The HTTP Protocol

RES, Lecture 4

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heig-vd

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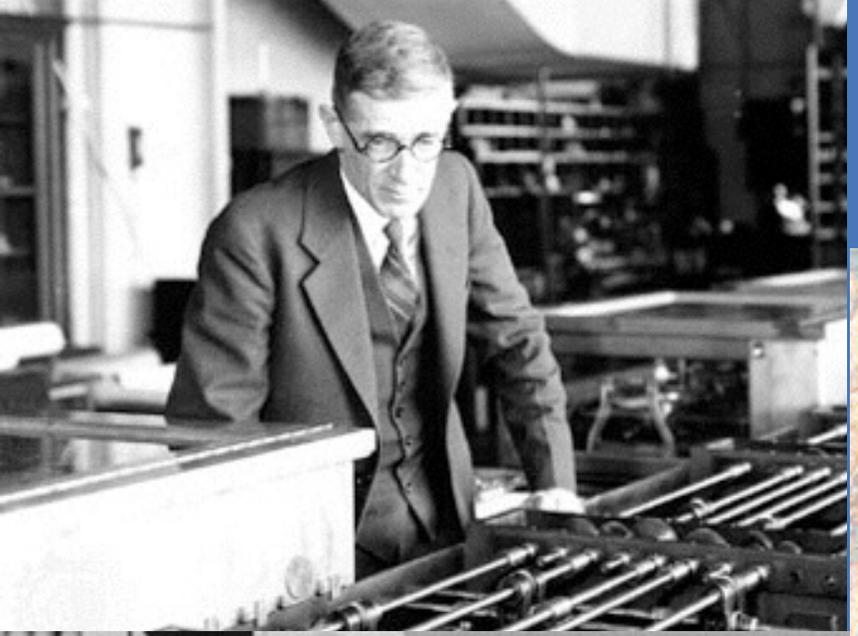
du Canton de Vaud

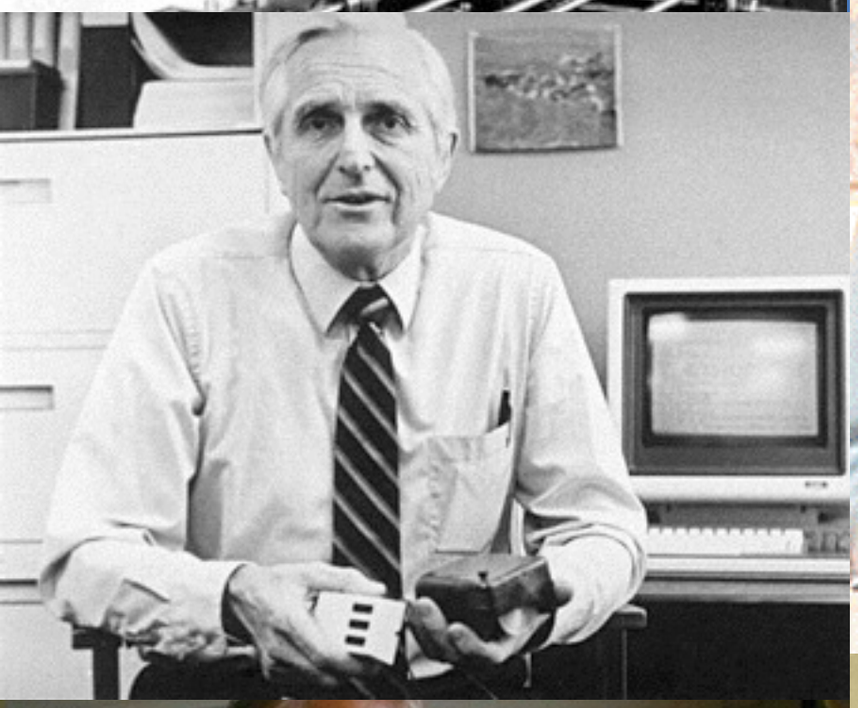
Welcome to “the Web”

