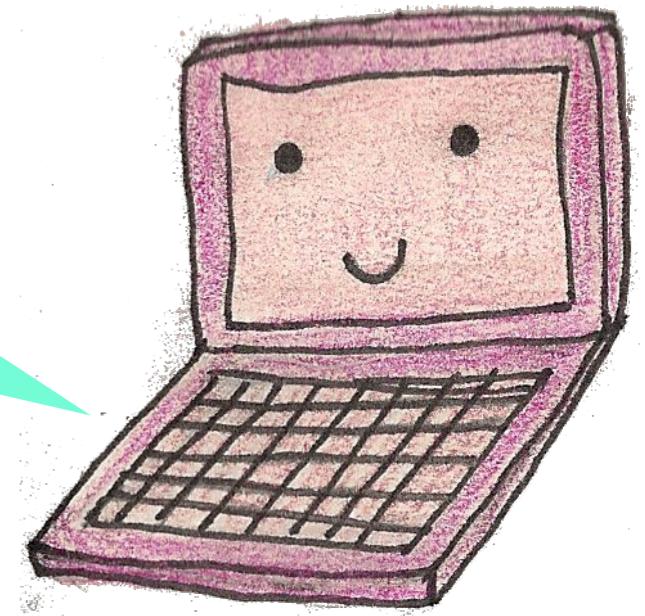


Server Farm to Table

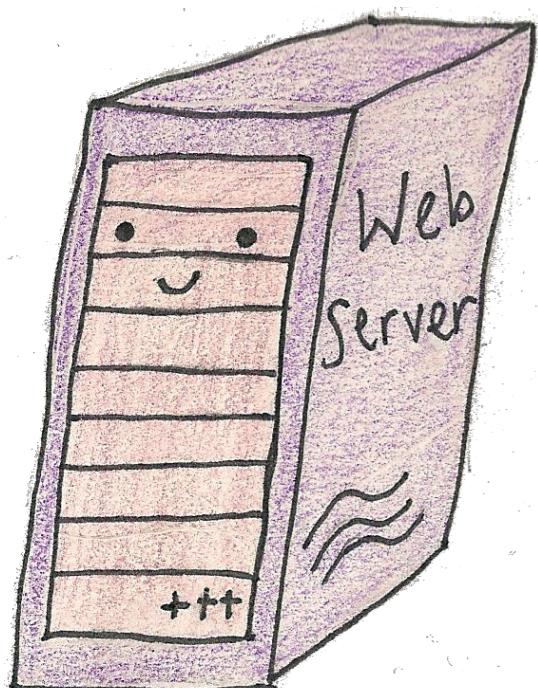
(or, how the Internet works)

Jenna Zeigen
@zeigenvector
November 3, 2015



Server Farm to Table

(or, how the Internet works)

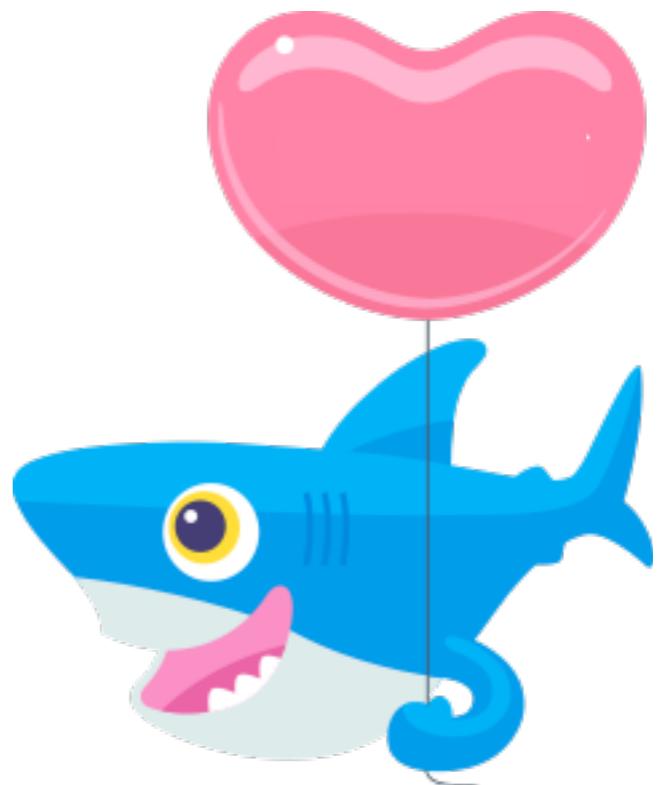


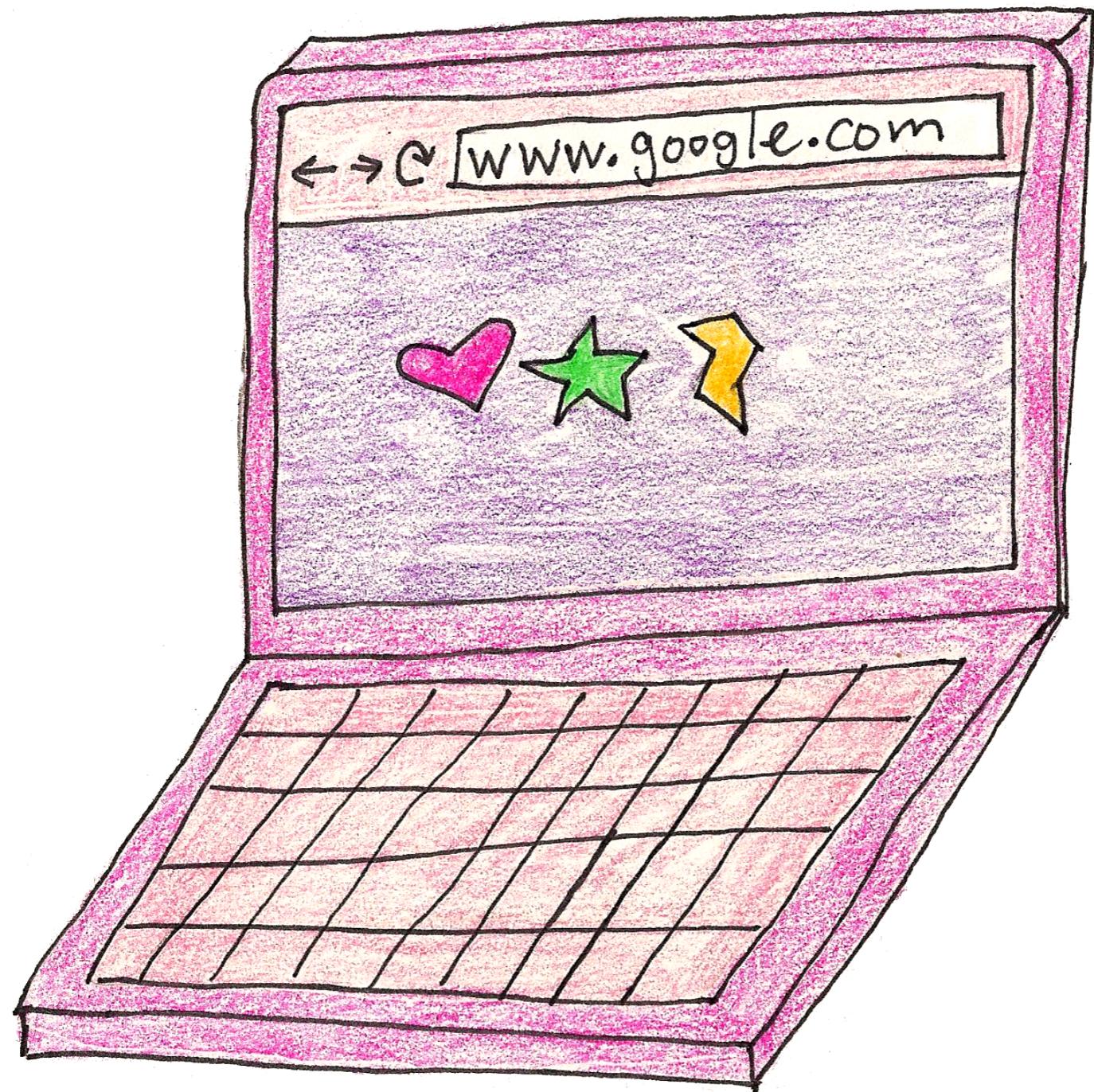
Jenna Zeigen
@zeigenvector
November 3, 2015

Engineering Manager
@ DigitalOcean



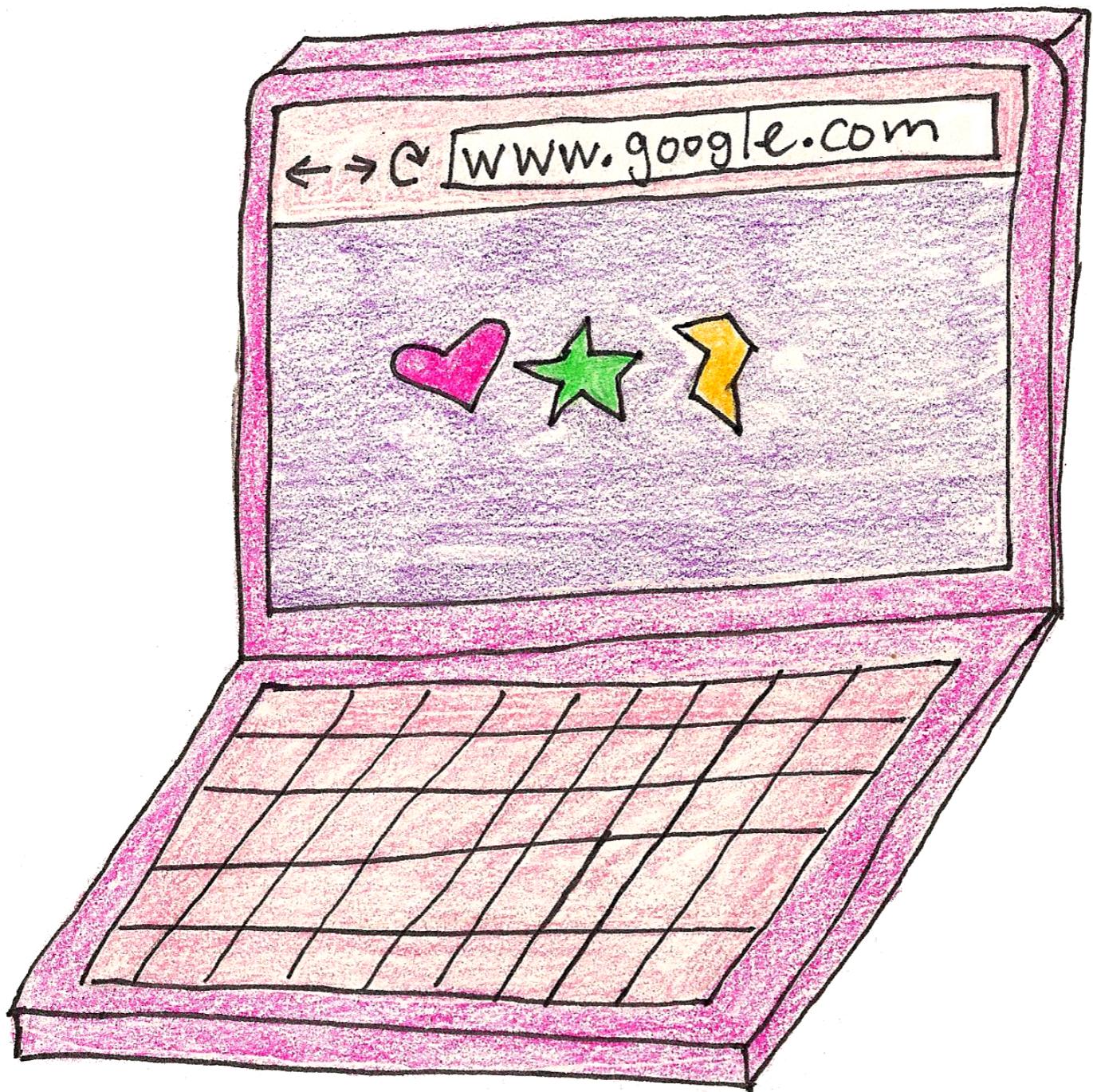
zeigenvector





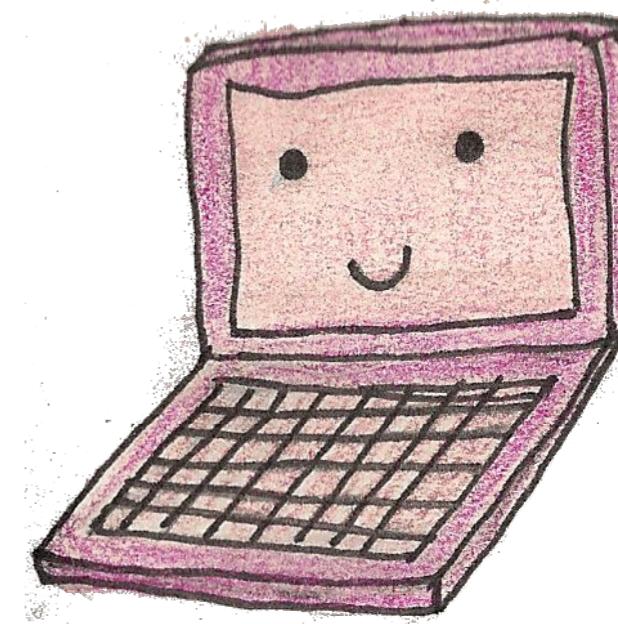
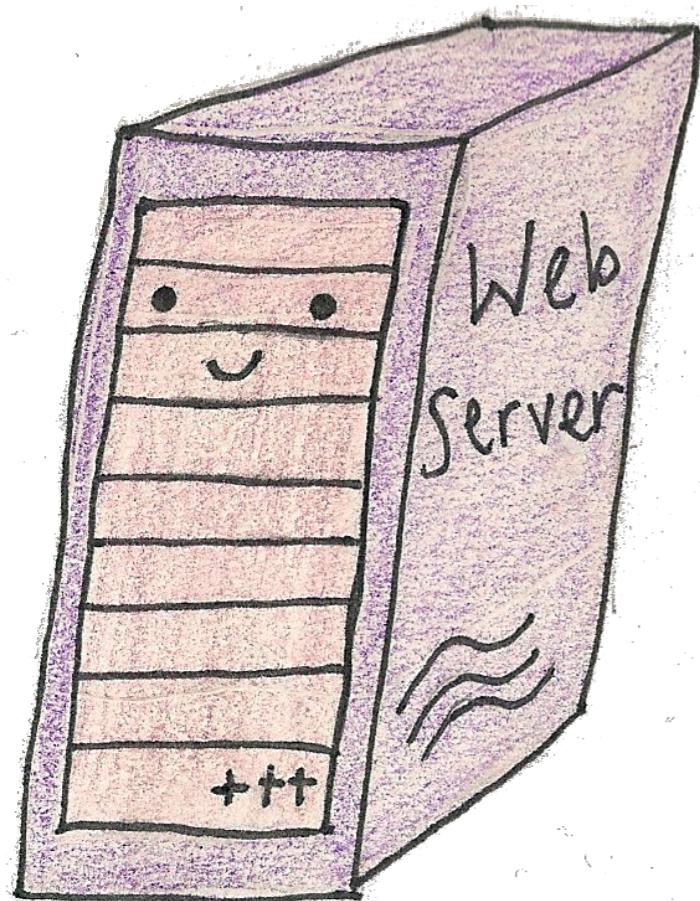
Overview

1. IP Address Lookup
2. Opening a socket
3. Security Stuff
4. HTTP Request
5. Server Things
6. HTTP Response
7. Parsing
8. Rendering



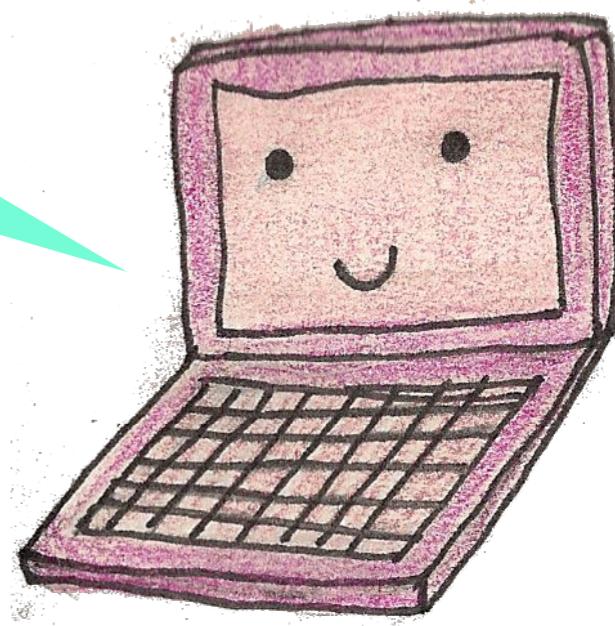
IP Address Lookup

You know my name
Look up the number



IP Address Lookup

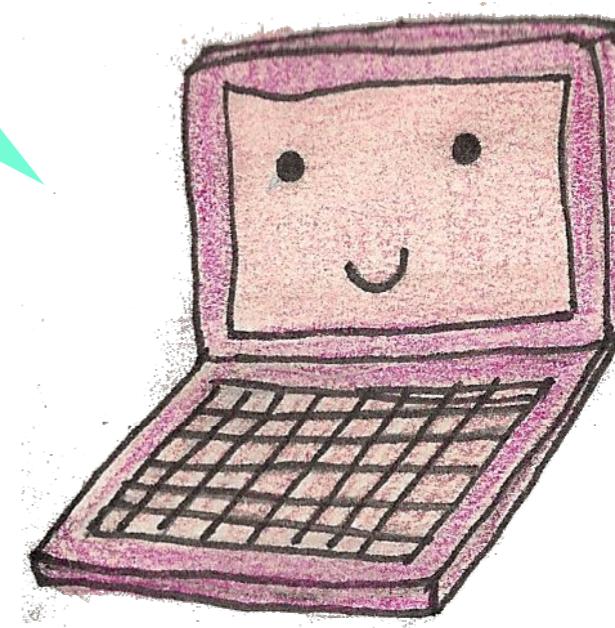
Hey, I just met you
This is easy
I still know your number
Super breezy!



IP Address Lookup

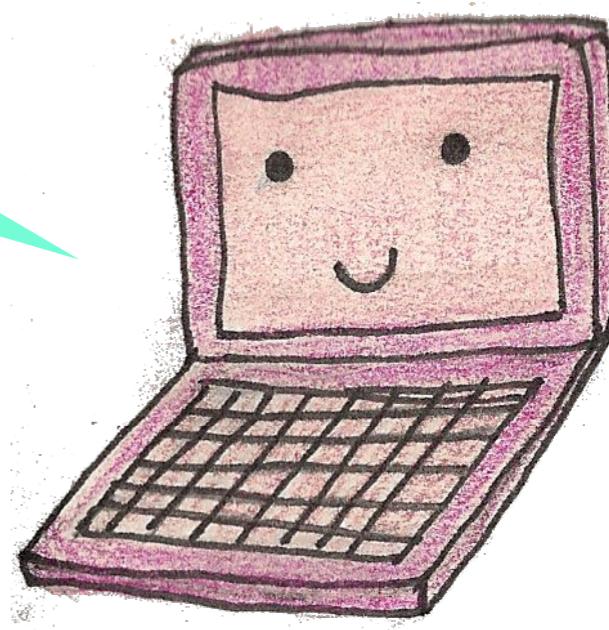
Is this name special?
So very special?

♪ ♪ ♪



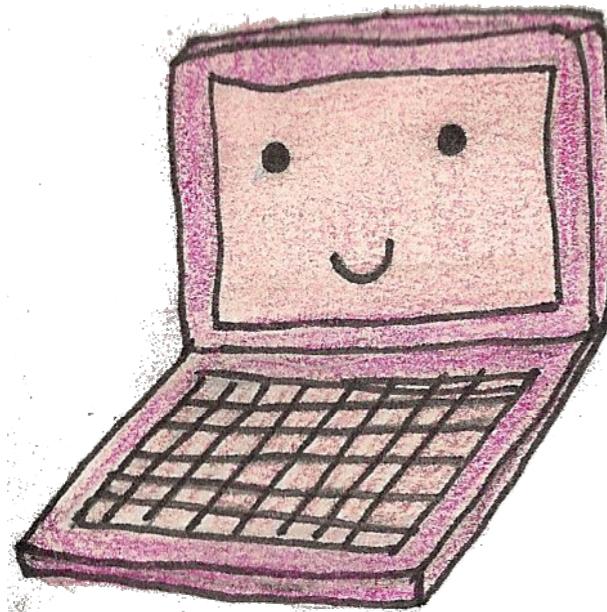
IP Address Lookup

Nope!

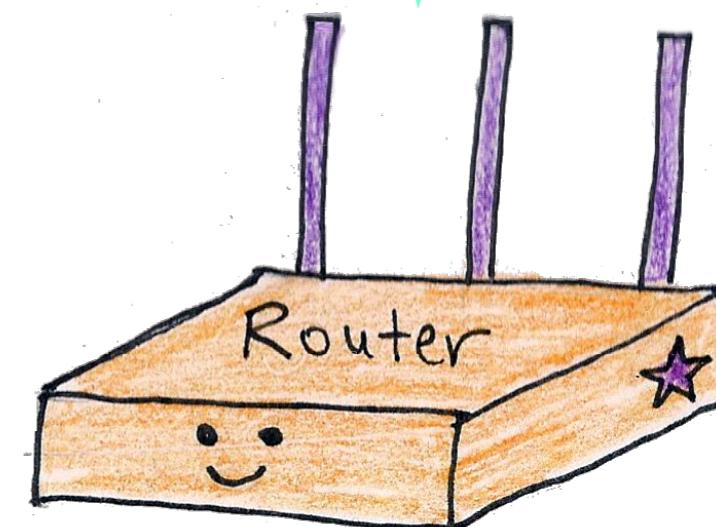


IP Address Lookup

Do you have
a www.google.com?

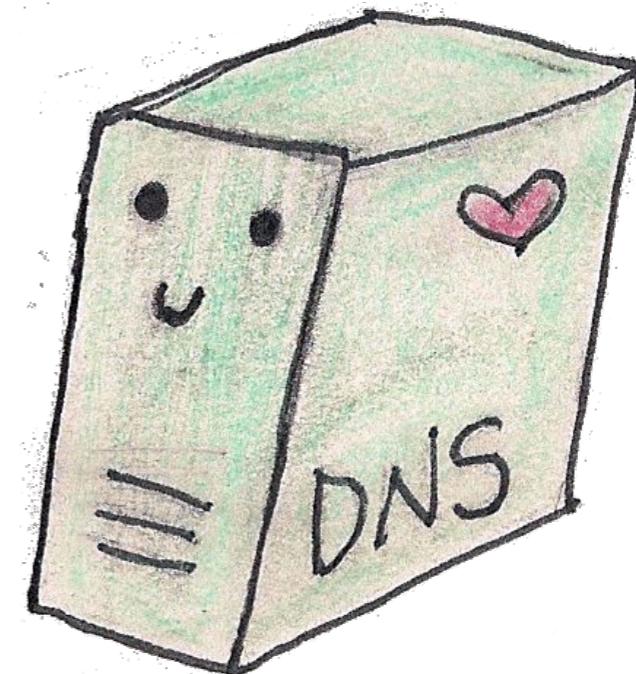
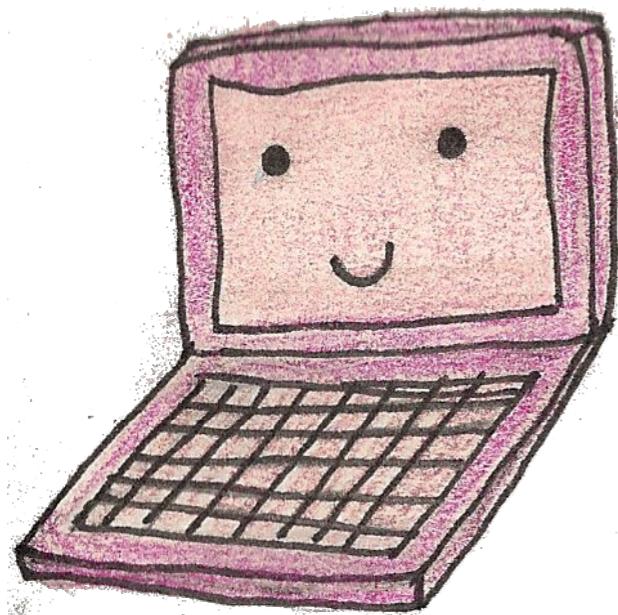


You weren't asking
me, but I know
where that is!
173.194.46.84!



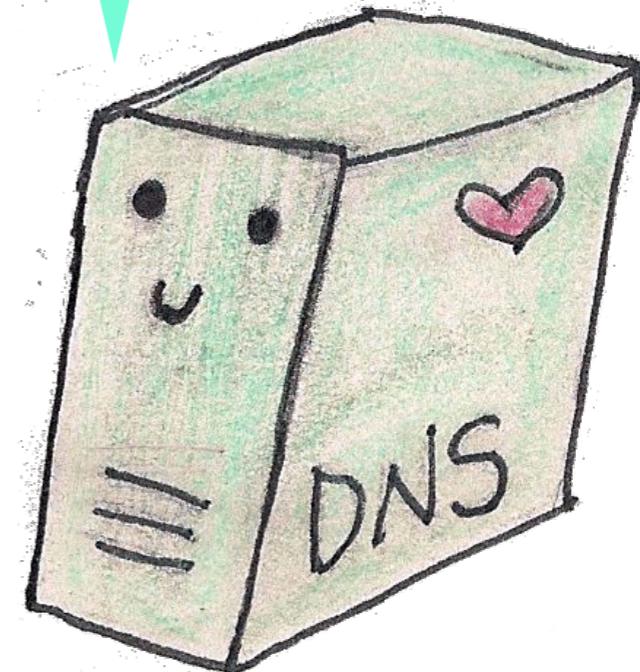
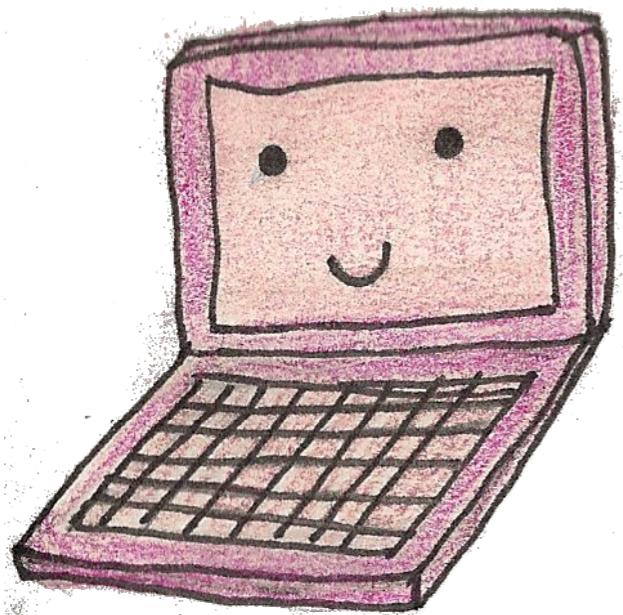
IP Address Lookup

Do you have
a www.google.com?



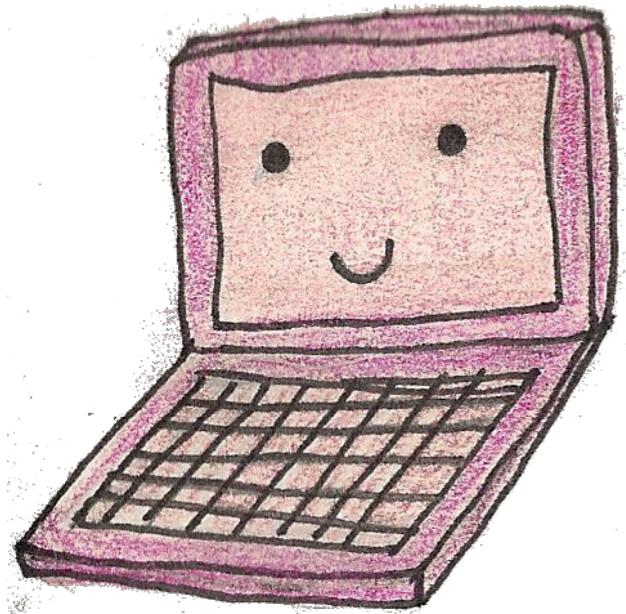
IP Address Lookup

Got a long list of these numbers
But if it's not in my "brain"
I'll ask some servers
And we'll find it by name

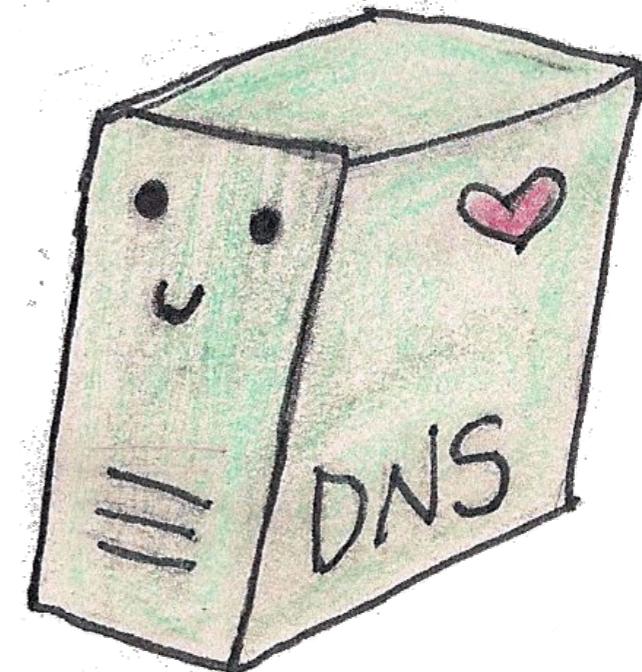


IP Address Lookup

Do you have
a `www.google.com`?

