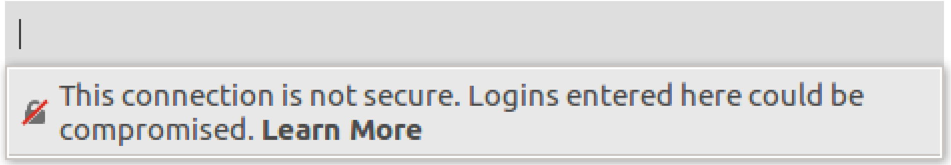
How mature is your HTTPS implementation ?

By Renaud Dubois and Stéphane Louis

<BSides Luxembourg 2017>
Some of the latest news about HTTPS

Introduction : Why https ?

- Higher security & privacy than HTTP
  - Specially for sensitive data



This connection is not secure. Logins entered here could be compromised. **Learn More**

- Better Google ranking

- Follow the initiative to make the web safer (initiatives such as Let's encrypt, HTTPS everywhere)

HTTP only: main risks

- Confidentiality
  - Credentials eavesdropping (login/password, cookies,..)
  - Data eavesdropping

- Integrity
  - Data manipulation (injection – replacement) including on files downloaded
  - Dynamic code injection (Javascript)
  - …

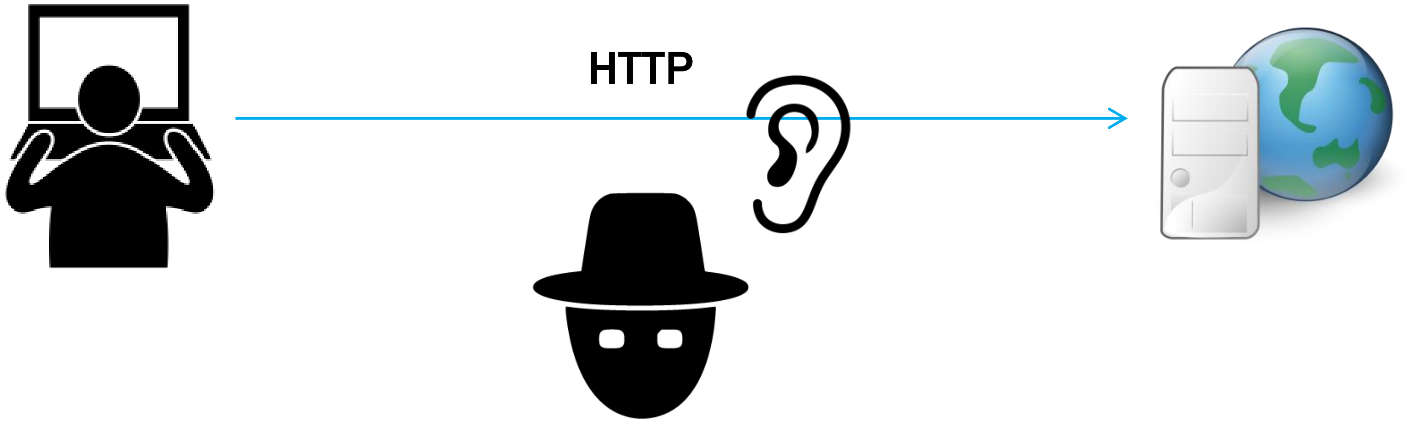
Game

Be the first to right answer to the question and win some gift

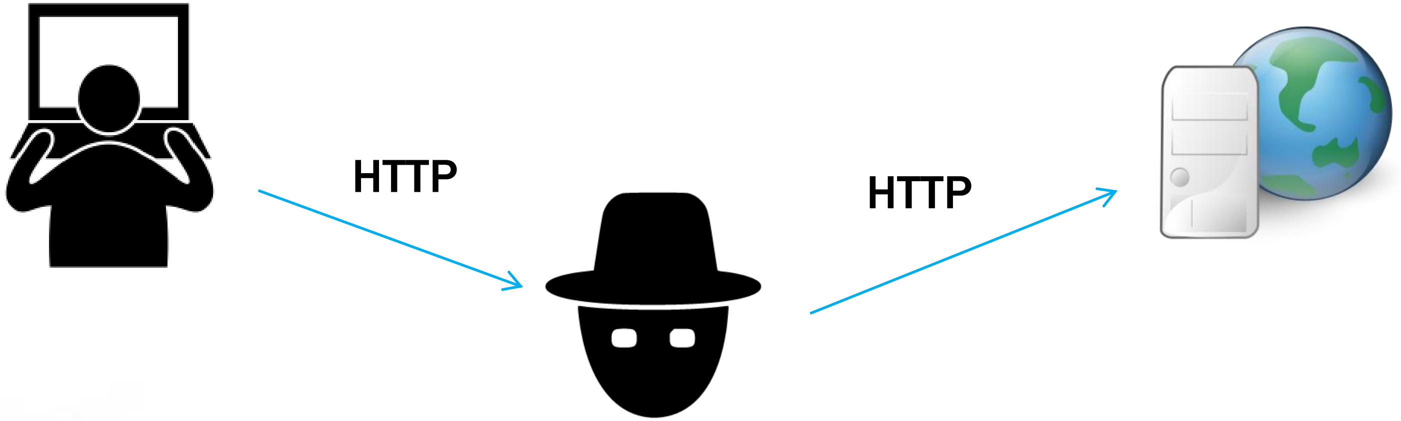
The slides where a gift is available are pinned

HTTP threats→ let's see in practice (1/3)

- Passive spoofing/eavesdropping with a Rogue Access WiFi Point
- Passive spoofing from a network or telecom equipment

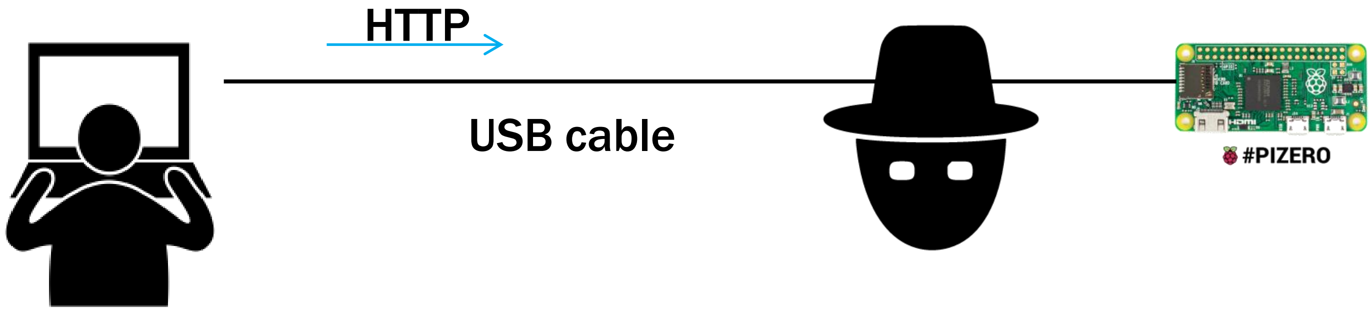


- Man-in-the-middle (e.g. based ARP poisoning in IPv4; fake RA in IPv6)



HTTP threats→ let’s see in practice (2/3)

- Cookie based credentials hijack (e.g. via PoisonTap and Raspberry Pi Zero)



- Emulate Ethernet device over USB
- Run DHCP, DNS Server
- Hijack all internet traffic
- Allow leaking over HTTP request and catching user’s cookie
  - Force HTTP traffic (even for HTTPS website)
  - Grab the users' cookie (if the website runs without HSTS or if ‘Secure flag’ is not enabled on the cookies)

HTTP threats

What can a bad guy concretely do ?

