HTTP: the language of web communication

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TU Delft

Web technology overview

1. **HTTP: the language of web communication**
2. **HTML** & web app design
3. **JavaScript**: interactions in the browser
4. **Node.js**: JavaScript on the server
5. **CSS**: adding style
6. Node.js: advanced topics
7. Cookies & sessions
8. Web security

Source: https://vimeo.com/110256895

1:50 min

Learning goals

- **Describe** how web servers and clients interact with each other.
- **Request** resources from web servers and understand the responses.
- **Describe** the different URL components.
- **Understand** and **employ** basic HTTP authentication.
- **Explain** the difference between HTTP and HTTPS.

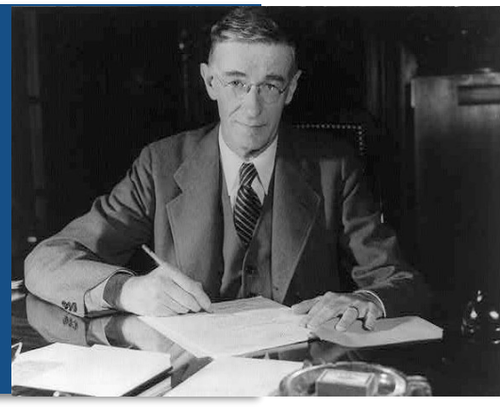
World Wide Web

vs.

Internet

The Web: a brief history

World Wide Web: a global system of interconnected hypertext documents available via the Internet (envisioned already in 1945)



- **1960s**: Precursor to the Internet (ARPANET) devised by the US department of Defense
  - Initial services: electronic mail, file transfer
- Late **1980s**: Internet opened to commercial interests
- **1989**: WWW created by Tim Berners-Lee (CERN)

Image sources: Wikipedia & Techspot

Skip to main content
[Fuji_EN_SWM_CustomerService._CB485884598_.png]
All
Select the department you want to search in [All Departments_____]
Go Go
Search _____
Deliver toNetherlands
EN Hello, Sign in Account & Lists Sign in Account & Lists Orders Cart 0
Departments
Today's Deals Your Amazon.com Gift Cards Help Registry Sell Disability Customer Supp
Welcome to Amazon.com. If you prefer a simplified shopping experience, try the mobil
www.amazon.com/access. The mobile web version is similar to the mobile app. Stay on
all the features of the main Amazon website.
Previous page

1. We ship over 45 million products around the world
2.
3.
4.

Next page

Shop by Category

Computers & Accessories
Computers & Accessories
Video Games

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- **1994**: Netscape released its first Web browser

Image sources: Wikipedia & Techspot

Mosaic Netscape version 0.9 beta

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The Web: a brief history

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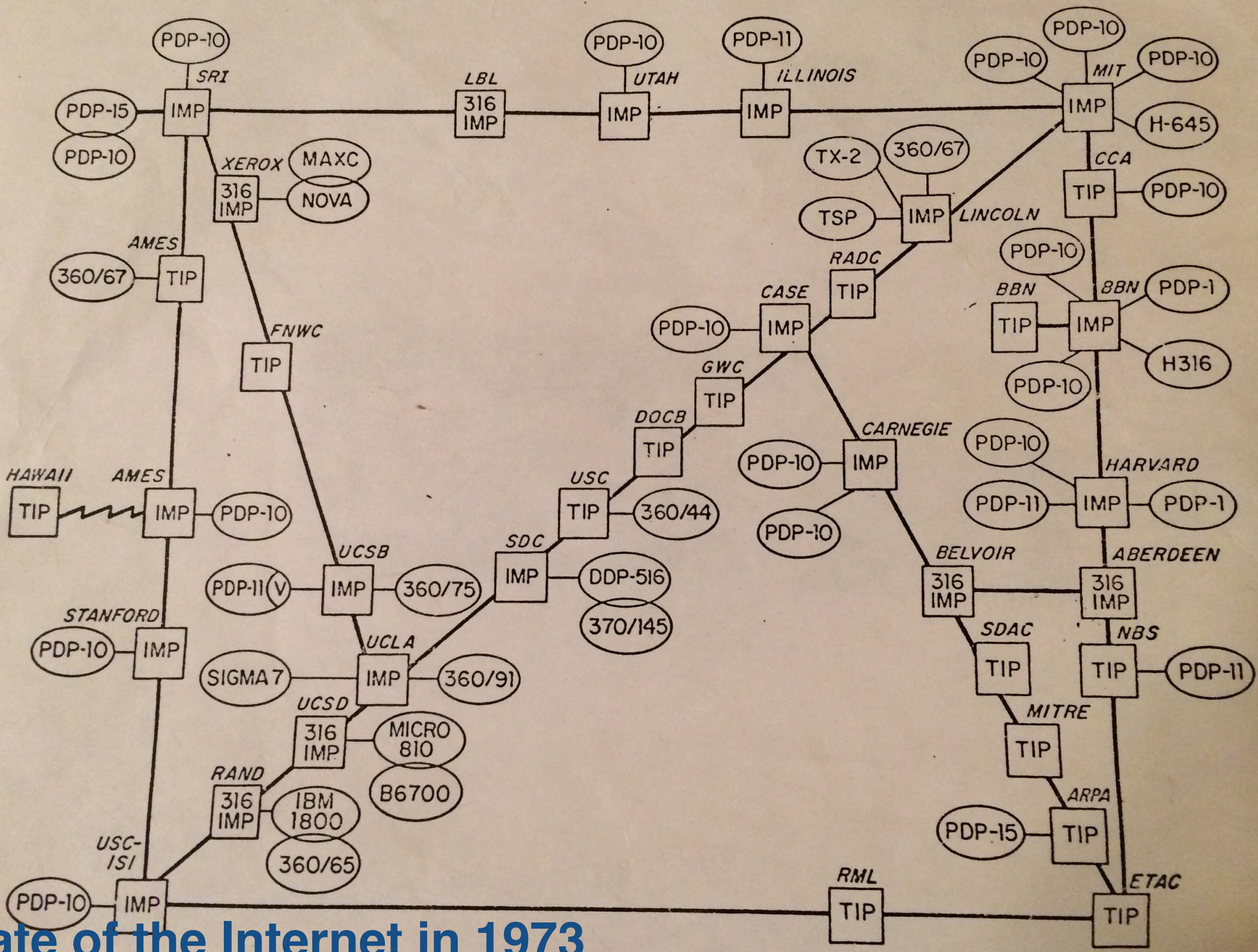
- **1994**: Netscape released its first Web browser
- **1995**: Microsoft released Internet Explorer v1
- **1998**: Google was founded
- **2002**: Mozilla released Firefox v1

Image sources: Wikipedia & Techspot

Key aspects of the Internet

Internet: interconnected computer networks that span the globe and communicate through a common standard (TCP/IP).

- Sub-networks function **autonomously**
- **No centralised** control
- Devices **dynamically** join/leave the network
- Devices interact through **open standards**
- **Easy** to use: server/client software widely available



State of the Internet in 1973

Image source: https://twitter.com/workergnome/status/807704855276122114

Two important organisations

Internet Engineering Task Force (IETF)

"The mission of the IETF is to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use, and manage the Internet."

Request for Comments (RFC)

World Wide Web Consortium (W3C)

"The W3C mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web."

