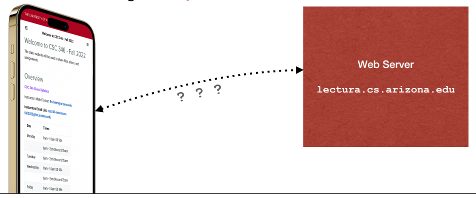
# CSC 346 - Cloud Computing

04 - Web Servers, Ports & Sockets

## Networking

### Sockets

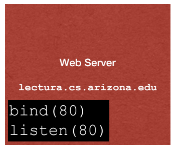
- How do things communicate over the internet? (the simple version)
- This is not a networking class 🤪



## Networking

### Sockets

- Some computing resource must ***bind*** to a specific ***port*** on its host, and then ***listen*** for incoming connections
- Listens on a specific ***port***
- For a HTTP, this software is our web server
- Since a bind must always precede a listen, we will typically omit the bind in our descriptions
- Most socket libraries will take care of this for you

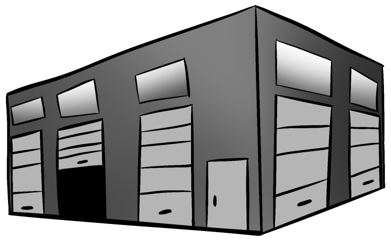


```
bind(80)
listen(80)
```

## Networking Ports

**What's a Port?**

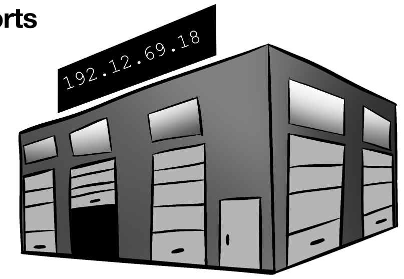
- It's basically a door
  - Italian: *Porta*
  - French: *Porte*
  - Spanish: *Puerta*
- I like to think of a port as a door to a building.



## Networking Ports

**What's a Port?**

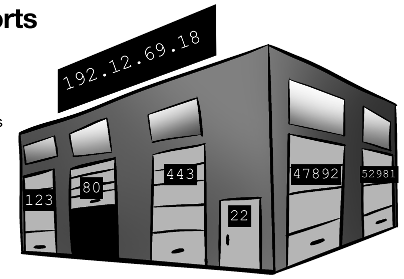
- If we have some device on the internet with an IP address assigned to it, we can think of that as a building.
- A port then can be thought of as a door to the building.
- Doors can let stuff in or out.



## Networking Ports

**What's a Port?**

- Each port has a number
  - 16 bit unsigned integers
  - 0 - 65535
- Internet Assigned Numbers Authority (IANA) has designated different port ranges for different thing, but there's nothing stopping you from using them for whatever



## Networking Ports

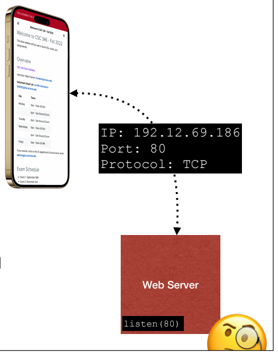
### Common Ports

| Port Number | Application |
|---|---|
| 22 | ssh - Secure Shell |
| 23 | Telnet (unsecure) |
| 25 | SMTP - Simple Mail Transport Protocol (unsecure) |
| 80 | HTTP - HyperText Transport Protocol (unsecure) |
| 123 | NTP - Network Time Protocol |
| 443 | HTTPS - HTTP Secure |
| 587 | SMTP Secure |
| 3306 | MySQL |
| 25565 | Minecraft |

## Networking

### Sockets

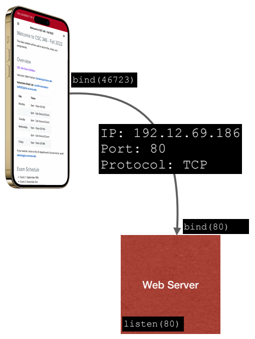
- A client then opens a socket to the server
- A socket data stream that sits on top of the network layer provided by the operating system.
- A socket is described by an ***IP address***, a ***port***, and a ***transport protocol***
- For our class, we'll use TCP for our protocol
  - Transmission Control Protocol