Injecting content in the html pages

Redirect to a phishing website

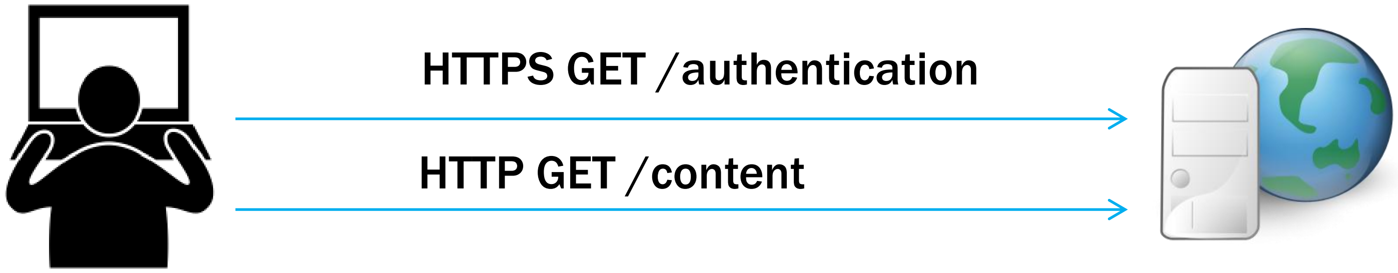
Stealing login/password

Stealing existing session (cookie)

Replacing downloaded files (by malware)

HTTPS implementation 1/2

Partial HTTPS implementation
limited to the login page (year ‘90)



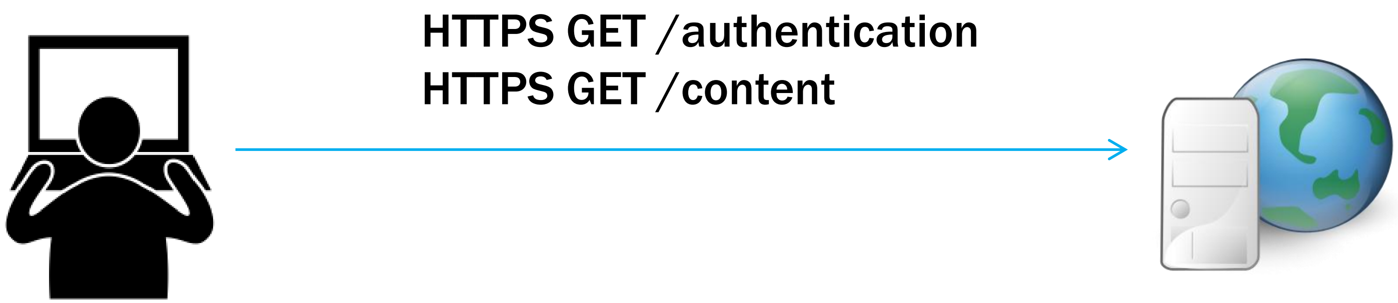
Secure architecture ??

→ Insufficient and still unsecure

→ Eavesdropping still possible of the session after authentication with the HTTP content (cookie)

HTTPS implementation 2/2

Full HTTPS implementation



HTTPS GET /authentication
HTTPS GET /content

→ Mitigate passive spoofing

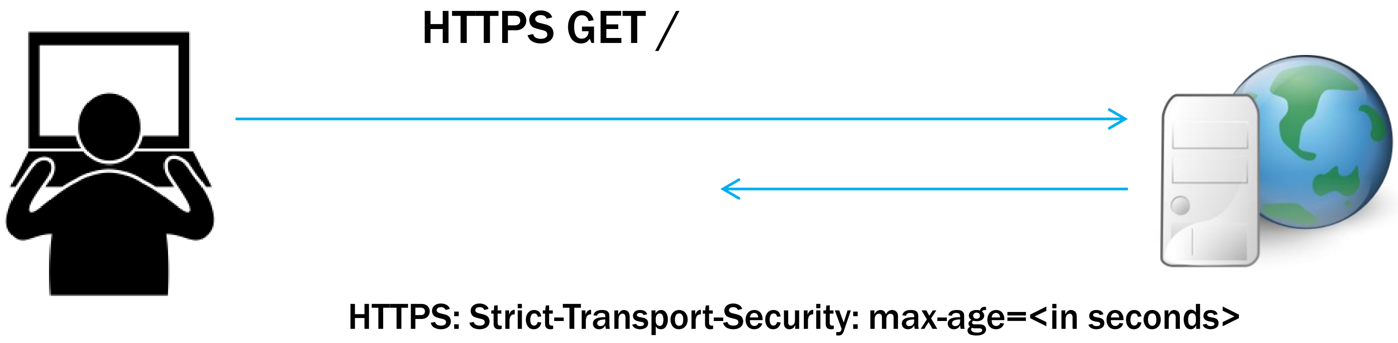
Secure architecture ??

→ Doesn’t always mitigate MITM attack → Downgrade attack to HTTP often still possible in some cases

HTTPS implementation demo let’s see in practice

Demo

HTTPS with HSTS



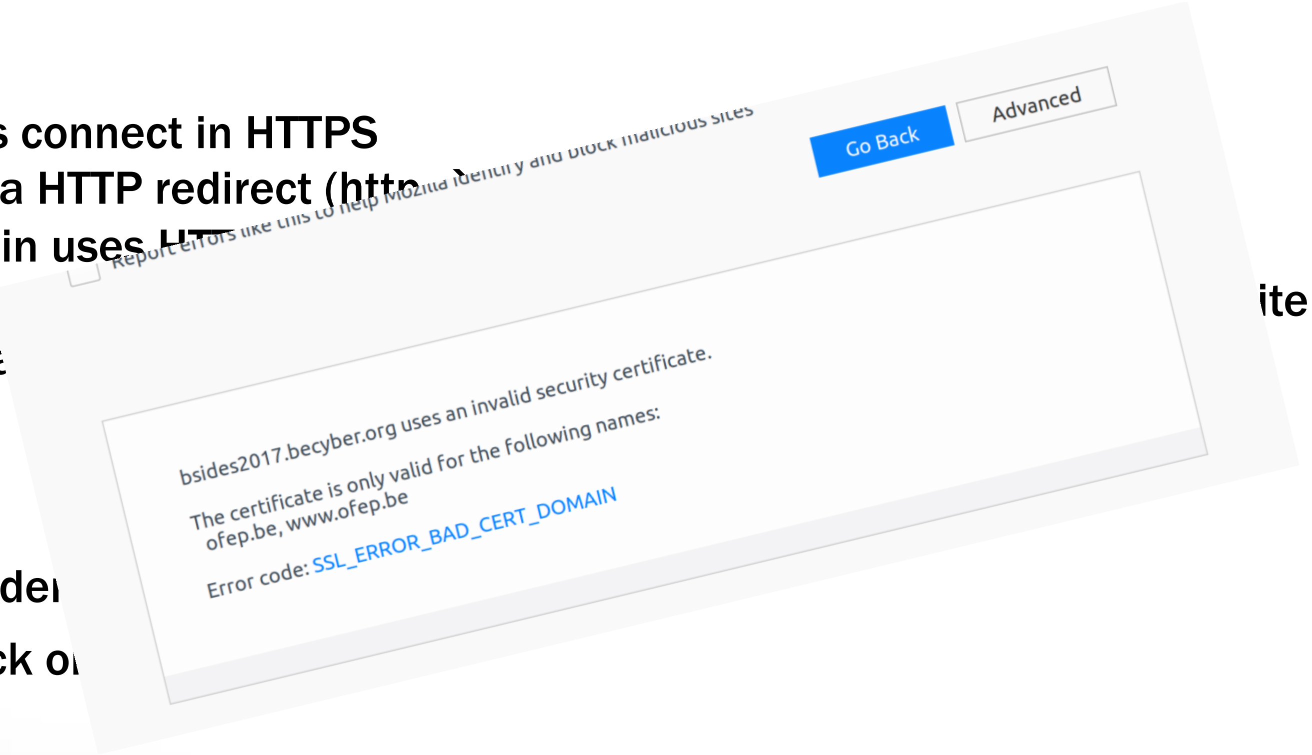
HTTP Strict Transport Security

- Force the browser to always connect in HTTPS
- To use in combination with a HTTP redirect (http
- Future request to the domain uses HT
- In case the connection can ite stays inaccessible
- The users cannot “bypass” a

→ Mitigate passive spoofing

→ Mitigate cookie based crede

→ Mitigate some MITM attack o



Report errors like this to help Mozilla identify and block malicious sites

bsides2017.becyber.org uses an invalid security certificate.