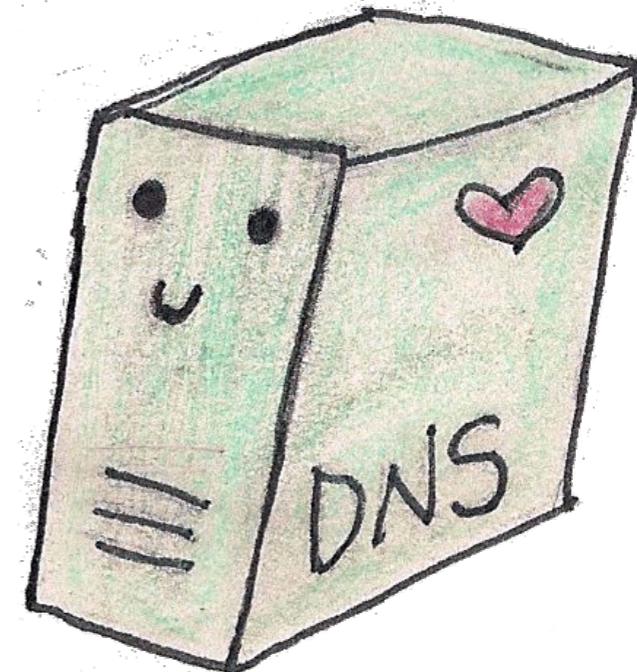
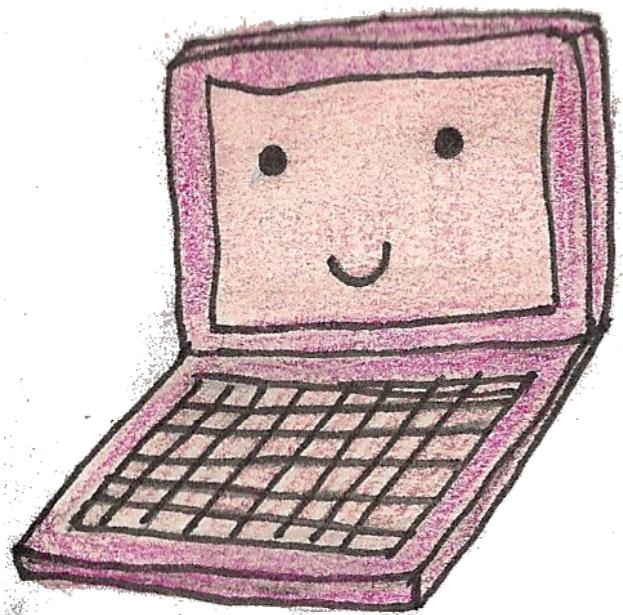


Hold on, lemme
phone a friend...



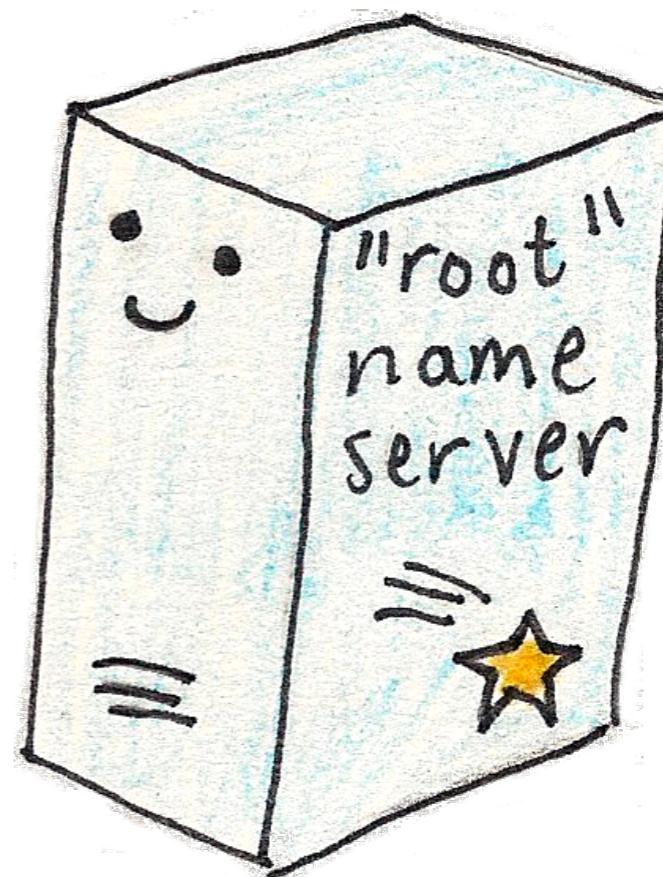
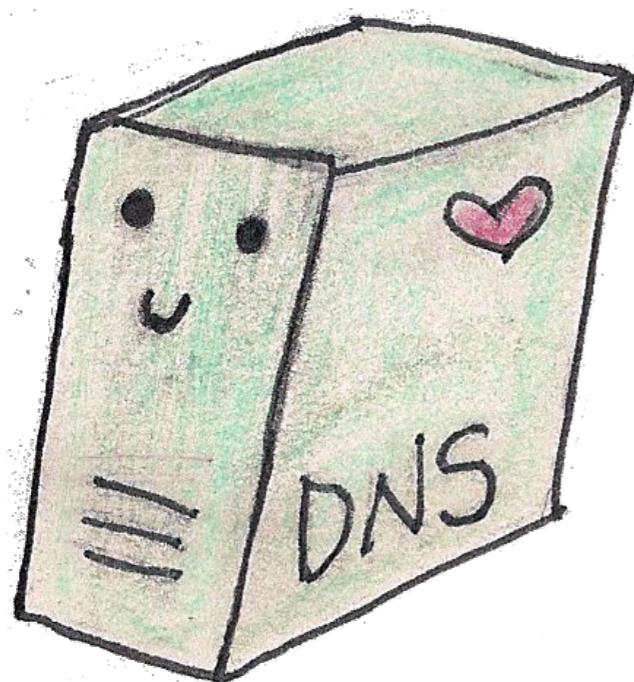
IP Address Lookup

You go talk to your friends,
talk to more friends,
talk to me



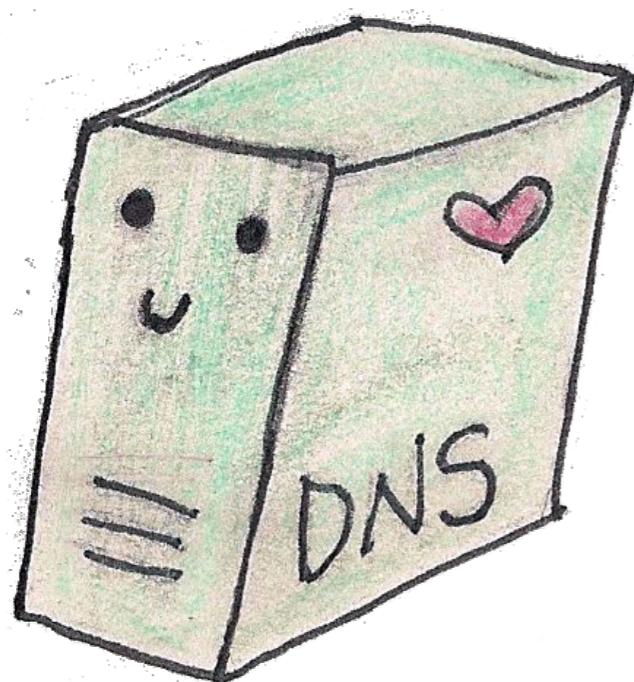
IP Address Lookup

Do you know where
www.google.com is?

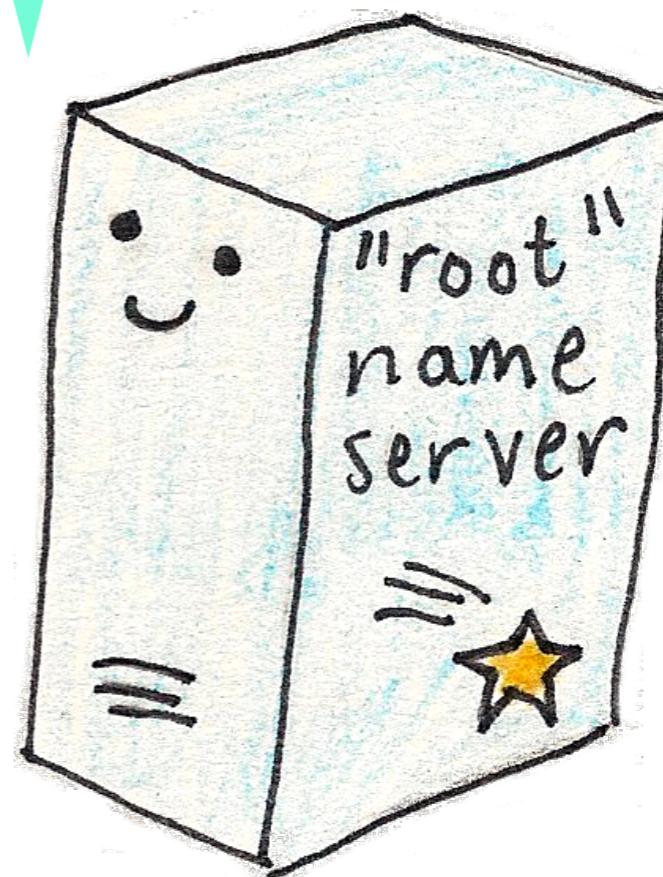


IP Address Lookup

Do you know where
www.google.com is?

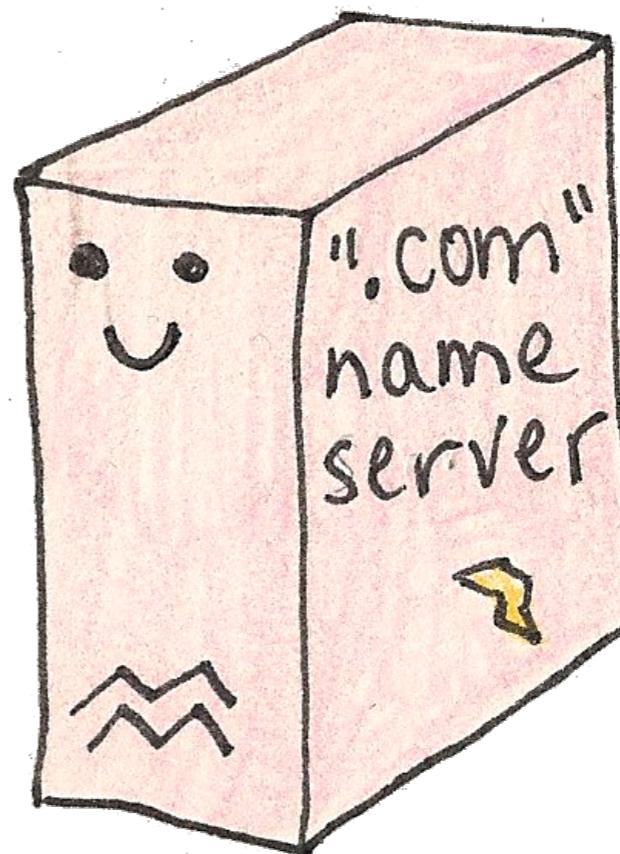
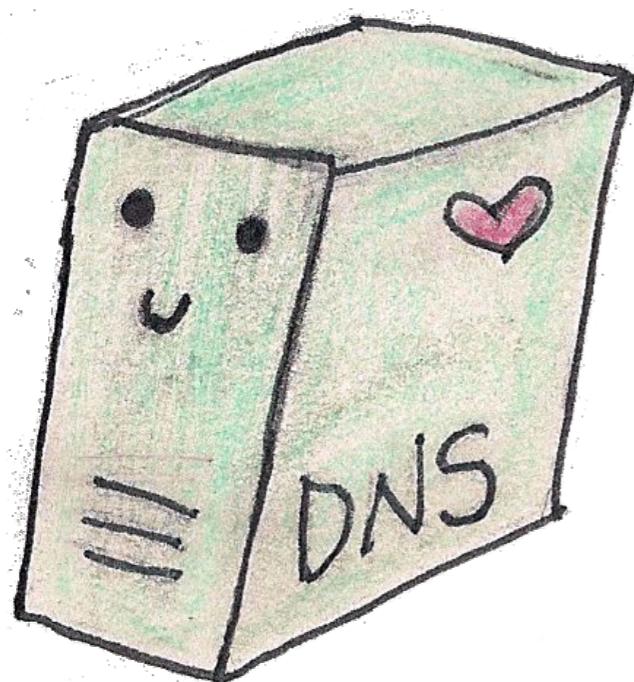


No, but maybe ask
.com?



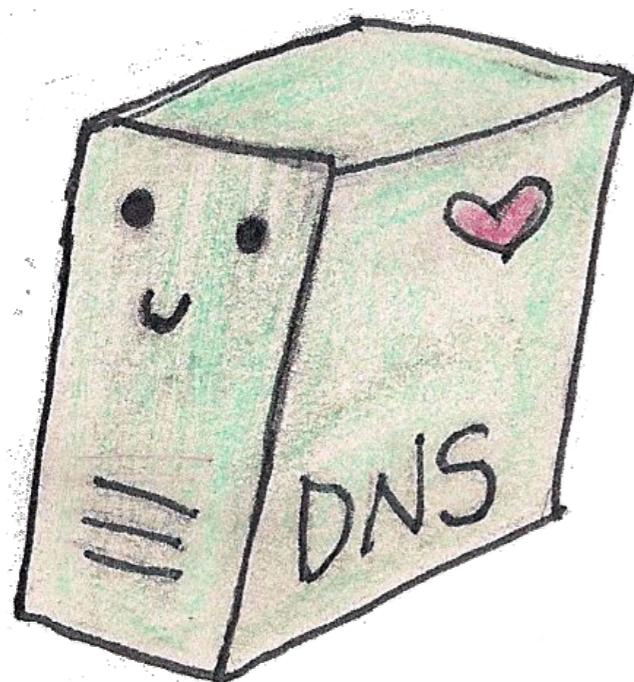
IP Address Lookup

Do you know where
www.google.com is?

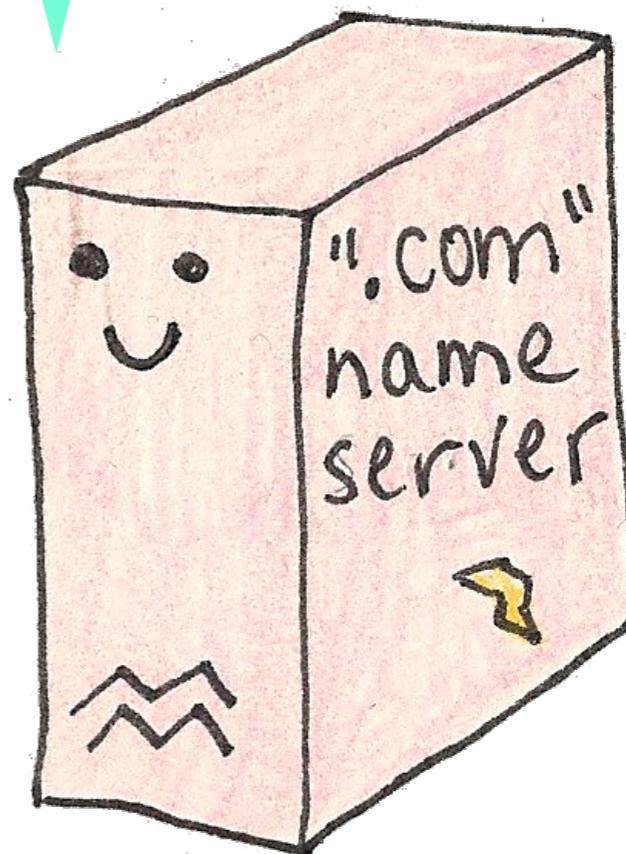


IP Address Lookup

Do you know where
www.google.com is?

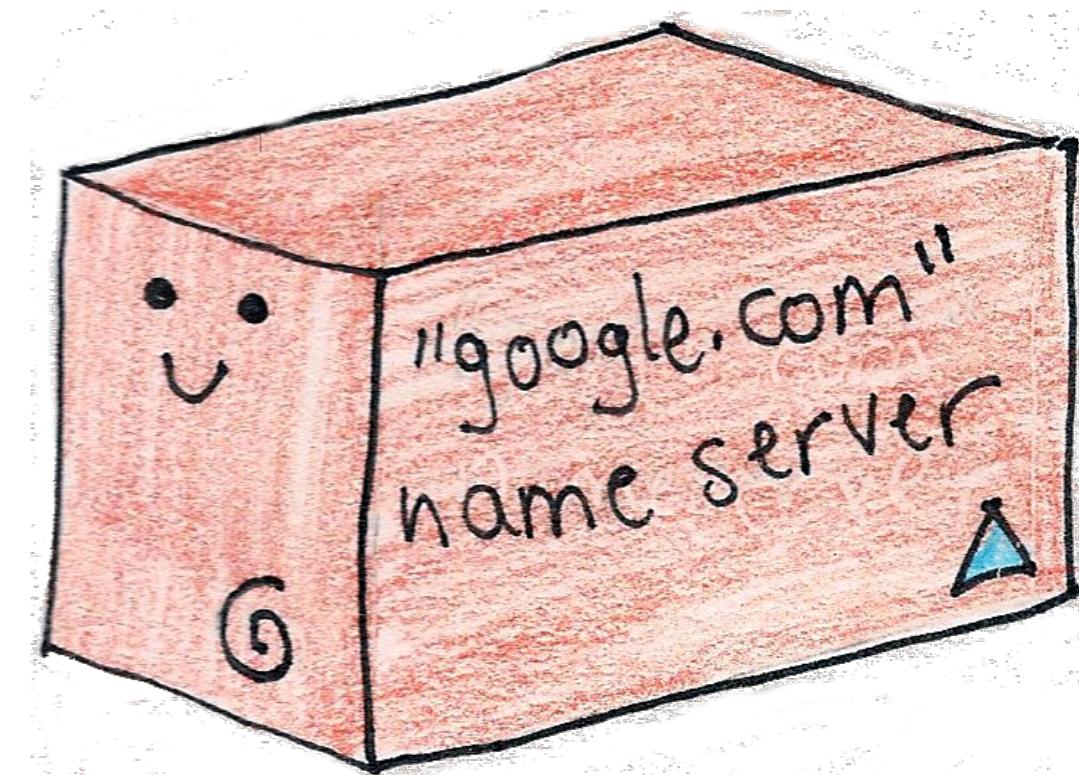
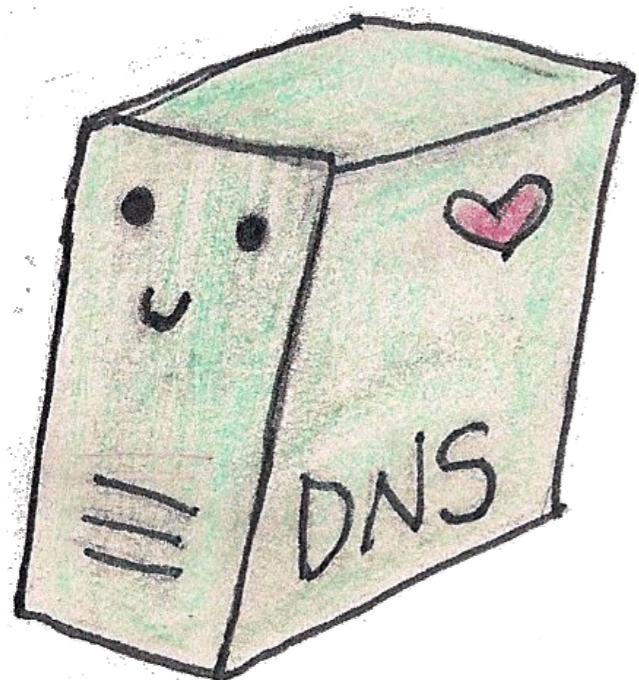


No, but maybe ask
“google.com”?



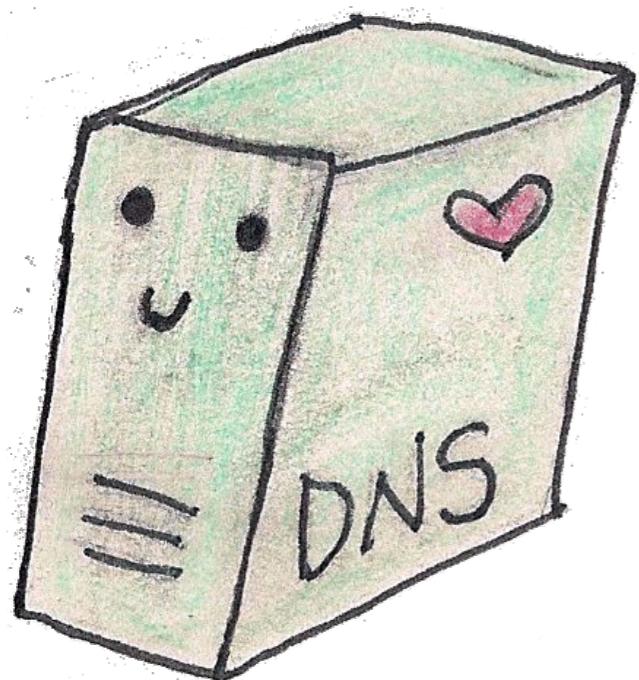
IP Address Lookup

Do you know where
www.google.com is?

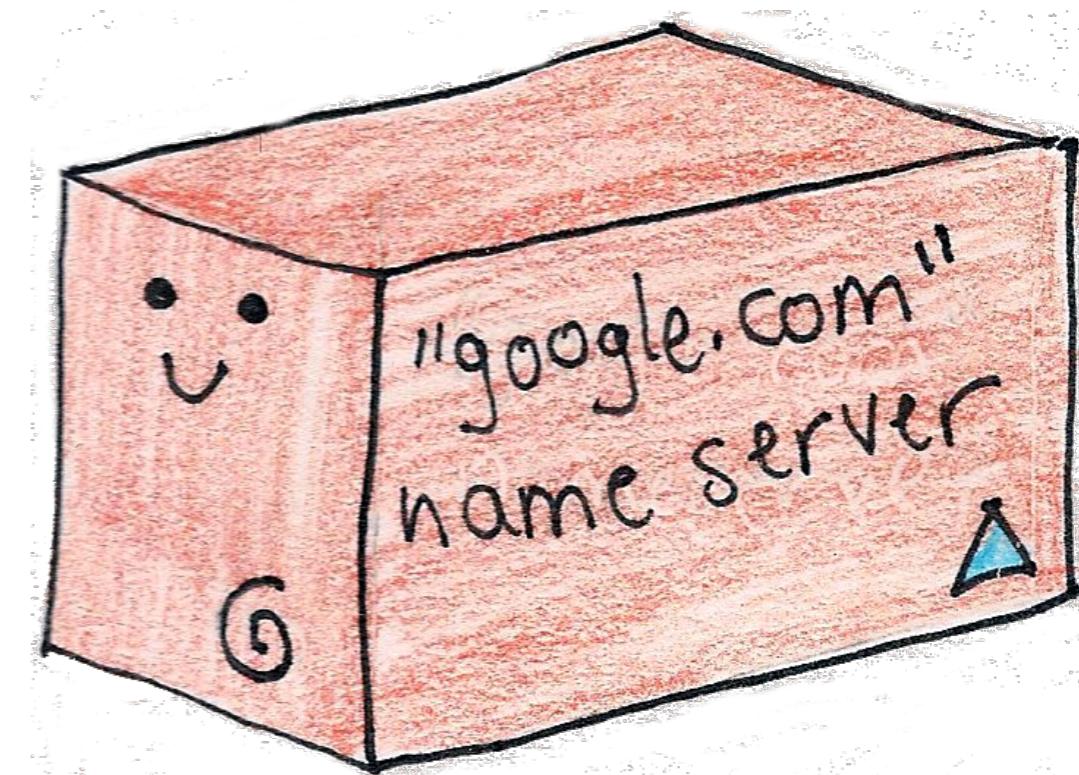


IP Address Lookup

Do you know where
www.google.com is?

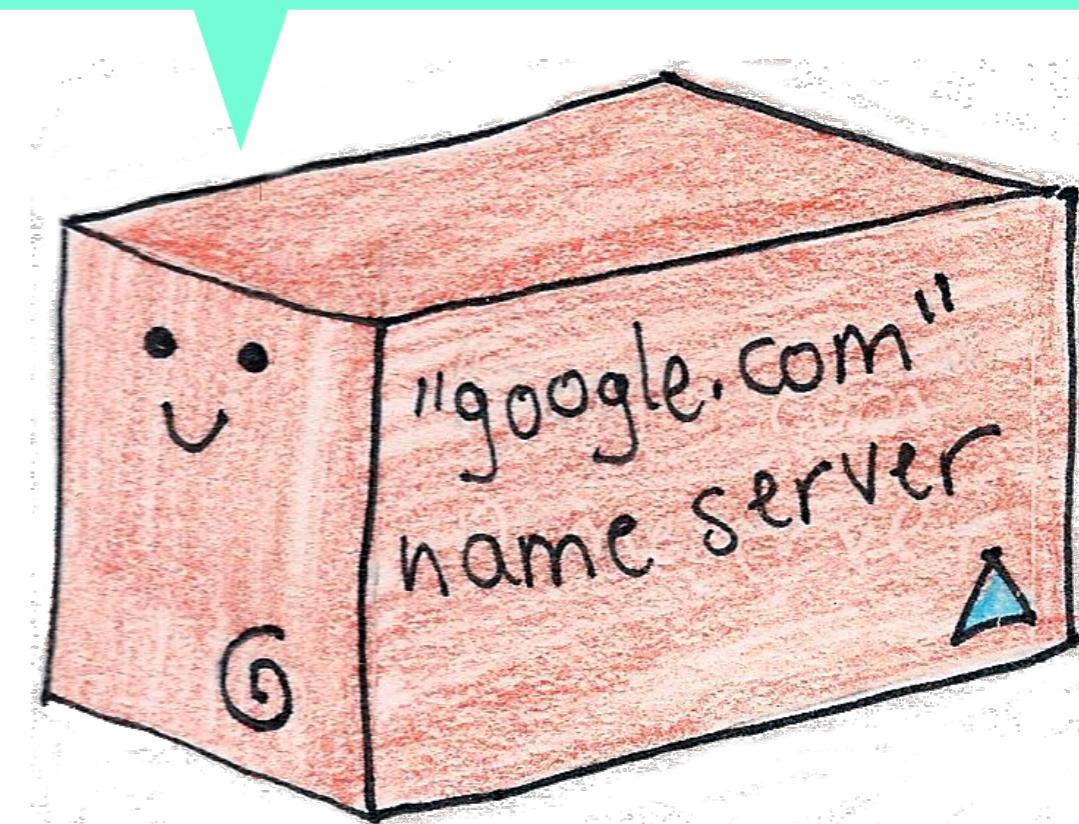
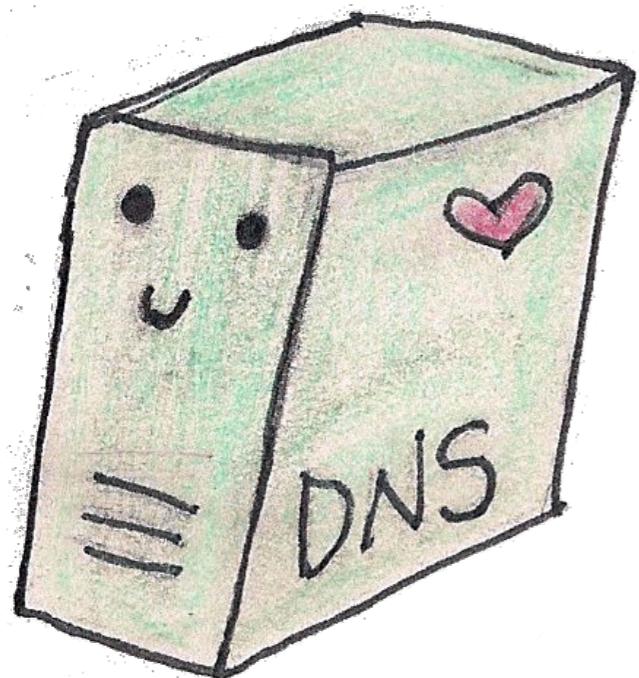


Yep!
173.194.46.84!



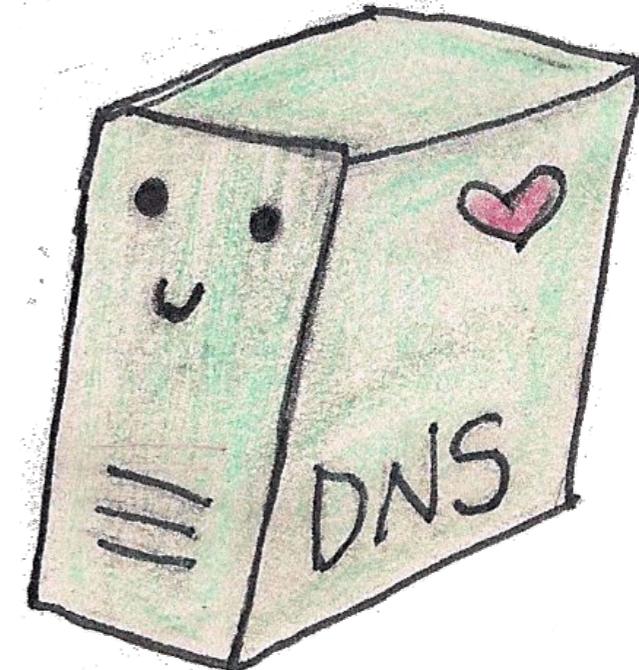
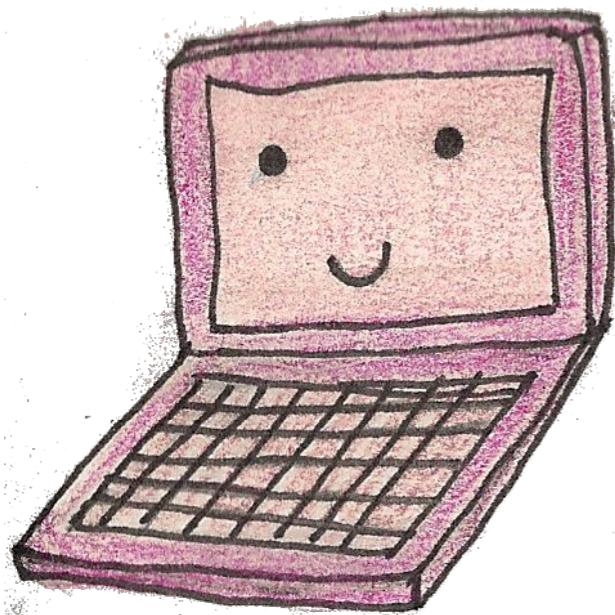
IP Address Lookup

Say you'll remember me
Or at least this IP address
So we don't have to relive this mess



IP Address Lookup

Yep!
173.194.46.84!