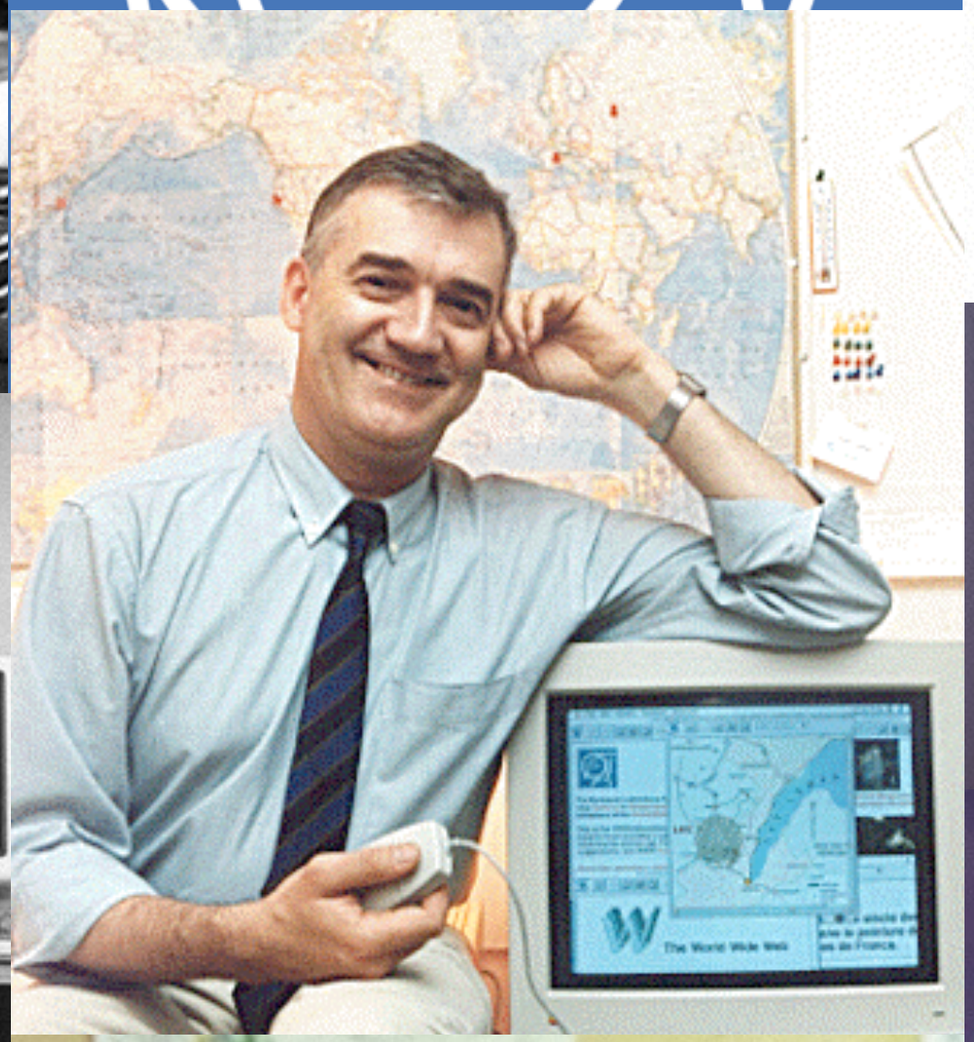
It started as an (hypertext) ***library****...*

... which is now blending with the ***physical*** *world*

... which evolved to become an online application ***platform****...*






The World Wide Web


amazon


facebook

http://en.wikipedia.org/wiki/Image:First_Web_Server.jpg

http://www.w3.org/Consortium/technology

What is HTTP?

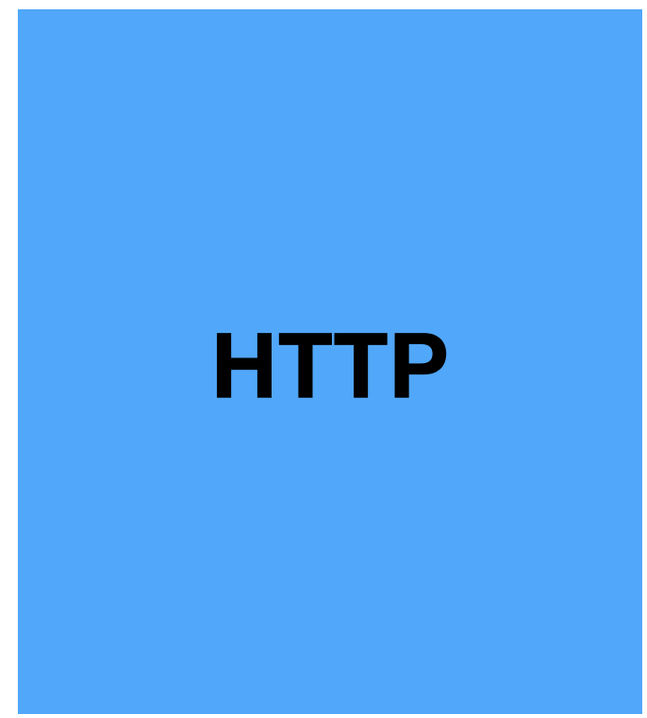
The Hypertext Transfer Protocol (HTTP) is an application-level protocol for distributed, collaborative, **hypermedia information systems**.