The certificate is only valid for the following names:
ofep.be, www.ofep.be

Error code: SSL_ERROR_BAD_CERT_DOMAIN

HTTPS with HSTS: in details

For specific domains/subdomain or for all subdomains (*.mydomain.com)
Good practice: implement HSTS for www.domain.com and domain.com

```
Strict-Transport-Security: max-age=63072000 [[;includeSubDomains]; preload]
```

Setting *includeSubDomains* on www.mydomain.com also applied for subdomains (e.g. app1.mydomain.com)
Be careful: could impact sites on subdomain that are not yet HTTP enabled

Preloaded list available in the browsers (Chrome, Firefox, Opera, Safari, IE 11 and Edge) https://hstspreload.org/
→ Mitigate the possible attack on the first connection and the time based attacks

HTTPS with HSTS: in details

Considered as « HIGH » security benefit by the Web Security Mozilla Sheet
Recommended « max-age » final value: 2 years (63072000 seconds)

How to still MITM websites using HSTS not part of the preload list ?

- First connection remains unprotected (with a risk of a downgrade attack and stripping the HSTS header)
- Vulnerable to time based attacks (e.g. false NTP packet)

Privacy:
"Supercookie" could lead to privacy issues

<img src=http://a.mydomain.com/pic.jpg »> → required HTTPS in future = Y
<img src=http://b.mydomain.com/pic.jpg »> → required HTTPS in future = N
<img src=http://c.mydomain.com/pic.jpg »> → required HTTPS in future = Y
<img src=http://d.mydomain.com/pic.jpg »> → required HTTPS in future = Y

HTTPS with HSTS: incognito mode

- HSTS is supported by all the recent versions of browser (incl. IE on Win 7 with KB3058515)
- Status of the browser and HSTS « Normal mode » vs « Incognito/Private mode »

→ Privacy vs Security

Browser	Shared between normal & private mode
Firefox 56	No
Internet Explorer 11 (KB3058515)	No
Chrome 61	Yes
Safari 11	Yes

Browser	Shared between 2 private mode sessions
Firefox 56	Yes
Internet Explorer 11 (KB3058515)	No
Chrome 61	Yes
Safari 11	Yes

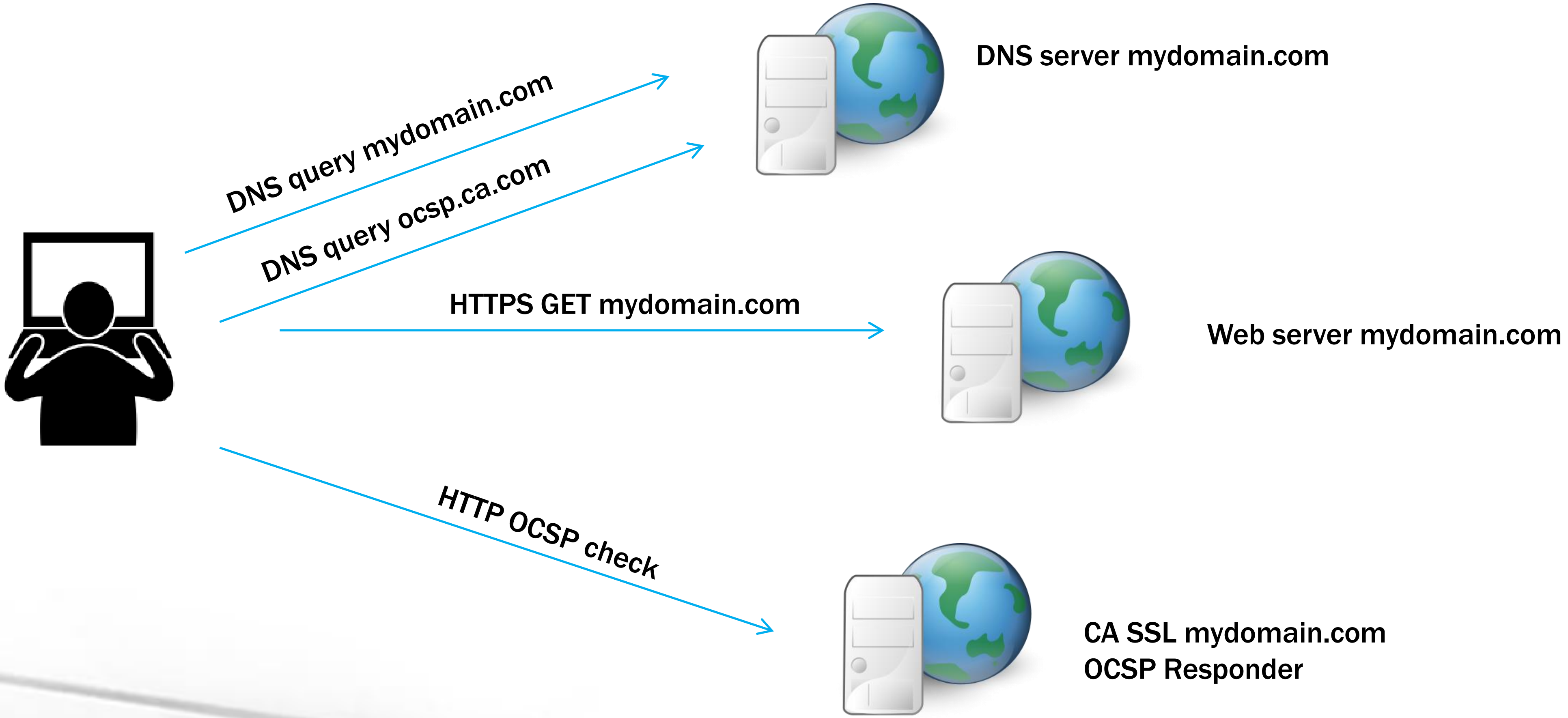
OCSP: Introduction

- Client must verify the validity of the server certificate
  - CRL → huge list → latency to download
  - OCSP (Online Certificate Status Protocol) → more lightweight

    → extra OCSP request to a 3d party OCSP responder

OCSP: Presentation

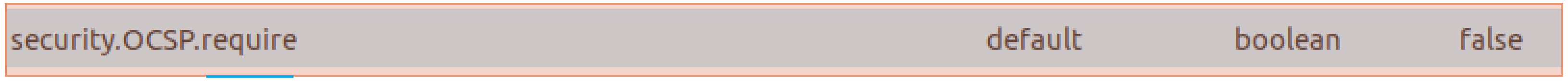
- Regular OCSP browser validation



OCSP: Presentation

- Privacy issue: the CA can potentially track the websites you visit
- What does the browser in case of a timeout from the OCSP Responder ?
  - Stop ? Availability risk (DoS)
  - Continue ? Confidentially/integrity risk

What does Firefox (v 56.0) do today ?