## Networking

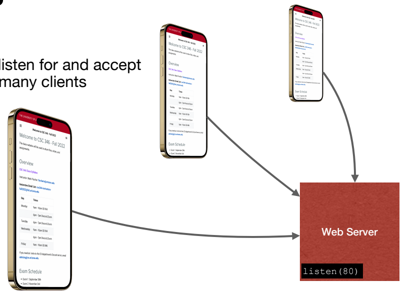
### Sockets

- Both sides must ***bind*** to a port
- The server binds to the well known port 80, since the clients need to know this
- The client typically uses a random high number available port
- As part of the socket connection, the client tells the server what port it is using



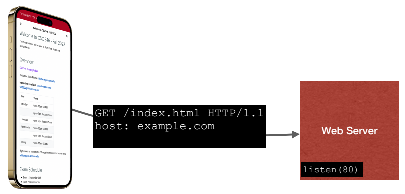
## Networking
### Sockets

- A web server can listen for and accept connections from many clients

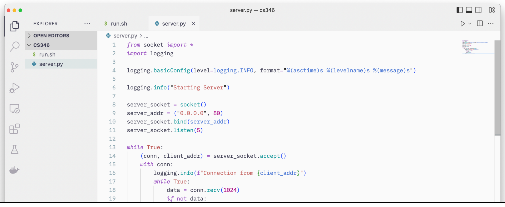


## Networking
### Sockets

- Once a socket is connected, the client and server can exchange data according to whatever protocol the server supports.
- For web servers, this is HTTP


```
GET /index.html HTTP/1.1
host: example.com
```

## Echo Server
### The world's worst web server



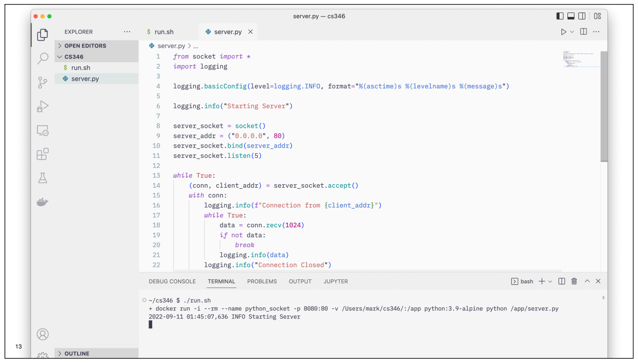
```python
from socket import *
import logging

logging.basicConfig(level=logging.INFO, format="%(asctime)s %(levelname)s %(message)s")

logging.info("Starting Server")

server_socket = socket()
server_addr = ("0.0.0.0", 80)
server_socket.bind(server_addr)
server_socket.listen(5)

while True:
    (conn, client_addr) = server_socket.accept()
    with conn:
        logging.info(f"Connection from {client_addr}")
        while True:
            data = conn.recv(1024)
            if not data:
```



server.py — cs346

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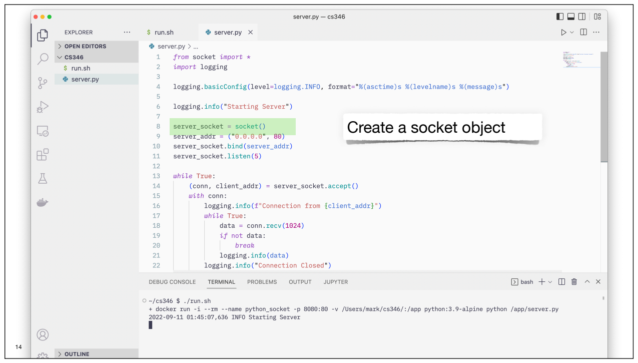
```