HTTP messages

We cover HTTP/1.1
in this lecture!

HTTP/1.1

RFC 2068

1997

HTTP 0.9

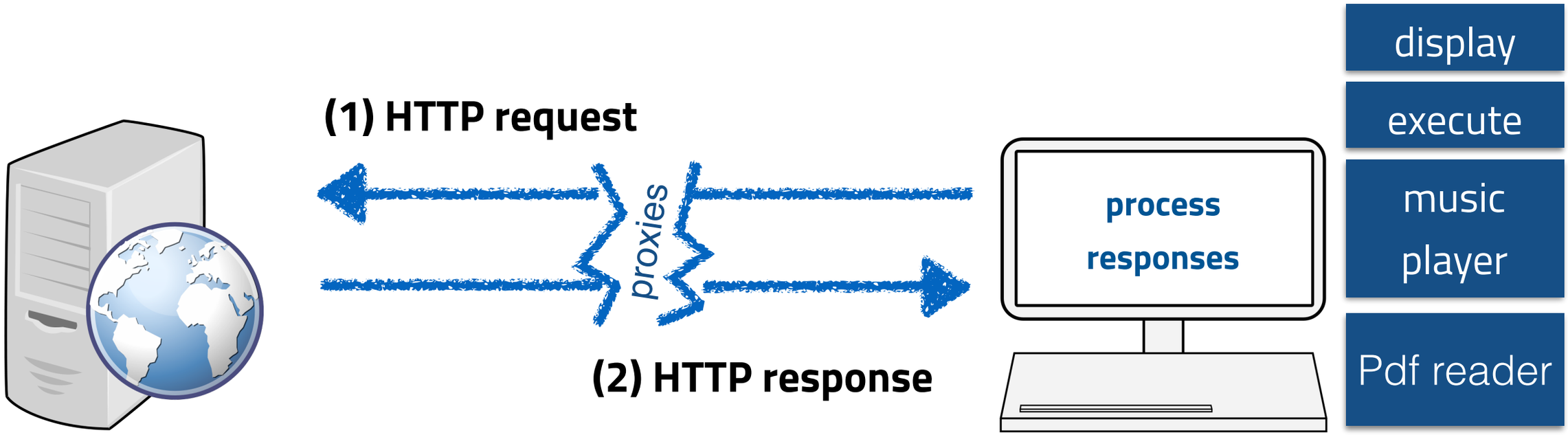
HTTP/2

RFC 7540

2015

HTTP/3

Web servers and clients



- Servers wait for data requests
- Answer thousands of clients simultaneously
- Host **web resources** (content with an identity)

- Proxies have several functions: filtering, caching, authentication, etc.

- Clients are often browsers
- Telnet

Network communication

textbook model

- Conceptual model **Open Systems Interconnection** (OSI) from 1995
- Network protocols matched to layers
- Many network protocols exist, we care about three in particular:

IP	Internet Protocol
TCP	Transmission Control Protocol
HTTP	Hypertext Transfer Protocol

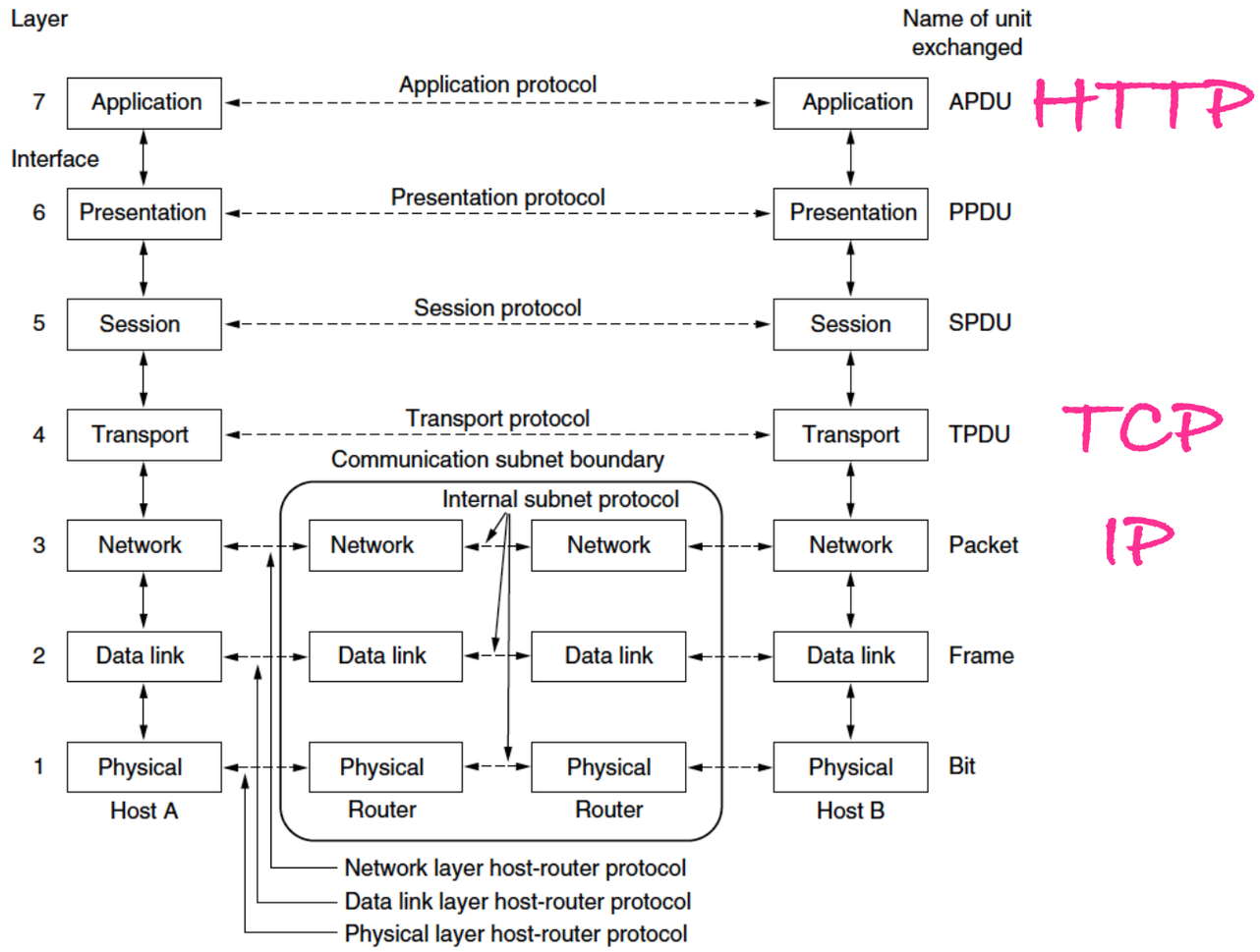


Image src: Computer Networks (5th edition), Tanenbaum & Whetherall, p. 42

HTTP uses **reliable** data-transmission protocols (inherited from TCP).

https://www.tudelft.nl

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Onderwijs Onderzoek Kennisvalorisatie Actueel Over TU Delft

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Inspector Console Debugger Style Editor Performance Memory Network Storage