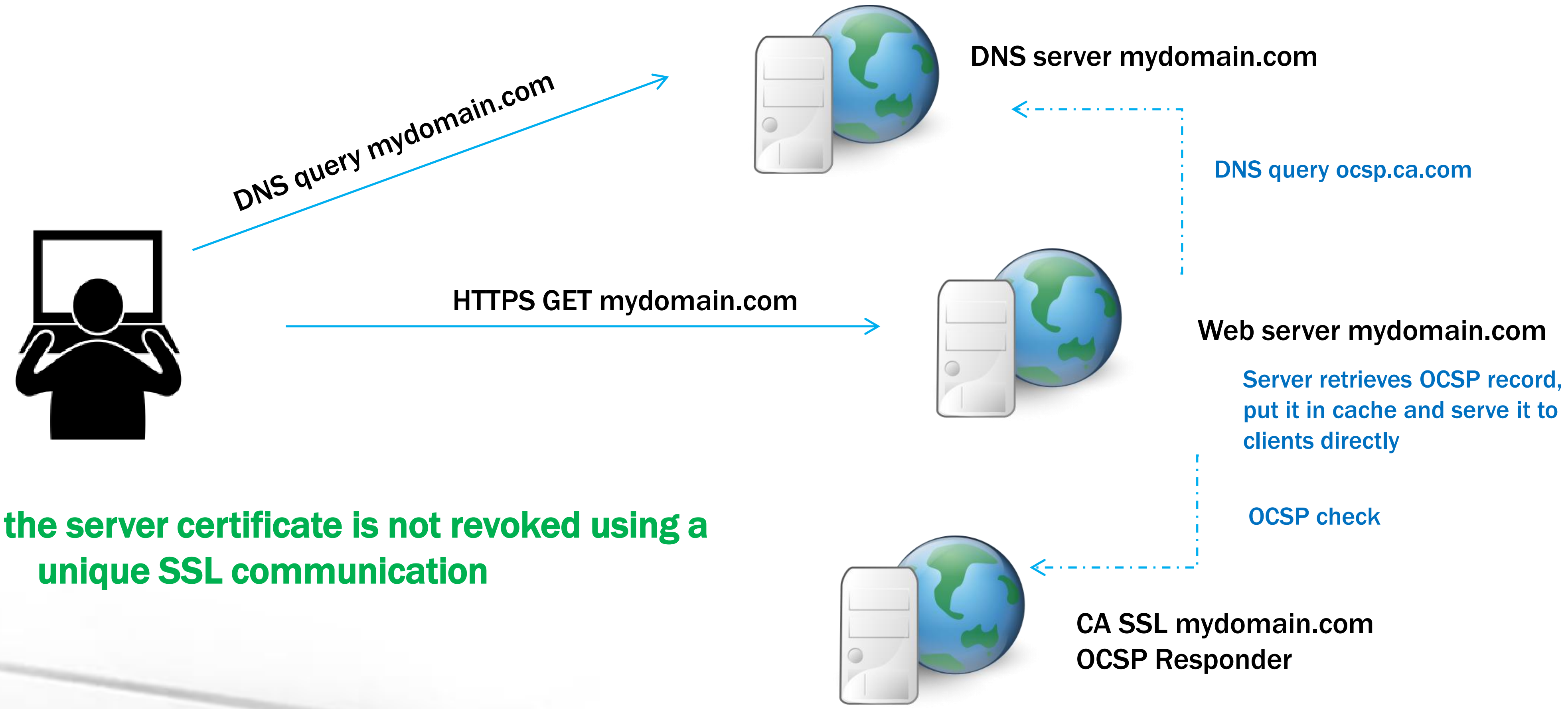


```
security.OCSP.require                                   default        boolean        false
```

By default, Firefox currently continues the connection.

OCSP Stapling : Presentation

- OCSP stapling browser validation
- « OCSP-must-staple »

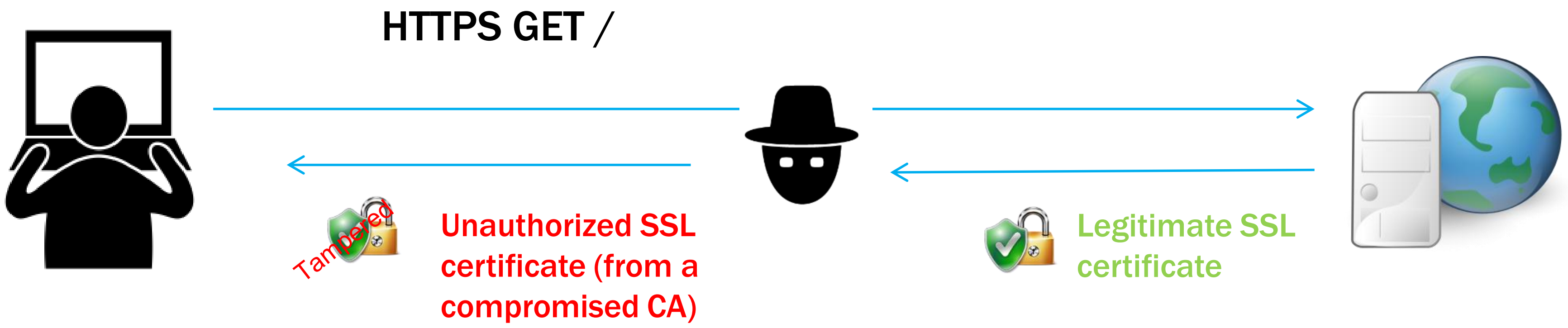


Check that the server certificate is not revoked using a unique SSL communication

HPKP : Presentation

HTTP Public Key Pinning Extension

- Without HPKP the browser will trust all the certificates signed by a CA present in the browser store when establishing a TLS connection
- With HPKP the browser will ONLY trust a list of pre-defined set of ‘pinned’ **public keys**



HTTPS GET /

Unauthorized SSL certificate (from a compromised CA)

Legitimate SSL certificate

Fraudulent certificates – known cases

Most popular cases:

2011 - GlobalTrust.it hacked – 9 fraudulent certificates generated

2011 - DigiNotar (NL) hacked - more than 500 fraudulent certificates generated

2014 - National Informatics Centre of India – several fraudulent certificates (google) generated

2015 - CNNIC (CN) – unauthorized digital certificates for several Google domains

HPKP : Presentation

→ Mitigate MITM attack with forged certificates

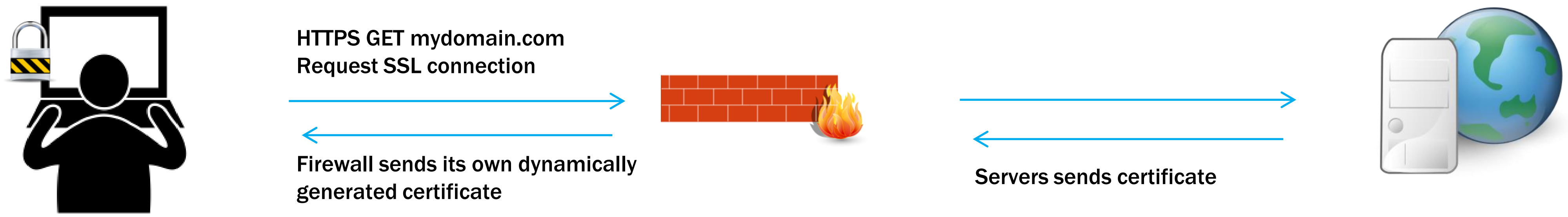
→ Detection of unauthorized certificate (from an compromised CA) AFTER the first connection

```
Public-Key-Pins-Report-Only: pin-sha256="base64=="; max-age=expireTime [; includeSubDomains]; report-uri="reportURI"
```

- At least one backup key must be pinned (in case current public key must be replaced → certificate revoked)
- Alerting mechanism with the optional “report-uri” to report forbidden public keys
  - POST a “violation report” in JSON format
  - Only supported by few browsers
- Possibility to “pin” the keys of Root and intermediate CA

HPKP : Presentation

- Preloaded list exists (built-in in the browser) but no submission pages
- What about HPKP and “outbound” SSL decryption ?