```
~/cs346 $ ./run.sh
+ docker run -i --rm --name python_socket -p 8080:80 -v /Users/mark/cs346/:/app python:3.9-alpine python /app/server.py
2022-09-11 01:45:07,636 INFO Starting Server
```

13



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```

Create a socket object

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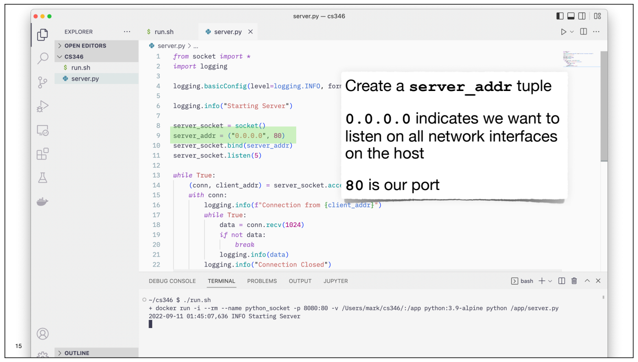
14



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```

Create a `server_addr` tuple

`0.0.0.0` indicates we want to listen on all network interfaces on the host

`80` is our port

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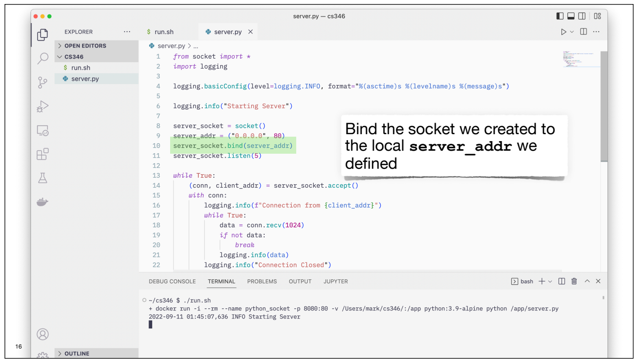
15



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```

Bind the socket we created to the local **`server_addr`** we defined

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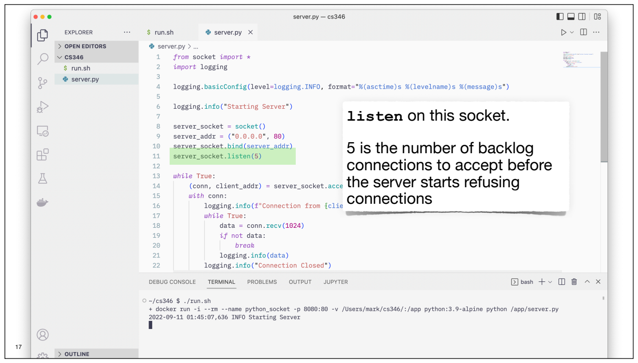
16



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```

**`listen`** on this socket.

5 is the number of backlog connections to accept before the server starts refusing connections

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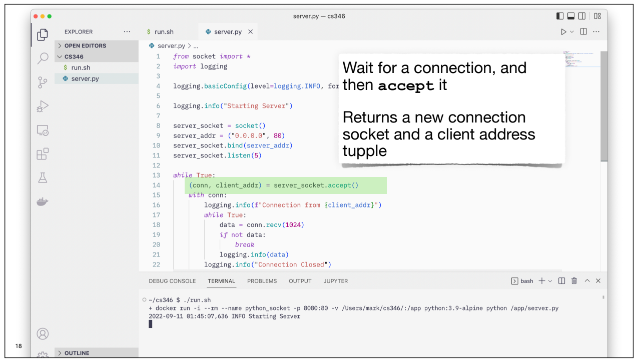
17



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```

Wait for a connection, and then **`accept`** it

Returns a new connection socket and a client address tupple

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2022-09-11 01:45:07,636 INFO Starting Server
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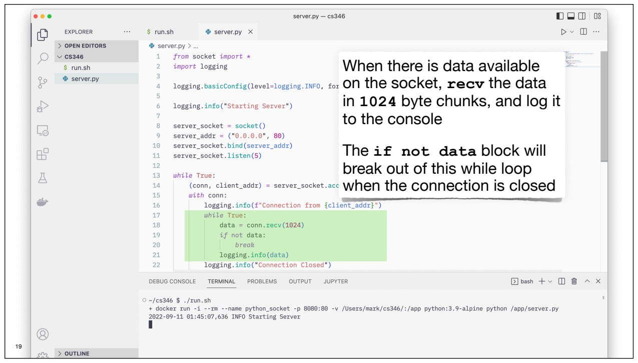
18



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        logging.info("Connection Closed")
```

When there is data available on the socket, **`recv`** the data in **`1024`** byte chunks, and log it to the console

The **`if not data`** block will break out of this while loop when the connection is closed

