Internet and HTTP

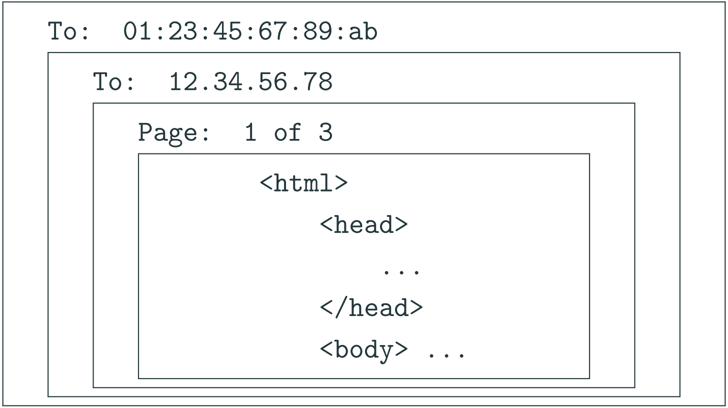
MPRI 2.26.2: Web Data Management

Antoine Amarilli

Friday, December 7th

General idea

- Several **scales** (local vs global)
- **Stack** of protocols
- Embedded **messages**



```
To:  01:23:45:67:89:ab
To:  12.34.56.78
Page:  1 of 3
<html>
    <head>
        ...
    </head>
    <body> ...
```

OSI model

#	Layer	Examples	Features
7	Application	HTTP, FTP, SMTP	high level task
4	Transport	TCP, UDP, ICMP	sessions, reliable data, fragmentation
3	Network	IPv4, IPv6	routing, addressing
2	Link	Ethernet, 802.11	local addresses
1	Physical	Ethernet, 802.11	physical exchange, unreliable

→ The outermost envelopes are for the lowest layers

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IP (Internet Protocol), layer 3

- Gives **addresses** to computers
- Routes **packets** between these addresses
- Can get approximate **geographic location** for an IP

	Year	Example	Addresses	Traffic
IPv4	1981	**208.80.152.201**	$\leq 2^{32}$	77%
IPv6	1998	**2620:0:860:**ed1a**::1**	$\leq 2^{128}$	23%[1]

- **Network Address Translation** to get more IPv4 addresses

→ **We can send messages to an address**

[1] `https://www.google.com/intl/en/ipv6/statistics.html`, May 2018

DNS (Domain Name System) – side note

- Convert names (www.wikipedia.org) to addresses (208.80.152.201)
- Hierarchy: `org`, `wikipedia.org`, `en.wikipedia.org`, etc.
- gTLDs, registrars, costs, effective TLDs

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- Caching at several layers
- Security problems (authentication, poisoning)
- Special characters (IDN, Punycode…) and problems
- Useful indirection layer:
  - Several addresses per domain name (multiple services, load balancing)
  - Multiple domain names per address (virtual host)

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→ **Political** implications

→ **Public** DNSes, **alternative** roots, **decentralized alternatives** (Namecoin…)

→ **We can send messages to a named machine.**

TCP (Transmission Control Protocol), layer 4

- IP is not **reliable**
  - → TCP provides **delivery receipts**
- IP limits the **packet size**
  - → TCP can **fragment** large data
- IP can **mix packets**
  - → TCP ensures **in-order delivery**
- IP is not **multiplexed**
  - → TCP has **sessions** and **ports** (e.g. 80 for the Web)

→ **We can have a two-way communication channel with a machine.**

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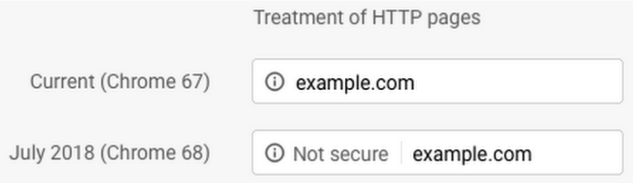
TLS (Transport Layer Security), layer 5-6

- Communicating in plaintext is risky! (passwords, credit cards...)
- Guarantees: integrity, authenticity, confidentiality
- HTTP + TLS = HTTPS. `https://`.
- Uses asymmetric cryptography
- Does not protect all metadata, possible side channels (size, etc.)
- Ongoing push towards HTTPS (+HSTS), marking HTTP as insecure



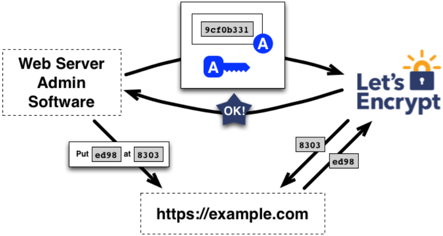
Treatment of HTTP pages

Current (Chrome 67)	ⓘ example.com
July 2018 (Chrome 68)	ⓘ Not secure | example.com

https://www.blog.google/products/chrome/milestone-chrome-security-marking-http-not-secure/