HTTPS GET mydomain.com
Request SSL connection

Firewall sends its own dynamically generated certificate

Servers sends certificate

- Browser should ignore the pinning in case of CA installed

- Shouldn’t conflict with « SSL decryption » (on NGFW/Forward proxy) implementation to inspect outgoing surf traffic

Firefox: security.cert_pinning.enforcement_level = 1

- ○ 0. Pinning disabled
- ○ 1. Allow User MITM (pinning <u>not enforced if the trust anchor is a user inserted CA</u>, default)
- ○ 2. Strict. Pinning is always enforced.
- ○ 3. Enforce test mode.

HPKP : Presentation

Limitations:

- Not supported by every browser such as Safari, IE11, Edge (under consideration),;
  - Supported by Firefox (>35), Chrome, Opera, Android
- First connection remains unprotected (TOFU)
- Hostile Pining: could be misused by a bad guy to block the access to your website (and ask ransom?)
  - The bad guy insert a HPKP header with his own public key and with a high ‘max-age’ value
  - The visitor got an error message and will not be able to visit the website until expiration of the ‘max-age’
  - Impact still occurs after the header has been corrected (persistent in the browsers)
  - Browsers decides of the maximum ‘max-age’ value – no RFC standard
  - Can only occur with HTTPs (not HTTP)
- Privacy concern (super cookie)

- Mozilla recommendation “Mandatory for maximum risk sites only - Not recommended for most site”

HTTPS protocols/ciphers suite/signature algorithms

- Protocols
  - TLS 1.3/1.2/1.1/1.0/SSLv3/SSLv2
- Ciphers Suites
- Certificates and signature algorithms (e.g. SHA256)

- Perfect Forward Secrecy (PFS)
  - Encrypted recorded communications in the past cannot be decrypted
  - Intercepted today decrypted tomorrow ?
  - Attribute of the specific key exchange mechanisms
  - Diffie-Hellman Ephemeral (DHE) or Elliptic Curves (ECDHE)

Certificate Transparency: Presentation

- Background
  - Fraudulent certificates takes time to be detected and revoked by browser vendors

- Certificate Transparency logs
- Certificate Transparency monitors
- Certificate Transparency auditors

DNS CAA

- How does it work ?
  - Use DNS entries to allow a CA to generate certificates for a domain
  - No check at the client (e.g. browser side → DANE)
  - The CA/Browser Forum decided every CA must support DNS CAA checking for 09/2017
  - Not always supported by widely used DNS providers (e.g. OVH,..) – recently added into cPanel and into AWS Route 53
- Advantages
- Implementation

```
example.com.       CAA  0   issue       “entrust.com"
                   CAA  0   issue       "letsencrypt.org“
                   CAA  0   issuewild  "entrust.com"
                   CAA  128 iodef       "mailto:security-incident@example.com"
beta.example.com CAA  0   issue        “digicert.com"
```

Current HTTPS implementations in Luxembourg

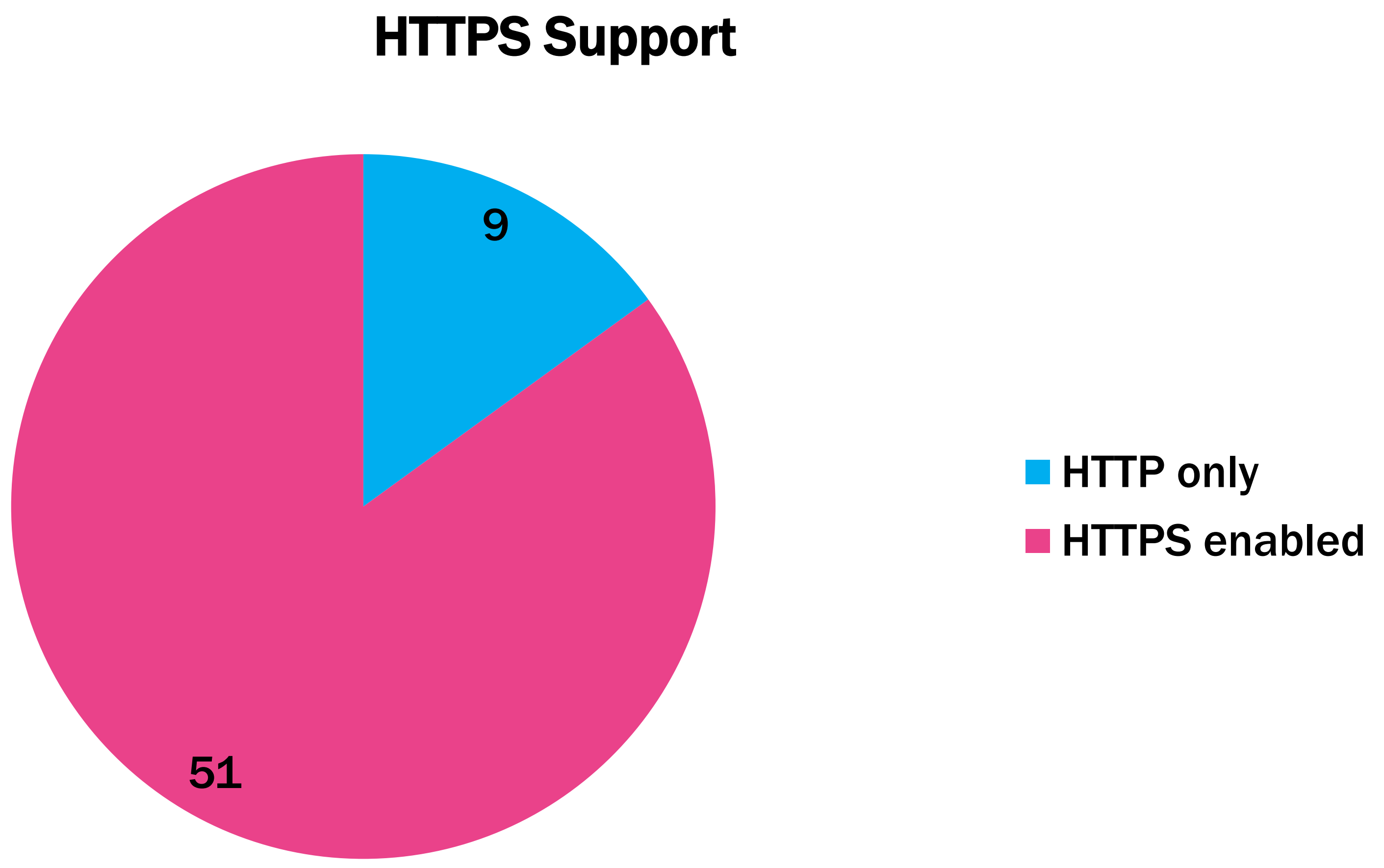
Let's see the statistics

- Top 60 country Luxembourg TLD .lu in October 2017 (source Alexa.com)