Filter URLs

All HTML CSS JS XHR Fonts Images Media WS

Status	Method	File	Domain	Cause	Type	Transferred	Size
200	GET	/	www.tudelft.nl	document	html	10.69 KB	53.84 KB
304	GET	dist.style.8be0425eaa.min.css	www.tudelft.nl	stylesheet	css	cached	177.21 KB
200	GET	modernizr.min.js	www.tudelft.nl	script	js	3.34 KB	6.68 KB
200	GET	dist.javascripts.831a266649.min.js	www.tudelft.nl	script	js	85.71 KB	279.57 KB
200	GET	logo.svg	www.tudelft.nl	img	svg	2.43 KB	5.07 KB
200	GET	torch.svg	www.tudelft.nl	img	svg	1.50 KB	2.12 KB
200	GET	siteanalyze_6005654.js	siteimproveanalytics.com	script	js	8.83 KB	26.24 KB
304	GET	csm_bachelorvoorlichting_4_fd66b0ebb8.jpg	d1rkab7tlqy5f1.cloudfront.net	img	jpeg	cached	116.95 KB
304	GET	GettyImages-691090647 hashtag twitteronderzoek_400x200_c_def.jpg	d1rkab7tlqy5f1.cloudfront.net	img	jpeg	cached	90.74 KB
304	GET	csm_News_180503_BoostPhysics_MJVanRiel_2_5517102b38.jpg	d1rkab7tlqy5f1.cloudfront.net	img	jpeg	cached	108.12 KB
200	GET	csm_GS_HARKOS 010_0355811622.jpg	d1rkab7tlqy5f1.cloudfront.net	img	jpeg	29.86 KB	29.43 KB
200	GET	csm_Backlit_keyboard_6959477114.jpg	d1rkab7tlqy5f1.cloudfront.net	img	jpeg	44.25 KB	43.82 KB
304	GET	csm_20140328_tudelft_campus_lente_R9B9442_dc999599da.jpg	d1rkab7tlqy5f1.cloudfront.net	img	jpeg	cached	166.64 KB
304	GET	csm_Building wetlands with soft mud5_b2e2da8269.jpg	d1rkab7tlqy5f1.cloudfront.net	img	jpeg	cached	113.41 KB

Demo time

33 requests | 2.40 MB / 2.24 MB transferred | Finish: 2.48 s | DOMContentLoaded: 1.35 s | load: 2.49 s

HTTP request message

plain text, line-oriented character sequences

```
GET / HTTP/1.1
Host: www.tudelft.nl
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X
10.9; rv:31.0) Gecko/20100101 Firefox/31.0
Accept: text/html,application/xhtml+xml,application/
xml;q=0.9,*/*;q=0.8
Accept-Language: en-gb,en;q=0.5
Accept-Encoding: gzip, deflate
DNT: 1
Cookie:
__utma=1.209235779361l1.16111.19805.2;utmcmd=(none);
```

HTTP response message

```
HTTP/1.1 200 OK
Date: Fri, 01 Aug 2014 13:35:55 GMT
Content-Type: text/html; charset=utf-8
Content-Length: 5994
Connection: keep-alive
Set-Cookie: fe_typo_user=d5e20a55a4a92e0;
path=/; domain=tudelft.nl
[....]
Server: TU Delft Web Server

....
....
```

start line

header fields

`name:value`

body
(optional)

HTTP headers dissected

Well-known header fields

Content-Type	Entity type
Content-Length	Length/size of the message
Content-Language	Language of the entity sent (e.g. English)
Content-Encoding	Data transformations applied to the entity
Content-Location	Alternative location of the entity
Content-Range	Range defines the pieces sent for partial entities
Content-MD5	Checksum of the content
Last-Modified	Date on which this entity was created/modified
Expires	Date at which the entity will become stale
Allow	Lists the legal request methods for the entity
Connection & Upgrade	Protocol upgrade

Entity bodies contain **raw** data. **Header** needed to **interpret** the data.

Content-Type

- **MIME** types are attached to all HTTP object data

Multipurpose Internet **Mail** Extensions

historic reasons

- Type determines clients' reaction to the data
- Pattern: `[primary object type]/[subtype]`
  - `text/plain`
  - `text/html`
  - `image/jpeg`
  - `video/quicktime`

Content-Types are diverse

Most popular
text/html
application/xhtml+xml
application/pdf
application/rss+xml
image/jpeg
application/atom+xml
text/plain
application/pdf
application/xml
text/calendar

Least popular
video/quicktime
text/rdf+n3
application/postscript
application/x-bzip2
application/msword
application/coreldraw
audio/midi
application/vnd.ms-powerpoint
application/pgp-signature

Common Crawl

The list is based on a sample of a 2019 large-scale web crawl.

Content-Length

- Indicates the **size** of the entity body

- Necessary to detect premature message truncation (e.g. due to a server crash, faulty proxy)

- Essential for **persistent connections** to discover where one HTTP message ends and the next begins

Persistent connections reuse the same TCP connection for multiple HTTP request/response messages.

Content-Encoding

- Commonly either `gzip`, `compress` (Unix compression), `deflate` (zlib compression) or `identity` (no encoding)

- Servers aim for **encodings** that clients understand
  - Clients send a list of acceptable encodings in a corresponding request header: `Accept-Encoding: gzip, deflate`

- **Compression** saves network bandwidth but increases processing costs

Content-MD5 (RFC 1321)

`Message Digest`

- HTTP messages are sent via TCP (*this will change in HTTP/3*)

- **However**: the Internet is huge, many servers interact to transport a message with different implementations (**bugs!**) of established protocols

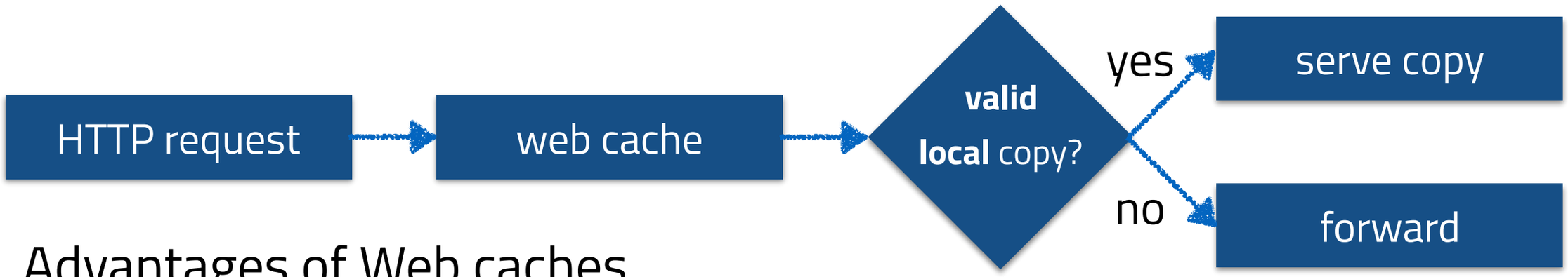
- **Sanity check**: sender generates a **MD5 checksum** of the content (hashed into a 128 bit value) to detect unintended modifications of the content

- Has been removed from the HTTP/1.1 specification (2014), but remains in use (simple technique, easy to implement)

Note: Web browsers also cache when possible.