IP Address Lookup

```
zeigenspace:~ jenna$ dig www.google.com
```

```
; <>> DiG 9.8.3-P1 <>> www.google.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 45898
;; flags: qr rd ra; QUERY: 1, ANSWER: 5, AUTHORITY: 0, ADDITIONAL: 0
```

```
;; QUESTION SECTION:
```

```
;www.google.com. IN A
```

```
;; ANSWER SECTION:
```

www.google.com.	251	IN	A	74.125.226.48
www.google.com.	251	IN	A	74.125.226.50
www.google.com.	251	IN	A	74.125.226.51
www.google.com.	251	IN	A	74.125.226.49
www.google.com.	251	IN	A	74.125.226.52

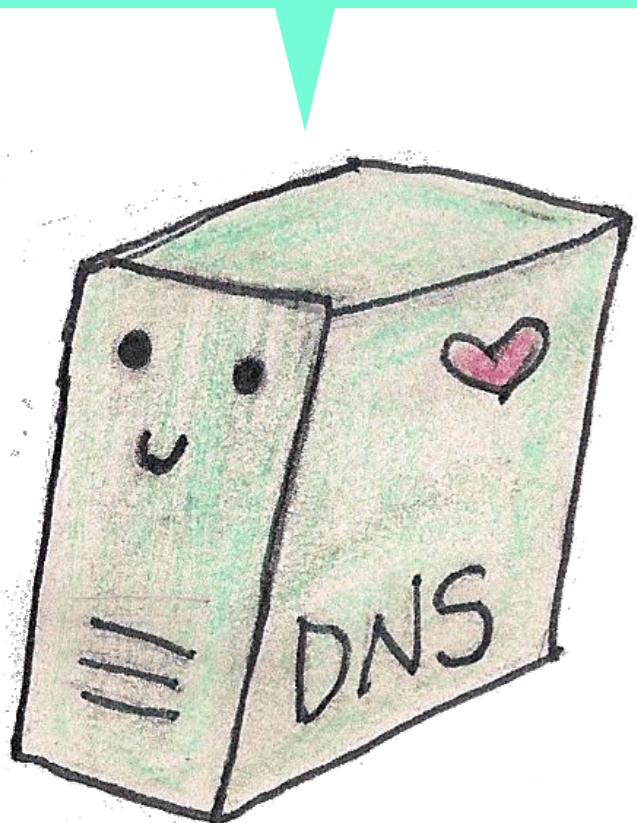
```
;; Query time: 16 msec
```

```
;; SERVER: 209.18.47.61#53(209.18.47.61)
```

```
;; WHEN: Sun Nov 1 17:10:36 2015
```

```
;; MSG SIZE rcvd: 112
```

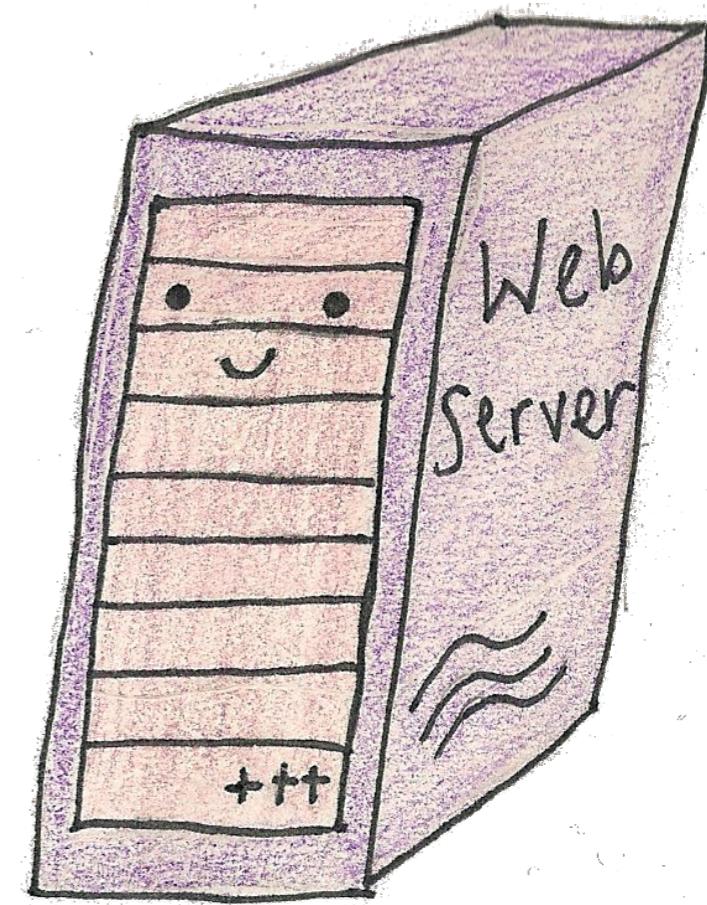
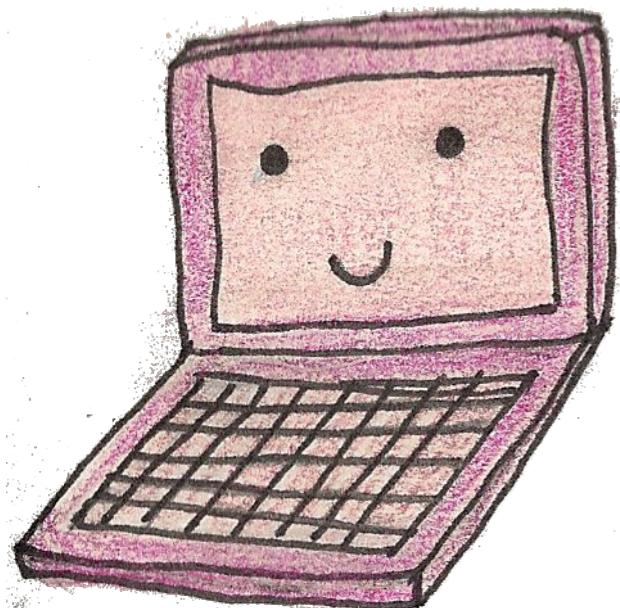
```
zeigenspace:~ jenna$ _
```



I dig it.

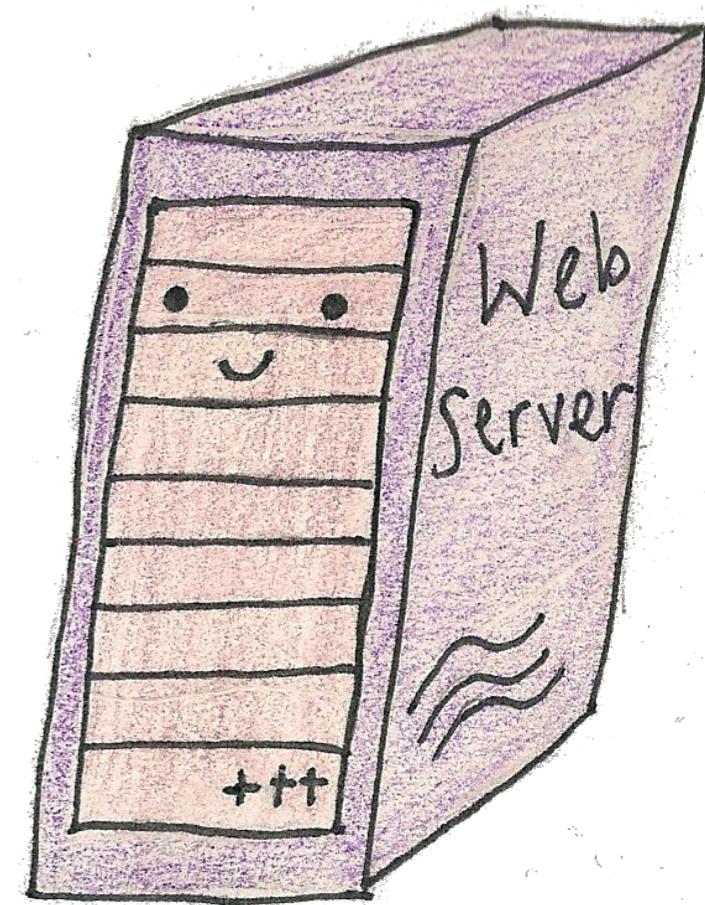
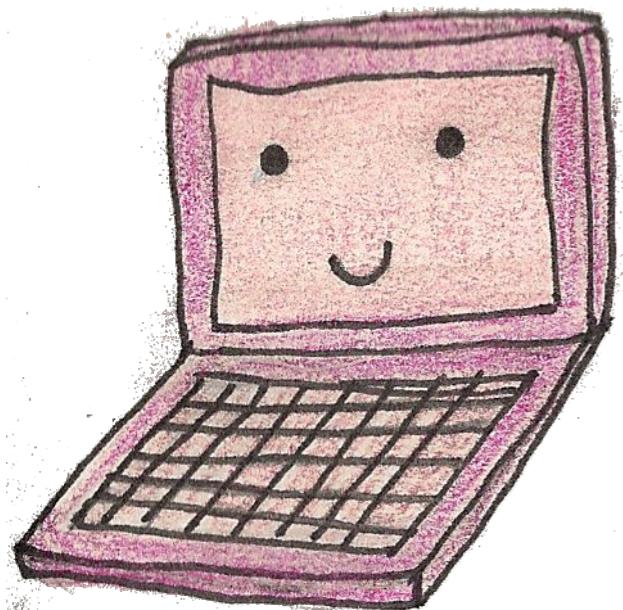
Opening a socket

Socket to me.



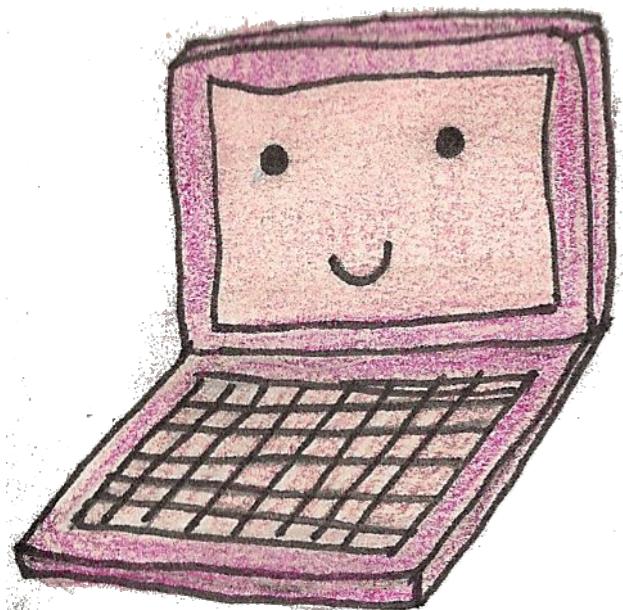
Opening a socket

Hey! Will you
talk to me?

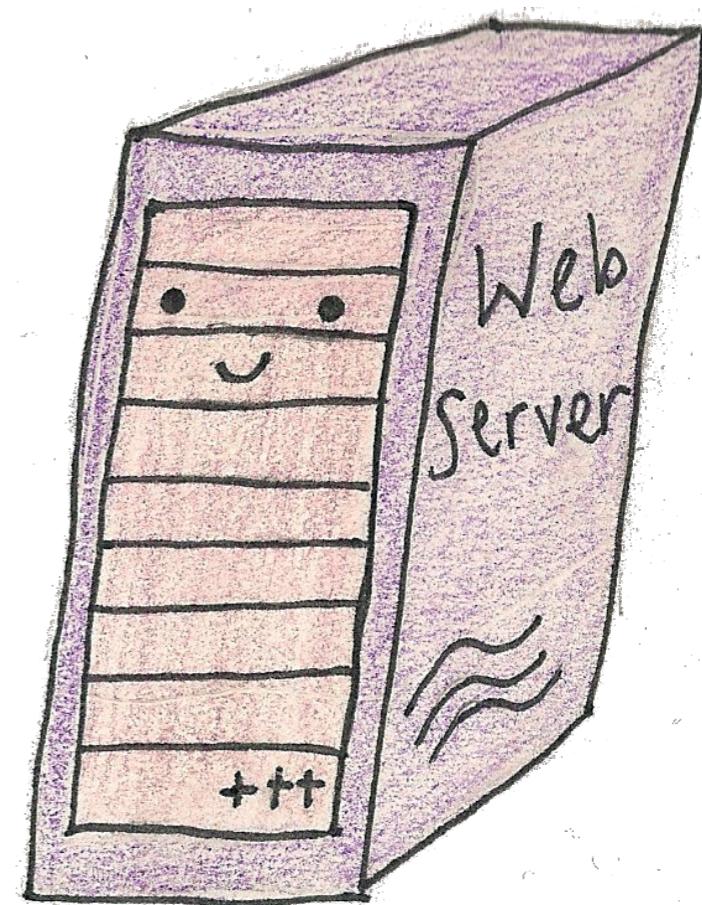


Opening a socket

Hey! Will you
talk to me?

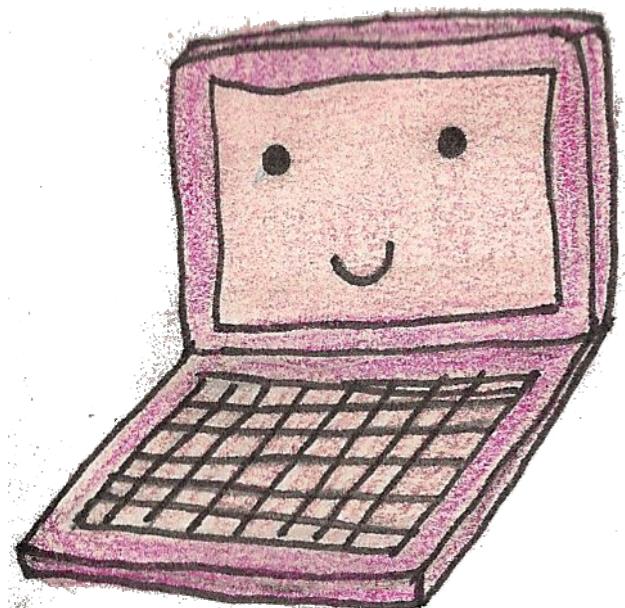


Sure!



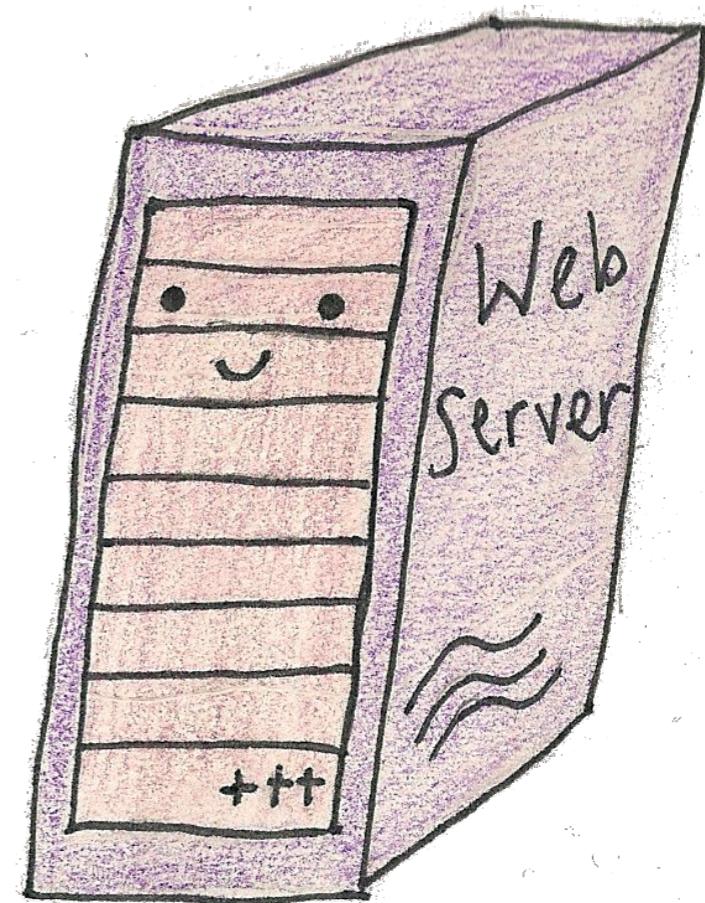
Opening a socket

Hey! Will you
talk to me?

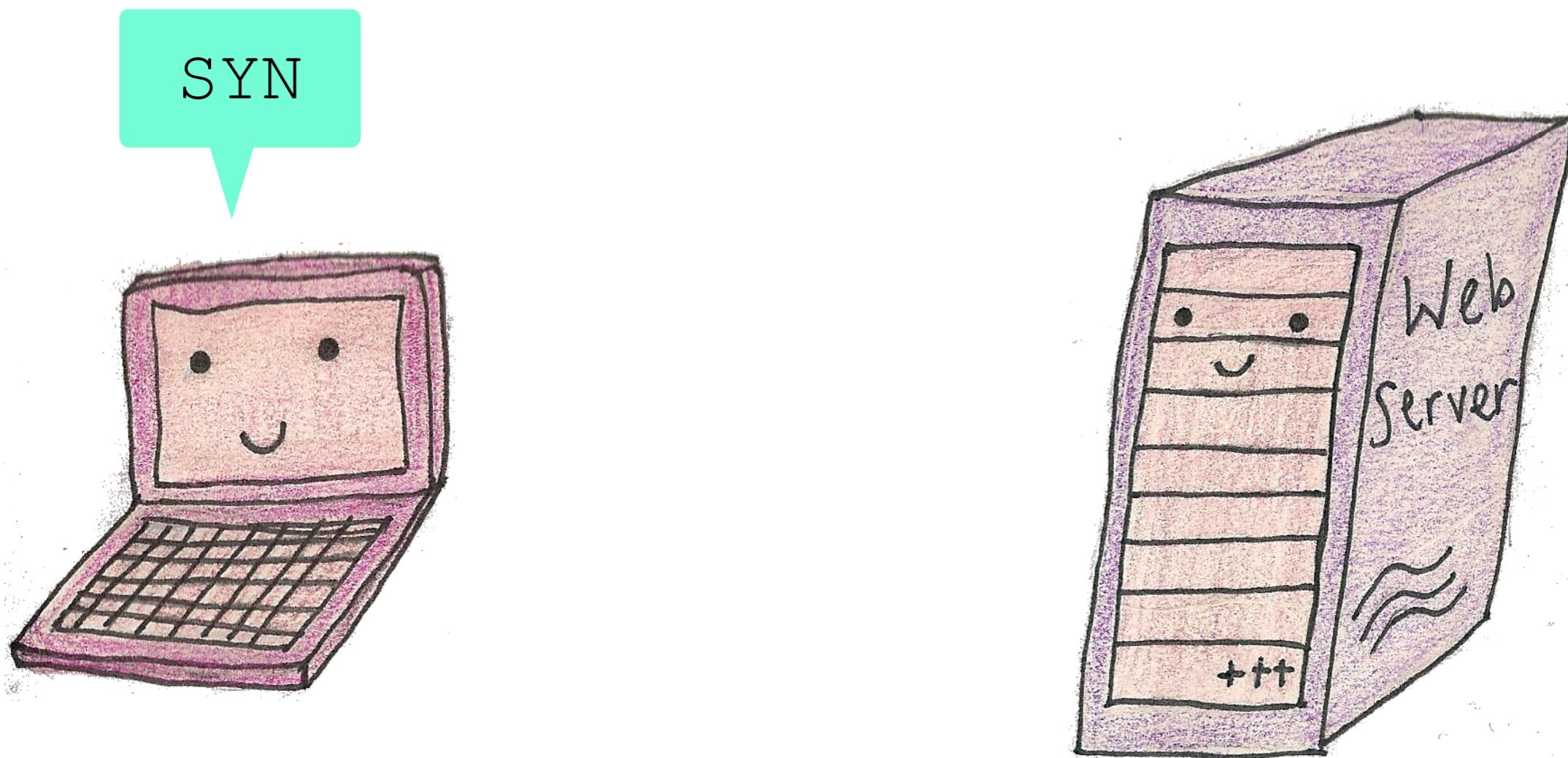


Sweet.

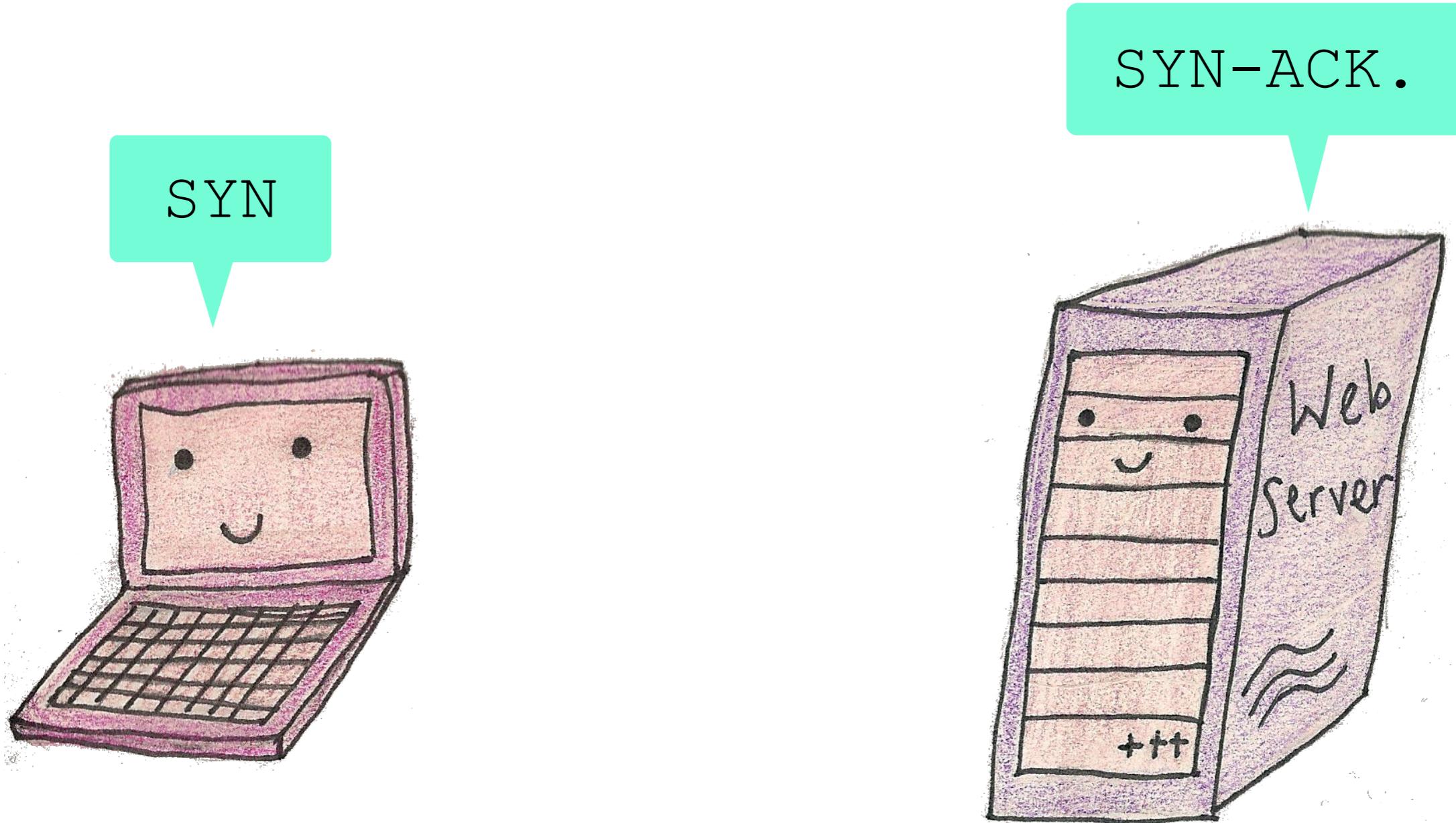
Sure!



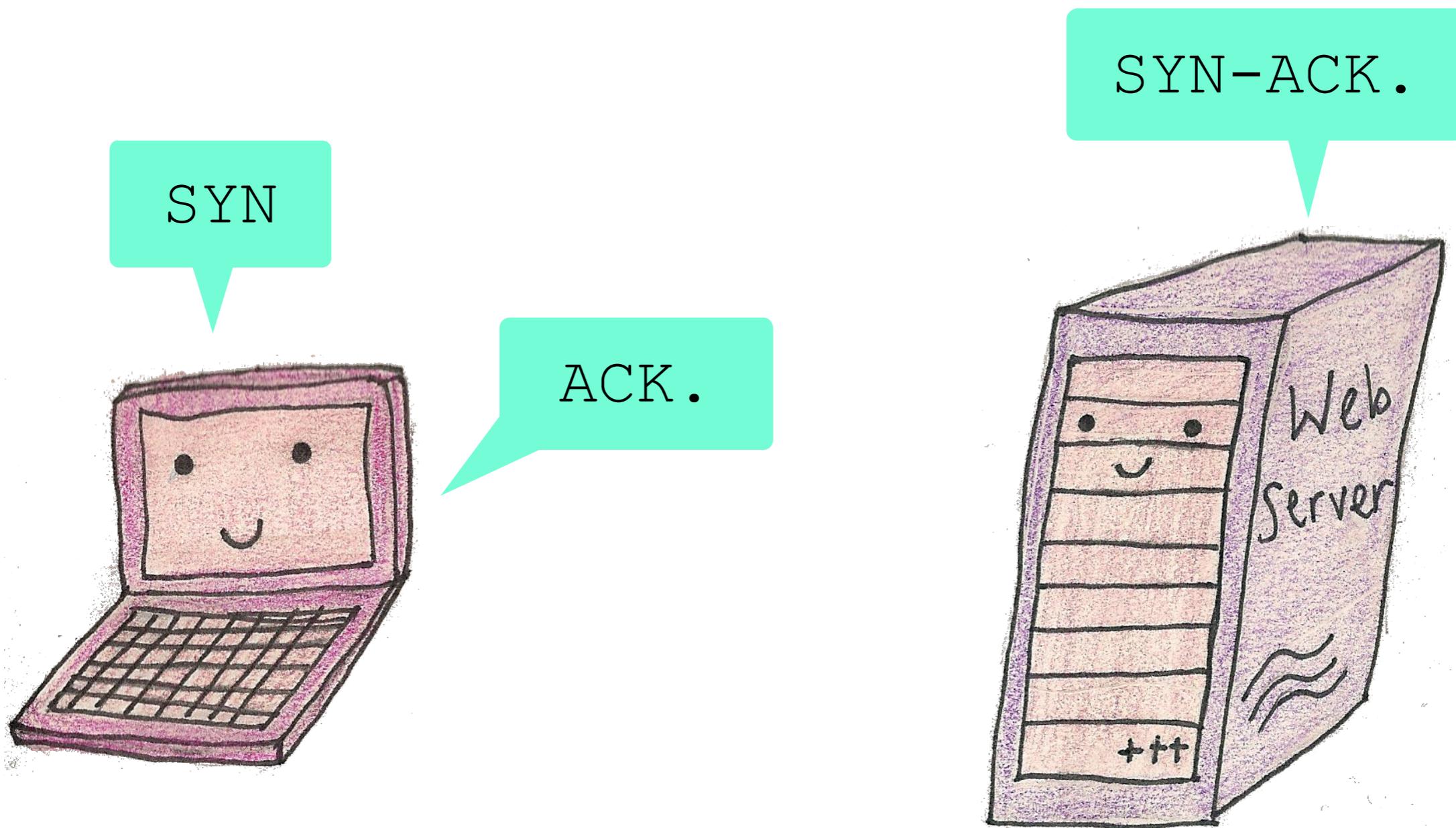
Opening a socket



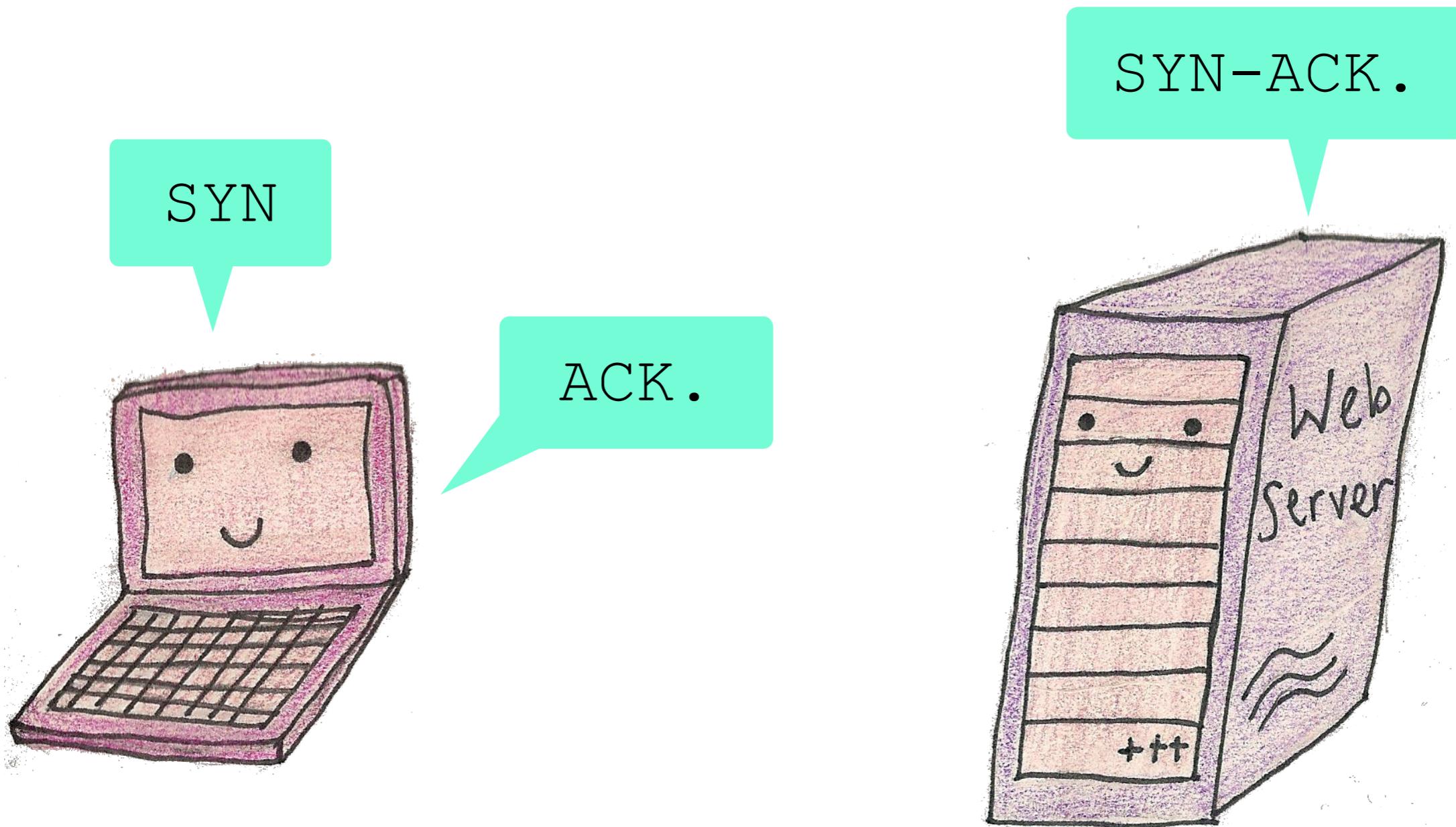
Opening a socket



Opening a socket



Opening a socket

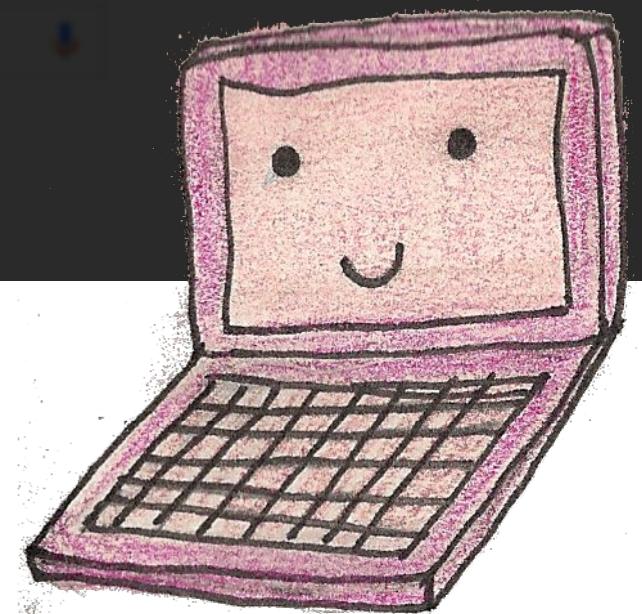


Opening a socket

```
zeigenspace:~ jenna$ sudo tcpdump -c3 host www.google.com
```