Alexa
The Web Information Company

- HSTS
- HPKP
- OCSP Stapling
- DNS CAA
- Forward secrecy
- Ciphers

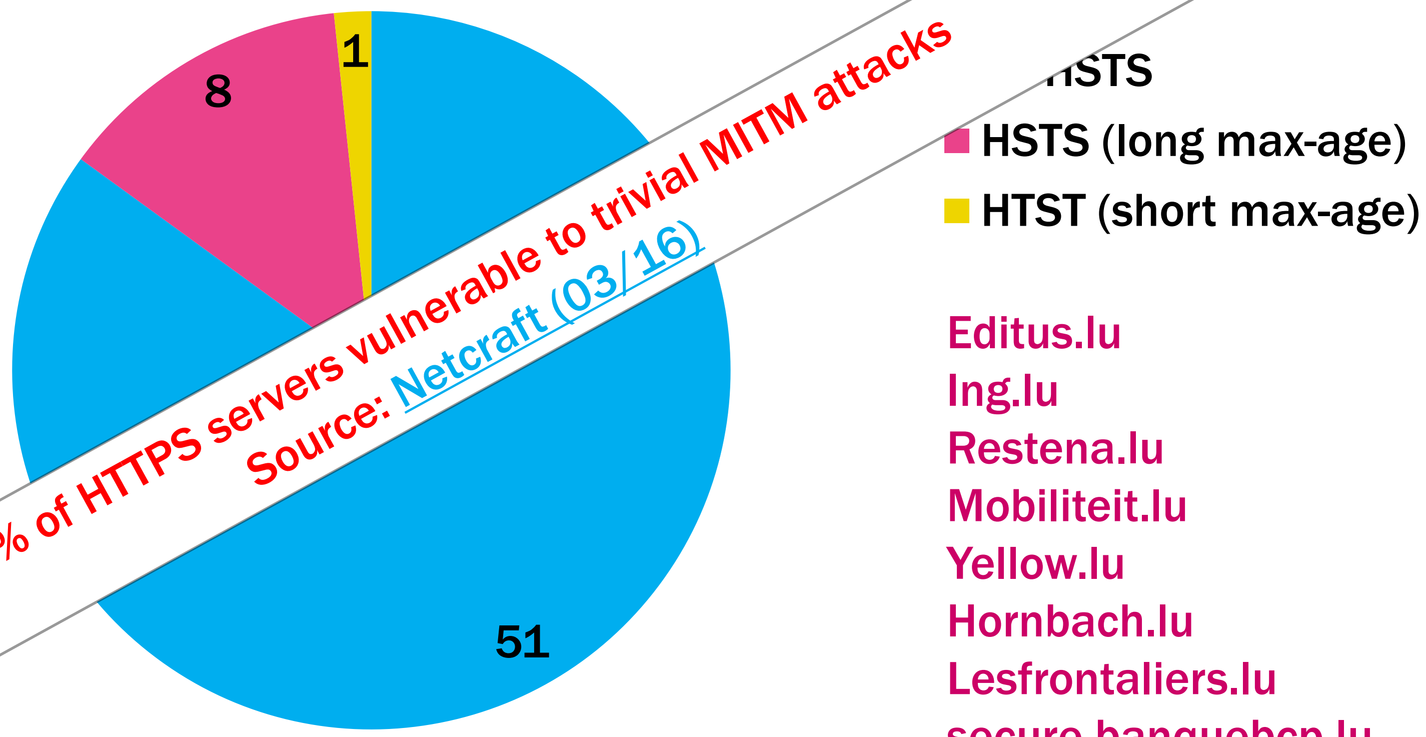
Current HTTPS implementations in Luxembourg



Current HTTPS implementations in Luxembourg

How many % of websites have implemented HSTS ?

HSTS support

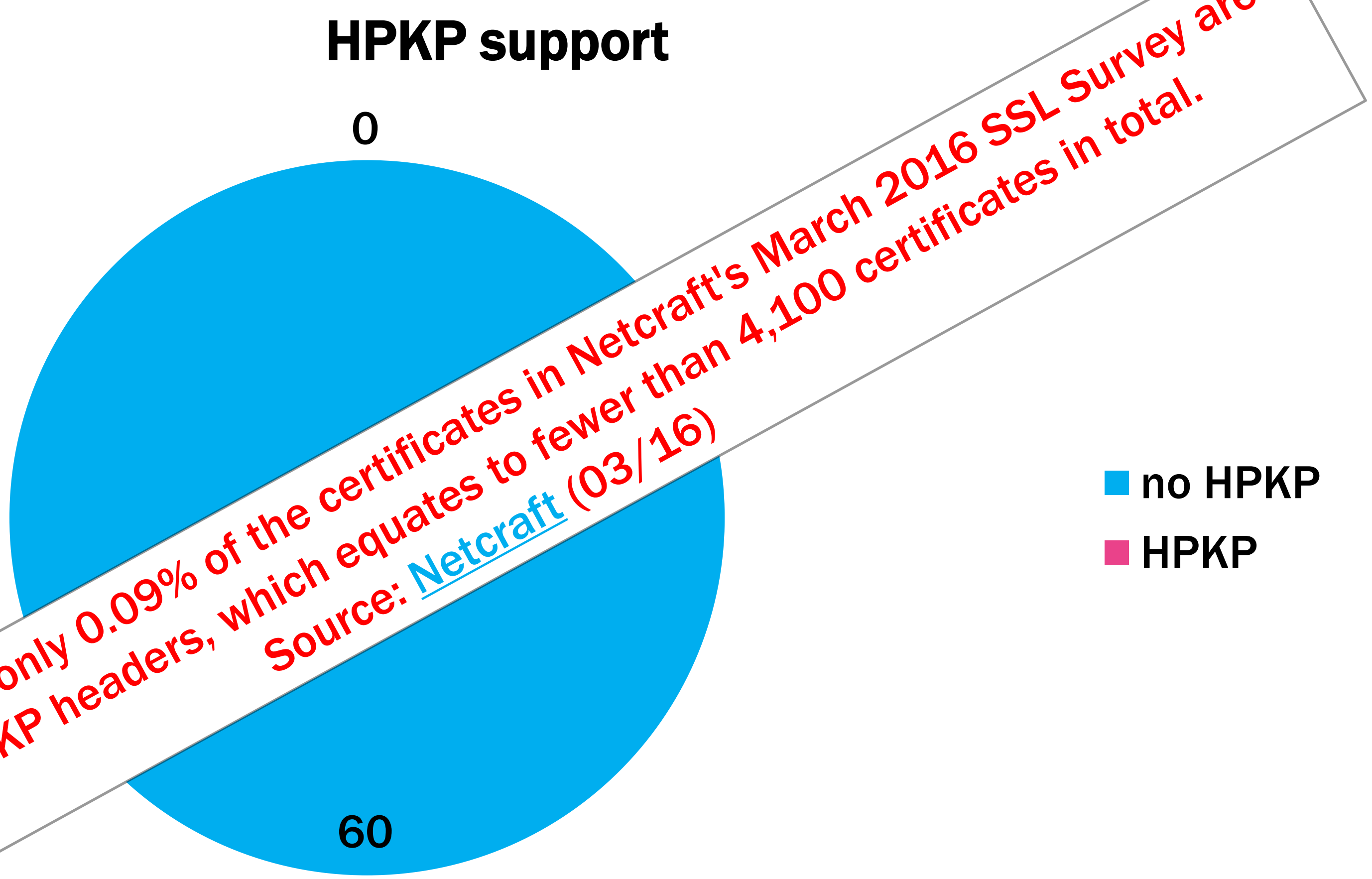


95% of HTTPS servers vulnerable to trivial MITM attacks

Source: Netcraft (03/16)

Editus.lu
Ing.lu
Restena.lu
Mobiliteit.lu
Yellow.lu
Hornbach.lu
Lesfrontaliers.lu
secure.banquebcp.lu
Orange.lu