Expires

- **Web caches** keep copies of *popular* resources



- Advantages of Web caches
  A. **Reduction** of redundant data transfer
  B. **Reduction** of network bottlenecks
  C. **Reduction** demand on origin servers
  D. **Reduced** distance delay

- `Expires` indicates when the resource is no longer valid

Expires & Cache-Control

- Content on the origin server can change
- Caches need to ensure that their copies are **in sync** with the origin server
- Caches can revalidate their copies at any time (inefficient)

- `Expires` in HTTP response header indicates a **resource's expiration date** in **absolute** terms — date determines when the cache revalidates
- `Cache-Control` indicates a resource's expiration date in **relative** terms (seconds since being sent)

Expires & Cache-Control

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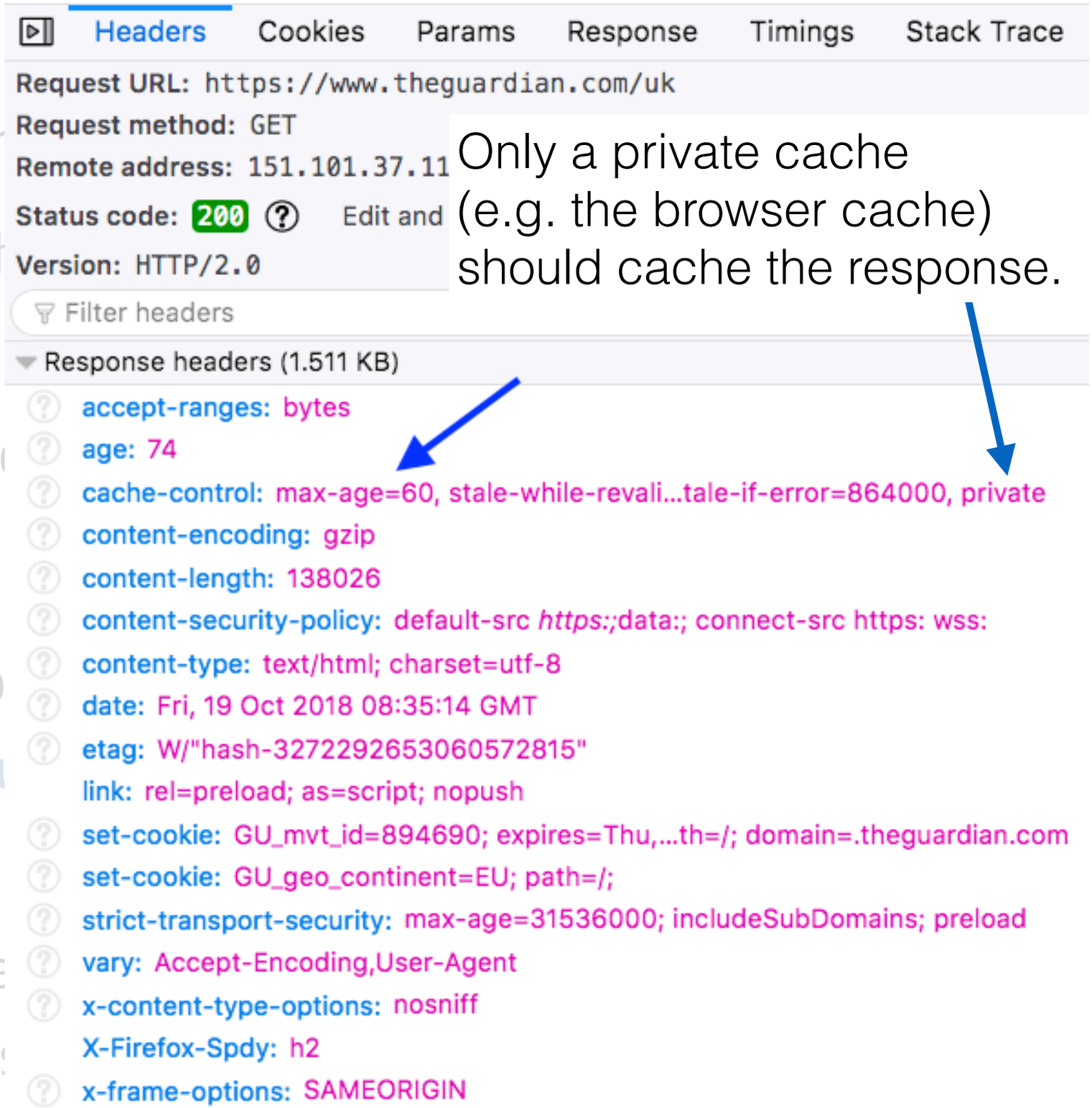


Only a private cache (e.g. the browser cache) should cache the response.

Last-Modified

- Contains the date when the resource was last **altered**

- **No indication** about the amount of changes

- Often used in combination with `If-Modified-Since` for cache revalidation requests: origin server only returns the document if it changed since the given date

- Last-Modified dates are **not reliable**

Connection & Upgrade

Polling the 2018 Midterm Elections in Real Time

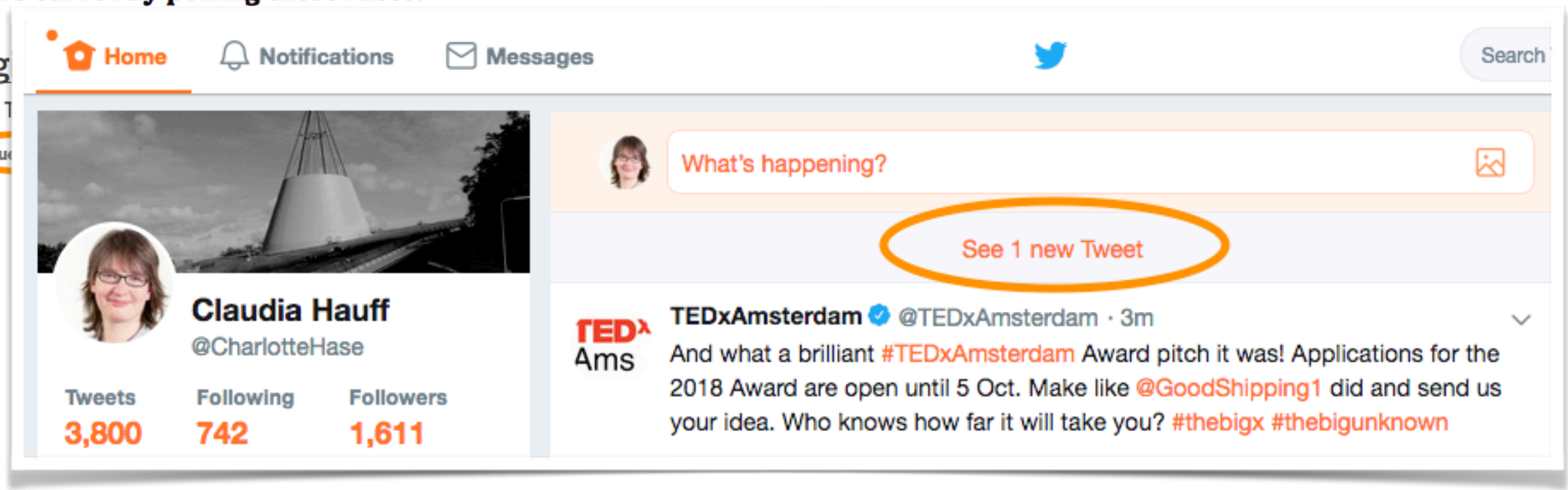
The Upshot has partnered with Siena College to poll dozens of the most competitive House and Senate races across the country. Our poll results are updated in real time, after every phone call. We hope to help you understand how polling works, and why it sometimes doesn't.
Related article »

185,872
calls made so far

Sign up for alerts

We're currently polling these races.