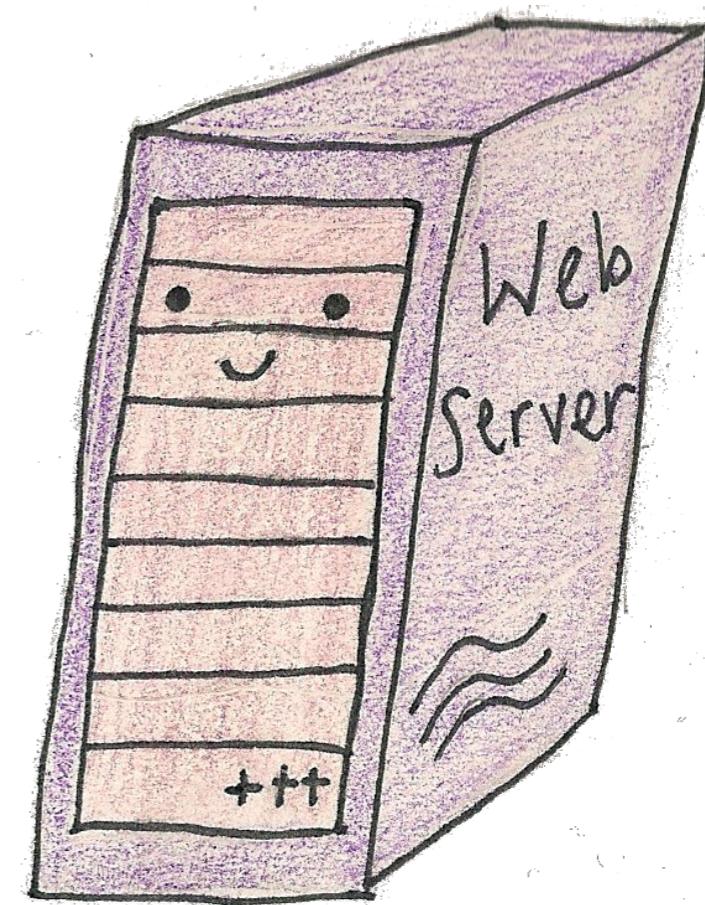
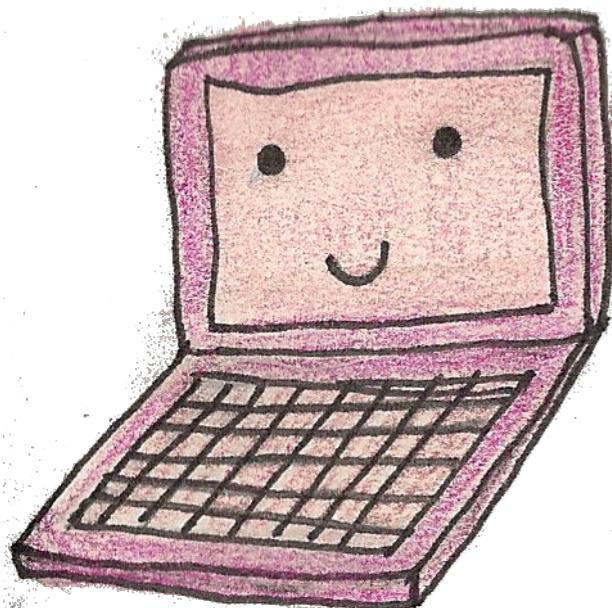
```
tcpdump: data link type PKTAP
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on ptkap, link-type PKTAP (Packet Tap), capture size 65535 bytes
01:05:42.209216 IP 192.168.0.23.52293 > lga25s40-in-f196.1e100.net.https: UDP, length 190
01:05:42.249138 IP lga25s40-in-f196.1e100.net.https > 192.168.0.23.52293: UDP, length 35
01:05:42.259526 IP lga25s40-in-f196.1e100.net.https > 192.168.0.23.52293: UDP, length 221
```

```
3 packets captured
16 packets received by filter
0 packets dropped by kernel
zeigenspace:~ jenna$ _
```



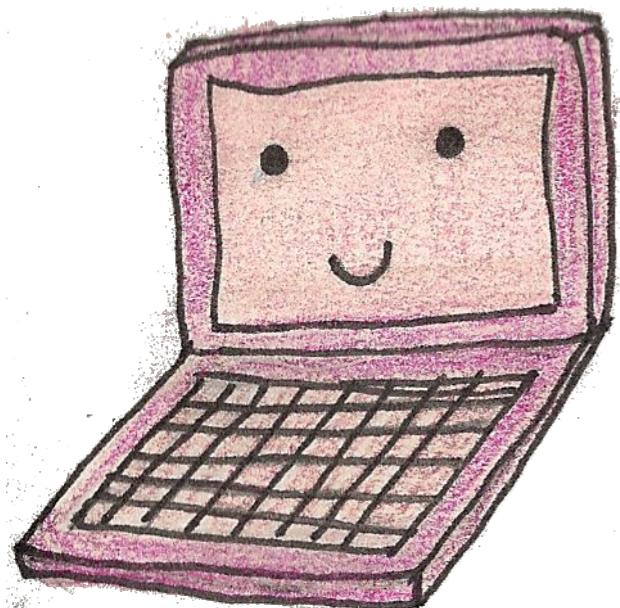
Security Stuff

clientHello

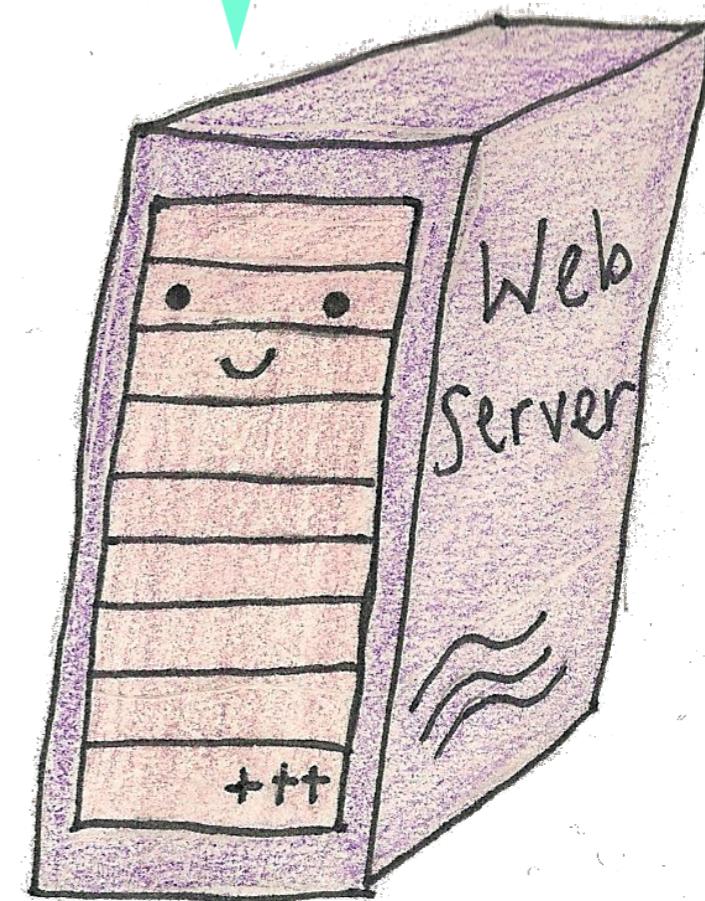


Security Stuff

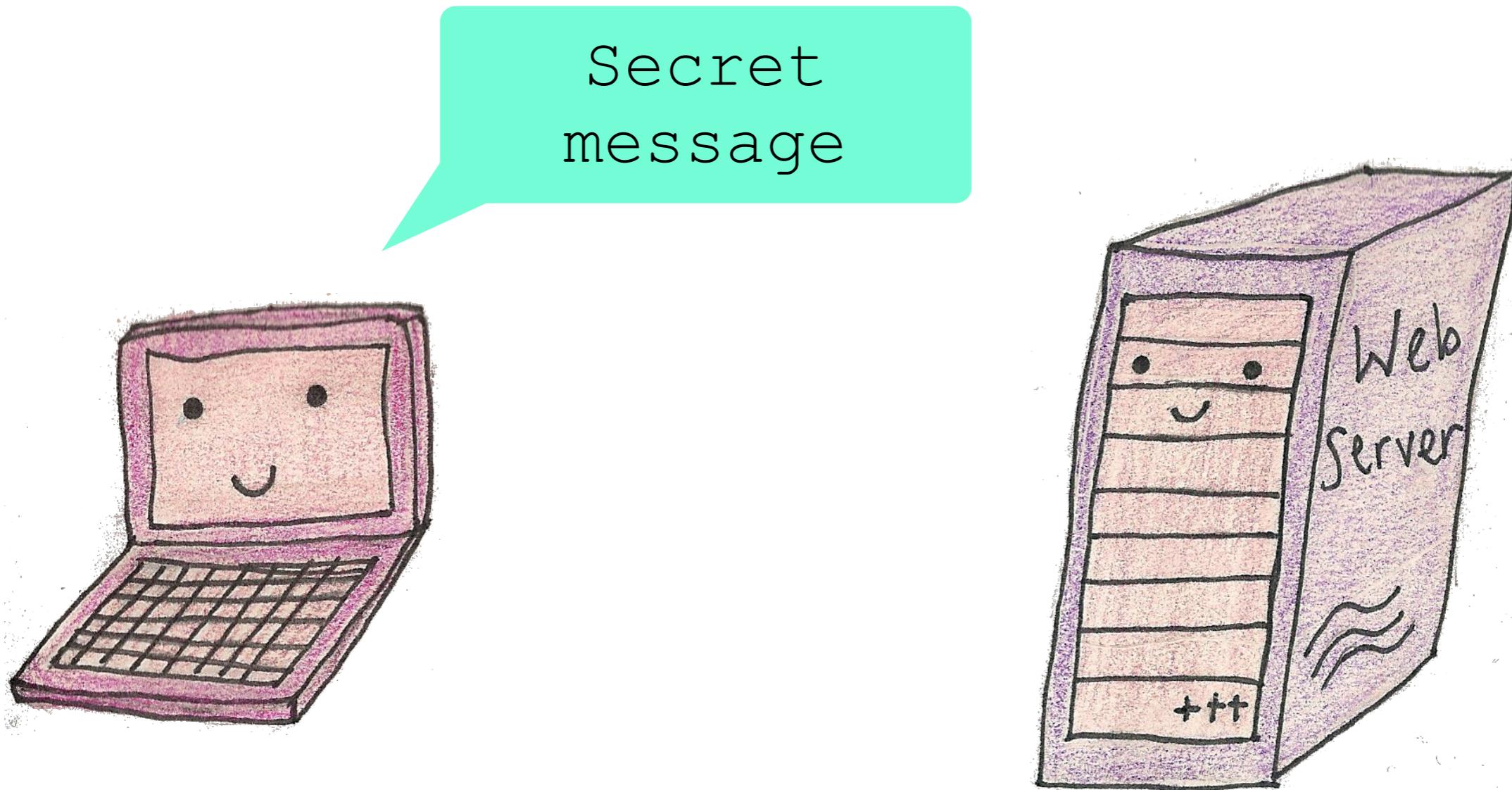
ClientHello



ServerHello

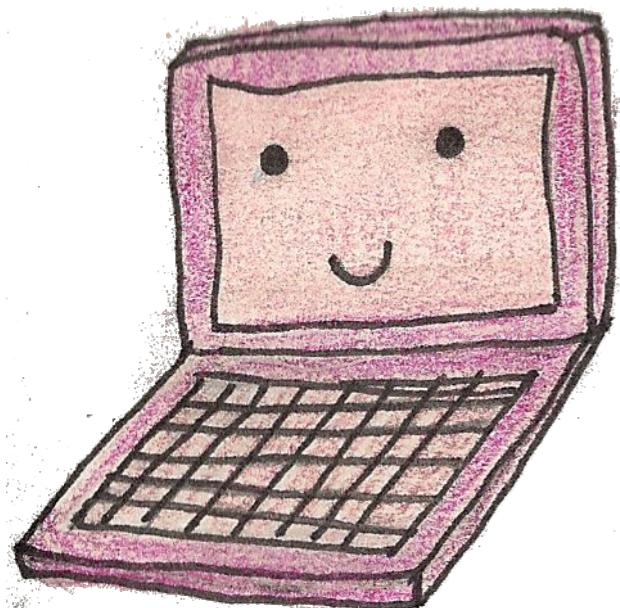


Security Stuff

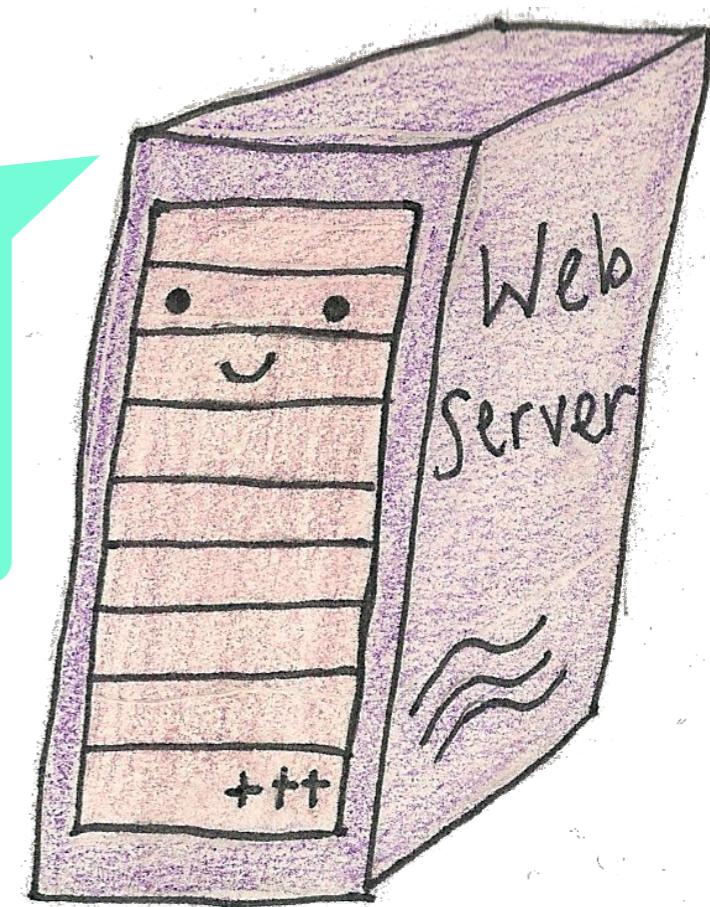


Security Stuff

Secret
message

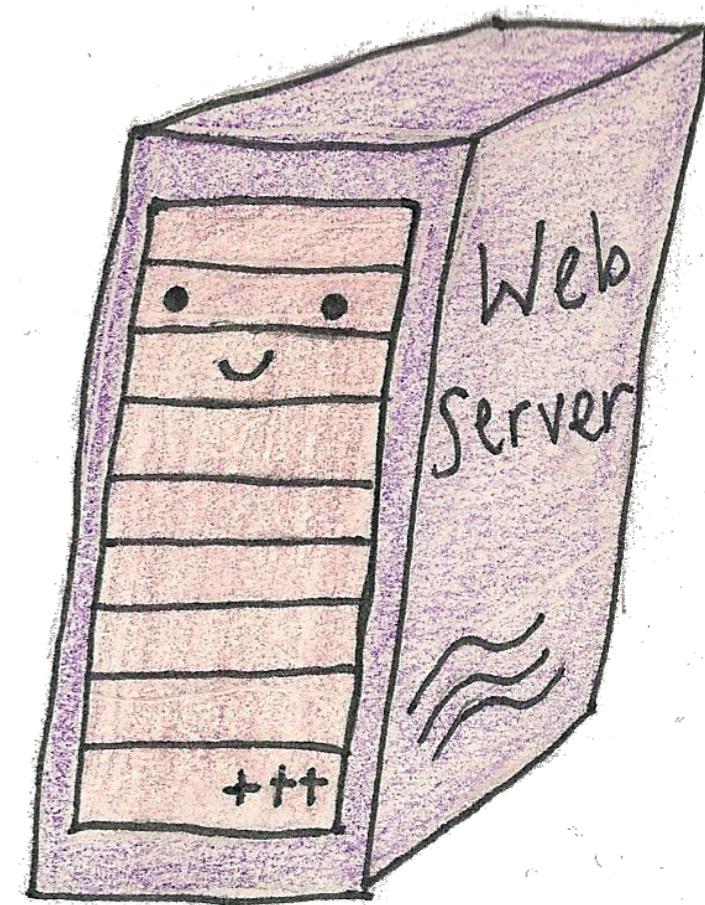
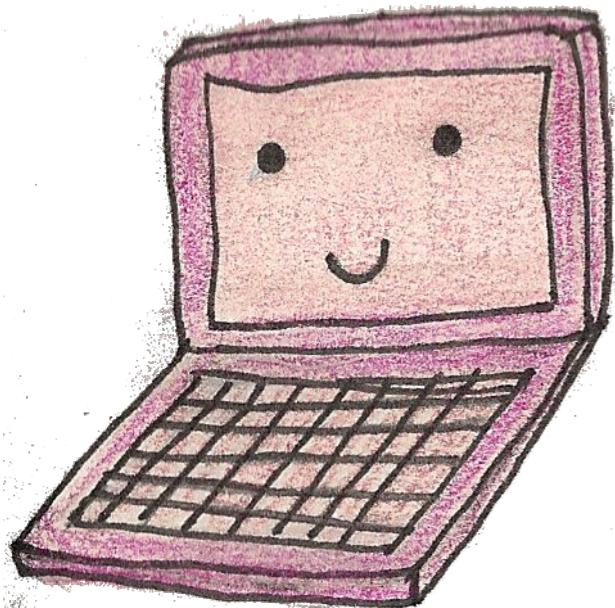


Decrypting
Secret
message

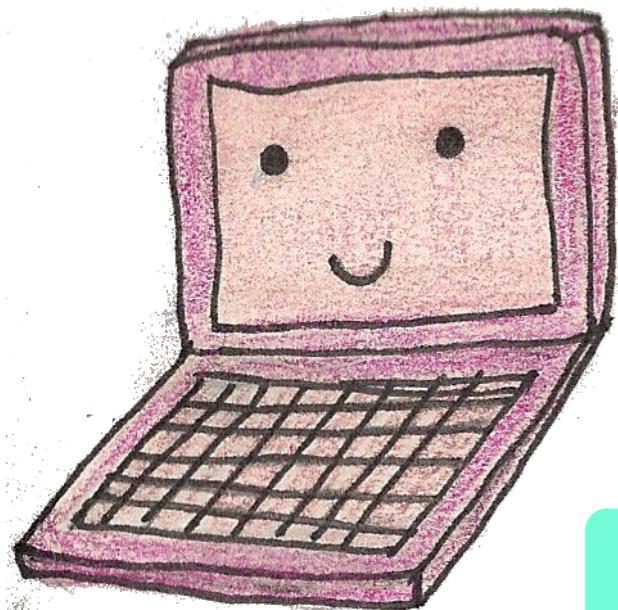


Security Stuff

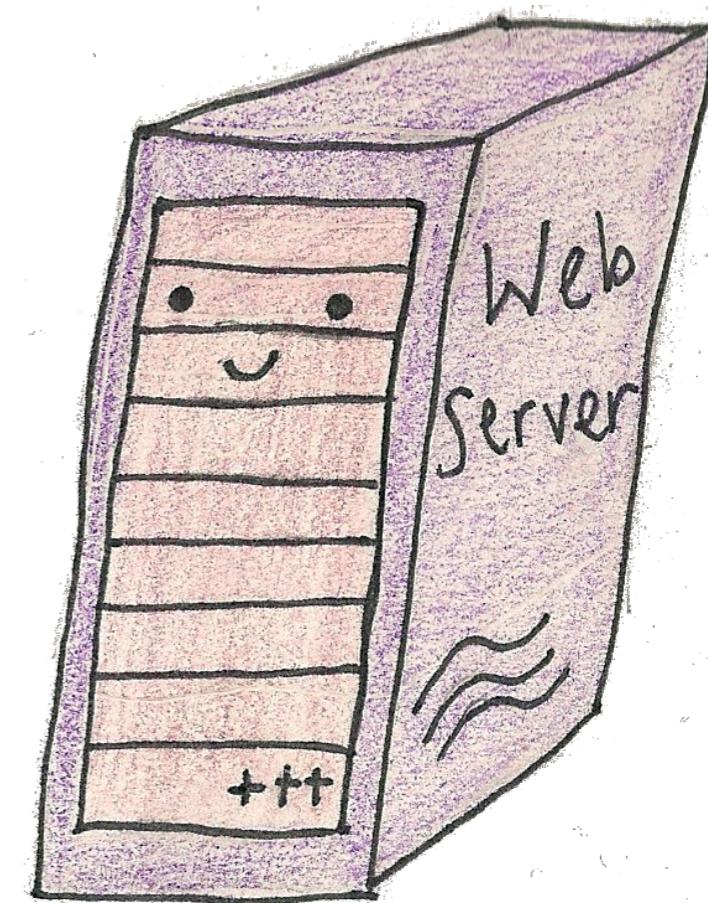
Finished



Security Stuff



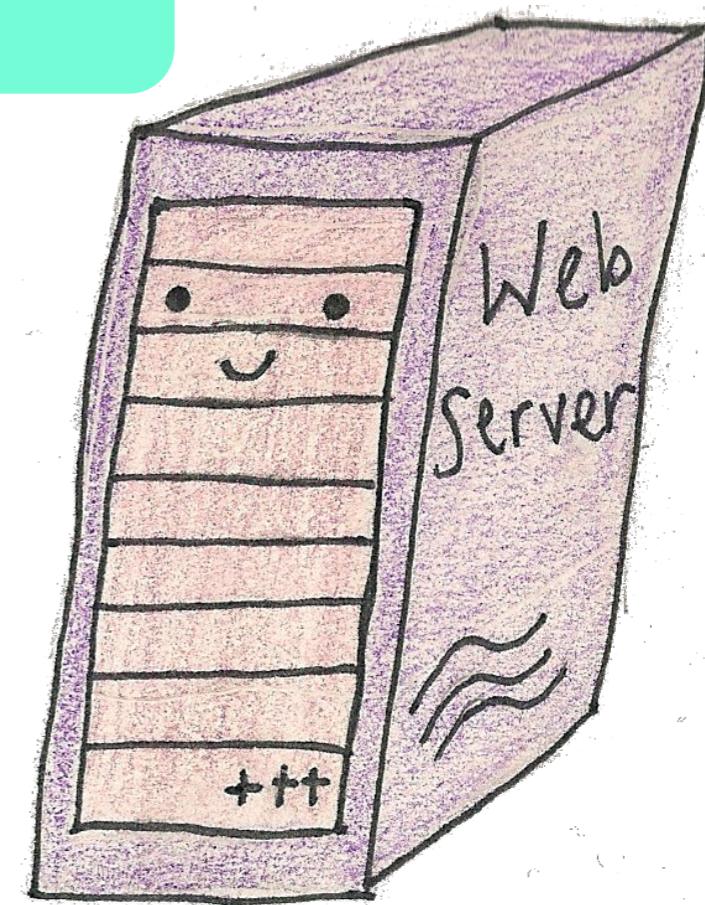
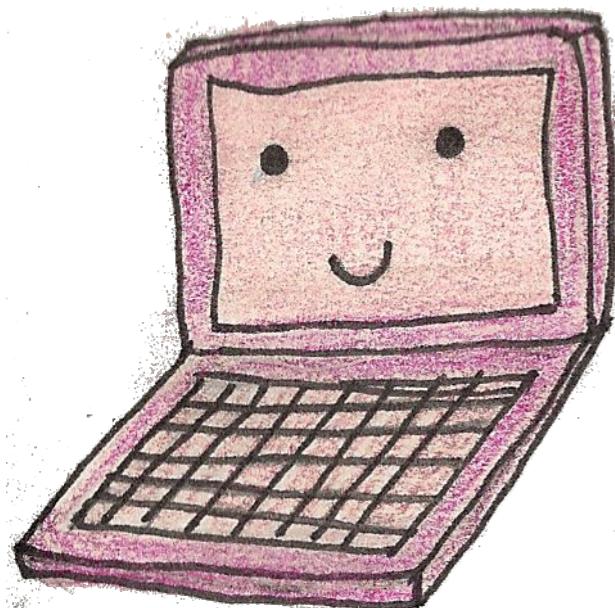
Finished



Finished

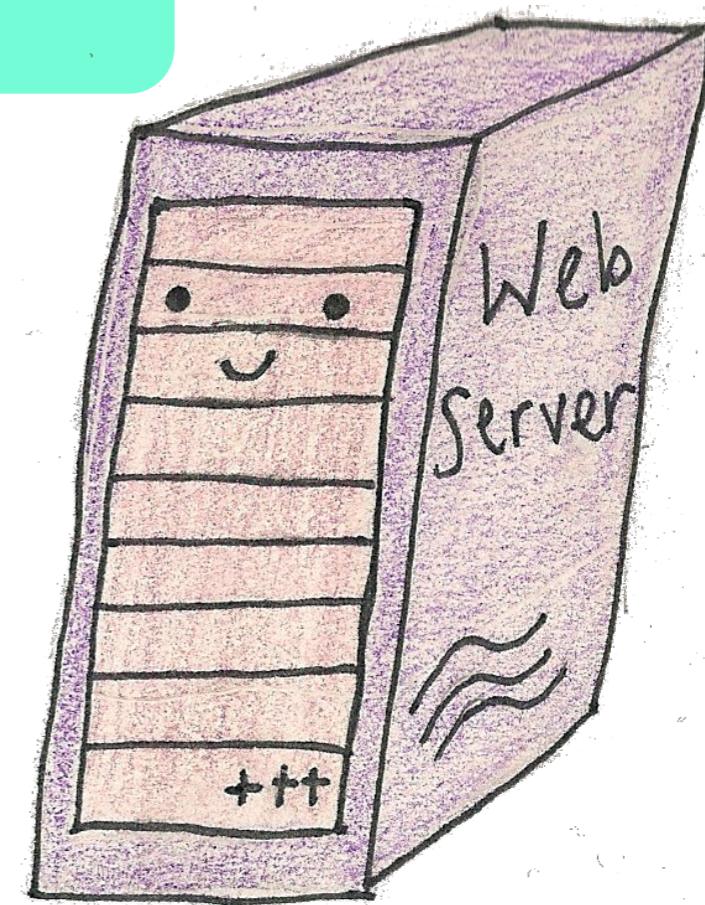
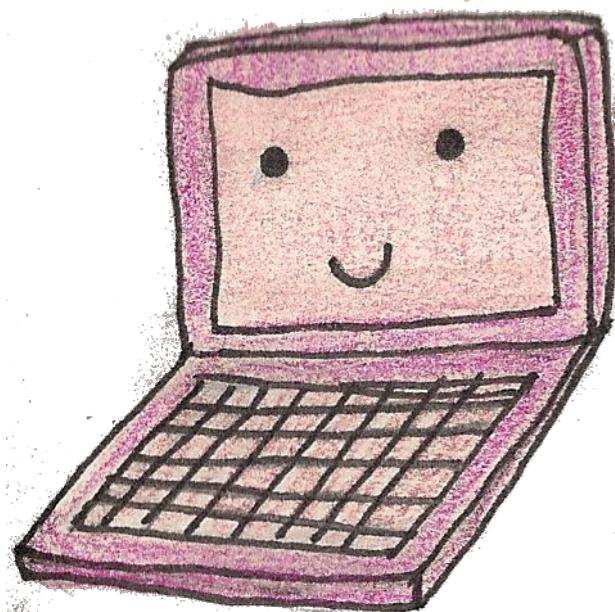
HTTP Request

```
> GET / HTTP/1.1  
> Host: google.com  
> Connection: close  
> [other headers]
```