Let’s Encrypt vs extended validation

- Let’s Encrypt: automated check (ACME protocol) and signature of an HTTPS certificate



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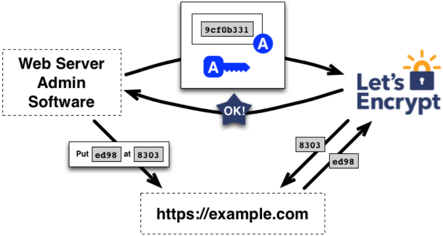
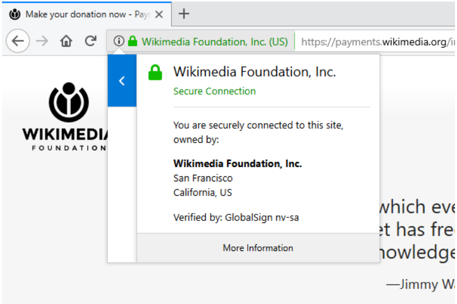


- **Extended Validation** certificates: manual identify check by **trusted parties**



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—Jimmy W

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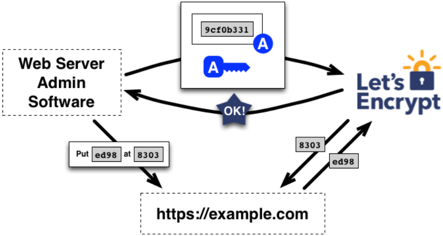

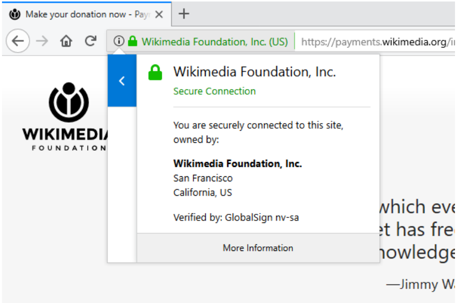

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→ We have an encrypted channel between two machines

`https://letsencrypt.org/how-it-works/`

`Wikimedia_donation_page_with_extended_validation_certificate_in_firefox.png` on Wikimedia commons

HTTP (HyperText Transfer Protocol), layer 7

- The World Wide Web (WWW)
- Protocol for Web browsing

→ Summary: we have

  - the client machine
  - a client software: the Web browser
  - a server machine
  - a server software: the Web server
  - a reliable, encrypted communication channel

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Overview

- Standardized by the Internet Engineering Task Force (IETF) and the World Wide Web Consortium (W3C)
- Official standard: RFC 2616 (114 pages, 1999, + followups)

[2] https://w3techs.com/technologies/details/ce-http2/all/all, November 2018

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- New version: HTTP/2 (originally SPDY by Google)
    - Official standard: RFC 7540 (96 pages, 2015)
    - Used by **32%** of websites[2]

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    - Used by **32%** of websites[2]
- Development version: HTTP/3 (November 2018) from a Google plan to make TCP faster (QUIC)

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HTTP queries (1.1)

- From client to server, TCP connection (+TLS)

```
GET /wiki/Telecom_ParisTech HTTP/1.1
Host: en.wikipedia.org
```

→ `http://en.wikipedia.org/wiki/Telecom_ParisTech`

Method Several choices:

`GET`	Most common
`POST`	Forms, side effects
`HEAD`	Only metadata
others	`PUT`, `DELETE`...

Path That of the URL

Version Here, 1.1

Headers More info (cf. later)

Body Give some parameters (with POST)

HTTP responses

- From **server** to client, in the same connection

```
HTTP/1.1 200 OK
Content-Type: text/html; charset=UTF-8

<!DOCTYPE html>
<html>
  <head>
    (...)
```

- **Status code** and **explanations**
- **Headers**
- **Response** (e.g., page content)

Most common status codes

2xx Success

- 200: OK

3xx Redirection

- 301: permanent
- 302: temporary

4xx Client error

- 400: syntax error
- 401: authentication required
- 403: forbidden
- 404: not found

5xx Server error

- 500: internal server error

Paths and parameters

- Paths are typically hierarchical (separator: /)
- Unix conventions: `https://en.wikipedia.org/./wiki/../`
- Can add key-value parameters
- Example : `https://www.google.com/search?q=telecom&ie=utf-8&oe=utf-8&client=iceweasel-a`
- Percent-encoding for special characters: `https://fr.wikipedia.org/wiki/T%C3%A9l%C3%A9com_ParisTech`

