


Basics of Networking 2: Security – P2

Daniel STAN

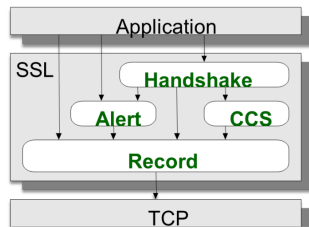


June 10, 2024

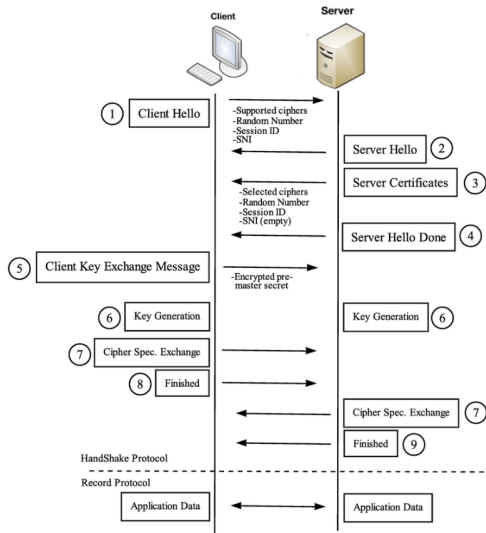
 *Éléments de réseau 2* Contrib and Speakers: Daniel Stan, Eric Milard, Nidà Meddouri, Elloh Adja, Suzana Dedefa, Christian Diaconu
Version: v1.0, feedback and remarks to: daniel.stan@epita.fr

TLS: Transport Security Layer

- The main goal of TLS is to provide a secure channel between two communicating peers
- Provides:
 - ▶ Authentication:
 - ★ Through asymmetric encryption
 - ★ The server side is always authenticated
 - ★ Client can also authenticate in some circumstances
 - ▶ Confidentiality
 - ▶ Integrity
- It is inserted between the **Transport** and the **Application** layer



TLS: Handshake



- Server presents its certificates to authenticate itself.
- Client validates this certificate (PKI).
- Client and servers are also negotiating what cryptographic algorithms to use (supported vs selected ciphers).
- Handshake goal: establish a secure bidirectional channel with a **symmetric encryption**

TLS: Versions

Ancestor name: *Secure Socket Layer* (SSL). Many versions, many security flaws¹

https://fr.wikipedia.org/wiki/Transport_Layer_Security

- 1994 : SSL 1.0. (Netscape)
- February 95: SSL 2.0
- March 96: SSL 3.0

¹these are security flaws in the design of the protocol, even when perfectly implemented by libraries

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- August 2018: TLS 1.3 ← **current version**

NB: you may still find the name "SSL" everywhere, even though it's TLS now.

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TLS Implementations

https://en.wikipedia.org/wiki/Comparison_of_TLS_implementations

- **OpenSSL**
- LibreSSL
- WolfSSL
- ...



Heartbleed vulnerability in OpenSSL exposed private keys of 12% of the internet (2012).

OpenSSL in CLI: analyze certificate

```
openssl x509
```

```
openssl x509 -text -in mycert.pem
```

NB: actually the subcommand x509 has nothing to do with TLS, it's just a PKI management tool.

OpenSSL in CLI: analyze certificate

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openssl x509
```

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```

OpenSSL: verify

```
openssl verify -CAfile RootCert.pem -untrusted Intermediate.pem \
    UserCert.pem
```

NB: again, nothing to do with TLS, it's just x509 certificate manipulation.



StartTLS vs New Protocol

TLS is used on top on an existing transport session, typically TCP. There are two ways to implement it:

- Start with a clear text session, then in your current protocol, implement a new command to switch communication to an encrypted session: "startssl", "starttls".
 - ▶ Examples: IMAP, SMTP, POP
 - ▶ **Advantages**: backward compatible, not a new protocol port.
 - ▶ **Drawbacks**: sensitive to downgrade attacks; a MITM can prevent going to the encrypted session.

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 - ▶ **Advantages**: backward compatible, not a new protocol port.
 - ▶ **Drawbacks**: sensitive to downgrade attacks; a MITM can prevent going to the encrypted session.
 - A completely new application protocol, on top of TLS:
 - ▶ HTTP is 80/tcp → **HTTPS** is TLS/443/tcp
 - ▶ SMTP is 25/tcp → **SMTPS** is TLS/465/tcp
 - ▶ IMAP is 143/tcp → **IMAPS** is TLS/993/tcp
 - ▶ FTP is 143/tcp → **FTPS** is TLS/993/tcp
- NB:  **FTPS** \neq **SFTP** (SSH subprotocol) 

A new net cat: openssl connect

Let's get an **HTTPS** webpage! Initiate a TLS session, on port 443, then talk clear HTTP:

```
openssl s_client -connect epita.fr:443
```

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```

```
depth=2 C = US, O = Google Trust Services LLC, CN = GTS Root R1  
verify return:1
```

```
depth=1 C = US, O = Google Trust Services LLC, CN = GTS CA 1P5  
verify return:1
```

```
depth=0 CN = epita.fr
```

```
...
```

```
GET / HTTP/1.1
```

```
Host: www.epita.fr
```

OpenSSL: it really checks the certificates!

Let's connect to the IP of `epita.fr` instead. Authentication **fails** because server's address doesn't match the presented certificate subject:

```
dstan@flan:~$ openssl s_client -connect 104.26.7.225:443
CONNECTED(00000003)
40C7D94FB4730000:error:0A000410:SSL routines:ssl3_read_bytes:ssl3 alert handshake failure:../ssl/record/rec_layer
-----
no peer certificate available
-----
```

`"104.26.7.225" ≠ "epita.fr"`

Exercise: showcerts

One can list the presented certificate (chain) with `-showcerts` option:

```
$ openssl s_client -connect www.epita.fr:443 -showcerts
[...]
-----BEGIN CERTIFICATE-----
MIIFXzCCBEegAwIBAgIRAKG/1Ew1oUu8E8TPtjDUREowDQYJKoZIhvcNAQELBQAw
...
```

Exercise: why can I connect to *www.epita.fr* while the certificate is for *epita.fr*?

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```

Exercise: why can I connect to *www.epita.fr* while the certificate is for *epita.fr*?