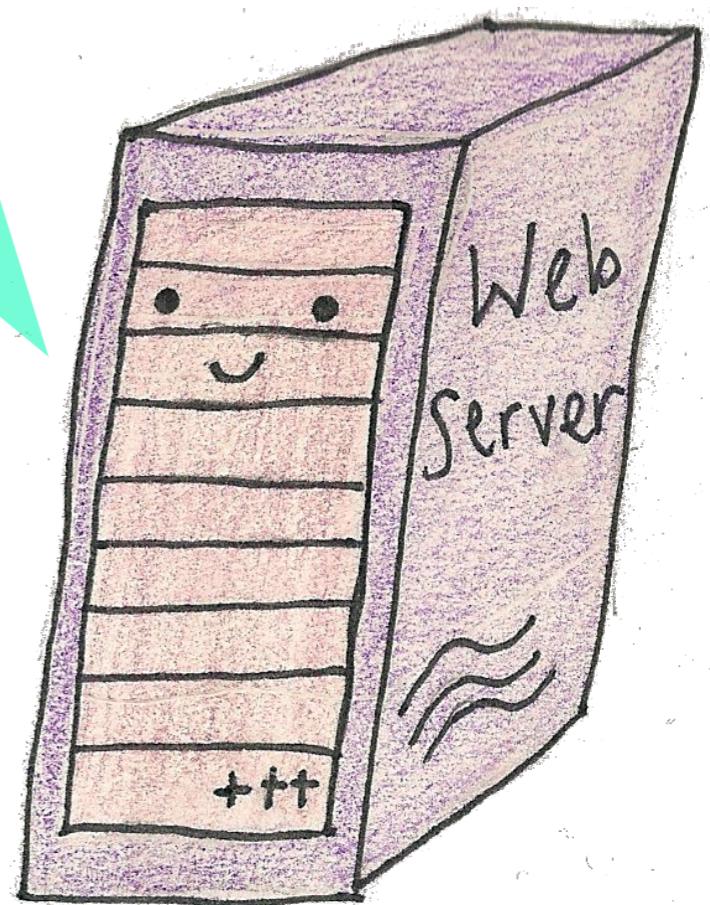
HTTP Request

```
> GET / HTTP/1.1  
> Host: google.com  
> Connection: close  
> [other headers]
```



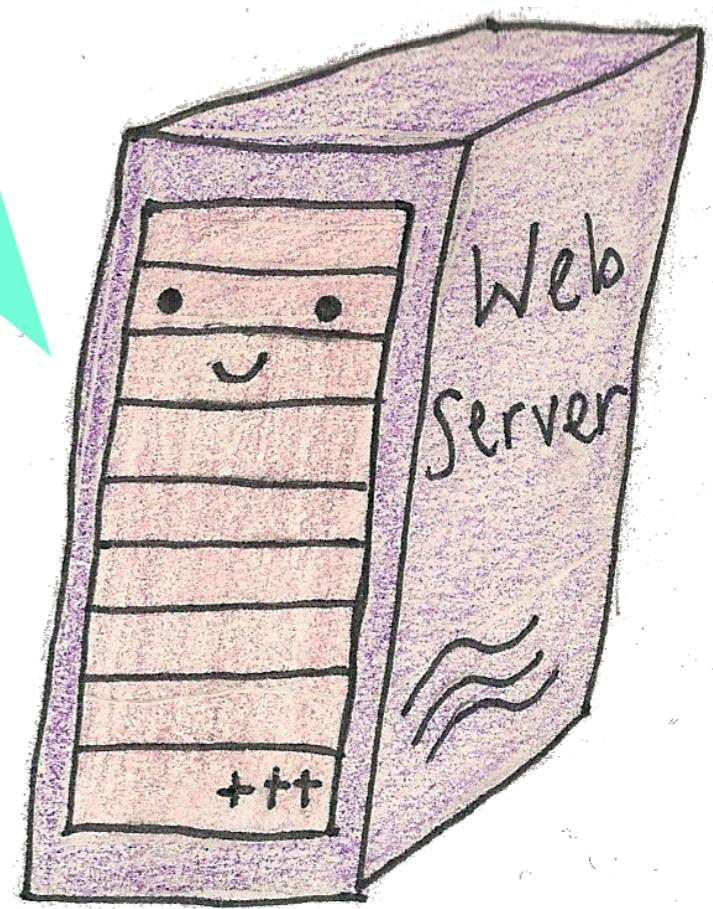
Server Things...

Look inside
It's where my daemon hides
♪ ♪ ♪



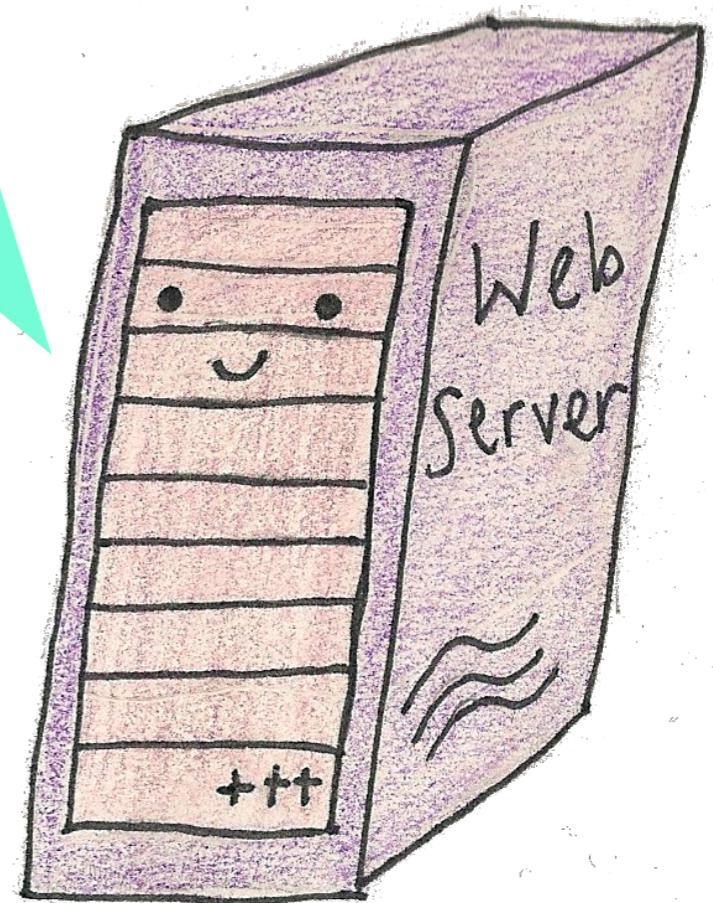
Server Things...

I got Rack on
racks on racks
♪ ♪ ♪



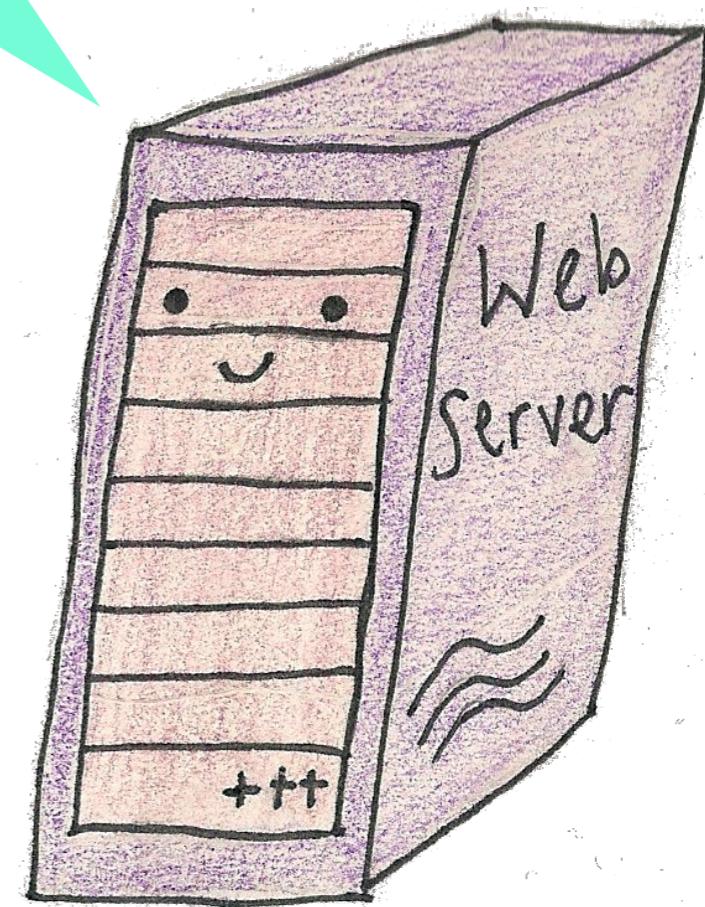
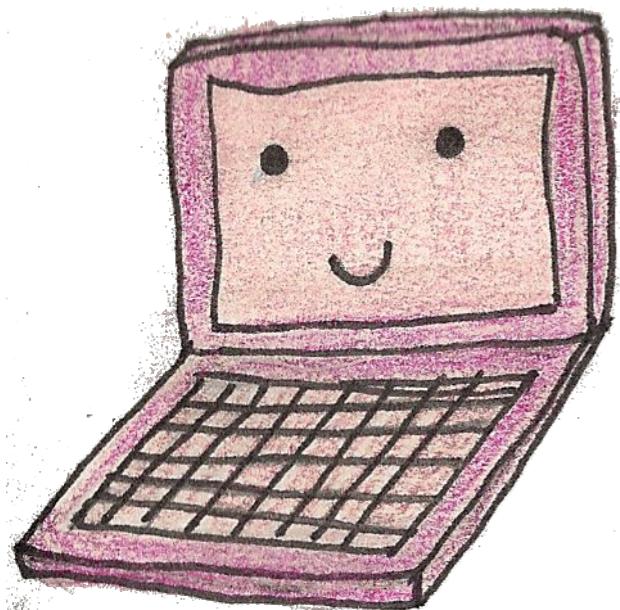
Server Things...

Whatcha, whatcha,
whatcha want?
(Whatcha want?)



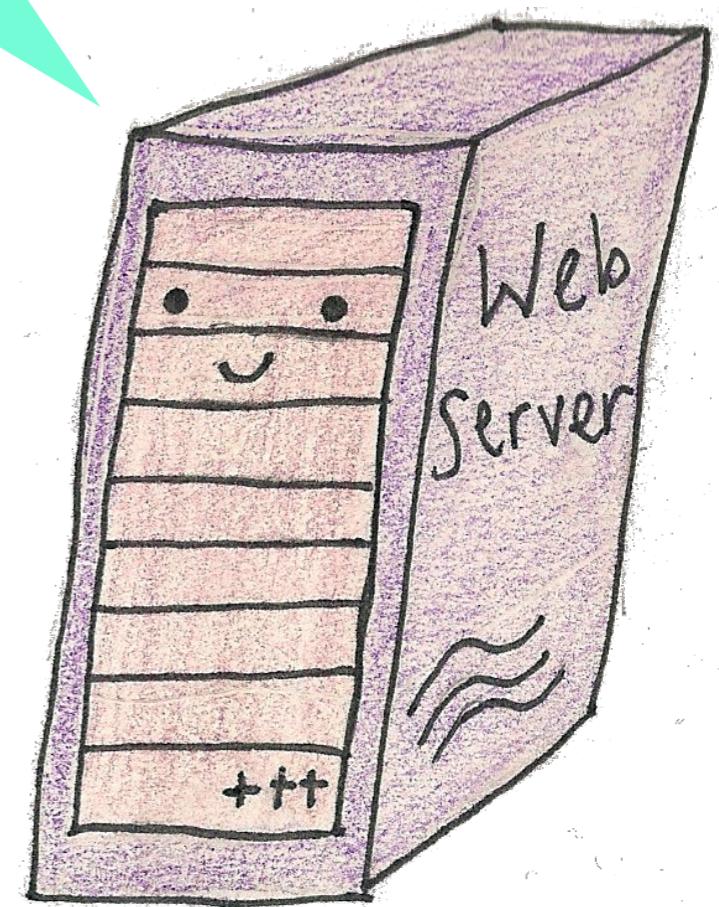
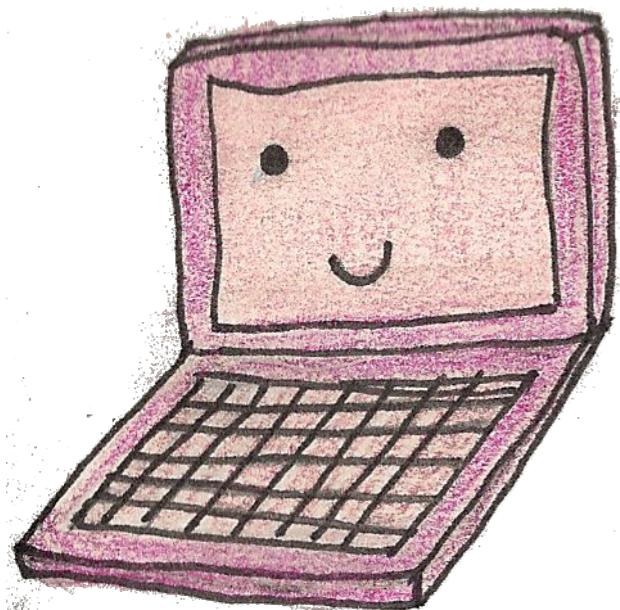
HTTP Response

< HTTP/1.1 304 Not Modified
[other headers]



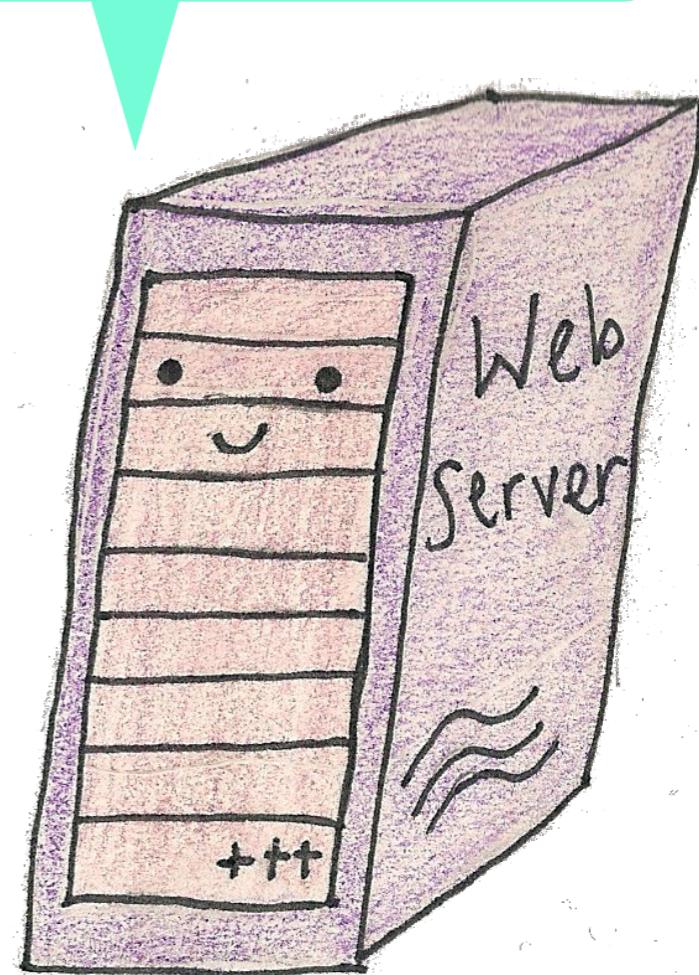
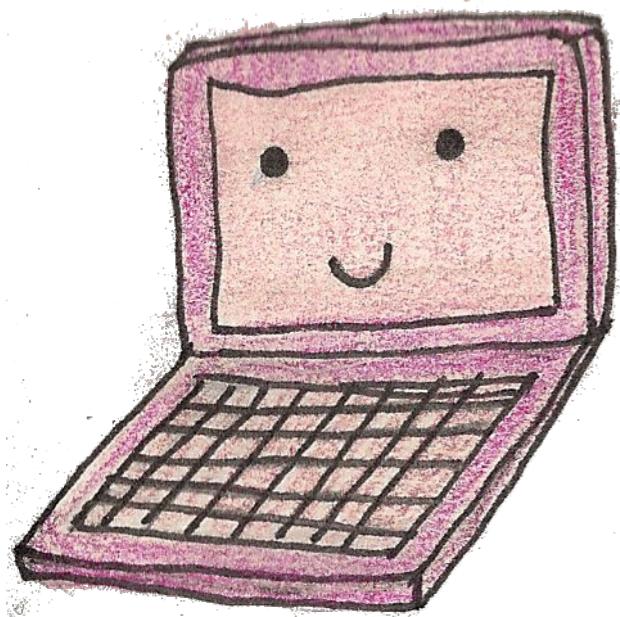
HTTP Response

< HTTP/1.1 304 Not Modified
[other headers]



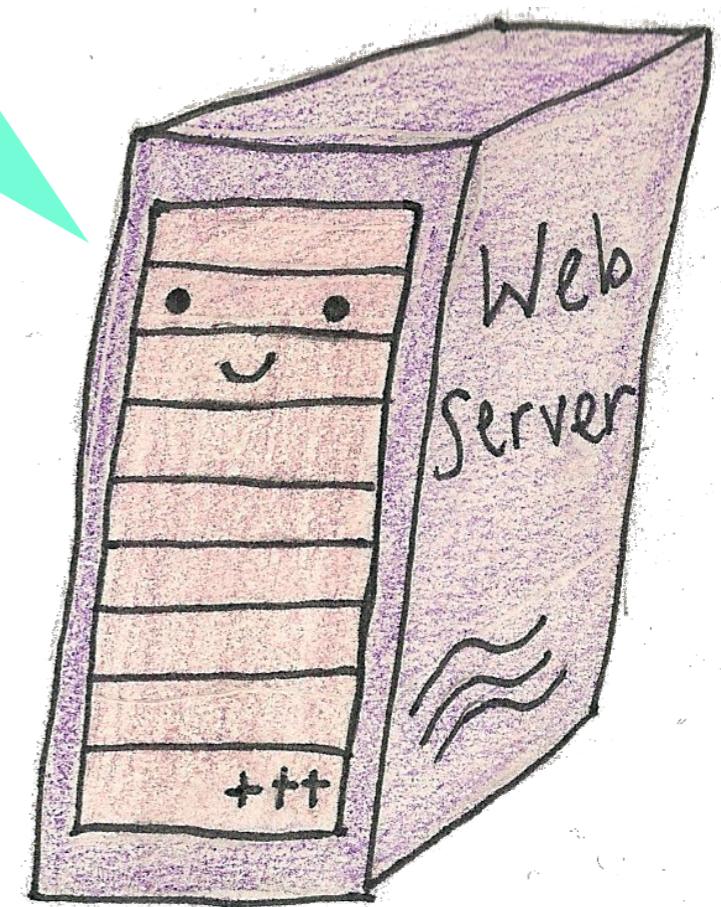
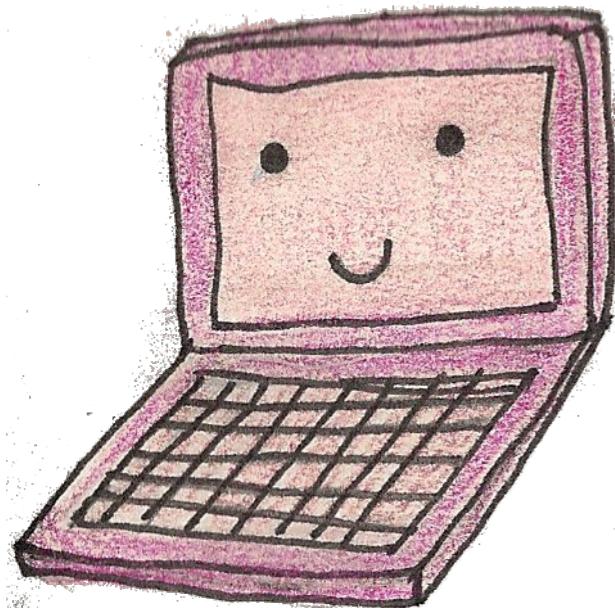
HTTP Response

Sorry, we had to change to that code
Updated that file and then changed its number
I guess you need the new stuff though
Now it's just some page that you used to know



HTTP Response

```
< HTTP/1.1 200 OK  
[other headers]  
<  
<!DOCTYPE html><html>...</html>
```



HTTP Response

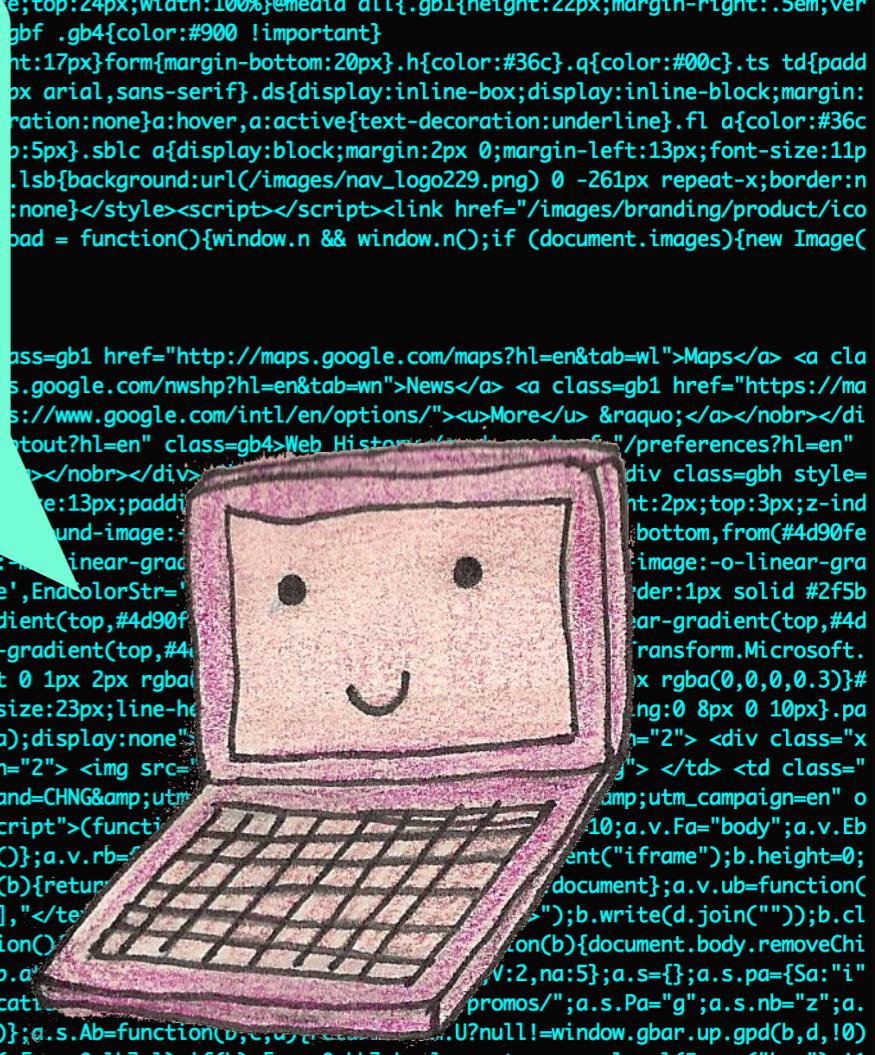
```
<!doctype html><html itemscope="" itemtype="http://schema.org/WebPage" lang="en"><head><meta content="Search the world's information, including webpages, images, videos and more. Google has many special features to help you find exactly what you're looking for." name="description"><meta content="nooodp" name="robots"><meta content="/images/branding/google_1x/google_Standard_color_128dp.png" itemprop="image"><title>Google</title><script>(function(){window.google={kEI:'sey2VrLI04nUmAGIrpCYDg',kEXPI:'4029815,4031109,4032677,4033307,4033344,4036527,4037333,4037569,4038012,4041440,4041837,4041898,4042492,4043255,4043457,4043458,4043492,4044246,4044606,4045841,4046304,4046400,4047930,4048007,4048011,4048141,4048144,4048346,4048452,4048570,4048770,4048854,4048901,4048909,4048972,4049250,4049597,4050323,4050735,4050766,4050802,4050814,4050891,4050912,4050916,4050927,4051115,4051155,4051195,4051290,8300096,8300227,8300272,8502095,8502221,8502312,8502315,8502342,8502444,8502468,8502482,8502529,8502537,8502552,10200083',authuser:0,kscs:'c9c918f0_10'};google.kHL='en';})();(function(){google.lc=[];google.li=0;google.getEI=function(a){for(var b;a&&(!a.getAttribute||!(b=a.getAttribute("eid"))));}a=a.parentNode;return b||google.kEI};google.getLEI=function(a){for(var b=null;a&&(!a.getAttribute||!(b=a.getAttribute("leid"))));}a=a.parentNode;return b};google.https=function(){return"https":==window.location.protocol};google.ml=function(){return null};google.wl=function(a,b){try{google.ml(Error(a),!1,b)}catch(d){}};google.time=function(){return(new Date).getTime()};google.log=function(a,b,d,e,g){a=google.logUrl(a,b,d,e,g);if("!=a){b=new Image;var c=google.lc,f=google.li;c[f]=b;b.onerror=b.onload=function(){delete c[f]};window.google&&window.google.vel&&window.google.vel.lu&&window.google.vel.a;b.src=a;google.logUrl=function(a,b,d,e,g){var c="",f=google.ls||"";if(!d&&-1==b.search("&ei")){var h=google.getEI(e),c=&ei+"h;-1==b.search("&lei")&&(!e.google.getLEI(e))?c+="&lei="+e:h!=google.kEI&&(c+="&lei="+google.kEI)}a=d||"/"+(g||"gen_204")+"?atyp=i&ct="+a+"&cad="+b+c+f+"&zx="+google.time();/^http://i.test(a)&&google.https()&&(google.ml(Error("a"),!1,{src:a,glmm:1}),a="");return a};google.y={};google.x=function(a,b){google.y[a.id]=[a,b];return!1};google.load=function(a,b,d){google.x({id:a+k++},function(){google.load(a,b,d)});var k=0;});var _gjwl=location;function _gjuc(){var a=_gjwl.href.indexOf("#");if(0<=a&&a=_gjwl.href.substring(a),0<=a.indexOf("#q"))&&(a=a.substring(1),-1=a.indexOf("#")){for(var d=0;d<a.length;){var b=d;"#"-=a.charAt(b)&&+b;var c=a.indexOf("&",b);-1==c&&(c=a.length);b=a.substring(b,c);if(0==b.indexOf("fp"))a=a.substring(0,d)+a.substring(c,a.length),c=d;else if("cad=h"==b) return 0;d=c}_gjwl.href="/search?" +a+"&cad=h";return 1}return 0}function _gjh(){!_gjuc()&&window.google&&google.x&&google.x[{id:"GJH"}],function(){google.nav&&google.nav.gjh&&google.nav.gjh});window._gjh&&_gjh;</script><style>#gbar,#guser{font-size:13px;padding-top:1px !important;}#gbar{height:22px}#guser{padding-bottom:7px !important;text-align:right}.gbh,.gbd{border-top:1px solid #c9d7f1;font-size:1px}.gbh{height:0;position:absolute;top:24px;width:100%}@media all{.gb1{height:22px;margin-right:.5em;vertical-align:top}#gbar{float:left}}.gb1,a.gb4{text-decoration:underline !important}.gb1,a.gb4{color:#00c !important}.gb1 .gb4{color:#dd8e27 !important}.gbf .gb4{color:#900 !important}</style><style>body,td,a,p,.h{font-family:arial,sans-serif}body{margin:0;overflow-y:scroll}#gog{padding:3px 8px 0}td{line-height:.8em}.gac_m td{line-height:17px}form{margin-bottom:20px}.h{color:#36c}.q{color:#00c}.ts td{padding:0}.ts{border-collapse:collapse}em{font-weight:bold;font-style:normal}.lst{height:25px;width:496px}.gsfi,.lst{font:18px arial,sans-serif}.gsfs{font:17px arial,sans-serif}.ds{display:inline-block;display:inline-block;margin:3px 0 4px;margin-left:4px}input{font-family:inherit}a.gb1,a.gb2,a.gb3,a.gb4{color:#11c !important}body{background:#fff;color:black}a{color:#11c;text-decoration:none}a:hover,a:active{text-decoration:underline}.fl a{color:#36c}a:visited{color:#551a8b}a.gb1,a.gb4{text-decoration:underline}a.gb3:hover{text-decoration:none}#ghead a.gb2:hover{color:#fff !important}.sblc{padding-top:5px}.sblc a{display:block;margin:2px 0;margin-left:13px;font-size:11px}.lsbb{background:#eee;border:solid 1px;border-color:#ccc #999 #999 #ccc;height:30px}.lsbb{display:block}.ftl,#ftl a{display:inline-block;margin:0 12px}.lsb{background:url(/images/nav_logo229.png) 0 -261px repeat-x;border:none;color:#000;cursor:pointer;height:30px;margin:0;outline:0;font:15px arial,sans-serif;vertical-align:top}.lsb:active{background:#ccc}.lst:focus{outline:none}</style><script></script><link href="/images/branding/product/icon/gogle_lodp.ico" rel="shortcut icon"></head><body bgcolor="#fff"><script>(function(){var iesg=false;document.body.onload = function(){window.n && window.n();if (document.images){new Image().src=src;}if (!iesg){document.f&&document.f.q.focus();document.gbf&&document.gbf.q.focus();}}})();<div id="mngb">    <div id="gbar"><nobr><b class=gb1>Search</b> <a class=gb1 href="http://www.google.com/imghp?hl=en&tab=wi">Images</a> <a class=gb1 href="http://maps.google.com/maps?hl=en&tab=wl">Maps</a> <a class=gb1 href="https://play.google.com/?hl=en&tab=w8">Play</a> <a class=gb1 href="http://www.youtube.com/?tab=w1">YouTube</a> <a class=gb1 href="http://news.google.com/nwshp?hl=en&tab=wn">News</a> <a class=gb1 href="https://mail.google.com/mail/?tab=wm">Gmail</a> <a class=gb1 href="https://drive.google.com/?tab=wo">Drive</a> <a class=gb1 style="text-decoration:none" href="https://www.google.com/intl/en/options/">&gt;More</a> &quo;</nobr></div><div id="user" width=100%><nobr><span id=abn class=gb1></span><span id=abf class=gbf></span><span id=abg></span><a href="http://www.google.com/history/output?hl=en" class=gb4>Web History</a> | <a href="/preferences?hl=en"
```