Virg
Can a T
Continue



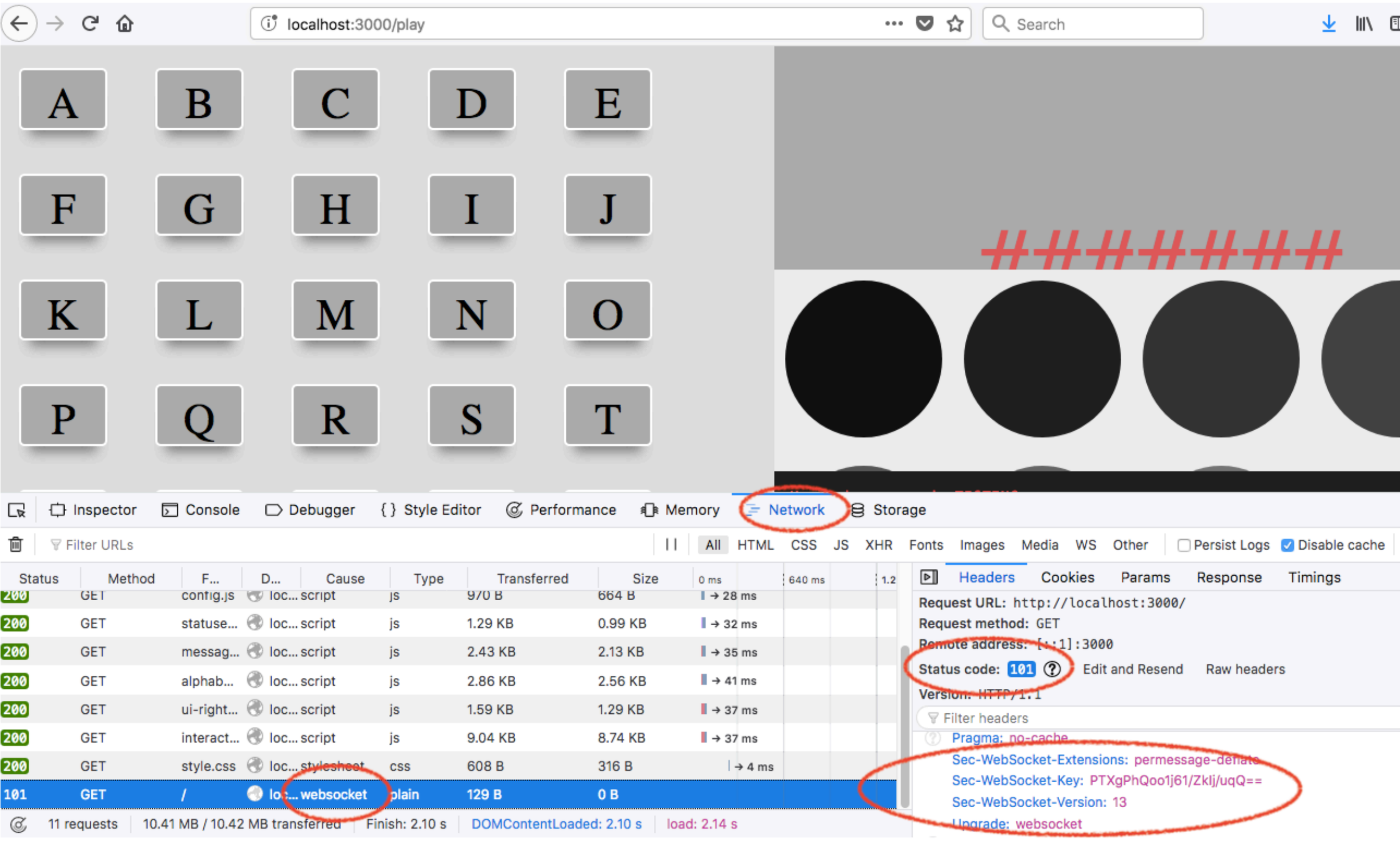
Connection & Upgrade

- HTTP/1.1: the client **always** initiates the conversation

- Simulating a **server-side push** of data:
  - **Polling**: client regularly sends HTTP requests
  - **Long polling**: client sends an HTTP request and the server holds it open until new data arrives
  - Issues: wasted bandwidth, complex backend

- From simulation to solution (standardized in 2011): the **WebSocket protocol** enables **bidirectional communication** between client & server

Connection & Upgrade



Connection & Upgrade

- Client and server have to agree to the **protocol upgrade**

- **Client initiates** the upgrade with two request headers:

```
Connection:Upgrade
Upgrade:[protocols]
```

- Server responds with a `101 Switching Protocols` status if a protocol upgrade is possible

- Once established, both the client and server can push data

Common response status codes

> **10.4.3 402 Payment Required**
>
> This code is reserved for future use.

1xx	Informational	(101 Switching …)
2xx	Success	(200 OK)
3xx	Redirected	
4xx	Client error	(404 Not Found)
5xx	Server error	

In practice only a few codes per category are supported.

HTTP methods

```
GET / HTTP/1.1
Host: www.tudelft.nl
User-Agent: Mozilla/5.0 (Macinto
10.9; rv:31.0) Gecko/20100101 Fi
Accept: text/html,application/xh
xml;q=0.9,*/*;q=0.8
Accept-Language: en-gb,en;q=0.5
Accept-Encoding: gzip, deflate
```

Common HTTP methods

GET	Get a document from the Web server.
HEAD	Get the header of a document from the Web server.
POST	Send data from the client to the server for processing.
PUT	Save the body of the request on the server.
TRACE	Trace the message through proxy servers to the server.
OPTIONS	Determine what methods can operate on a server.
DELETE	Remove a document from a Web server.

Servers may implement more or fewer methods than shown.

Use openssl to test ssl/https!

```
 2018-11-09 16:08:26 ⌚ wlan-145-94-166-99 in ~
○ → telnet microsoft.com 80
Trying 40.112.72.205...
Connected to microsoft.com.
Escape character is '^]'.
HEAD / HTTP/1.1
host:microsoft.com

HTTP/1.1 301 Moved Permanently
Date: Fri, 09 Nov 2018 15:08:45 GMT
Server: Kestrel
Location: https://www.microsoft.com/
```

Demo time: telnet (RFC 15!)

Telnet opens a **TCP connection** to a web server; chars are typed directly into the port. The server treats telnet as web client, the returned data is displayed onscreen.