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Client `Host` header

- Indicate again the **original domain name**
- Find the correct **virtual host**

```
Host: en.wikipedia.org
```

Other main client headers

- `User-Agent`: declare which browser is used

```
User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:17.0)
  Gecko/20130810 Firefox/17.0 Iceweasel/17.0.8
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- Accept and Accept-*: give preferred filetype and language

```
Accept: text/html,application/xhtml+xml,
  application/xml;q=0.9,\alert{/};q=0.8
Accept-Language: en-US,en;q=0.5
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- `Referer`: declare the previous webpage

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Referer: https://en.wikipedia.org/wiki/Telecom_ParisTech
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- Range: request only part of content (e.g., resume a download)

Main server headers

- `Server`: declare the server software
- `Content-Type` and `Content-Length`: declare the file type, encoding, size (progress bar)

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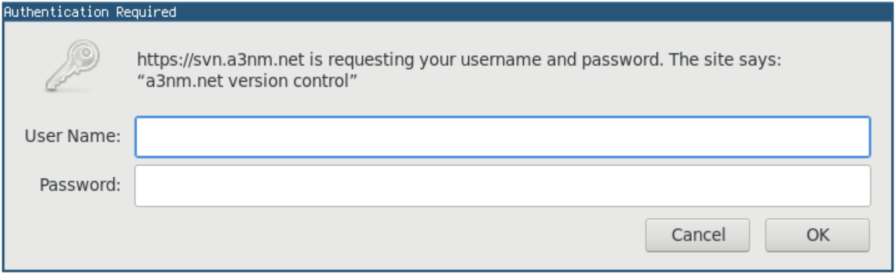
Basic and digest authentication

- HTTP can **authenticate** the client with a password (in cleartext)



Authentication Required

https://svn.a3nm.net is requesting your username and password. The site says: “a3nm.net version control”

User Name:

Password:

- **Insecure** unless HTTPS is used
- Also a **Digest** authentication where the password is not exchanged in cleartext

→ Still **not very flexible** for websites

Proxies

- Proxy: do or relay queries for someone else
- Can be on the server side or client side
- Main uses:
    - Filter or censor content (employer, authoritarian states, schools, parents, etc.)
    - Log the activity, keep a cache
    - Anonymize the query. Example: Tor anonymization network
- Difficult with HTTPS (the proxy no longer sees the content!)

Content delivery networks (CDNs)

- Ensure that static content can be widely and reliably distributed
  - e.g., JSDelivr, BootstrapCDN, Cloudflare, Google Hosted Libraries, Google Fonts
- Often work together with Internet Service Providers (ISPs)
- Optimize the connection between the CDN datacenter and content provider
- Often provide bot filtering, DDOS protection, etc.
- Security implications and subresource integrity
- Also: Facebook’s Instant Articles, and Google AMP

Caching

- **Save** the result of a query to avoid doing the query again
- Web browsers usually have a **cache**
- The server can indicate **whether** a response should be cached and **for how long**

`Cache-Control`	Indicates whether to cache
`Expires`	Expiry date
`ETag`	Version identifier

- Client :

`If-Modified-Since`	Get the content if modified since some date
`If-None-Match`	Get the content if the ETag has changed

Cookies

- No sessions in HTTP
- The server can ask the client to store a value:
  `Set-Cookie: name=value; option1; option2`:
  - `expires`: expiry date (can be in the distant future)
  - can limit the scope (domain, path), etc.
- The client will provide the value with every query:
  `Cookie: name=value`
- Of course the client can decide to alter cookies or remove them

Using cookies

- Storing an opaque **session identifier**
- Ensuring that the user remains **logged in** for a long time
- **Privacy risk**: can track a user (hence: EU cookie consent)
- **Security risk:** with a stolen cookie, you can impersonate the user

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Compression

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  `Accept-Encoding: gzip, deflate`
- With HTTP 2, even headers can be compressed

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- HTTP 1.1: the connection stays open by default (until timeout)
  `Connection: keep-alive`
- Pipelining: send multiple queries and get responses in order
  → Not commonly used because badly supported in practice
- With HTTP 2 you can do multiplexing: send many queries and get responses in arbitrary order
- With HTTP 2, the server can also push resources to the client before it requests them

Credits

- Matériel de cours inspiré de notes par Pierre Senellart et Georges Gouriten
- Merci à Pierre Senellart pour sa relecture