HTTP Response

zeigenspace:~ jenna\$ curl www.google.com

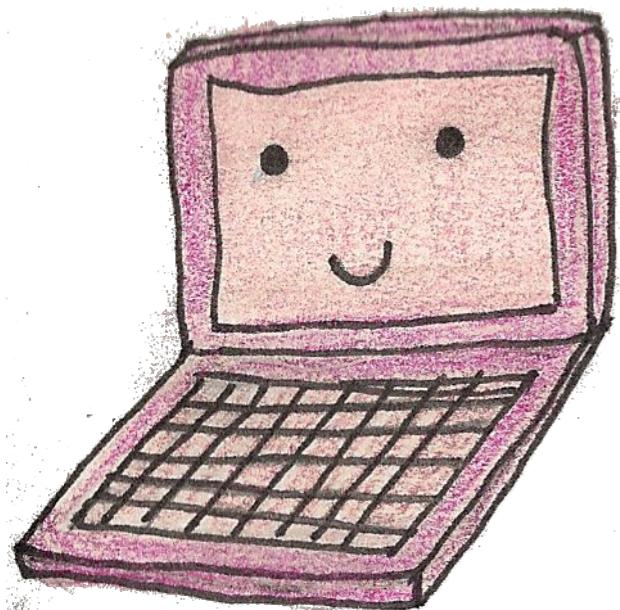
<!doctype html><html itemscope="" itemtype="

My curl, my curl, my curl
Talkin' 'bout my curl
my curl



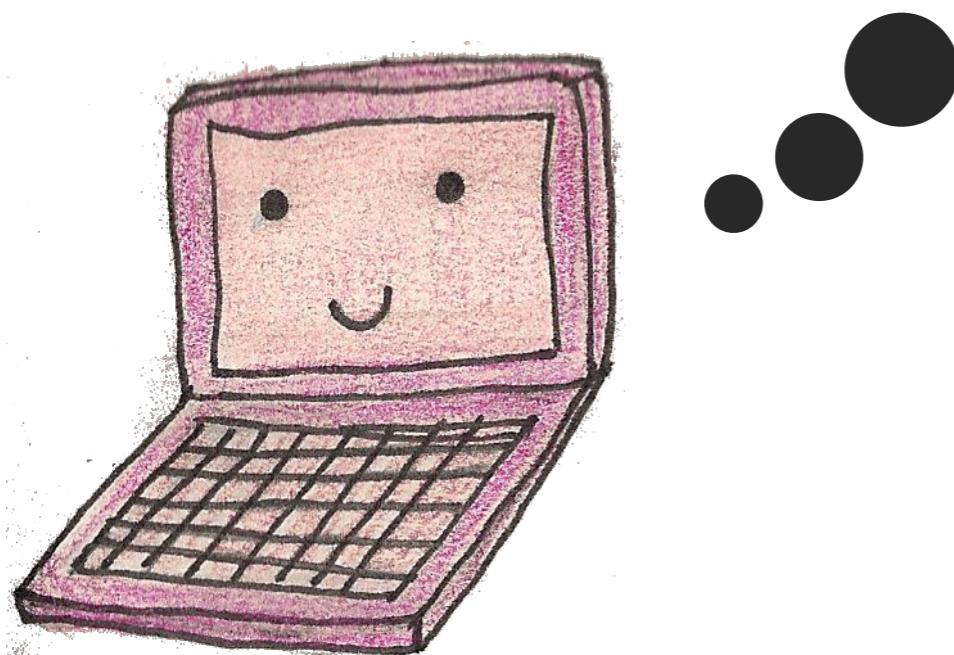
HTTP Response

Shrink it down,
gzip it
(Don't reverse it...)



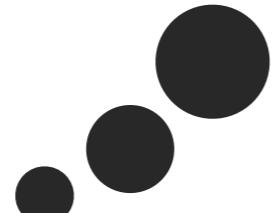
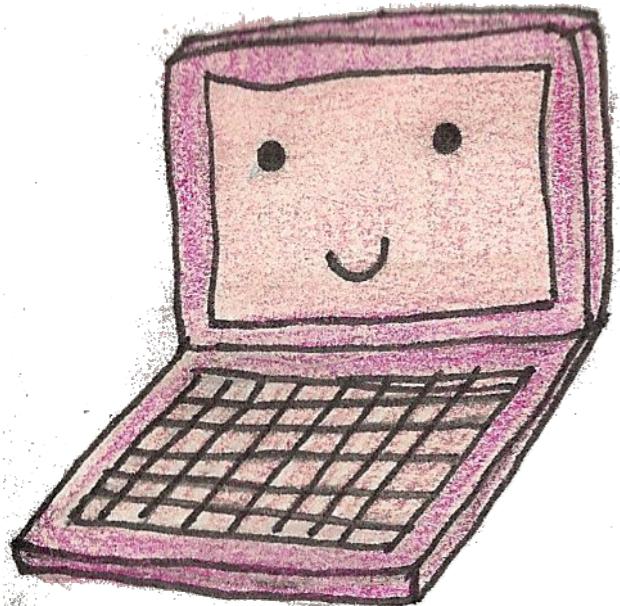
HTML Parsing

```
1 <!doctype html>
2 <html>
3   <head>
4     <script type="text/javascript" src="library.js"></script>
5     <link rel="stylesheet" type="text/css" href="styles.css">
6     <script type="text/javascript" src="website.js"></script>
7   </head>
8   <body>
9     <div>Let's pretend this is all of google</div>
10  </body>
11 </html>
```



HTML Parsing

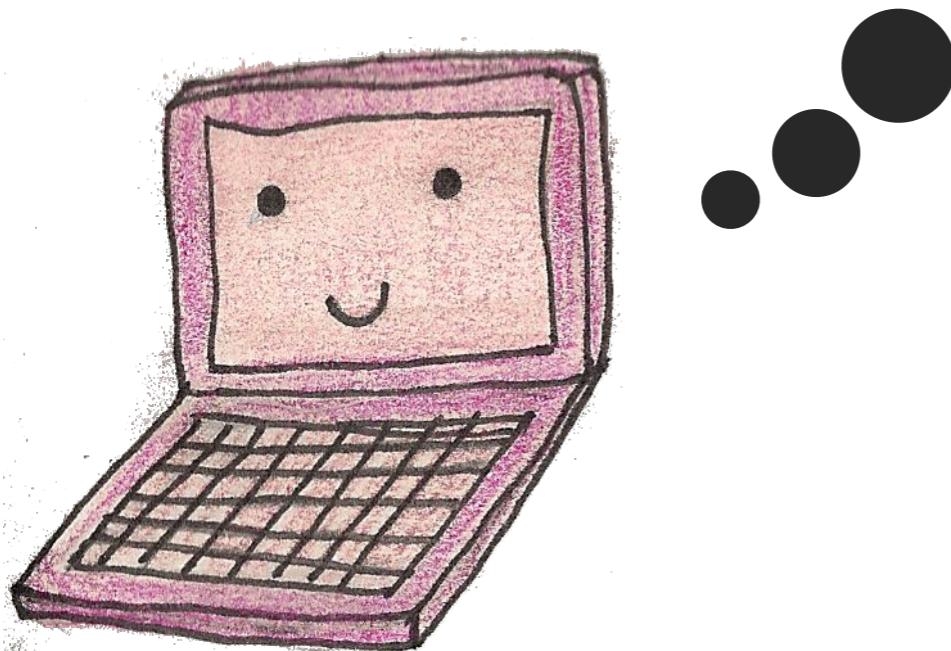
```
1 <!doctype html>
2 <html>
3   <head>
4     <script type="text/javascript" src="library.js"></script>
5     <link rel="stylesheet" type="text/css" href="styles.css">
6     <script type="text/javascript" src="website.js"></script>
7   </head>
8   <body>
9     <div>Let's pretend this is all of google</div>
10  </body>
11 </html>
```



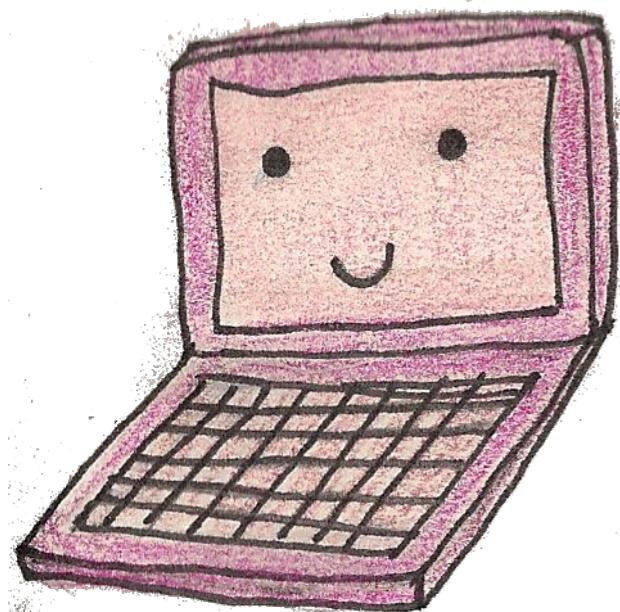
Come back server! I
need more things!

HTML Parsing

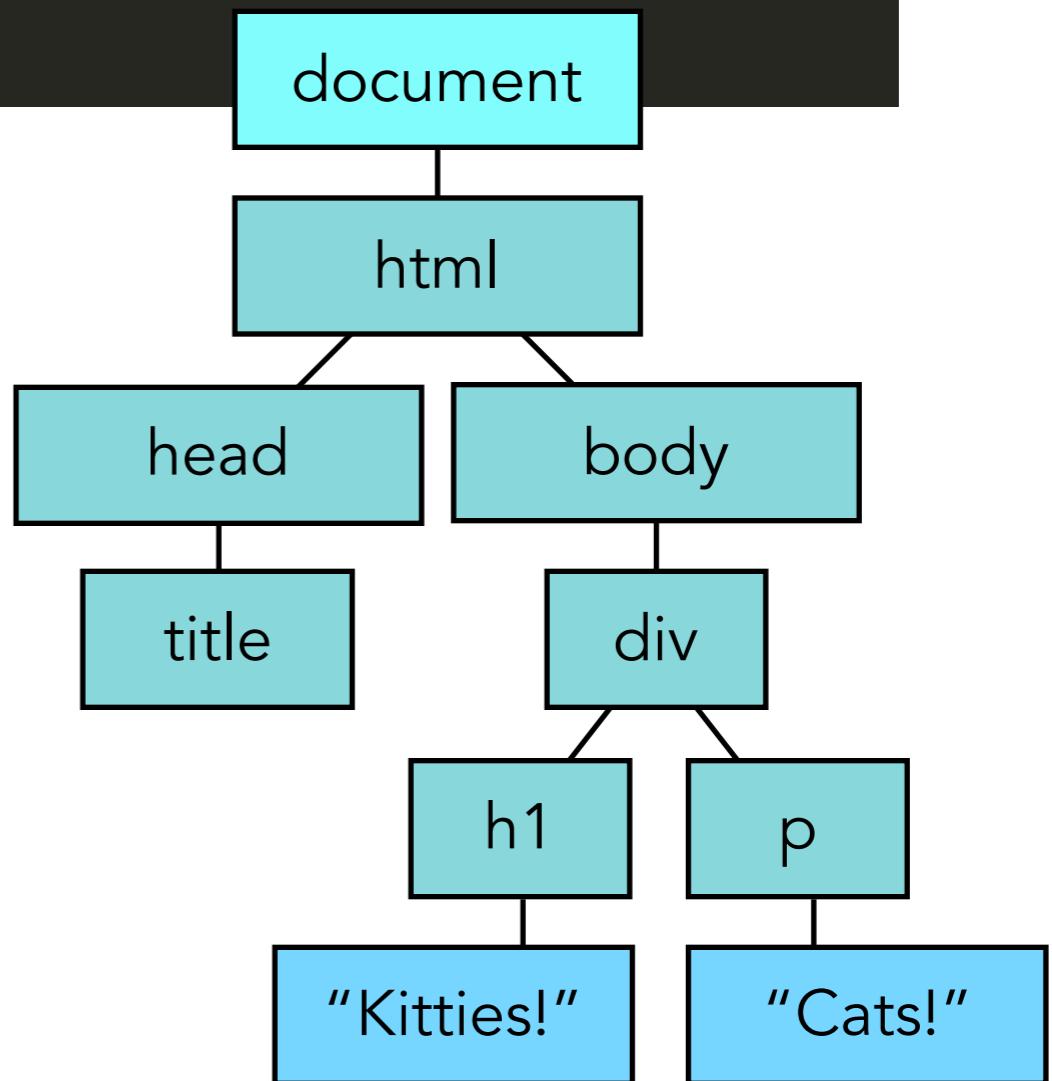
```
1 <!doctype html>
2 <html>
3   <head>
4     <script type="text/javascript" src="library.js"></script>
5     <link rel="stylesheet" type="text/css" href="styles.css">
6     <script type="text/javascript" src="website.js"></script>
7   </head>
8   <body>
9     <div>Let's pretend this is all of google</div>
10   </body>
11 </html>
```



HTML Parsing

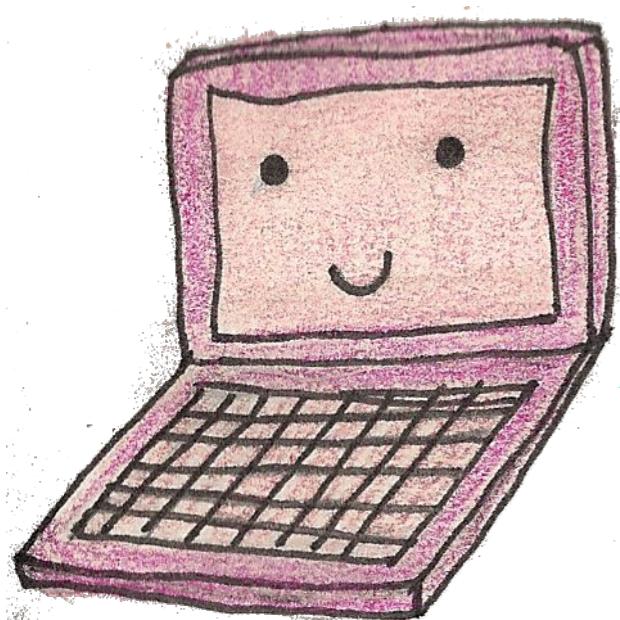


```
1 <!doctype html>
2 <html>
3   <head>
4     <script type="text/javascript" src="library.js"></script>
5     <link rel="stylesheet" type="text/css" href="styles.css">
6     <script type="text/javascript" src="website.js"></script>
7   </head>
8   <body>
9     <div>Let's pretend this is all of google</div>
10  </body>
11 </html>
```



HTML Parsing

```
1 <!doctype html>
2 <html>
3   <head>
4     <script type="text/javascript" src="library.js"></script>
5     <link rel="stylesheet" type="text/css" href="styles.css">
6     <script type="text/javascript" src="website.js"></script>
7   </head>
8   <body>
9     <div>Let's pretend this is all of google</div>
10  </body>
11 </html>
```

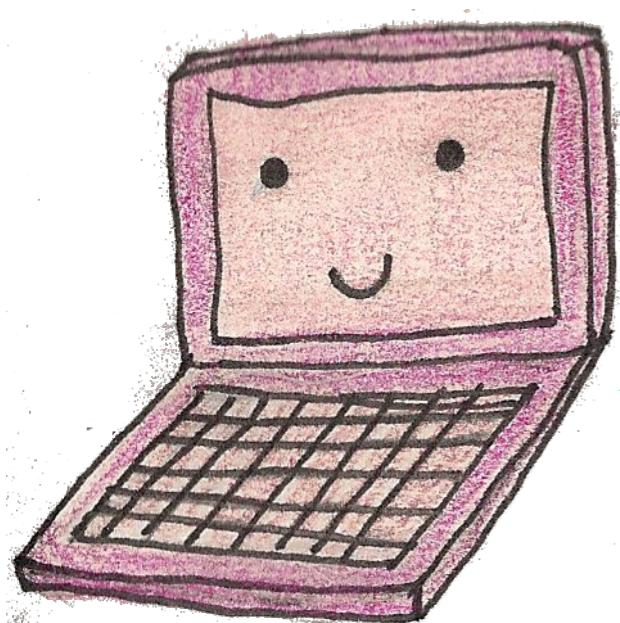


Whatever, wherever
I'm gonna make it render!



HTML Parsing

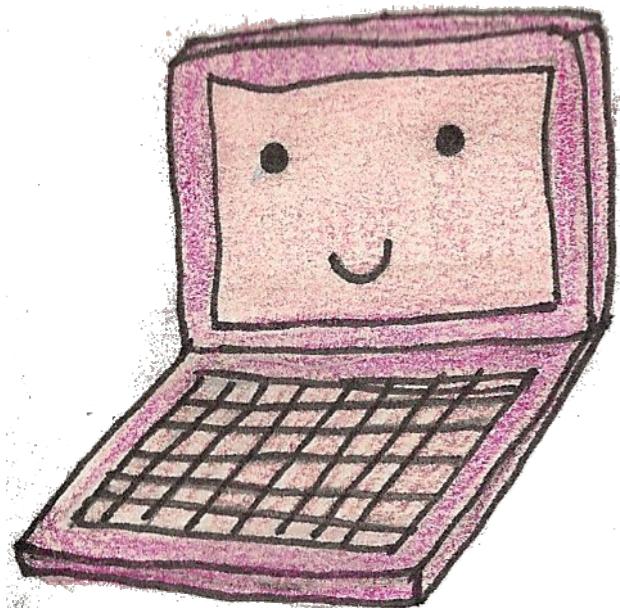
```
1 <!doctype html>
2 <html>
3   <head>
4     <script type="text/javascript" src="library.js"></script>
5     <link rel="stylesheet" type="text/css" href="styles.css">
6     <script type="text/javascript" src="website.js"></script>
7   </head>
8   <body>
9     <div>Let's pretend this is all of google</div>
10   </body>
11 </html>
```



Whatever, wherever
I'm gonna make it render!

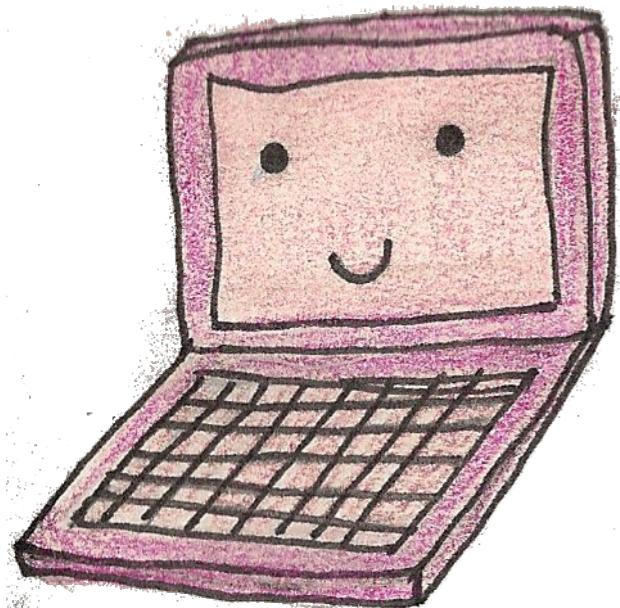


HTML Parsing



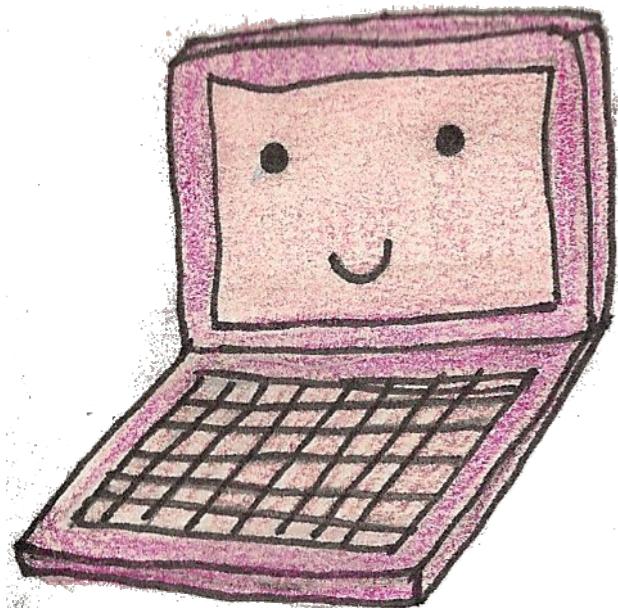
Just doing that
browser thing...

HTML Parsing



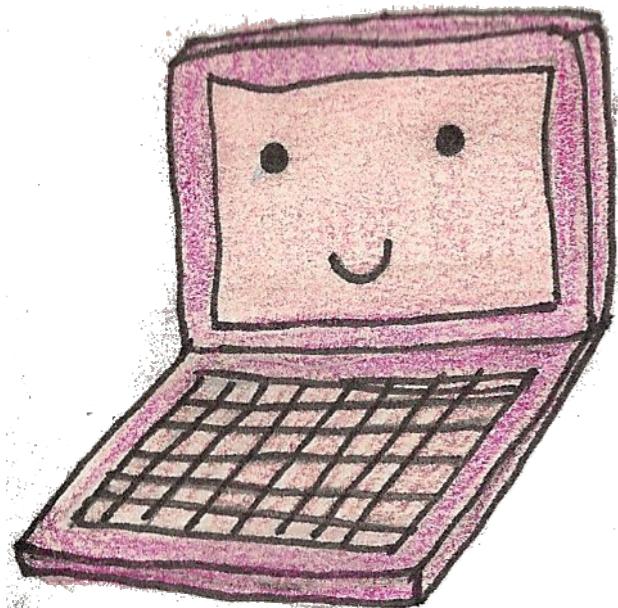
Just doing that
browser thing...

HTML Parsing



Cache moneyyy.

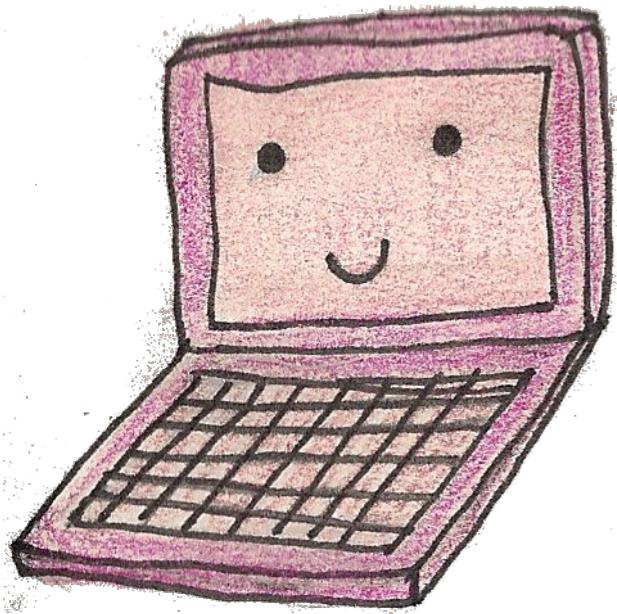
HTML Parsing



Harder, Better,
Faster, Smaller

♪ ♪ ♪

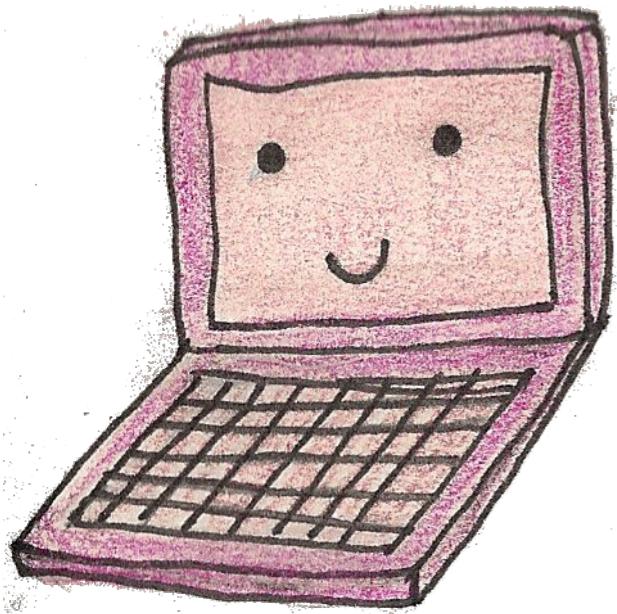
HTML Parsing



Stop, JavaScript time!
♪ ♪ ♪

```
<head>
  <script src="library.js"></script>
  <link href="styles.css">
  <script src="website.js"></script>
</head>
<body></body>
```

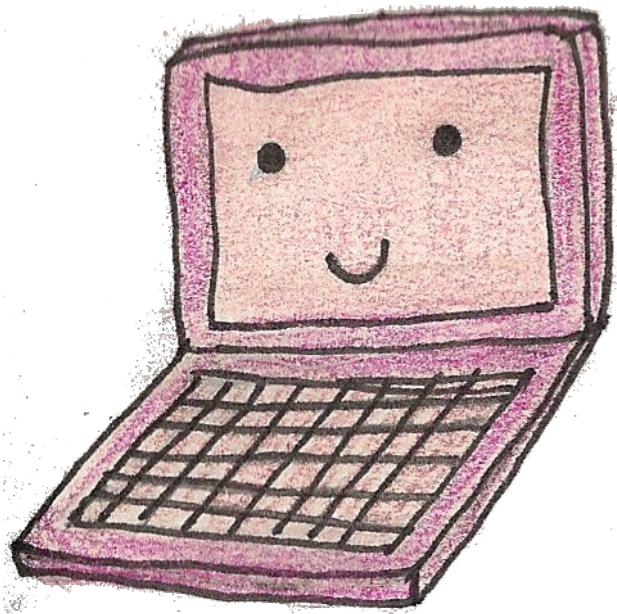
HTML Parsing



Just doing that
browser thing...

```
<head>
  <script defer src="library.js"></script>
  <link href="styles.css">
  <script src="website.js"></script>
</head>
<body></body>
```

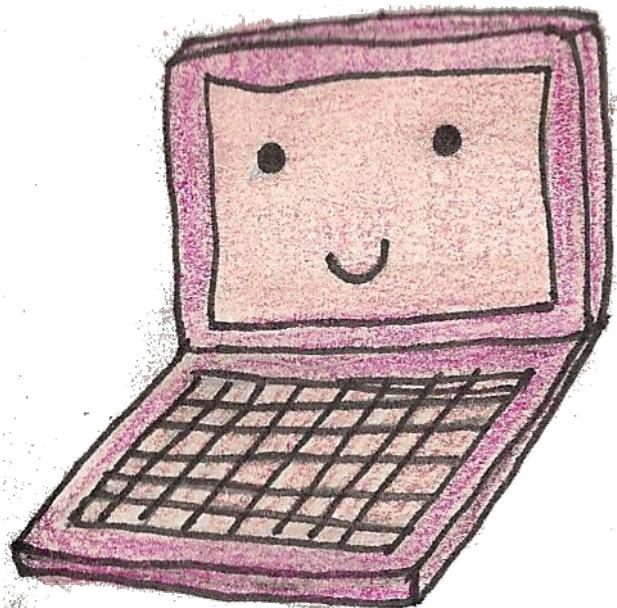
HTML Parsing



Just doing that
browser thing...

```
<head>
  <script async src="library.js"></script>
  <link href="styles.css">
  <script src="website.js"></script>
</head>
<body></body>
```