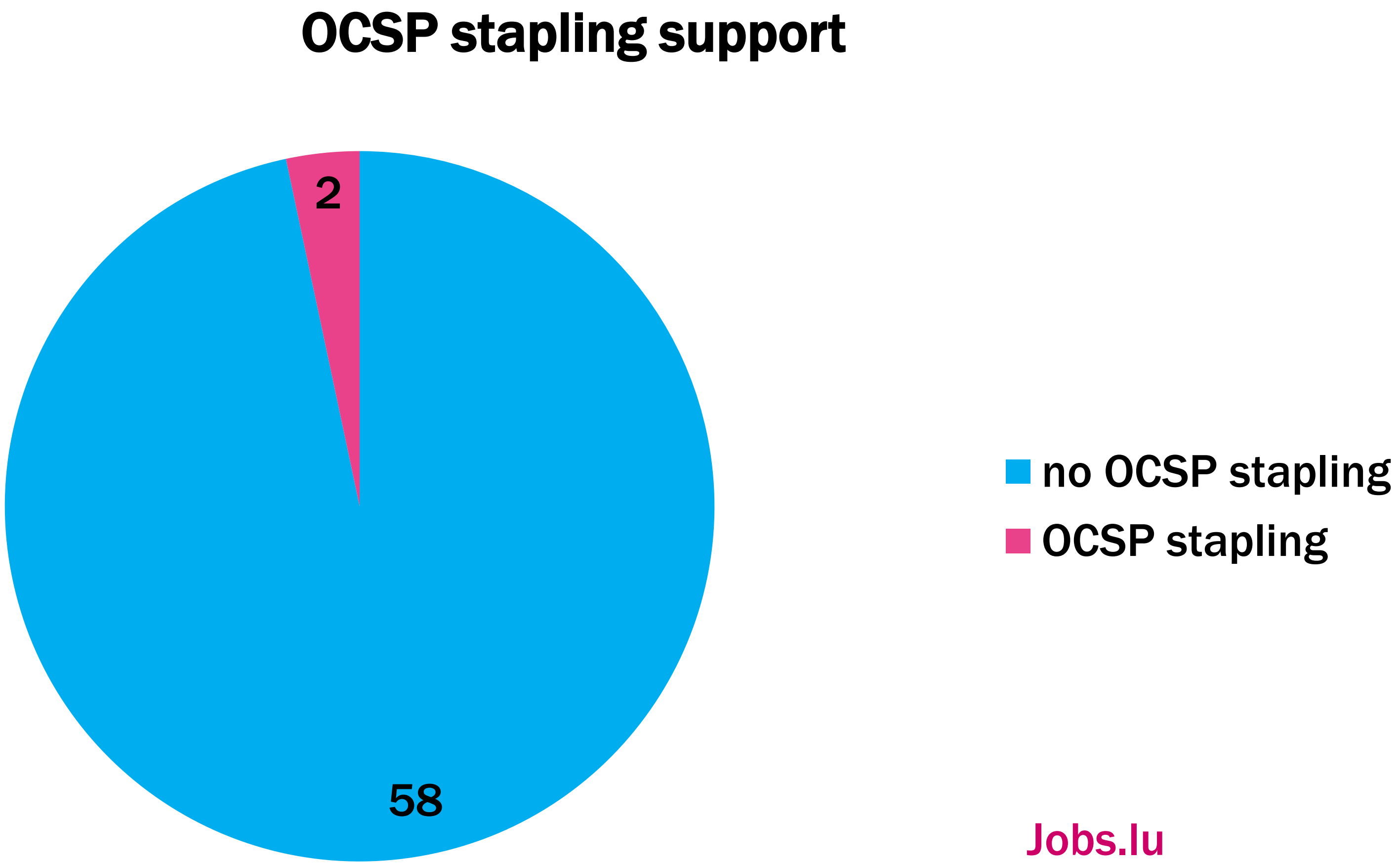
Current HTTPS implementations in Luxembourg



Not really a surprise: only 0.09% of the certificates in Netcraft's March 2016 SSL Survey are served with HPKP headers, which equates to fewer than 4,100 certificates in total.

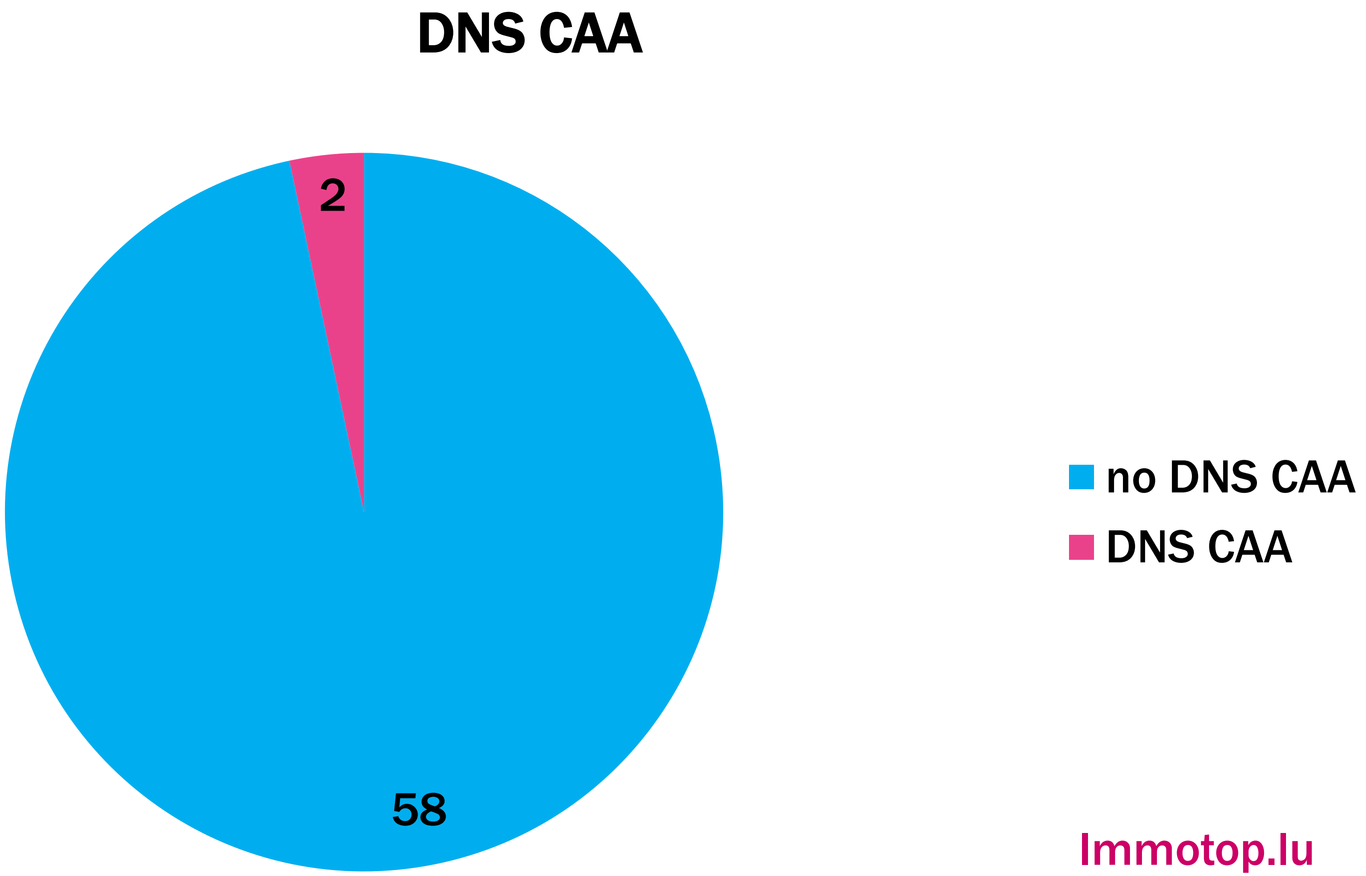
Source: Netcraft (03/16)