It is a **generic**, **stateless**, protocol which can be used for many tasks beyond its use for hypertext, such as name servers and distributed object management systems, through **extension** of its request methods, error codes and headers [47].

A feature of HTTP is the typing and **negotiation of data representation**, allowing systems to be built independently of the data being transferred.

HTTP is one of the first two standards of “the Web”

Markup Language to **create** hypertext documents



Protocol to **transfer** hypertext documents (and other content)

What is HTTP?

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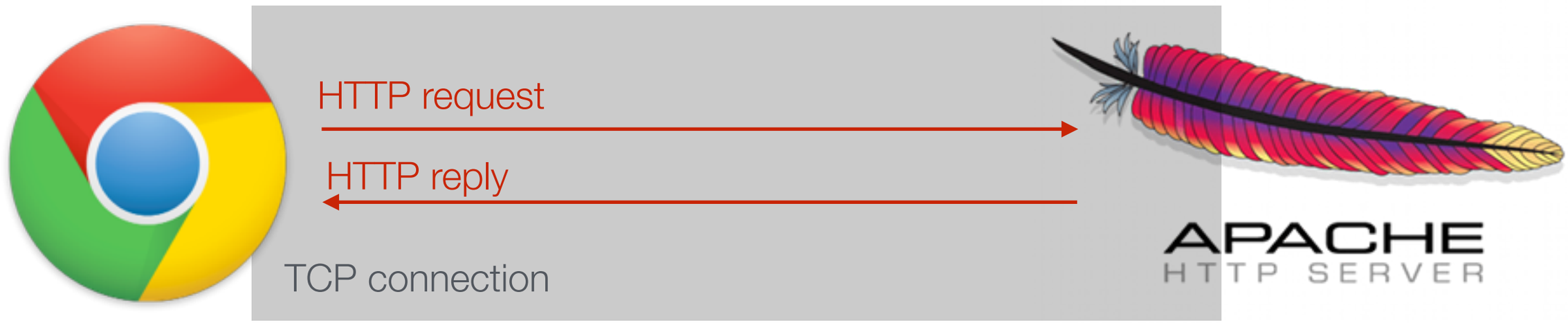
- **H**yper**T**ext **T**ransfer **P**rotocol.
- HTTP is an **application-level** protocol.
- HTTP is used to **transfer different types of payloads** (HTML, XML, JSON, PNG, MP4, WAV, etc.) between **clients** and **servers**
  - Sometimes, the client issues a request to GET (i.e. obtain, fetch, download) a payload from a server.
  - Sometimes, the client issues a request to POST (i.e. send, upload) a payload to a server.
- HTTP is built on top of **TCP** (the standard specifies that a server should accept requests on port 80).



The browser is an HTTP client

The HTTP server accepts TCP connection requests (by default on port 80)

Looking at a Conversation...

chrome

WIRESHARK

Firebug

```
GET / HTTP/1.1 CRLF
Host: www.nodejs.org CRLF
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.8; rv:28.0) Gecko/20100101 Firefox/28.0 CRLF
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8 CRLF
Accept-Language: en-us,en;q=0.8,fr;q=0.5,fr-fr;q=0.3 CRLF
Accept-Encoding: gzip, deflate CRLF
Cookie: __utma=212211339.431073283.1392993818.1395308748.1395311696.27;
__utmz=212211339.1395311696.27.19.utmcsr=stackoverflow.com|utmccn=(referral)|utmcmd=referral
|utmcct=/questions/7776452/retrieving-a-list-of-network-interfaces-in-node-js- CRLF
Connection: keep-alive CRLF
CRLF
```

```
HTTP/1.1 200 OK CRLF
Server: nginx CRLF
Date: Sat, 05 Apr 2014 11:45:48 GMT CRLF
Content-Type: text/html CRLF
Content-Length: 6368 CRLF
Last-Modified: Tue, 18 Mar 2014 02:18:40 GMT CRLF
Connection: keep-alive CRLF
Accept-Ranges: bytes CRLF
CRLF
<!doctype html>
<html lang="en">
  <head>
    <meta charset="utf-8">
    <link type="image/x-icon" rel="icon" href="favicon.ico">
    <link type="image/x-icon" rel="shortcut icon" href="favicon.ico">
    <link rel="stylesheet" href="pipe.css">
...
```