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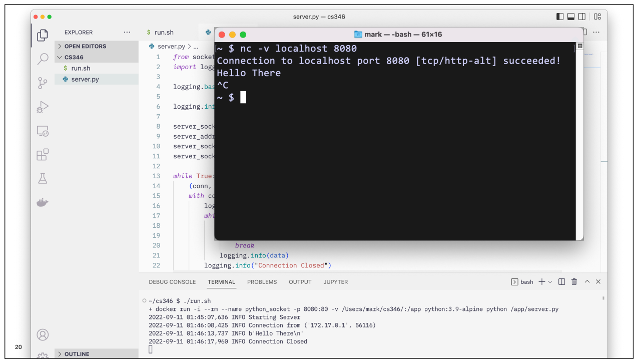
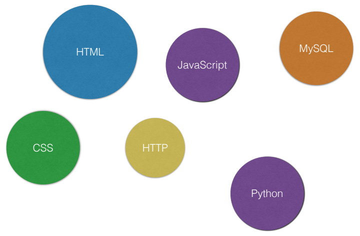


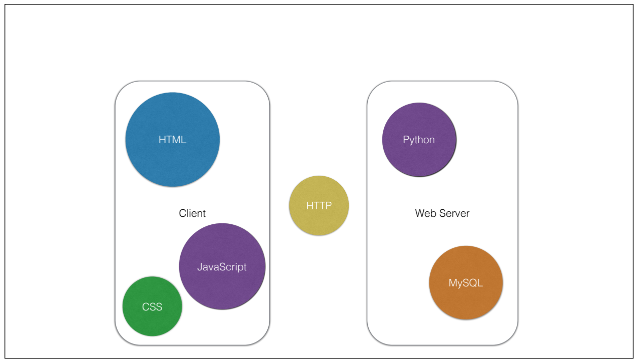
mark — -bash — 61×16

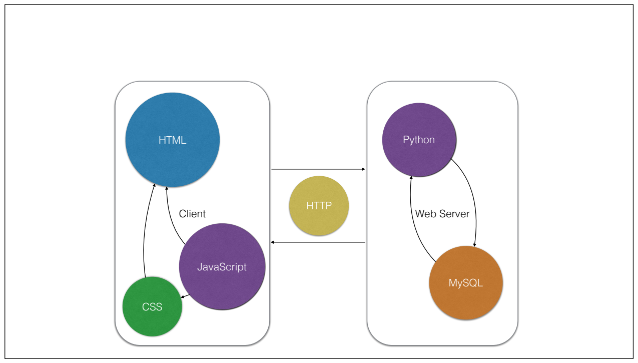
```
~ $ nc -v localhost 8080
Connection to localhost port 8080 [tcp/http-alt] succeeded!
Hello There
^C
~ $
```

```
~/cs346 $ ./run.sh
+ docker run -i --rm --name python_socket -p 8080:80 -v /Users/mark/cs346/:/app python:3.9-alpine python /app/server.py
2022-09-11 01:45:07,636 INFO Starting Server
2022-09-11 01:46:08,425 INFO Connection from ('172.17.0.1', 56116)
2022-09-11 01:46:13,737 INFO b'Hello There\n'
2022-09-11 01:46:17,960 INFO Connection Closed
```