From domain to IP address

```
2018-11-09 16:23:25 ⌚ wlan-145-94-166-99 in ~
○ → telnet microsoft.com 80
Trying 40.112.72.205...
Connected to microsoft.com.
Escape character is '^]'.
```

Domain Name System server

domain

IP address (v4): 32 bit

0-255 . **0-255** . **0-255** . **0-255**

4x8 bits; **4,294,967,296 addresses**

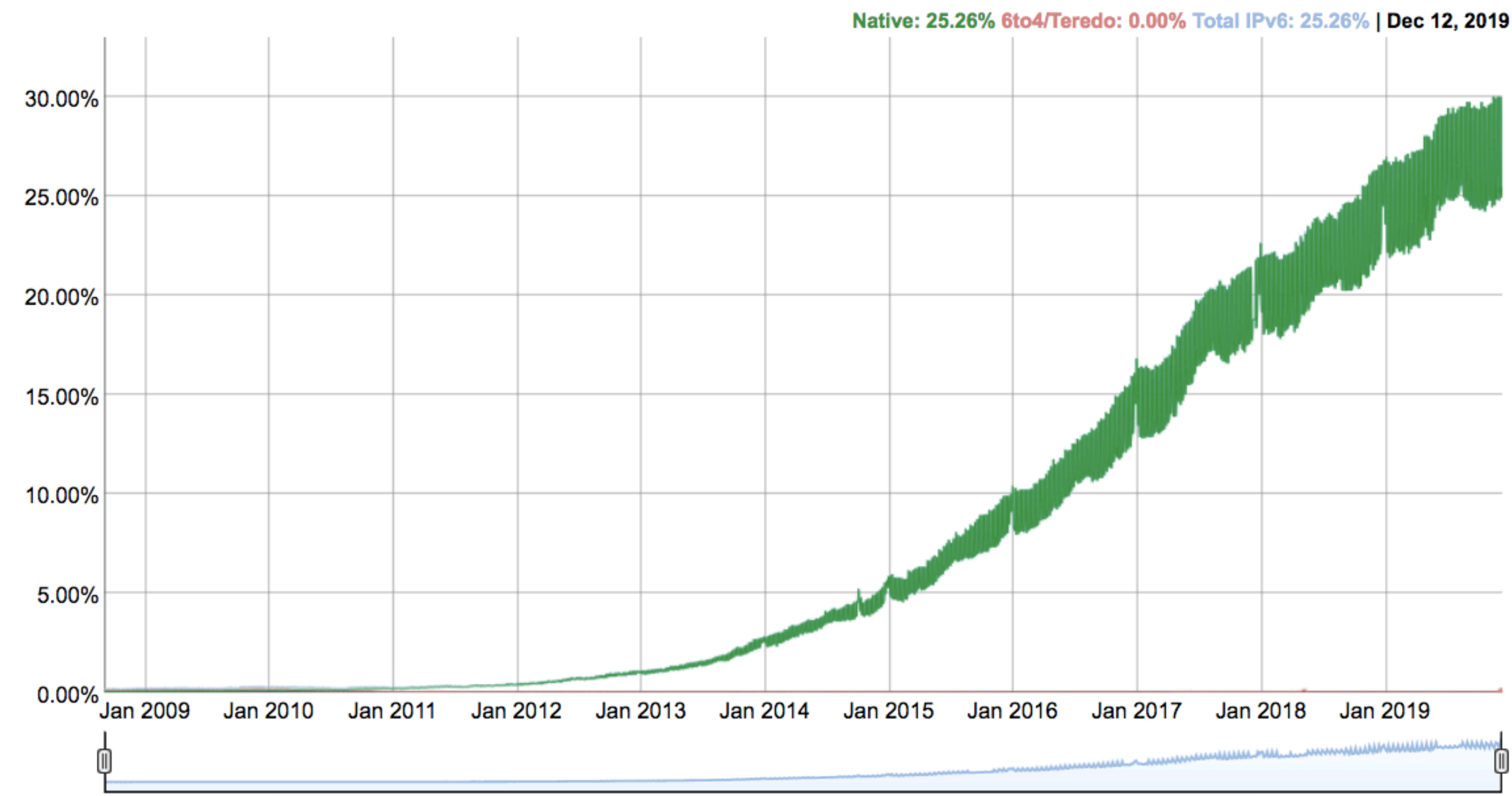
IP address (v6): 128 bit

2A41 : **0000** : **3341** : **3AAA** : **0000** : **FFFF** : **86AA** : **B92E**

From domain to IP address

IPv6 Adoption

We are continuously measuring the availability of IPv6 connectivity among Google users. The graph shows the percentage of users that access Google over IPv6.



Source: http://www.google.com/intl/en/ipv6/statistics.html

Uniform Resource Locators (URLs)

URL syntax

- Uniform resource locators offer a standardised way to point to any resource on the Internet

- Not restricted to **`http`**, however, the syntax slightly varies from scheme to scheme

- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

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```

determines the protocol to use when connecting to the server

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- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

the username/password (to access a protected resource)

URL syntax

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- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

the domain name or numeric IP address of the server

URL syntax

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- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

the port on which the server is expecting requests

URL syntax

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- Not restricted to **`http`**, however, the syntax slightly varies from scheme to scheme

- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

the local path to the resource

URL syntax

- Uniform resource locators offer a standardised way to point to any resource on the Internet

- Not restricted to **`http`**, however, the syntax slightly varies from scheme to scheme

- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

additional input parameters applications may require

URL syntax

- Uniform resource locators offer a standardised way to point to any resource on the Internet

- Not restricted to **`http`**, however, the syntax slightly varies from scheme to scheme

- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

parameters passed to gateway resources (e.g. a search engine)

URL syntax

- Uniform resource locators offer a standardised way to point to any resource on the Internet

- Not restricted to **`http`**, however, the syntax slightly varies from scheme to scheme

- General format:

```
<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>
```

the name of a piece of a resource; only used by the client

https://duckduckgo.com/?q=delft&t=hp&ia=web

<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>

common convention: name1=value1&name2=value2&…

Web Images

Netherlar

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Book Now, No Booking Fees, Book for Tonight
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Your cityguide to Delft — Delft.com

Discover the story of William of Orange, get up close and personal with Johannes Vermeer and see how the world-famous **Delft** Blue is made.
https://www.delft.com

Delft 2018: Best of Delft, The Netherlands Tourism - TripAdvisor

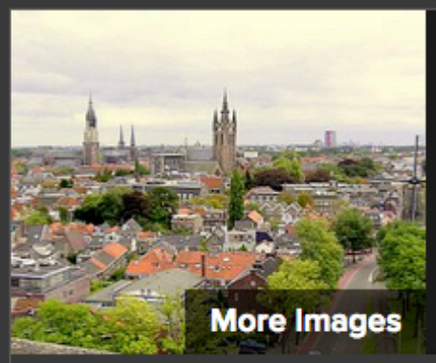
Vermeer's birthplace and a true gem, **Delft** sits between The Hague and Rotterdam in the country's southwest. The city's name comes from the Dutch word for digging, fitting since canals are a highlight here. Others include the 13th-century Old Church, the 15th-century New Church and the ...
https://www.tripadvisor.com/Tourism-g188626-Delft_South_Holland_Provi...