Request

```
GET / HTTP/1.1 CRLF
Host: www.nodejs.org CRLF
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.8; rv:28.0) Gecko/20100101 Firefox/28.0 CRLF
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8 CRLF
Accept-Language: en-us,en;q=0.8,fr;q=0.5,fr-fr;q=0.3 CRLF
Accept-Encoding: gzip, deflate CRLF
Cookie: __utma=212211339.431073283.1392993818.1395308748.1395311696.27;
__utmz=212211339.1395311696.27.19.utmcsr=stackoverflow.com|utmccn=(referral)|utmcmd=referral
|utmcct=/questions/7776452/retrieving-a-list-of-network-interfaces-in-node-js- CRLF
Connection: keep-alive CRLF
CRLF
```

n header lines

no content (because it is a GET)

1 request line

1 empty line

Response

```
HTTP/1.1 200 OK CRLF
Server: nginx CRLF
Date: Sat, 05 Apr 2014 11:45:48 GMT CRLF
Content-Type: text/html CRLF
Content-Length: 6368 CRLF
Last-Modified: Tue, 18 Mar 2014 02:18:40 GMT CRLF
Connection: keep-alive CRLF
Accept-Ranges: bytes CRLF
CRLF
<!doctype html>
<html lang="en">
  <head>
    <meta charset="utf-8">
    <link type="image/x-icon" rel="icon" href="favicon.ico">
    <link type="image/x-icon" rel="shortcut icon" href="favicon.ico">
    <link rel="stylesheet" href="pipe.css">
...
```

n header lines

1 status line

1 empty line

body

Docker Setup

Environment (1)

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- Let's create a **Docker image** to setup an HTTP server:
  - In this setup, we will **not use apache httpd** server (nor nginx).
  - Instead, we will **use the express.js** web framework (which runs on top of Node.js).
  - When we start the server, it will **accept HTTP requests on port 3000** (default port used by the express.js framework).

http://expressjs.com/

Environment (2)

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```
#
# This image is based on another image
#
FROM dockerfile/nodejs:latest

#
# For information: who maintains this Dockerfile?
#
MAINTAINER Olivier Liechti

#
# When we create the image, we copy files from the host into
# the image file system. This is NOT a shared folder!
#
COPY file_system /opt/res/

#
# With RUN, we can execute commands when we create the image. Here,
# we install the PM2 process manager
#
RUN npm install -g pm2@0.12.9

#
# Run npm install in the app folder, to install dependencies
#
WORKDIR /opt/res/
RUN npm install

#
# With CMD, we start the PM2 process manager. The process manager is responsible
# for starting the node.js script (the express.js app)
#
CMD pm2 start -x /opt/res/bin/www --no-daemon
```

1. Create a Docker image

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Remember that we have prepared an environment in
`git@github.com:SoftEng-HEIGVD/Teaching-HEIGVD-RES-2015-Vagrant.git`

```
host $ vagrant ssh

vagrant $ cd /vagrant/docker/image_expressjs/
```

This folder contains a **Dockerfile** and a **file_system** directory that will be copied into the image file system.