## The Big Picture




HTML
Client
JavaScript
CSS
HTTP
Python
Web Server
MySQL


HTML
Client
JavaScript
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HTTP
Python
Web Server
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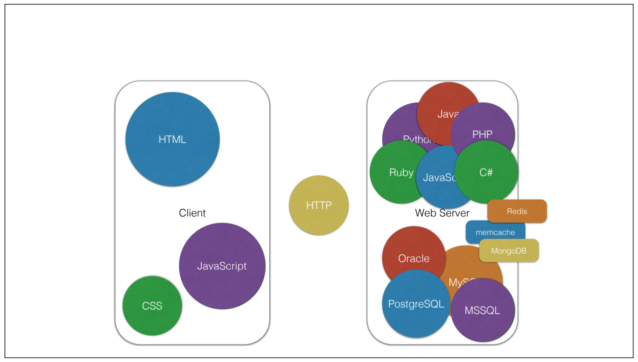
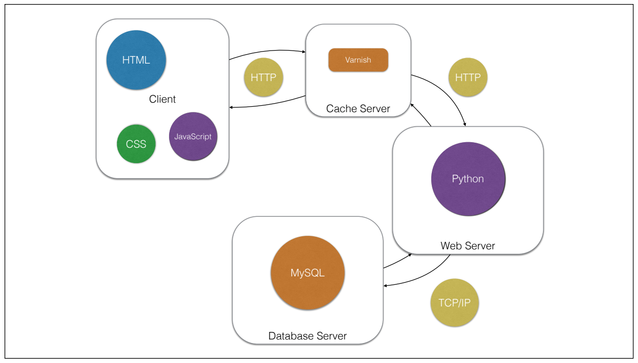
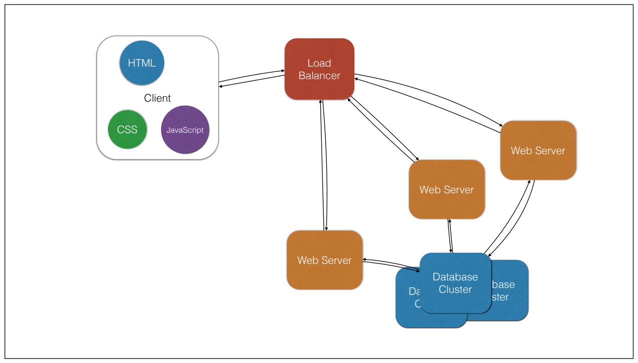
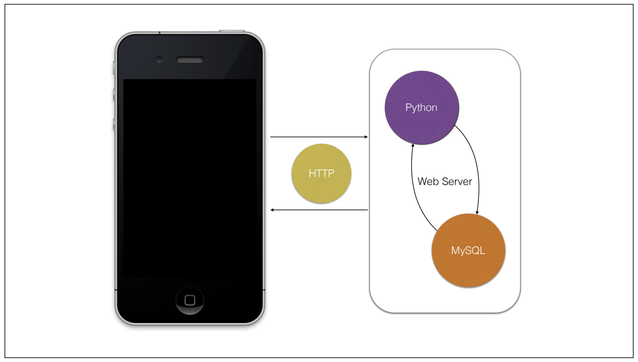
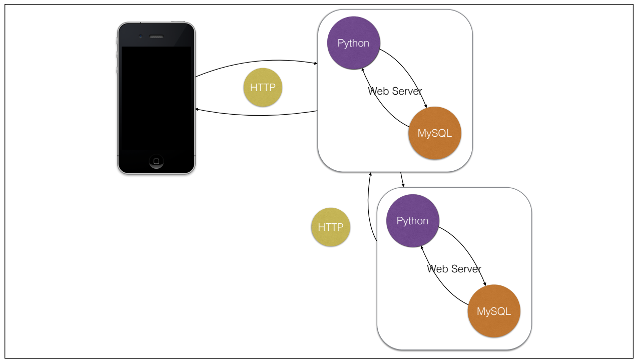
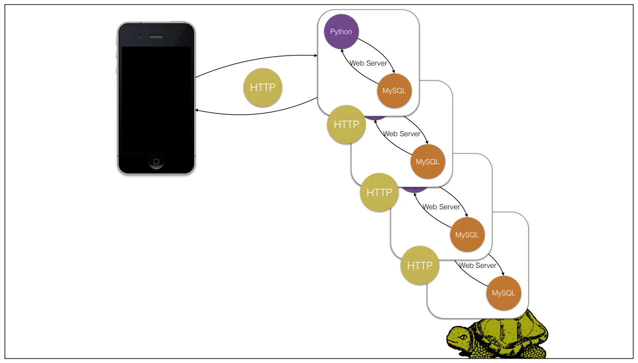

HTML
Client
JavaScript
CSS
HTTP
Java
Pytho
PHP
Ruby
JavaSc
C#
Web Server
Redis
memcache
MongoDB
Oracle
My
PostgreSQL
MSSQL

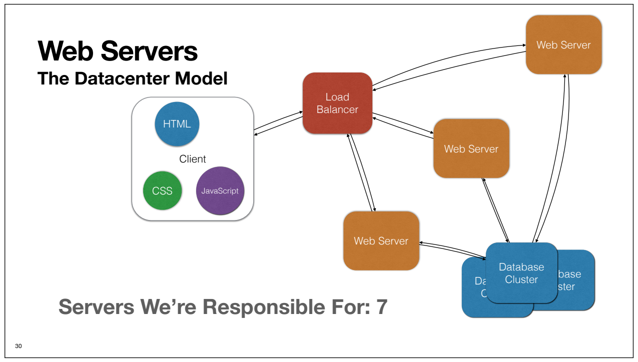

HTML
Client
CSS
JavaScript
HTTP
Varnish
Cache Server
HTTP
Python
Web Server
MySQL
Database Server
TCP/IP