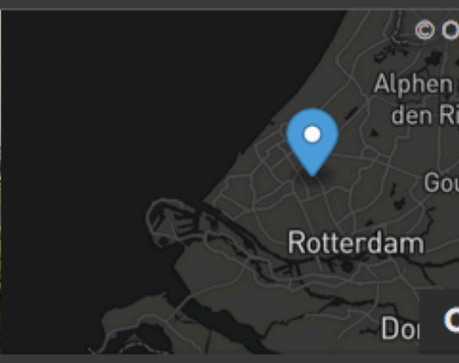
Delft - Wikipedia

Delft ((listen)) is a city and municipality in the province of South Holland, Netherlands.It is located between Rotterdam, to the southeast, and The Hague, to the northwest.
https://en.wikipedia.org/wiki/Delft

Delft travel - Lonely Planet

Explore **Delft** holidays and discover the best time and places to visit. | An amalgam of austere medieval magnificence and Golden Age glory, **Delft's** exquisite town centre is a hugely popular Dutch day-trip destination, awash with visitors strolling its narrow, canal-lined streets and central Markt.
https://www.lonelyplanet.com/the-netherlands/the-randstad/delft





Delft

delft.nl

Delft is a city and municipality in the province of South Holland Netherlands. It is located between Rotterdam, to the southeast The Hague, to the northwest. Together with them, it is part of t Rotterdam–The Hague metropolitan area and the Randstad. **More at Wikipedia**

Country: Netherlands

Body: Municipal council

Mayor: Marja van Bijsterveldt (CDA)

Spode Delft Plate - Free Shipping, Orders $99 or More A

Free Shipping, Orders $99 or More. Get Details and Your Patter
Replacements.com/Spode | Report Ad

CV ketel Delft Voordeelactie - Welke korting ga jij kiezen?

Alleen nog in Maart: €100 huurtegoed of gratis slimme thermos €199

Schemes: more than just http(s)

```
http://<host>:<port>/<path>?<query>#<frag>

https://<host>:<port>/<path>?<query>#<frag>

mailto:<valid-email-address>

file://<host>/<path>

file:///Users/my_home_dir/tmp.html

ftp://<user>:<passwd>@<host>:<port>/<path>;<params>
```

Relative vs. absolute URLs

absolute

```
https://www.tudelft.nl/studenten/
```

relative

```
<h1>Resources</h1>
<ol>
<li><a href="brightspace">Brightspace</a></li>
<li><a href="../disclaimer">Disclaimer</a></li>
</ol>
```

.. parent directory

URLs can be complex.
RFC 3986 governs conversion rules.

```
https://www.tudelft.nl/studenten/brightspace
https://www.tudelft.nl/disclaimer
```

URL design restrictions

- **Initial design goals**: *portable* across protocols and human *readable* (no invisible/non-printing characters)
  - URLs initially restricted to a very small "safe" alphabet: ASCII

    Heavily biased in favour of English speakers.

    latin alphabet, `0123456789 - _ .~`
    and additional reserved chars like `! ( ) @ &`

- **Added later**: character encoding, e.g. whitespace `%20`

`http://правительство.рф`

Punycode (RFC 3492)

"Punycode is a simple and efficient transfer encoding syntax designed for use with Internationalized Domain Names in Applications. It **uniquely** and **reversibly** transforms a Unicode string into an ASCII string."

```
http://правительство.рф
      => http//:xn--80aealotwbjpid2k.xn--p1ai
http://nl.wikipedia.org/wiki/Itali%C3%AB
      => http://nl.wikipedia.org/wiki/Itali%C3%AB
```

A potential security issue in *mixed scripts*: http://paypal.com

Authentication

Authentication

So far: HTTP as **anonymous**, **stateless** request/response protocol.
The same request, sent by different clients, is treated in exactly the same manner.

Now: identification via

A. HTTP headers
B. Client IP address tracking
C. Fat URLs
D. User login (HTTP Basic Authentication)

In lecture 7: Cookies & Sessions.

User-related HTTP header fields

From	Request	User's email address	**mostly web crawler**
User-Agent	Request	User's browser	**device customization**
Referer	Request	Page the user came from	**user interests**
Client-IP	Request (Extension)	Client's IP address	
Authorization	Request	Username & password	

Mozilla/5.0 (Macintosh; Intel Mac OS X 10.13; rv:69.0) Gecko/20100101 Firefox/69.0

Client IP address tracking

- Idea: **Client IP address** as user identifier

- **Several issues**:

  A. IP addresses describe the **machine**, not the user

  B. ISPs **dynamically assigned IP** addresses to users

  C. Users may access the Web through **firewalls**

  D. HTTP **proxies** and **gateways** open new TCP connections (IP of the proxy/gateway is shown), `X-Forwarded-For` might help (it quickly gets complicated)

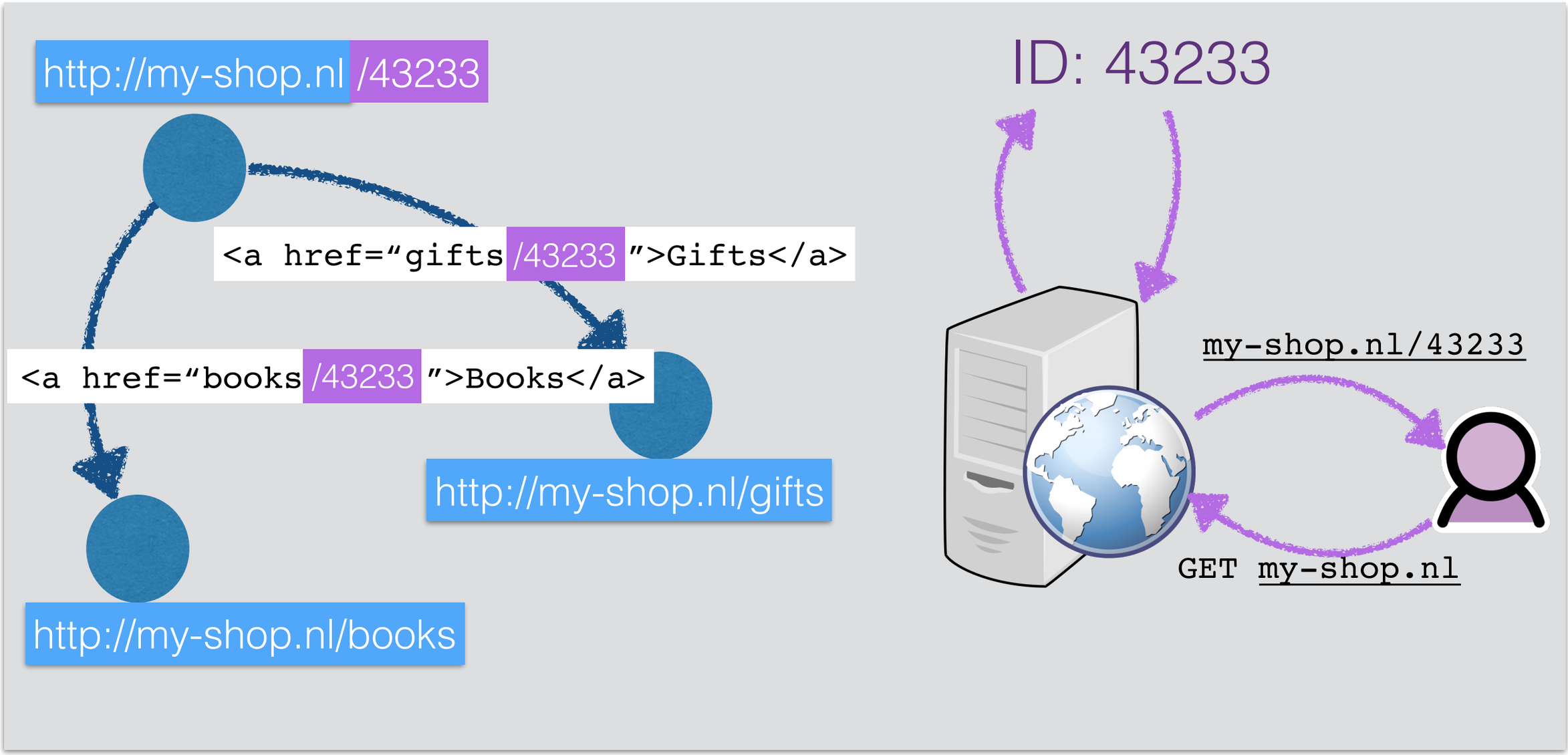
Fat URLs

- Idea: track users through the **generation of unique URLs**
  - First time a user visits a resource within a Web site, a **unique ID** is generated by the server
  - Server **redirects** client to the fat URL (URL+unique ID)
  - Server **rewrites the HTML** when an HTTP request with a fat URL is received (adds ID to all hyperlinks)

```
<a href="/browse/002-1145265-8016838">Gifts</a>
<a href="/wishlist/002-1145265-8016838">Wish List</a>
```