HTML Parsing

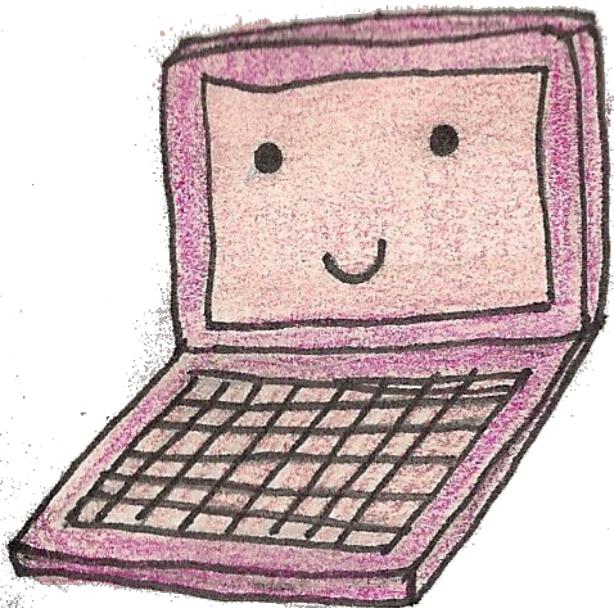


Just doing that
browser thing...

```
<head>
  <script src="library.js"></script>
  <link href="styles.css">
  <script src="website.js"></script>
</head>
<body></body>
```

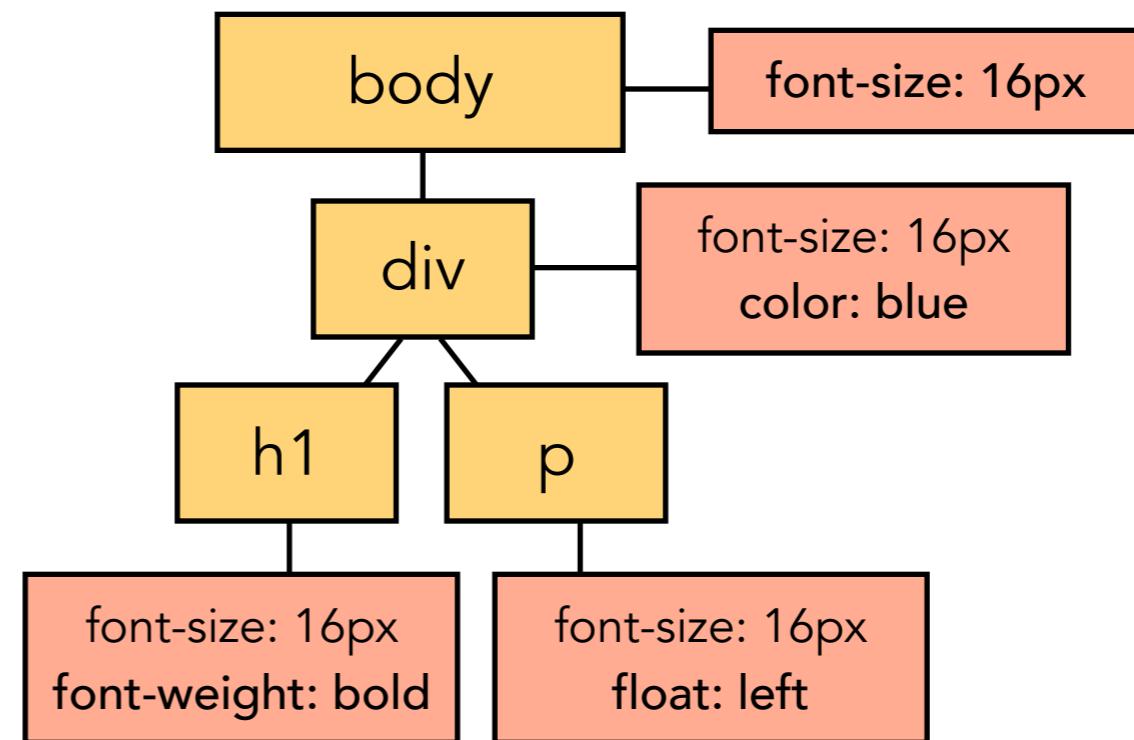
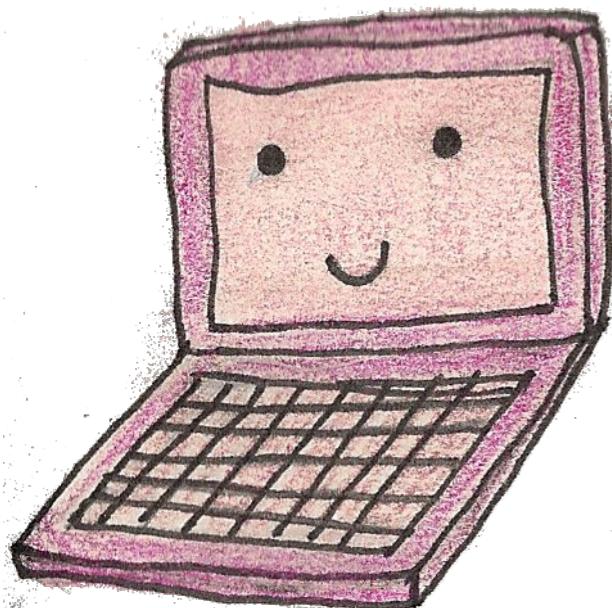
CSS Parsing

Just doing that
browser thing...

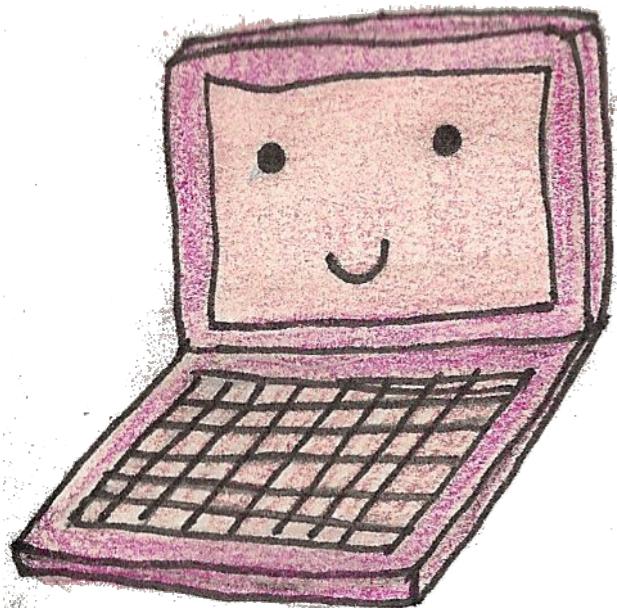


CSS Parsing

'Cause we know how to style
We know how to style
♪ ♪ ♪



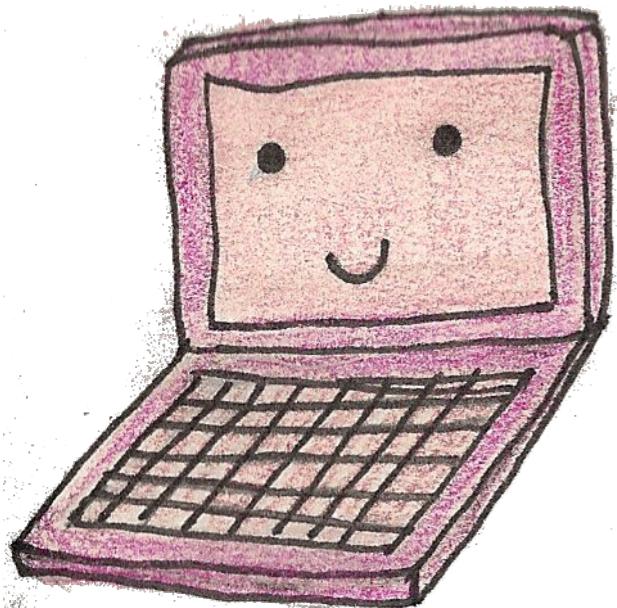
HTML Parsing



Just doing that
browser thing...

```
<head>
  <script src="library.js"></script>
  <link href="styles.css"> ✓
  <script src="website.js"></script>
</head>
<body></body>
```

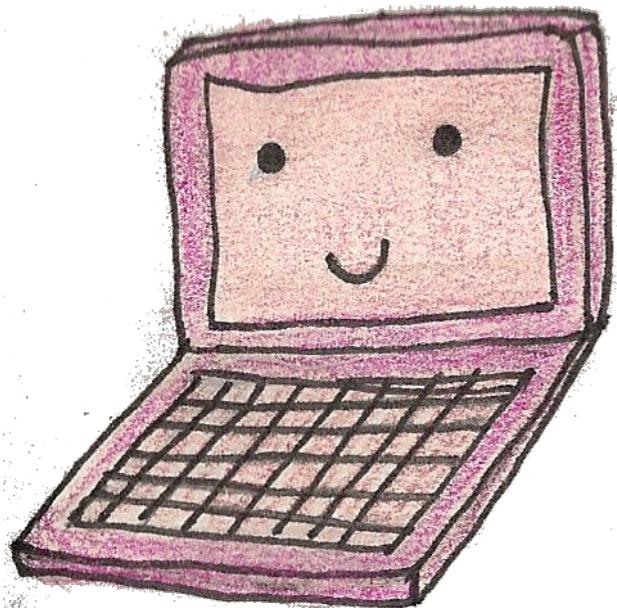
HTML Parsing



Just doing that
browser thing...

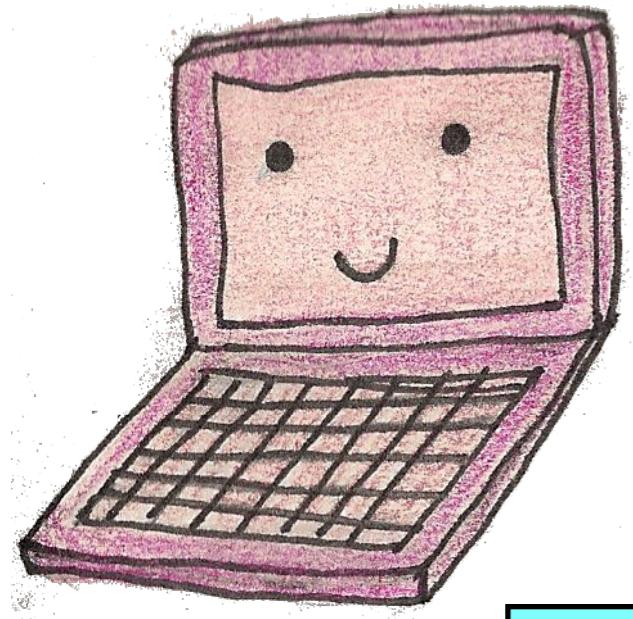
```
<head>
  <script src="library.js"></script> ✓
  <link href="styles.css"> ✓
  <script src="website.js"></script>
</head>
<body></body>
```

HTML Parsing

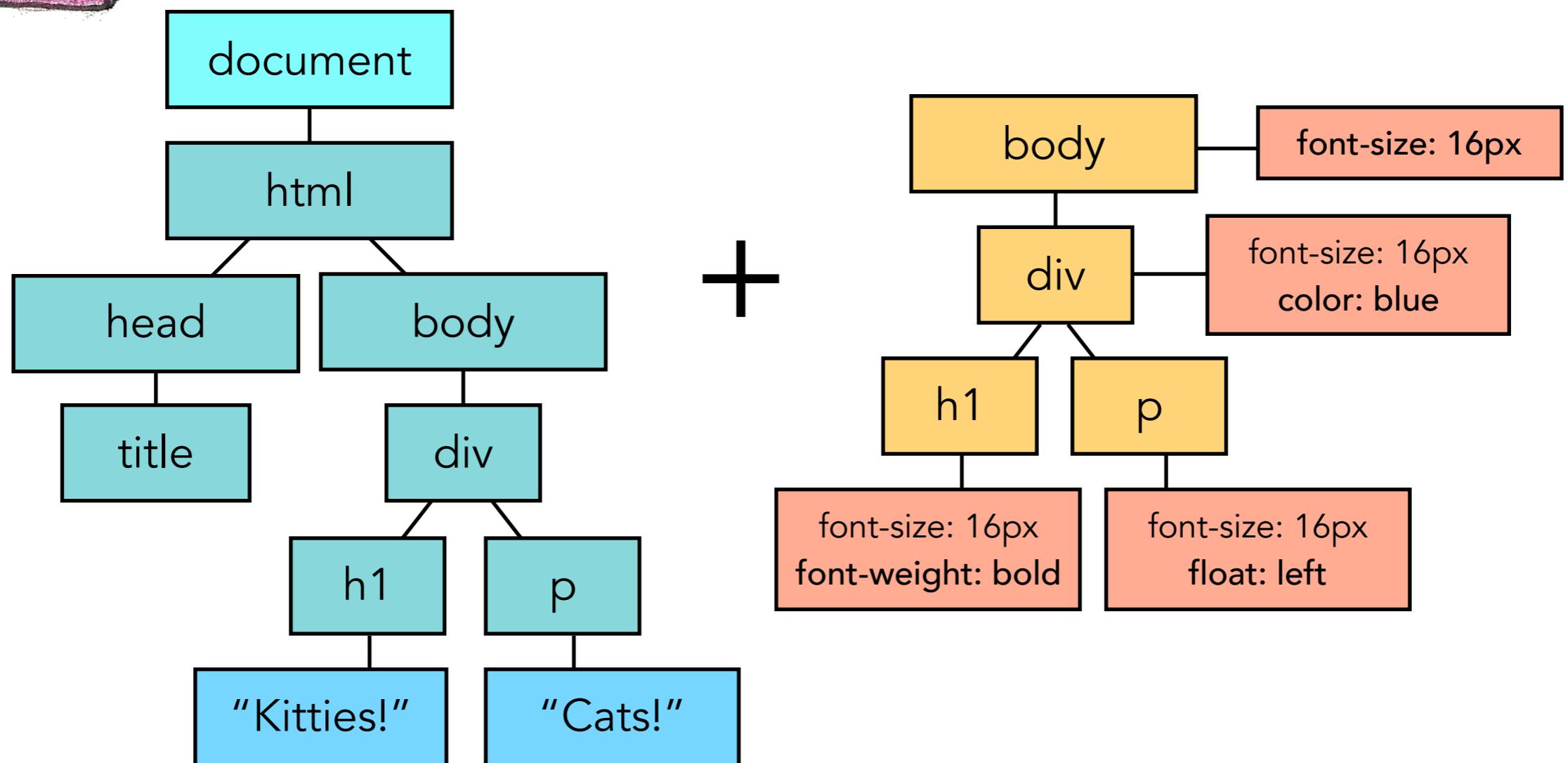


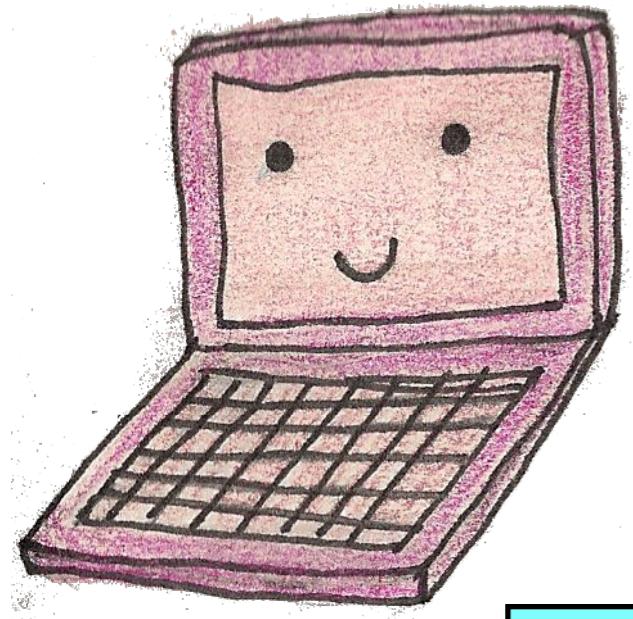
Just doing that
browser thing...

```
<head>
  <script src="library.js"></script> ✓
  <link href="styles.css"> ✓
  <script src="website.js"></script> ✓
</head>
<body></body>
```

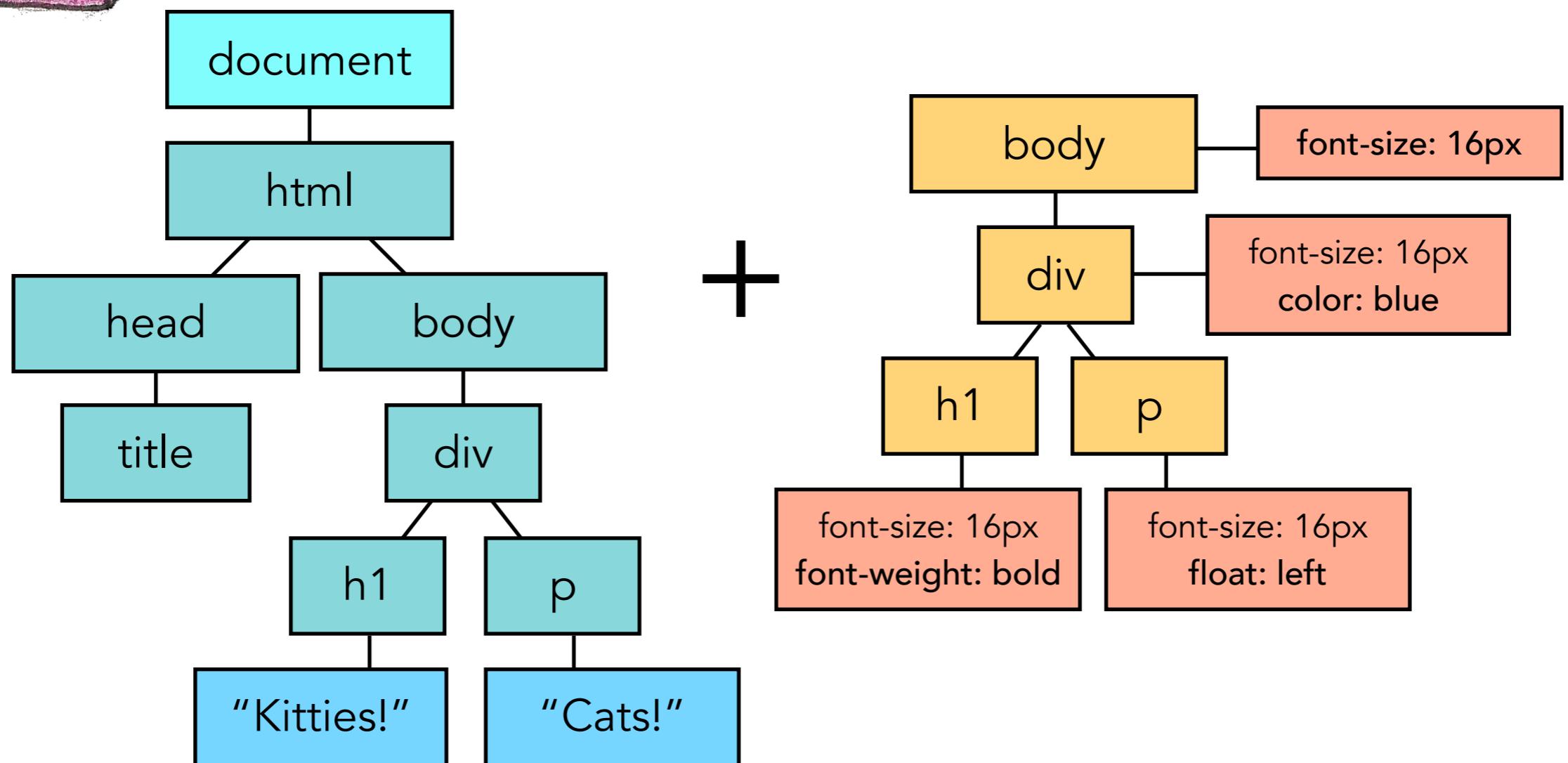


Rendering

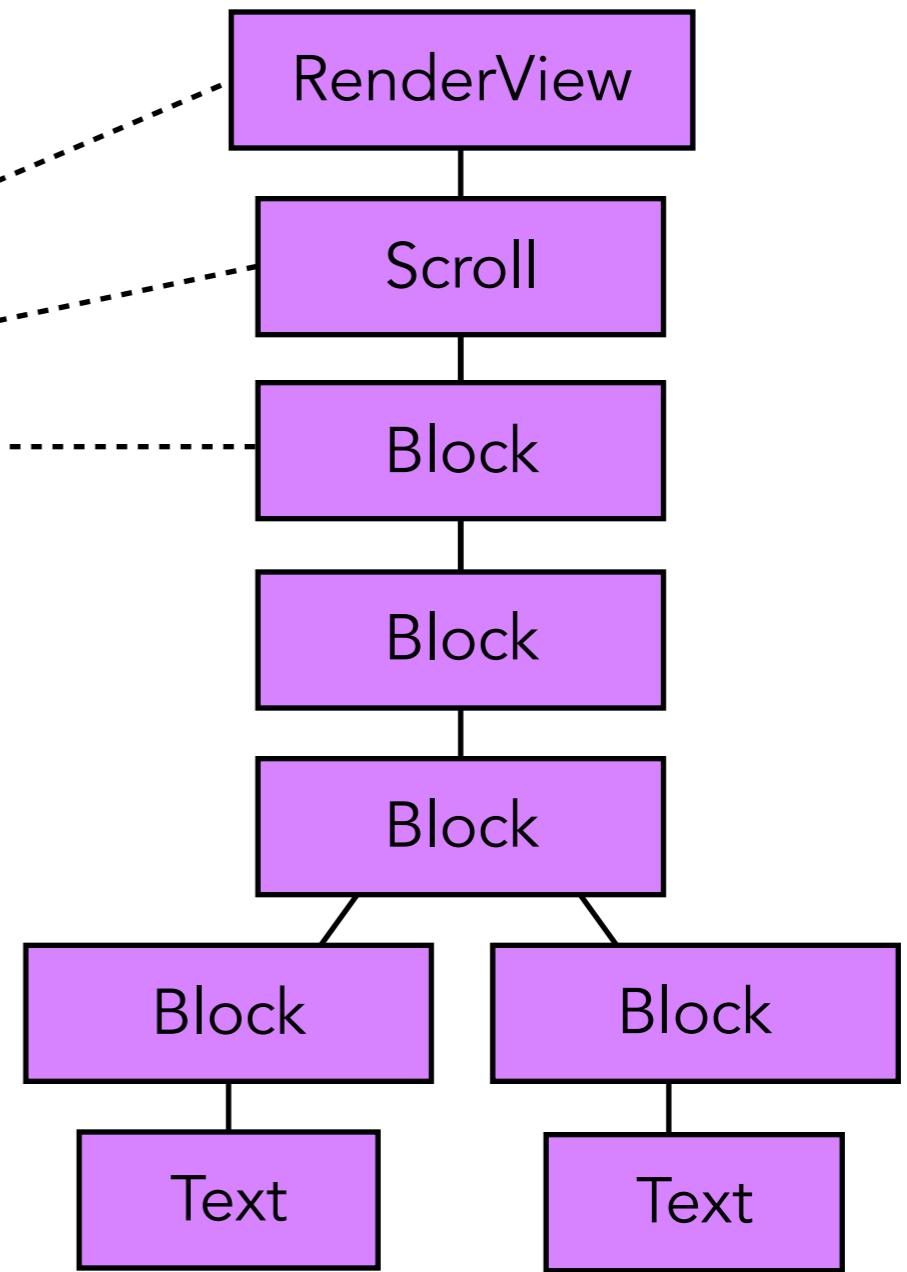
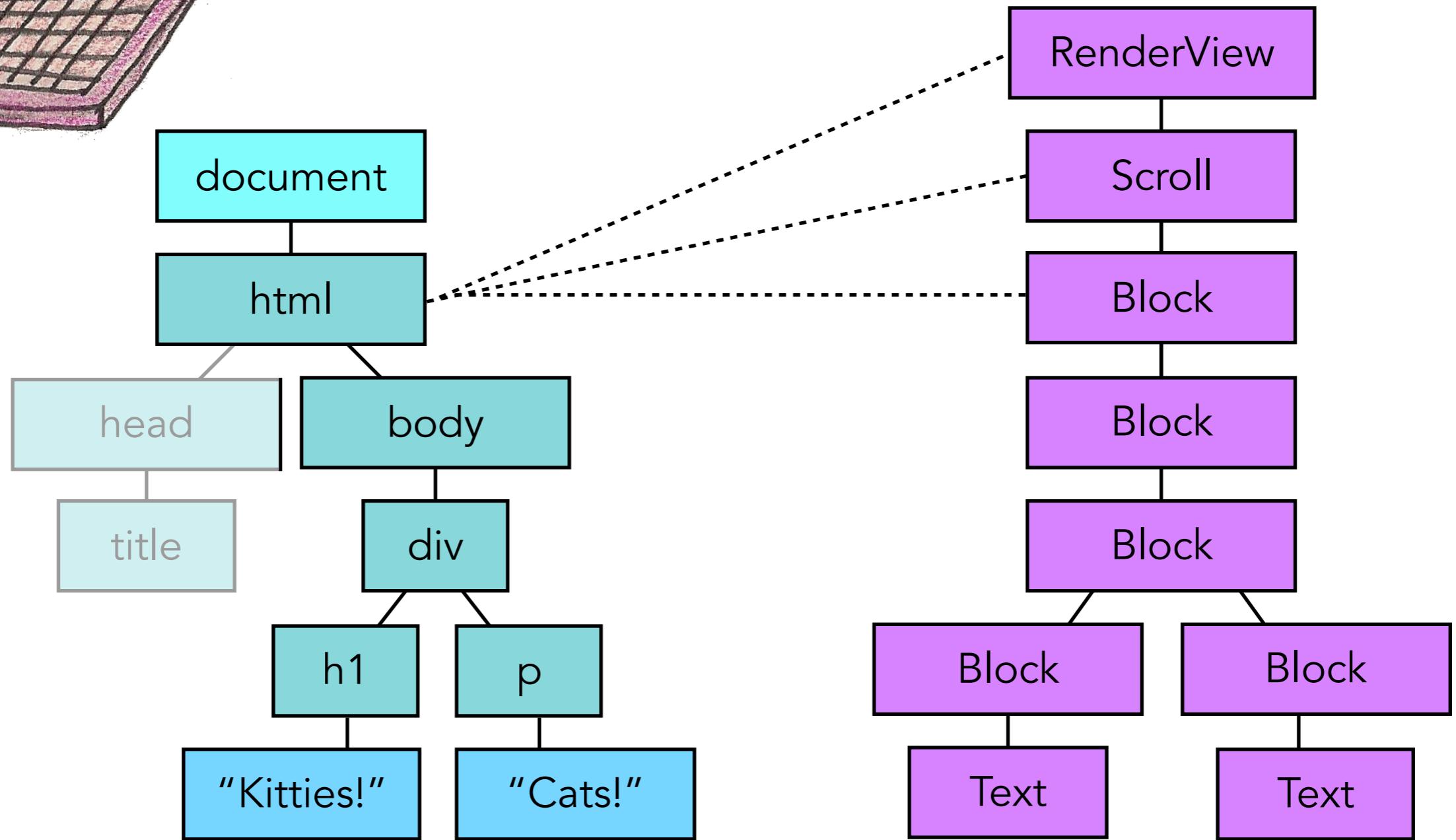
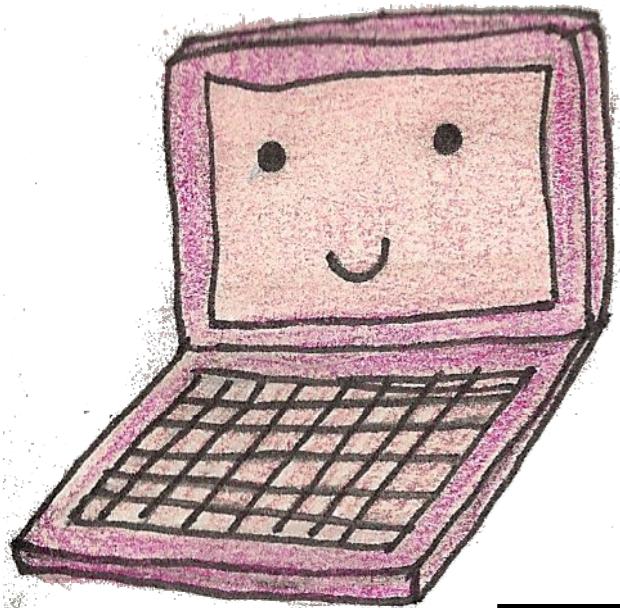