HTML
Client
CSS
JavaScript
Load Balancer
Web Server
Web Server
Web Server
Database Cluster


HTTP
Python
Web Server
MySQL





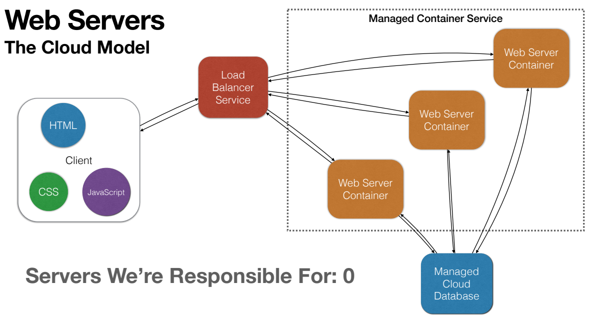


## Web Servers
### The Datacenter Model

Servers We're Responsible For: 7

## Web Servers

### The Cloud Model



**Servers We're Responsible For: 0**

## Web Servers

### Many Different Types

- Apache 2 - httpd
- nginx (pronounced "Engine X")
- IIS
- Tomcat
- Jetty
- Gunicorn

## Web Servers

### Many Different Types

- Apache 2 - httpd
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General Purpose HTTP Servers

## Web Servers
**Many Different Types**

- Apache 2 - httpd
- nginx (pronounced “Engine X”)
- IIS
- Tomcat
- Jetty
- Gunicorn

Language Specific HTTP Servers

## Web Servers
**Revisiting Containers**

- We’ve already used containers to run a web server in Homework 2

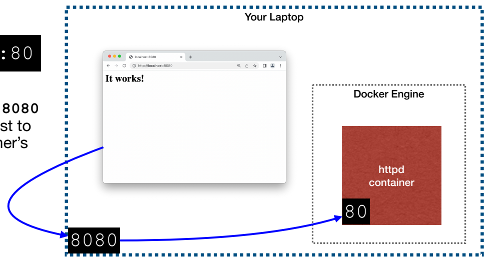
```
docker run -it --rm -p 8080:80 hw02:latest
```

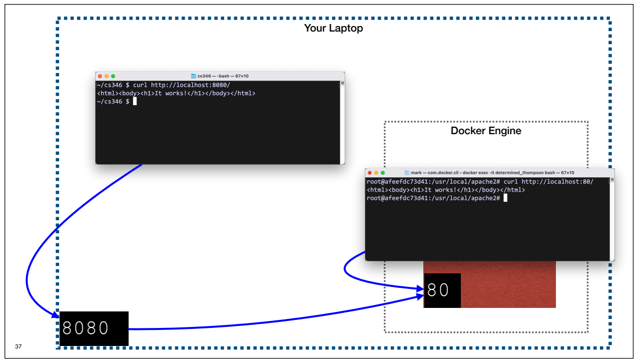
- Let’s look closer at what those port mappings mean

## Web Servers
**Revisiting Containers**

```
-p 8080:80
```

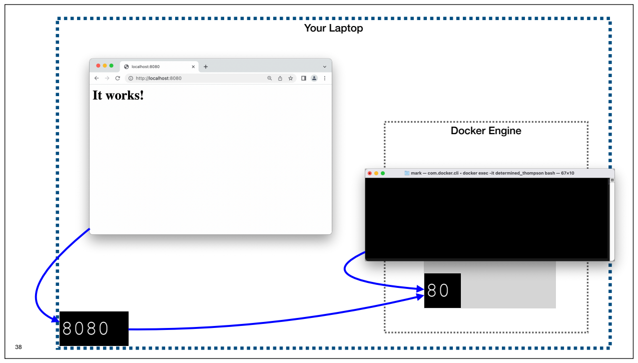
- Maps port **8080** on your host to the container’s port **80**.