```
vagrant $ docker build -t heigvd/express-demo .
vagrant $ docker images
```

Let's give a **name** to our image.

2. Run 2 Docker containers

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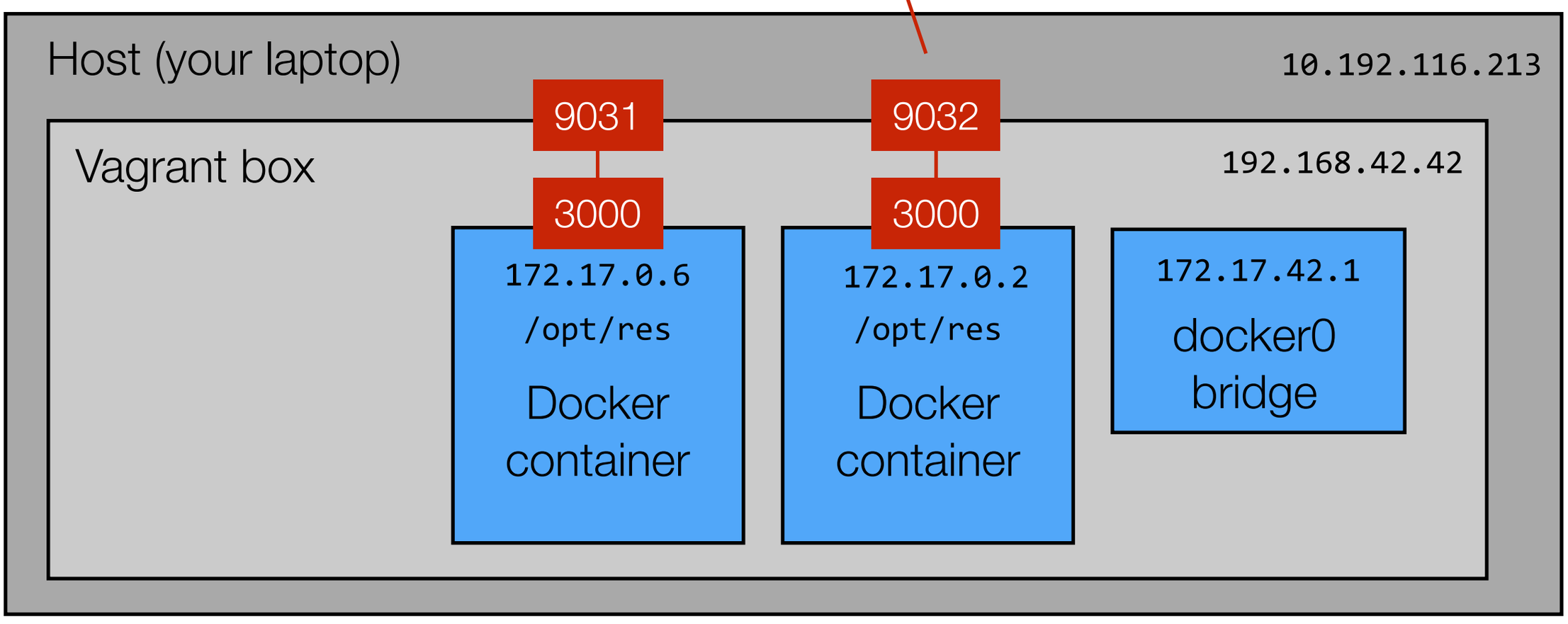
We want to run containers based on this image

```
vagrant $ docker run -d -p 9031:3000 heigvd/express-demo
vagrant $ docker run -d -p 9032:3000 heigvd/express-demo
vagrant $ docker ps -a
```

map the container TCP port to a box TCP port



3. Find the container IP address

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```
vagrant $ docker ps
```

```
CONTAINER ID        IMAGE                       COMMAND                  CREATED             STATUS              PORTS                    NAMES
37b67054c0ad        heigvd/express-demo:latest  "/bin/sh -c 'pm2 sta   11 hours ago        Up 11 hours         0.0.0.0:9030->3000/tcp   goofy_perlman
```

We did not give a name to our container when starting it (unlike last week), so Docker chose a random name for it.

docker inspect gives a lot of information about a container; we are only interested by the IP address, so we **grep** that information.

```
vagrant $ docker inspect goofy_perlman | grep -i ipaddress
        "IPAddress": "172.17.0.10",
```

4. Connect to the HTTP server

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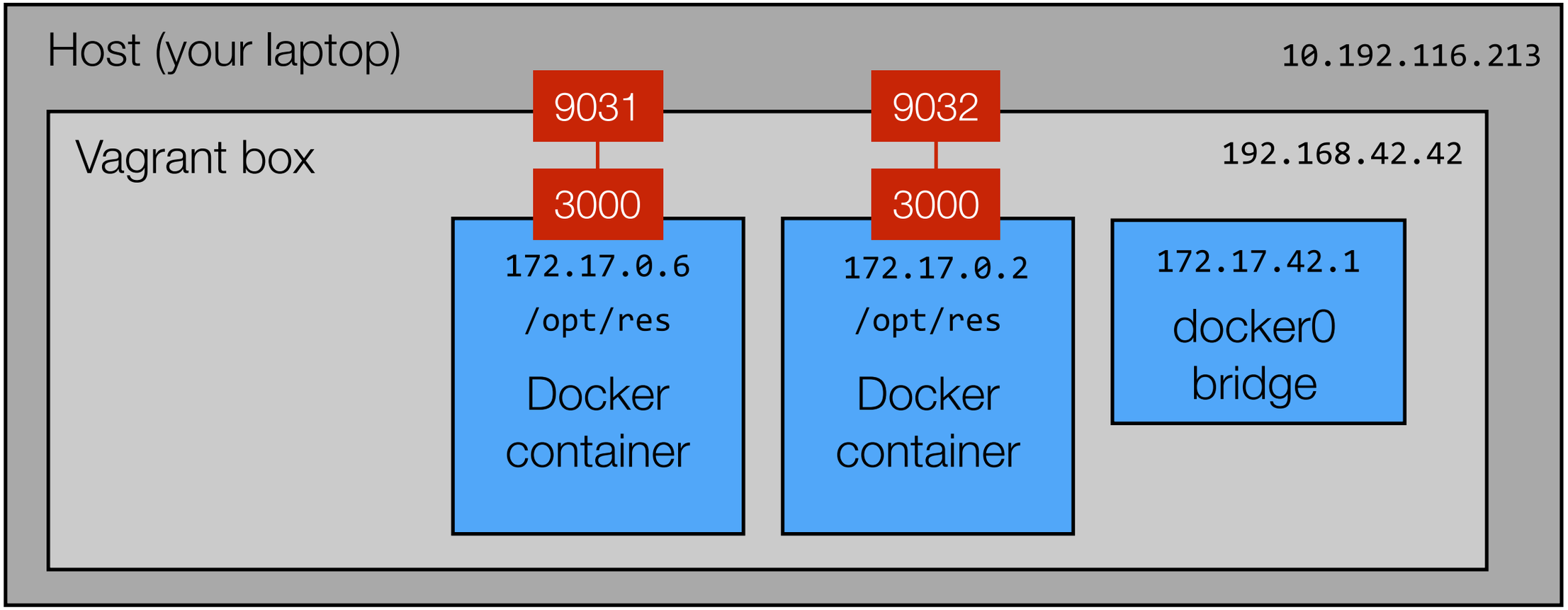
When connecting to the HTTP server, the IP address and TCP port depends on where you are (on your host, in your box, etc.)

```
   host $ telnet 192.168.42.42 9031
vagrant $ telnet localhost 9031
vagrant $ telnet 172.17.0.6 3000
```