Rendering

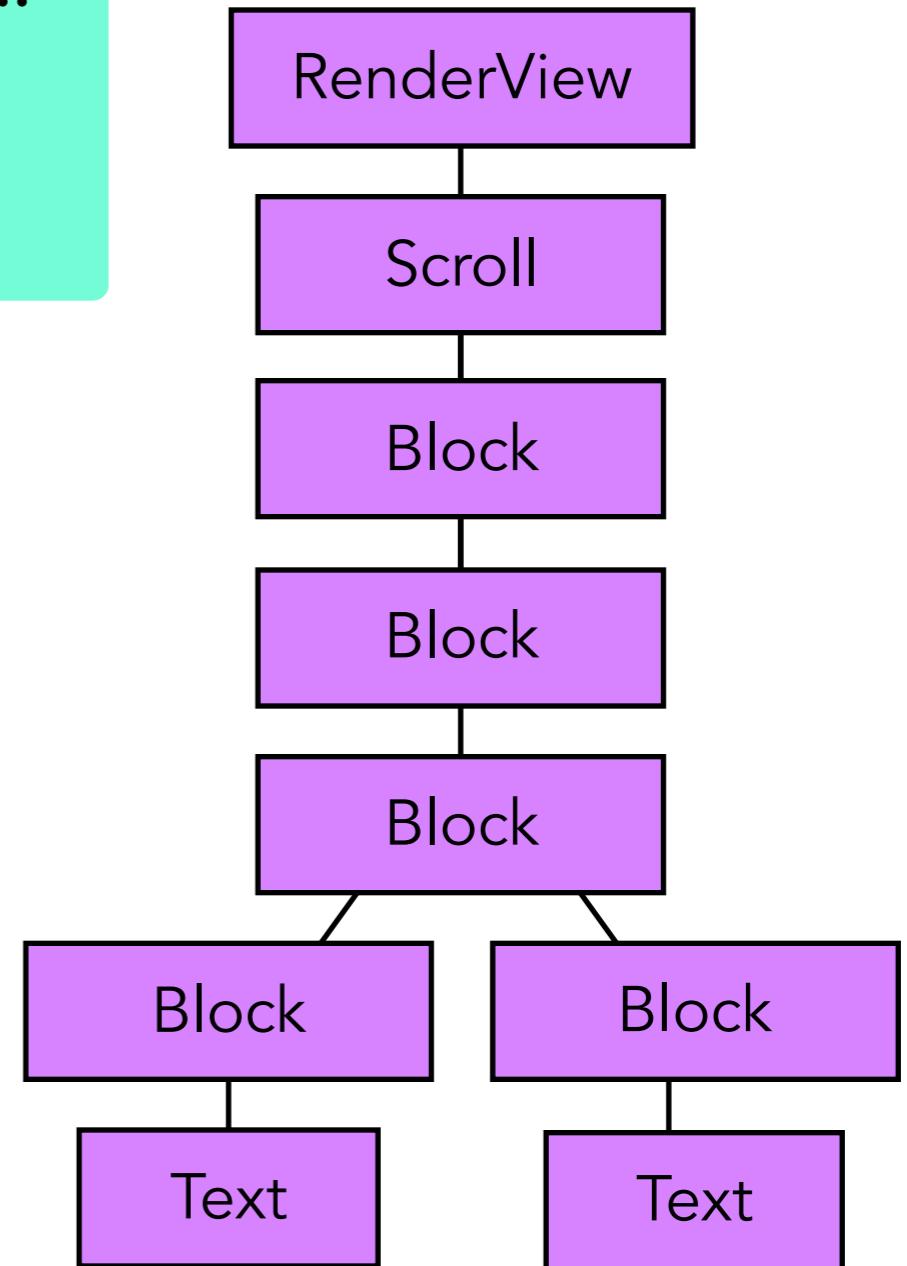
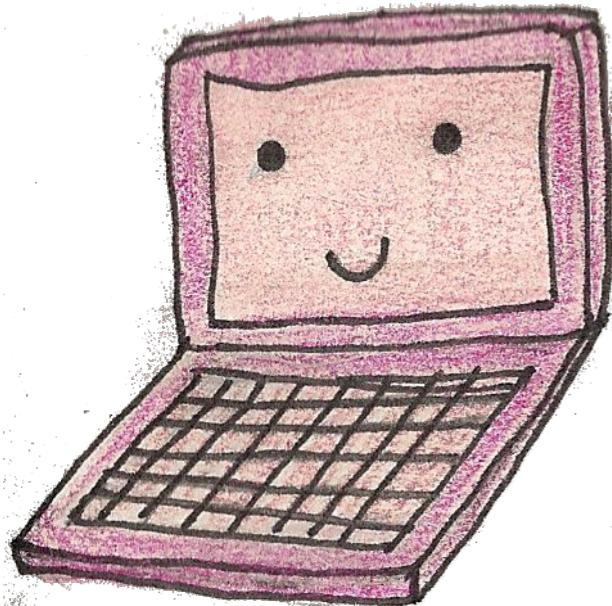


Rendering



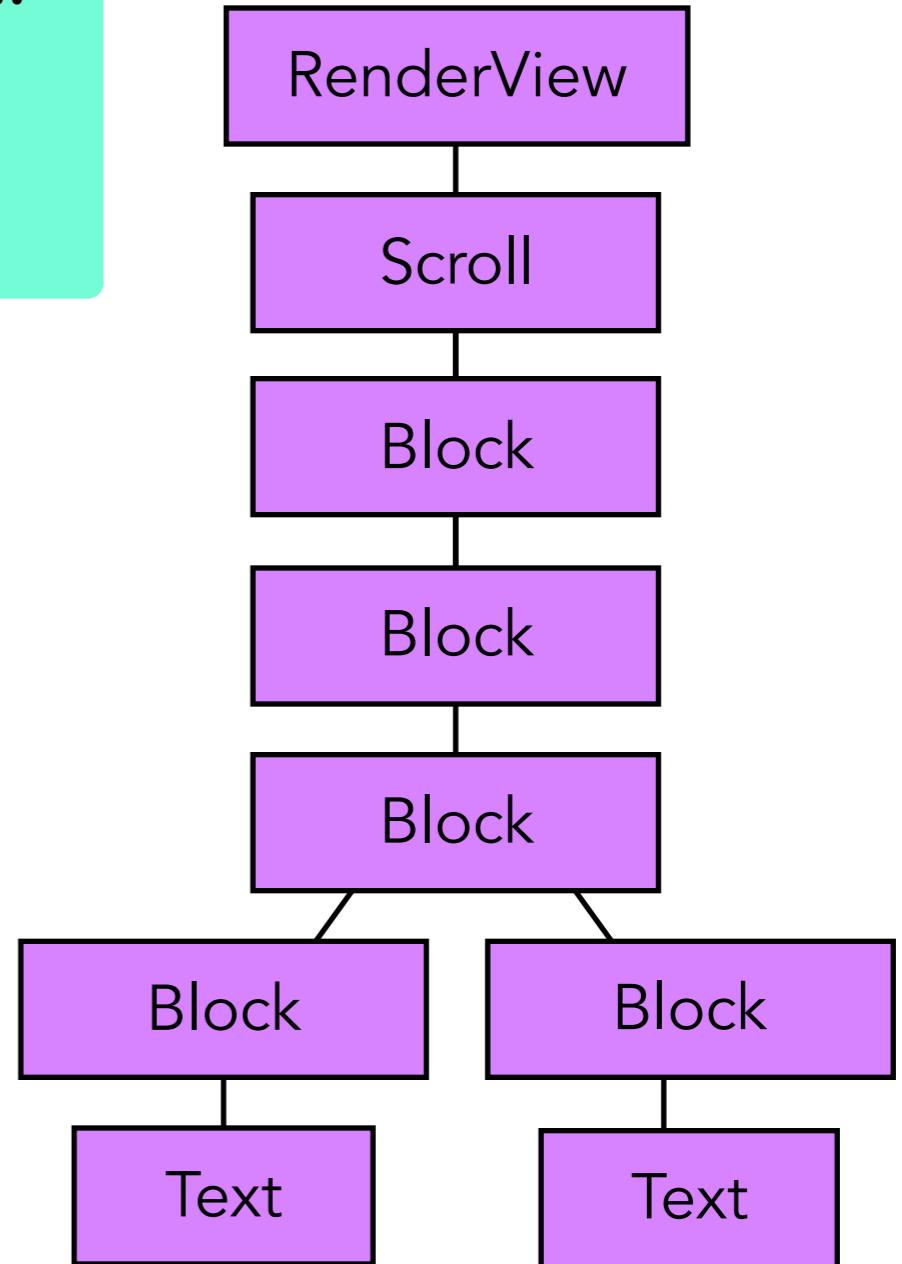
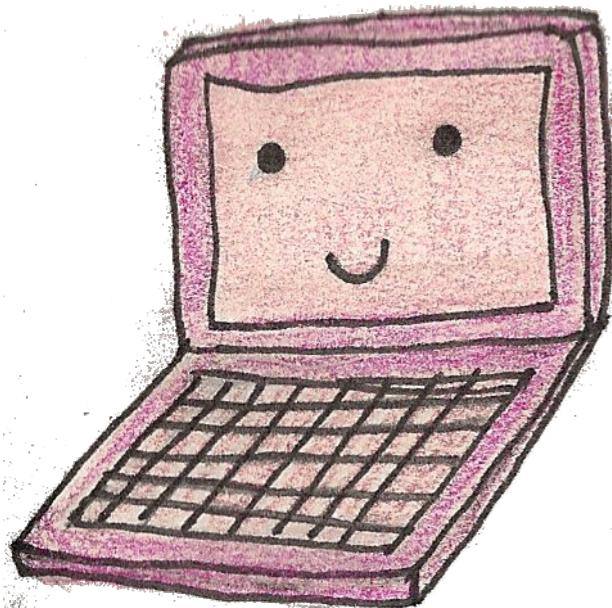
Rendering

Cause the render's gonna...
rend, rend, rend?



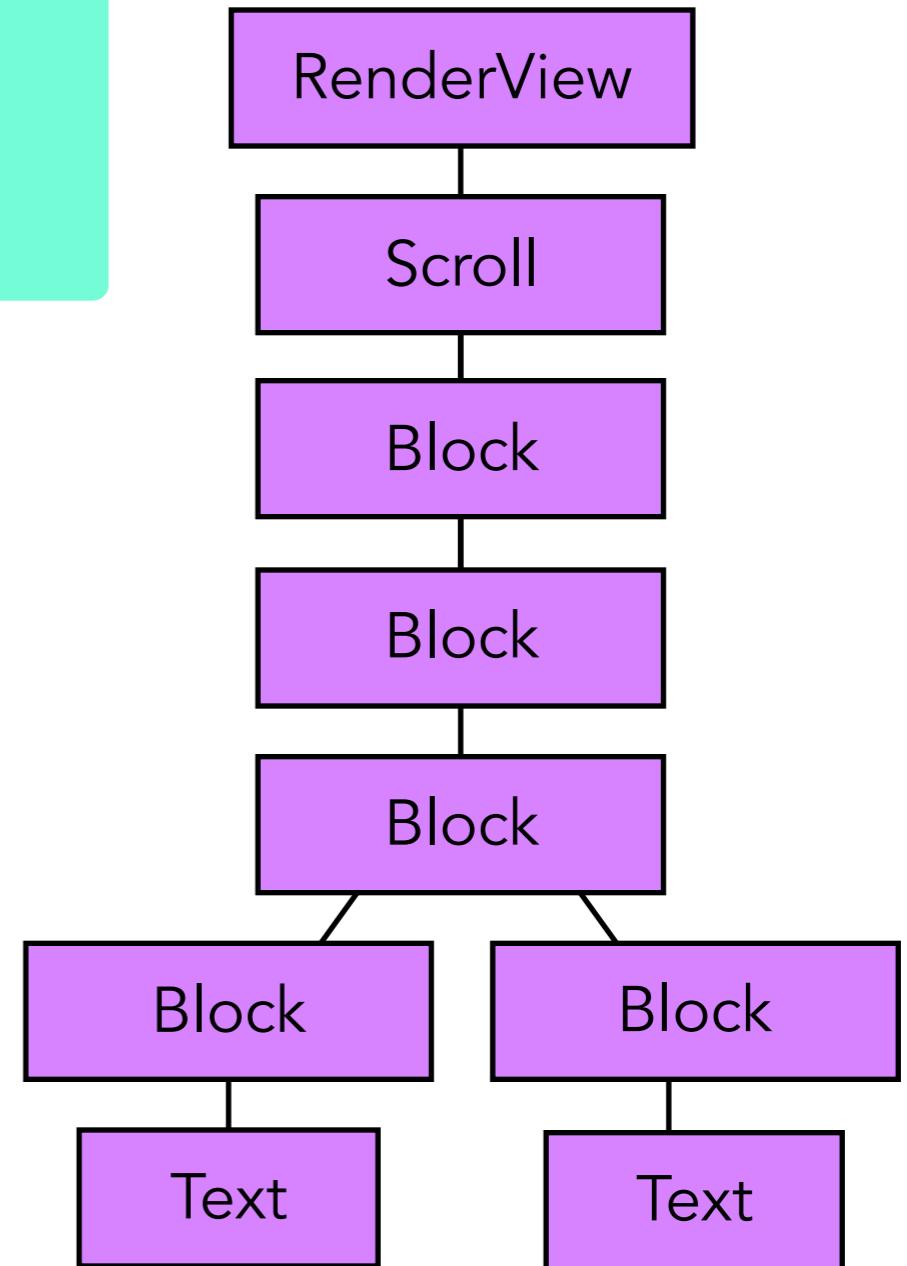
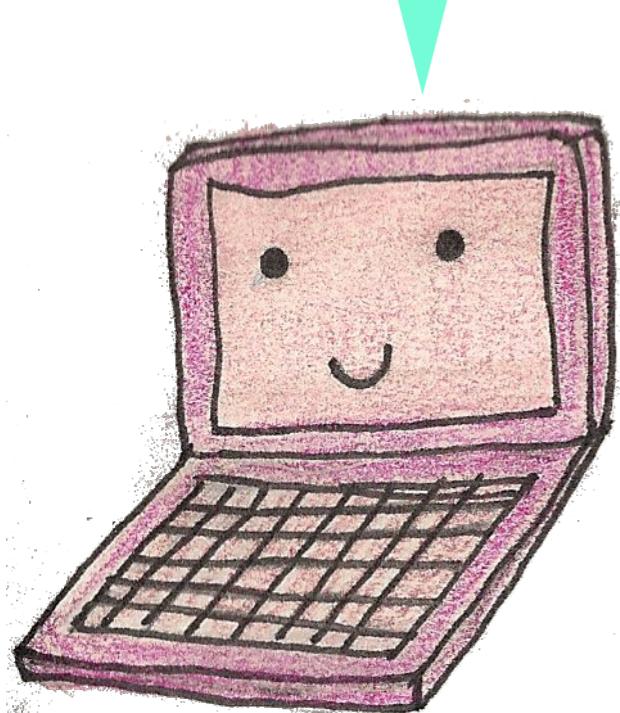
Rendering

Cause the render's gonna...
rend, rend, rend?



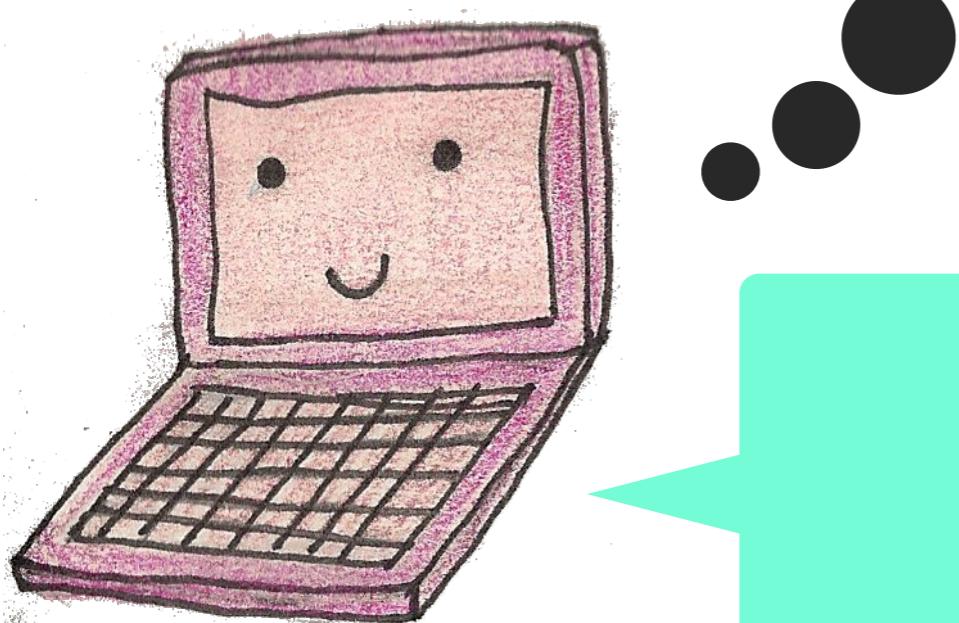
Rendering

And the painter's gonna
paint, paint, paint...



HTML Parsing

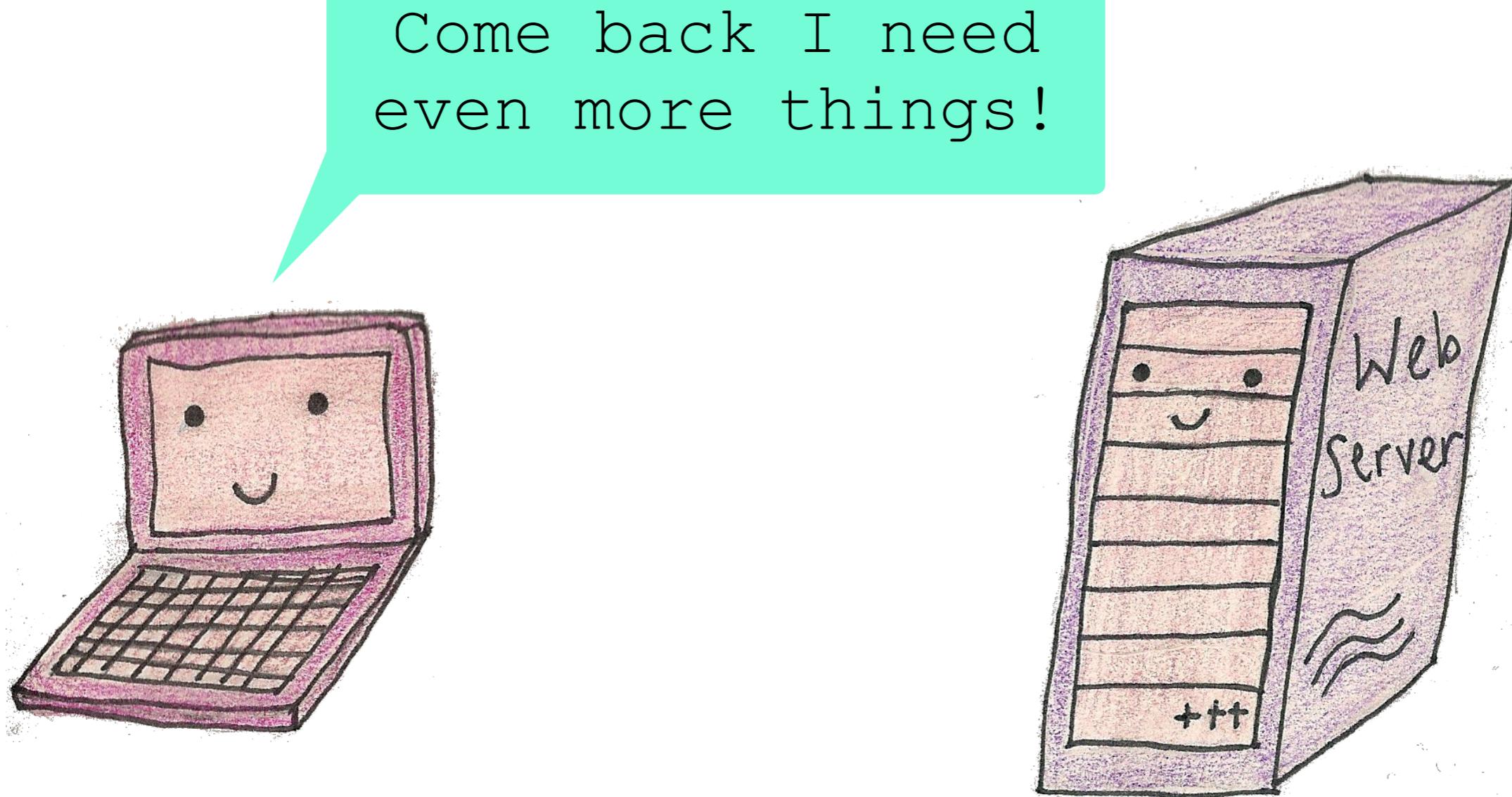
```
1 <!doctype html>
2 <html>
3   <head>
4     <script type="text/javascript" src="library.js"></script>
5     <link rel="stylesheet" type="text/css" href="styles.css">
6     <script type="text/javascript" src="website.js"></script>
7   </head>
8   <body>
9     <div>Let's pretend this is all of google</div>
10   </body>
11 </html>
```



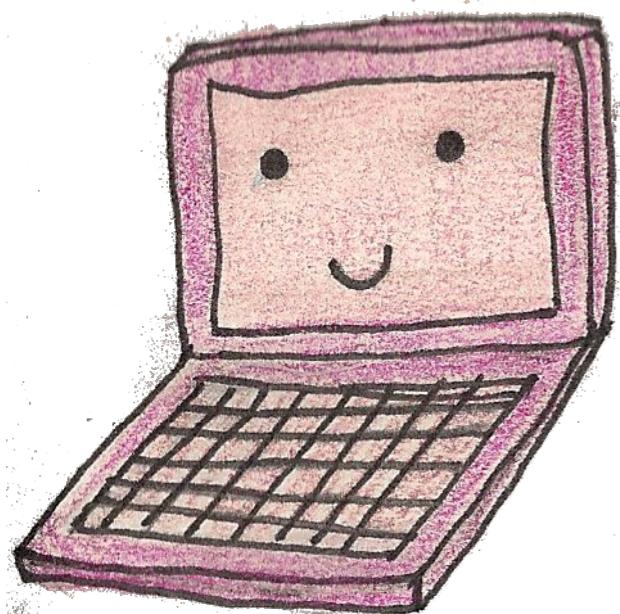
Whoa, oh, oh, oh, oh
Whoa, oh, oh, oh,
The DOM's interactive
DOM's interactive



HTML Parsing



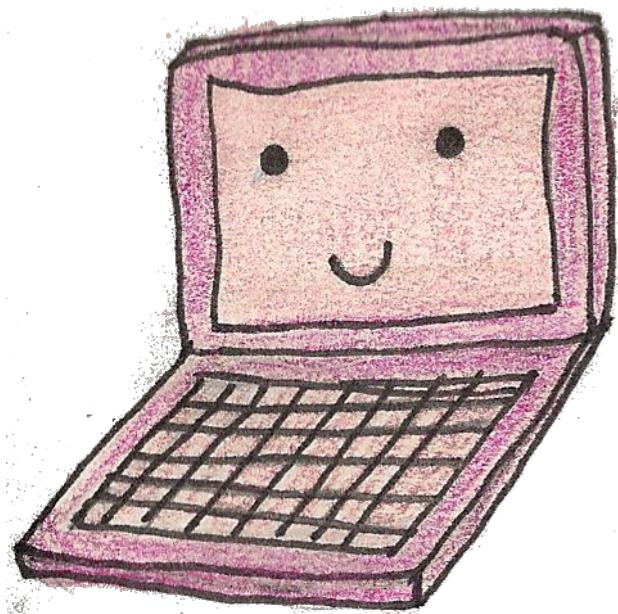
HTML Parsing



In your eyes
The light, the heat
In your eyes
The DOM's complete

♪ ♪ ♪

HTTP/2



The future is
kinda now!

Overview

1. IP Address Lookup
2. Opening a socket
3. Security Stuff
4. HTTP Request
5. Server Things
6. HTTP Response
7. Parsing
8. Rendering

Resources

General

- What Happens When (Github)

Transport

- DNS (Wikipedia)
- TCP (Wikipedia)
- TLS (Wikipedia)

Parsing, Rendering, and Painting

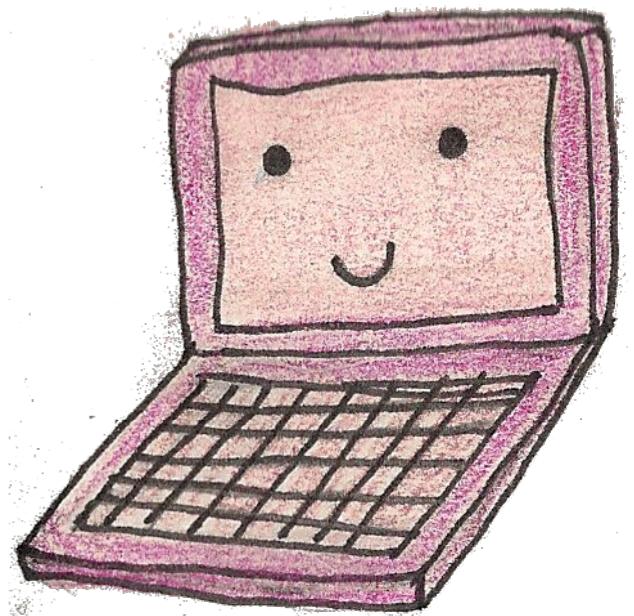
- How Browsers Work (HTML5 Rocks)
- Critical Rendering Path (Google Developers)

Performance

- Yahoo's FE Performance Rules
- Raul Fraile: How GZIP compression works (JSConfEU 2014)

HTTP/2

- Andy Davies: The Case for HTTP/2 (TXJS 2015)



Complete Tracklist

The Beatles - You Know My Name (Look Up The Number)

Carly Rae Jepsen - Call Me Maybe

Radiohead - Creep

Taylor Swift - Blank Space

Taylor Swift - We Are Never Ever Getting Back Together

Taylor Swift - Wildest Dreams

Imagine Dragons - Demons

Young Chris – Racks

Beastie Boys - So What'cha Want

Gotye - Somebody That I Used To Know

The Temptations - My Girl

Missy Elliot - Work It

Shakira - Whenever, Wherever

Daft Punk – Harder, Better, Faster, Stronger

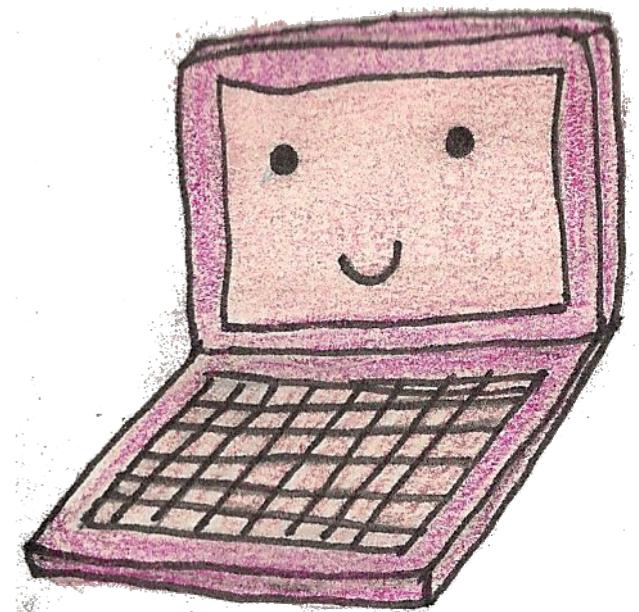
MC Hammer - U Can't Touch This

Taylor Swift - Style

Taylor Swift - Shake It Off

Imagine Dragons - Radioactive

Peter Gabriel - In Your Eyes



Complete Tracklist

The Beatles - You Know My Name (Look Up The Number)

Carly Rae Jepsen - Call Me Maybe

Radiohead - Creep

Taylor Swift - Blank Space

Taylor Swift - We Are Never Ever Getting Back Together

Taylor Swift - Wildest Dreams

Imagine Dragons - Demons

Young Chris – Racks

Beastie Boys - So What'cha Want

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Daft Punk – Harder, Better, Faster, Stronger

MC Hammer - U Can't Touch This

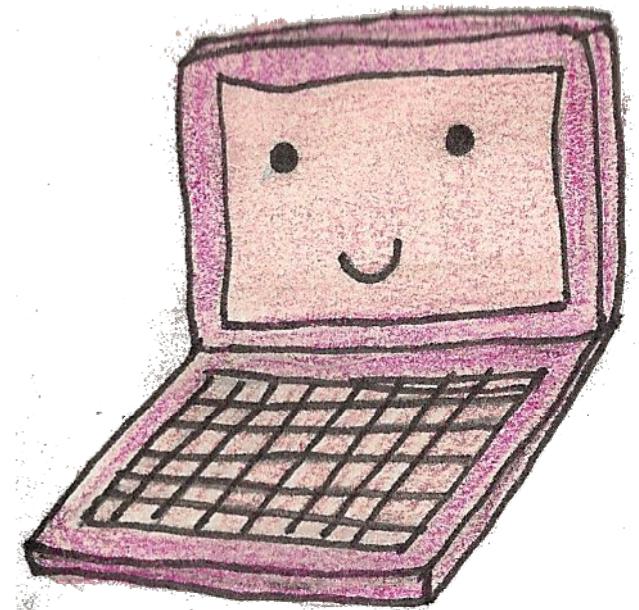
Taylor Swift - Style

Taylor Swift - Shake It Off

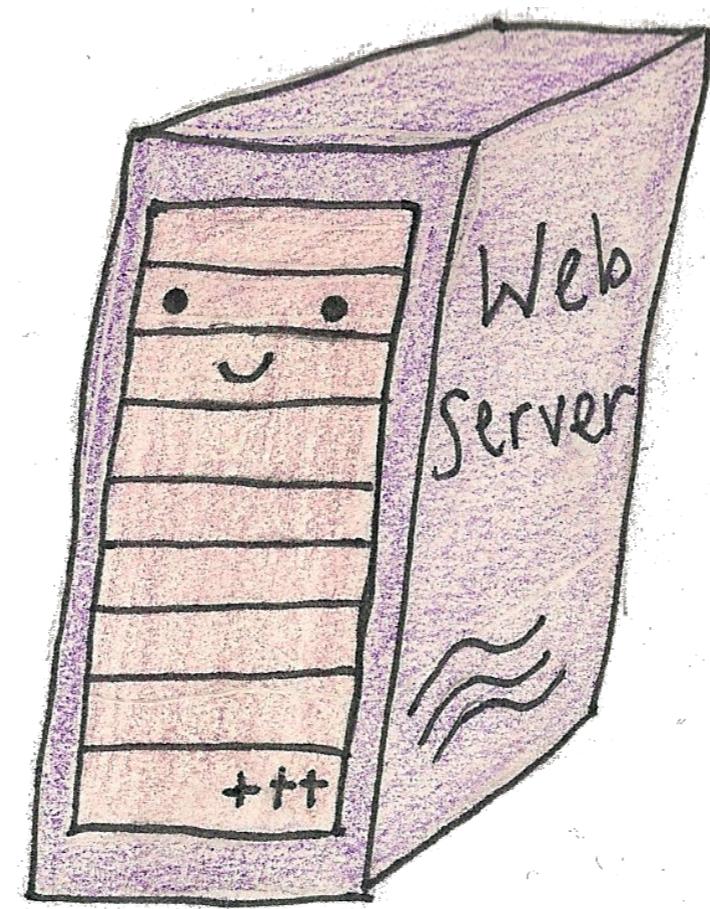
Imagine Dragons - Radioactive

Peter Gabriel - In Your Eyes

*something
witty about a
POP server...*



jenna.is/thunderplains



Thanks!