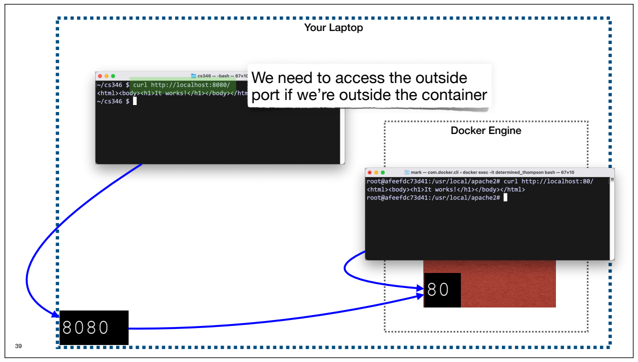

Your Laptop
Docker Engine
cs346 — -bash — 67×10
mark — com.docker.cli ‹ docker exec -it determined_thompson bash — 67×10
80
8080

```
~/cs346 $ curl http://localhost:8080/
<html><body><h1>It works!</h1></body></html>
~/cs346 $
```

```
root@afeefdc73d41:/usr/local/apache2# curl http://localhost:80/
<html><body><h1>It works!</h1></body></html>
root@afeefdc73d41:/usr/local/apache2#
```


Your Laptop
localhost:8080
http://localhost:8080
Docker Engine
mark — com.docker.cli ‹ docker exec -it determined_thompson bash — 67×10
80
8080

It works!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80
8080

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~/cs346 $ curl http://localhost:8080/
<html><body><h1>It works!</h1></body></htm
~/cs346 $
```
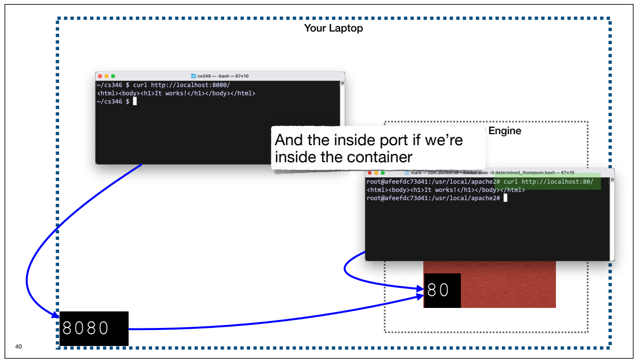

We need to access the outside port if we're outside the container

```
root@afeefdc73d41:/usr/local/apache2# curl http://localhost:80/
<html><body><h1>It works!</h1></body></html>
root@afeefdc73d41:/usr/local/apache2#
```



And the inside port if we're inside the container

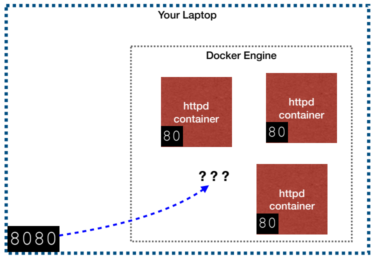
```
~/cs346 $ curl http://localhost:8080/
<html><body><h1>It works!</h1></body></html>
~/cs346 $
```

```
root@afeefdc73d41:/usr/local/apache2# curl http://localhost:80/
<html><body><h1>It works!</h1></body></html>
root@afeefdc73d41:/usr/local/apache2#
```

## Web Servers

### Revisiting Containers

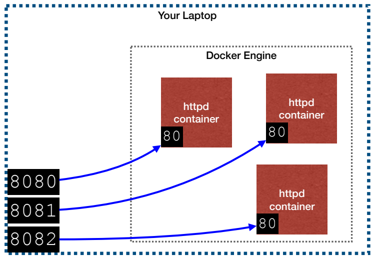
- We can run multiple containers, all with the same internal port.
- We can't map the same port on the host to multiple containers!



## Web Servers

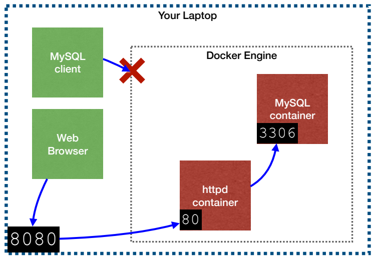
### Revisiting Containers

- We need separate ports on the host for each container we want to forward traffic to



## Web Servers
### Revisiting Containers

- Not all containers need their ports mapped to the host
- Containers can also talk to each other directly, without having to leave the internal docker network



Up Next: Javascript!