5. Issue an HTTP request

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```
vagrant $ telnet localhost 9030
Trying ::1...
Connected to localhost.
Escape character is '^]'.
GET / HTTP/1.0

HTTP/1.1 200 OK
X-Powered-By: Express
Content-Type: text/html; charset=utf-8
Content-Length: 355
ETag: W/"163-390ef0c8"
Date: Wed, 15 Apr 2015 03:57:17 GMT
Connection: close

<!DOCTYPE html><html><head><title>RES Web Server, powered by Express</
title><link rel="stylesheet" href="/stylesheets/style.css"></
head><body><h1>RES Web Server, powered by Express</h1><p>
Welcome to <b>RES Web Server, powered by Express</b>.</p><p>This is a
simple page to demonstrate how express.js can be used to create a web
server.</p></body></html>Connection closed by foreign host.
```

Resources, Resource Representations & Content Negotiation

Resource vs Resource Representation

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- **The notion of resource is very generic and can represent anything...**
  - An online document
  - A list of online documents
  - A stock quote updated in realtime
  - A vending machine
- **What is transferred is not the resource, but a representation of the resource**
  - HTML representation, JSON representation, PNG representation
  - french representation, english representation, japanese representation
  - etc.

Content Negotiation

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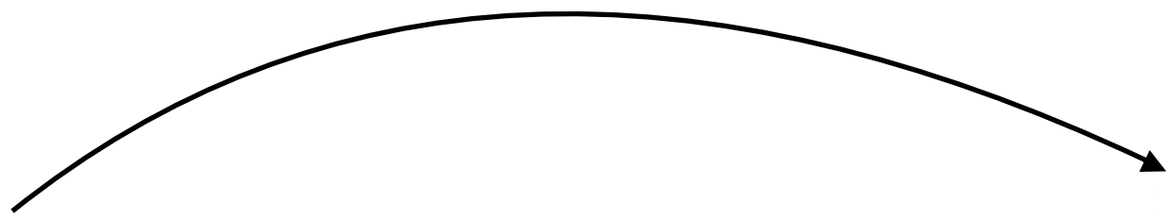
- **When making a request, the client specifies its abilities and preferences**
  - media type: image, text, structured text?
  - media format: JSON, XML, etc.?
  - language: english, french, etc.
  - character encoding: UTF-8, ASCII, etc.
- **When answering the request, the server tries to do its best and indicates what it has been able to do**
- **Special headers are used to support this process**
  - **Request:** `Accept, Accept-Charset, Accept-Language`
  - **Response:** `Content-Type, Content-Language`

"This is what I am **able to** process, and these are my **preferences**..." (e.g. I am able to deal with plain text and XML, but I prefer JSON)"



"I am **able** to generate XML (not JSON), so you should be able to process this payload"

Protocol Syntax

HTTP Methods

GET
POST
PUT
DELETE

(PATCH)

URI

http://www.heig-vd.ch

Protocol Version

HTTP/1.0

HTTP/1.1

HTTP/2.0

HTTP Requests