- Independent HTTP requests thus tied into a single session

Fat URLs


http://my-shop.nl /43233
Gifts
Books
http://my-shop.nl/gifts
http://my-shop.nl/books
ID: 43233
my-shop.nl/43233
GET my-shop.nl

Fat URLs have issues too!

- Fat URLs are **ugly**
- Fat URLs **cannot be shared** (private info shared)
- Fat URLs **break web caching** mechanisms
- **Extra server load** (HTML page rewrites)
- Users can "**escape**" (ID is lost when user navigates away from the site)

HTTP basic authentication

- Server explicitly asks the user for authentication (**username and password**)

- HTTP has a **built-in mechanism** to support username/ password based authentication via `WWW-Authenticate` and `Authorization` headers

- HTTP is **stateless**: once logged in, the client sends the login information with each request

HTTP basic authentication

1

```
GET /index.html HTTP/1.1
host: www.microsoft.com
```

```
HTTP/1.1 401 Login Required
WWW-Authenticate: Basic realm="B&R"
```

2

security realm and authentication algorithm

client presents login screen

3

```
GET /index.html HTTP/1.1
host: www.microsoft.com
Authorization: Basic am910jRmdW4=
```

4

```
HTTP/1.1 200 OK
Content-length: 1234
Content-type: text/html
…
```

In future HTTP requests to the site, the browser automatically issues the stored username/password.

HTTP basic authentication

`Authorization: Basic`

- Username and password are joined together by a colon and converted to **base-64 encoding** (binary-to-text encoding)

- Base-64 encoding ensures that **only HTTP compatible characters** are entered into the message (takes as input binary, text and international character data strings)

`Normandië`	`Tm9ybWFuZGnDqw==`
`Delft`	`RGVsZnQ=`
`España`	`RXNwYcOxYQ==`

HTTP basic authentication: secure?

- Username and password can be **decoded trivially** (sent over the network in the clear)
- **Users tend to reuse login/password combinations**; a non-critical web site may use basic authentication without SSL that an opponent can capture and try on critical sites

HTTP basic authentication: overall

Basic authentication prevents **accidental** or **casual access** by curious users (privacy is desired but not essential).

Basic authentication is useful for **personalisation** and access control within a “friendly” environment (intranet).

“In the wild”, basic authentication should always be used in combination with **secure HTTP (e.g. https)** — avoids sending username/password **in the clear** across the network.

Secure HTTP

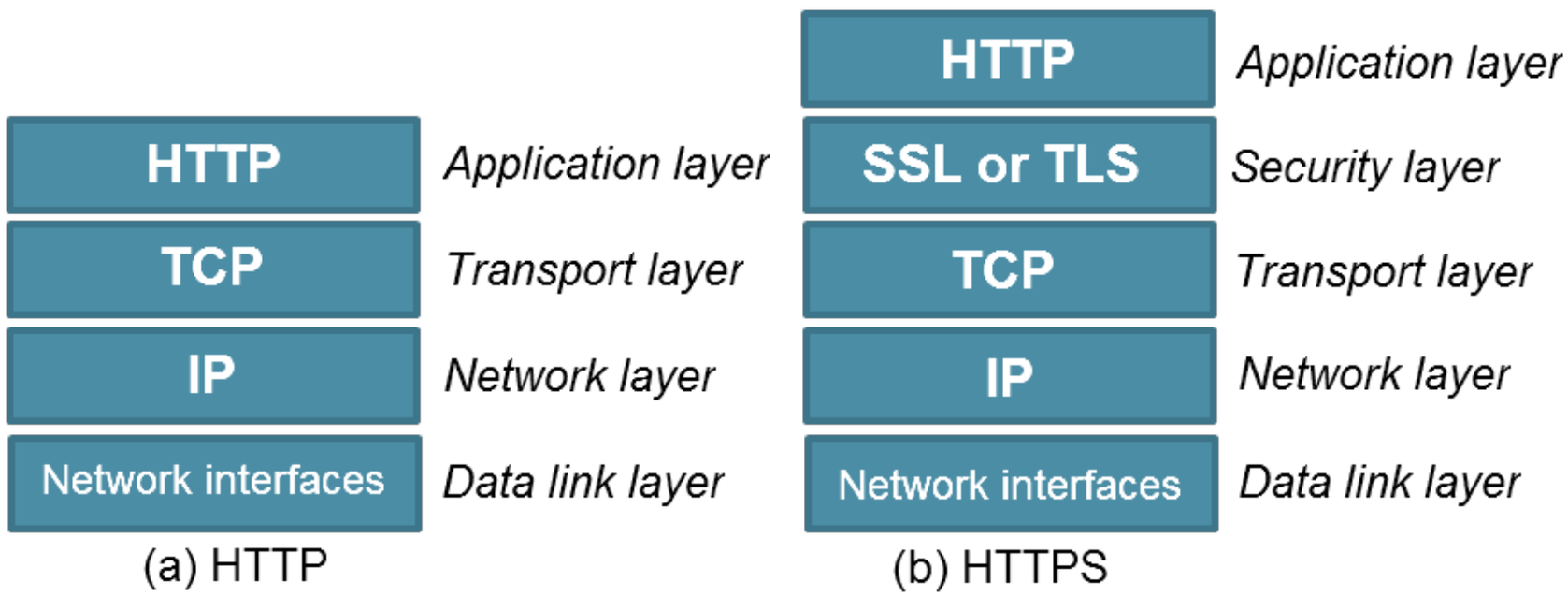
Secure HTTP

- So far: lightweight authentication
  - Not useful for purchasing, bank transactions or confidential data
- Secure HTTP should provide

A. Server authentication (client is sure to talk to the right server)
B. Client authentication (server is sure to talk to the right client)
C. Integrity (client and server are sure their data is intact)
D. Encryption
E. Efficiency

Secure HTTP: HTTPS

- HTTPS is the most popular secure form of HTTP
- URL scheme is `https://` instead of `http://`
- Request and response data are **encrypted** before being sent across the network (SSL: Secure Socket Layer)



Client & server **negotiate** the cryptographic protocol to use.

- Get acquainted with the organisation of the web materials!

- Work through **Chapter 2** (intro to HTML) of the web course book before the next lecture!

- Start working on **Assignment 1**.

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