```
$ openssl x509 -text
...[paste your certificate here]...
X509v3 Subject Alternative Name:
    DNS:epita.fr , DNS:*.epita.fr
```

The HTTPS problem.

- Reminder (**Virtual Host**): in HTTP (cleartext), multiple websites can be hosted on the same IP address/port: the server process picks which site to serve depending on the Host field value sent by the client.
- Reminder: HTTPS works with an encrypted session from the beginning, so a single certificate can be presented in the negotiation.
 - ▶ → x509 certificates with **multiple domain names** (alternate DNS) are super useful.
 - ▶ **Drawback 1** lots of websites may be hosted on the same server so a large certificate might be there.
 - ▶ **Drawback 2**: this discloses the set of websites hosted on a server.

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 - ▶ → x509 certificates with **multiple domain names** (alternate DNS) are super useful.
 - ▶ **Drawback 1** lots of websites may be hosted on the same server so a large certificate might be there.
 - ▶ **Drawback 2**: this discloses the set of websites hosted on a server.
 - ▶ → **Wildcard certificates** (For example: *.epita.fr) :
 - ▶ **Drawback**: harder to make, only a solution for FQDNs of a same domain (www., intra.).

HTTPS: Virtual Host vs SNI

Two websites, **same IP** so **same process**, **different domains**, **different certificates**

fr.archive.ubuntu.com / ubuntu.lafibre.info - Chromi...

Certificate Viewer: fr.archive.ubuntu.com

Issued To

Common Name (CN)	fr.archive.ubuntu.com
Organization (O)	<Not Part Of Certificate>
Organizational Unit (OU)	<Not Part Of Certificate>

Issued By

Common Name (CN)	R3
Organization (O)	Let's Encrypt
Organizational Unit (OU)	<Not Part Of Certificate>

Validity Period

Issued On	Saturday, May 4, 2024 at 5:42:14 PM
Expires On	Friday, August 2, 2024 at 5:42:13 PM

SHA-256 Fingerprints

Certificate	8477eb4ecb58749f61b7a1f2ee8f23fba777b7b4a b705cf8cd527ff6
Public Key	a1f56d9e92c81b5793673d7d430b5846bd7d58db9 e08ffc4a36e5fa95

Quelle est mon IPv4 / IPv6 ? -

Certificate Viewer: ip.lafibre.info

Quelle est mon adresse IPv4 :

- Votre IPv4 publique est 51.158.154.169
- Votre reverse DNS IPv4 est ip.lafibre.info
- Le port TCP source utilisé est 54288
- La version du protocole est 6
- Le port TCP destination est 80
- Votre connexion sur cette page est sécurisée
- La version du protocole est TLS 1.3
- Votre navigateur est Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:109.0) Gecko/20100101 Firefox/115.0

=> Retour sur <https://ip.lafibre.info>

Issued To

Common Name (CN)	ip.lafibre.info
Organization (O)	<Not Part Of Certificate>
Organizational Unit (OU)	<Not Part Of Certificate>

Issued By

Common Name (CN)	R3
Organization (O)	Let's Encrypt
Organizational Unit (OU)	<Not Part Of Certificate>

Validity Period

Issued On	Tuesday, April 23, 2024 at 11:00:00 PM
Expires On	Monday, July 22, 2024 at 10:00:00 PM

SHA-256 Fingerprints

Certificate	de861a820e27c62b3cbfb899c59111f3b44a89dd4a76ba21b0d14140 c0b15191
Public Key	e2147f0c6e6db4338aef3ee99af8de172b7fcd41bc37c32ca3311fc 3be8f7

```

dstan@flan:~$ host -t A fr.archive.ubuntu.com
fr.archive.ubuntu.com is an alias for ubuntu.lafibre.info.
ubuntu.lafibre.info has address 51.158.154.169
dstan@flan:~$ host -t A ip.lafibre.info
ip.lafibre.info has address 51.158.154.169
dstan@flan:~$

```

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Two websites, **same IP** so **same process**, **different domains**, **different certificates**

A bit puzzling, isn't it? How can the process server guess what certificate to present, **before** knowing what website will be requested?!!

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TLS has a mechanism similar to HTTP's Virtual Host feature: **Server Name Indication (SNI)**.

```
openssl s_client -showcerts -servername www.example.com \
               -connect www.example.com:443
```

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```
openssl s_client -showcerts -servername www.example.com \
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Note that this problem would not have happened:

- With a "starttls" style protocol (**less secure**)
- If only a single website was hosted behind an IP address: these "fixes" (Virtual Host and SNI) are needed due to the **IP shortage problem**.

TLS: summary

- Protocol to secure communication: **authentication** and **confidentiality**
- Based on x509 certificates and PKI
- **backward-compatible**: just wrap your clear text application protocol into a TLS session, instead of a TCP session.
- Some "hack" to preserve the "Virtual Host" feature of HTTP: SNI.
- Major (widespread) implementation of the protocol: **OpenSSL**.