```
Full-Request   = Request-Line              ; Section 5.1
                 *( General-Header         ; Section 4.3
                  | Request-Header         ; Section 5.2
                  | Entity-Header )        ; Section 7.1
                 CRLF
                 [ Entity-Body ]           ; Section 7.2

Request-Line = Method SP Request-URI SP HTTP-Version CRLF

Request-Header = Authorization             ; Section 10.2
               | From                      ; Section 10.8
               | If-Modified-Since         ; Section 10.9
               | Referer                   ; Section 10.13
               | User-Agent                ; Section 10.15

Entity-Header  = Allow                     ; Section 10.1
               | Content-Encoding          ; Section 10.3
               | Content-Length            ; Section 10.4
               | Content-Type              ; Section 10.5
               | Expires                   ; Section 10.7
               | Last-Modified             ; Section 10.10
               | extension-header
```

HTTP Responses

```
Full-Response   = Status-Line               ; Section 6.1
                  *( General-Header         ; Section 4.3
                   | Response-Header        ; Section 6.2
                   | Entity-Header )        ; Section 7.1
                   CRLF
                   [ Entity-Body ]          ; Section 7.2

Status-Line = HTTP-Version SP Status-Code SP Reason-Phrase CRLF

Response-Header = Location                  ; Section 10.11
                | Server                    ; Section 10.14
                | WWW-Authenticate          ; Section 10.16


Entity-Header  = Allow                      ; Section 10.1
               | Content-Encoding           ; Section 10.3
               | Content-Length             ; Section 10.4
               | Content-Type               ; Section 10.5
               | Expires                    ; Section 10.7
               | Last-Modified              ; Section 10.10
               | extension-header
```

Status Codes

The first digit of the Status-Code defines the class of response. The last two digits do not have any categorization role. There are 5 values for the first digit:

- o 1xx: Informational - Not used, but reserved for future use

- o 2xx: Success - The action was successfully received, understood, and accepted.

- o 3xx: Redirection - Further action must be taken in order to complete the request

- o 4xx: Client Error - The request contains bad syntax or cannot be fulfilled

- o 5xx: Server Error - The server failed to fulfill an apparently valid request

Status Codes

```
Status-Code     = "200"   ; OK
                | "201"   ; Created
                | "202"   ; Accepted
                | "204"   ; No Content
                | "301"   ; Moved Permanently
                | "302"   ; Moved Temporarily
                | "304"   ; Not Modified
                | "400"   ; Bad Request
                | "401"   ; Unauthorized
                | "403"   ; Forbidden
                | "404"   ; Not Found
                | "500"   ; Internal Server Error
                | "501"   ; Not Implemented
                | "502"   ; Bad Gateway
                | "503"   ; Service Unavailable
                | extension-code