Current HTTPS implementations in Luxembourg



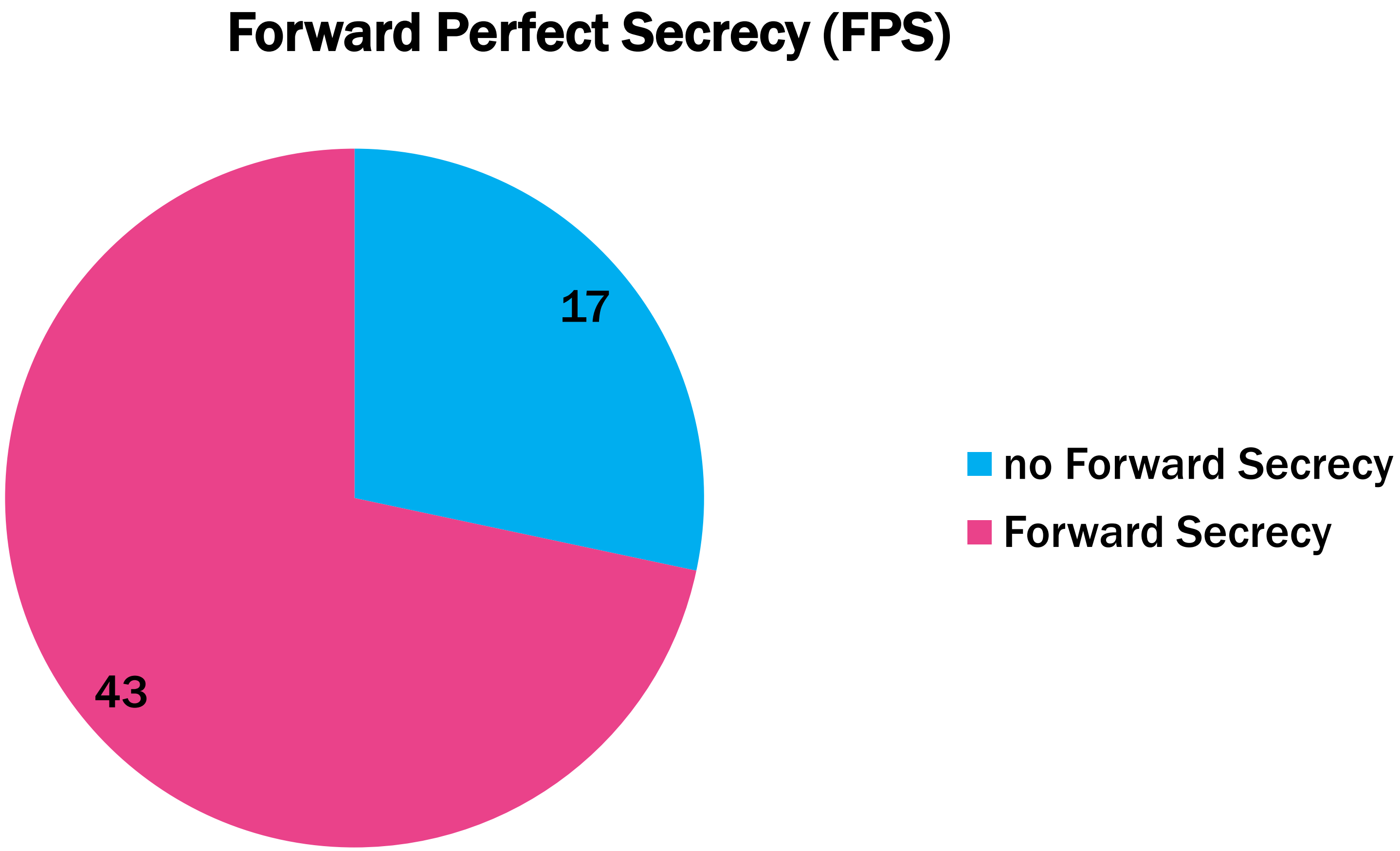
Jobs.lu
Pwc.lu

Current HTTPS implementations in Luxembourg

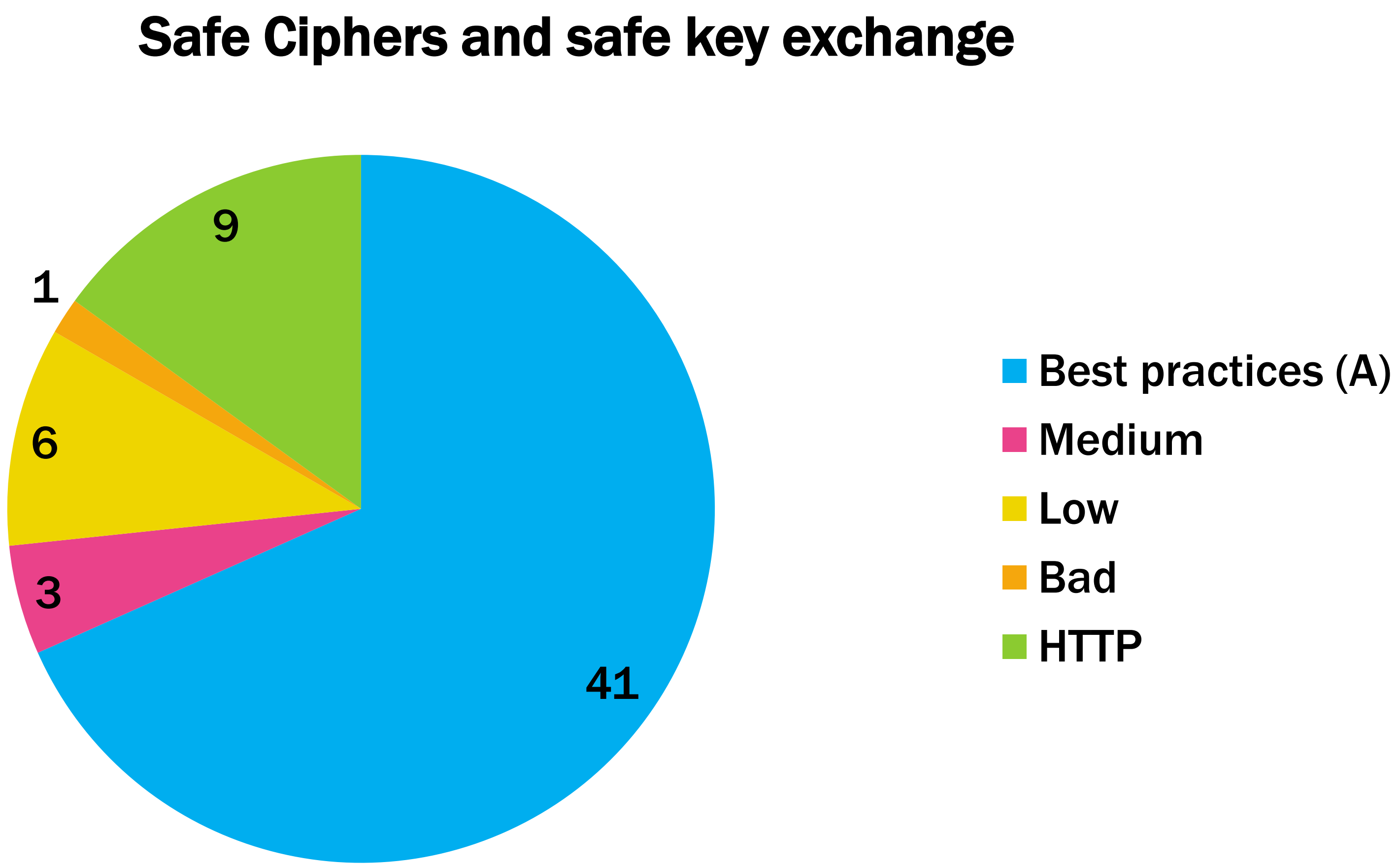


Immotop.lu
Vdl.lu

Current HTTPS implementations in Luxembourg



Current HTTPS implementations in Luxembourg



Contact

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Let’s now discuss together about it

- Webmasters
- HTTP or HTTPS website
- HSTS implementation status
  - Preload list
- Implementation issues
- Victim of target attacks
- DNS CAA implementation status
- OCSP stapling implementation status