extension-code = 3DIGIT
Reason-Phrase  = *<TEXT, excluding CR, LF>
```

Parsing HTTP Messages

Process for Parsing HTTP Messages

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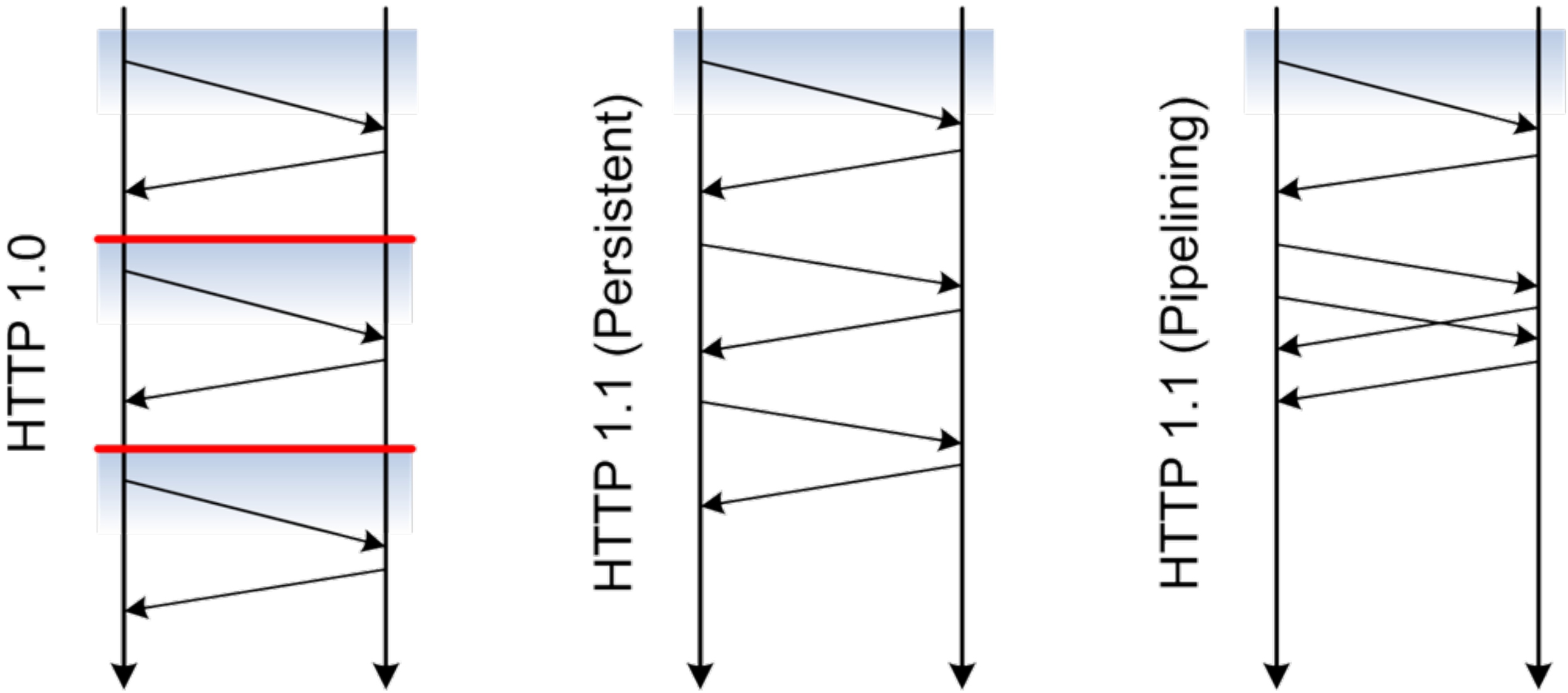
- **Do NOT read characters, read <u>bytes</u>**
  - At the beginning, you want to parse line by line
  - When consuming the body, you may be dealing with binary content
- **HTTP 1.0**
  - On the client side, read until the connection is closed (end of stream reached).
  - On the server side, use the **`Content-Length`** header (for `POST` requests)
- **HTTP 1.1**
  - Static content: use the **`Content-Length`** header
  - Dynamic content: use the **`chunked`** transfer encoding

Recommendations

- **Implement your own LineByLineInputStream**
  - Remember the lecture about IOs & decorators?
  - You would like to have a `readLine()` method... but this one is available only in `Reader` classes
  - Implement your subclass of FilterInputStream and detect `\r\n` sequences
- **Add functionality incrementally, starting with a client**
  - Start with HTTP 1.0 (read until close of connection)
  - Deal with `Content-Length` header
  - Deal with `chunked` transfer encoding

HTTP & TCP Connections



http://dret.net/lectures/web-fall07/foundations#(20)
http://www.apacheweek.com/features/http11

HTTP is a Stateless
Request-Reply Transfer Protocol

Stateless Protocol... but Stateful Applications!

Managing State on Top of HTTP

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- **Approach 1: moving the state back-and-forth**
  - One way to do it is to used **hidden fields** in HTML forms
- **Approach 2: maintaing state on the backend, transfer session IDs**
  - One way to do it is to use parameters in the **query string** (security...)
  - One way is to use **cookies**

Passing State Back and Forth

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C: Hello, I am new here. My name is Bob.

S: Welcome, let's have a chat [You told me that "My name is Bob"].

C: [My name is Bob]. What's the time?

S: Hi again Bob. It's 10:45 AM. [You told me that "My name is Bob". You asked me what is the time]

Passing Session ID Back and Forth

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```
C: Hello, I am new here. My name is Bob.
S: Welcome Bob, let's have a chat. Your session id is 42.
C: My session id is 42. What's the time?
S: -- checking my notes… hum… ok, I found what I remember about
session 42…
S: Hi again Bob. It's 10:45 AM.
C: My session id is 42. How do you do?
S: -- checking my notes… hum… ok, I found what I remember about
session 42…
S: I am fine, Bob, thank you.
C: My session id is 42. How do you do?
S: -- checking my notes… hum… ok, I found what I remember about
session 42…
S: I told you I am fine… are you stupid or what?
C: My session id is 42. If you take it like that, I am gone.
Forever.
S: -- checking my notes… hum… ok, I found what I remember about
session 42…
S: -- putting 42 file into trash…
S: Bye Bob.
```