uc3m | Universidad Carlos III de Madrid

LAB ASSIGNMENT: Digital Signature and PKI. OpenSSL

CRYPTOGRAPHY AND COMPUTER SECURITY

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TOOLS

OpenSSL is a cryptographic framework available in Linux distributions, like Ubuntu. Pay attention to the changes taking place while executing the commands proposed in this assingment.

OPENSSL. Available in most Linux by default. For Windows, follow specifications: https://wiki.openssl.org/index.php/Binaries

- For Windows systems, in order to execute the command from anywhere in the system, you must include the *bin* folder of OpenSSL in the environment variable PATH. Use the following command:

  ```
  set PATH=%PATH%;[OPENSSL_INSTALL_PATH]/bin
  ```

INTRODUCTION

This lab is structured in three different parts: 1) Creation of a PKI, 2) Digital Signature, 3) Obtaining a certificate through a website

The objective of this practice is to understand the concepts underlying a public key infrastructure based on the hierarchical trust model.

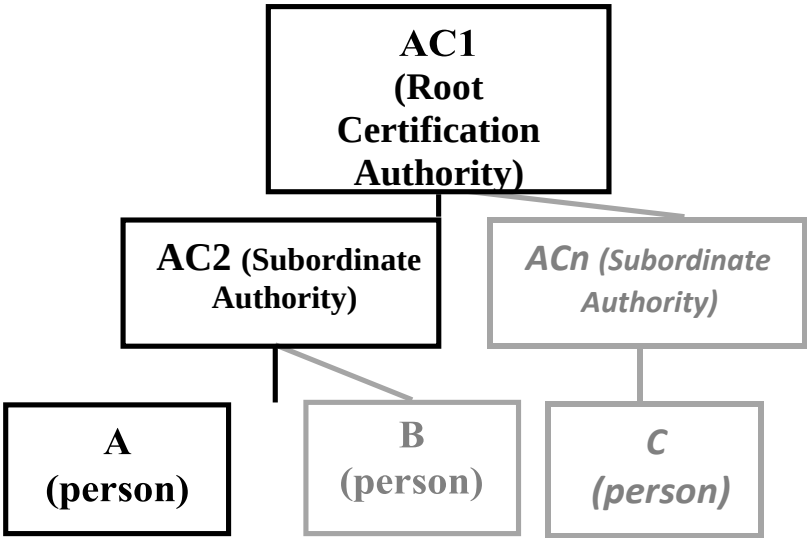
Specifically, the objectives are the following:

1. Understand required steps in order to an Authority issues a certificate
2. Understand causes that produce a certificate revocation and steps required to carry out this process.
3. Understand what the certificates role is regarding the signing and verifying documents.

To achieve these objectives each group becomes a ROOT CERTIFICATION AUTHORITY (equal to the “Fábrica Nacional de Moneda y Timbre” is in the real world). Such Authority (AC1), according to organizational reasons (for example, to

have a local office in all different districts), has some SUBORDINATE CERTIFICATION AUTHORITIES (AC2, AC3,…CAn). Moreover, these last Authorities are in charge of issuing public key certificates to people (A,B,C…)

The group of all the Authorities composes a Public Key Infrastructure (PKI).



To reduce the amount of work, in this assignment only the root certification authority (AC1), a single subordinate authority (AC2) and a person (A) must be configured.

To help with the organization of the practice, create 3 directories, one for each entity: AC1, AC2 and A .

```
# lab> mkdir AC1 AC2 A
```

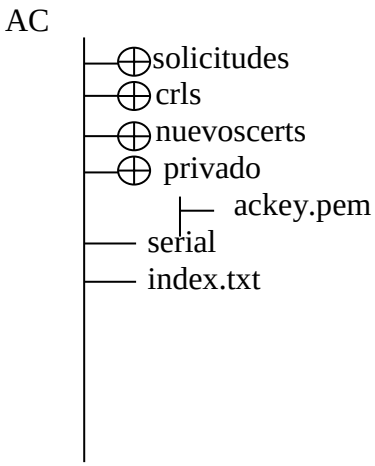
In order to issue the certificates, the Authorities use a certification POLICY. Copy the configuration files openssl_AC1.cnf and **openssl_AC2.cnf** (available in Aula Global) **to the corresponding directories AC1 and AC2.** Analyze these files against the default configuration file (in Linux: /etc/ssl/openssl.cnf)

Before starting the assignment, change de configuration file such that the name of each AC will be AC1 XXXXX and AC2 XXXXX, being XXXXX the five last digits of the student ID.

Relevant OpenSSL commands to do the assignment:

- ca: enables creating and managing a Certification Authority according to the hierarchical model.
- req: nables reating nd anaging ertificate equest
- x509: enables managing X.509 certificates
- verify: nables erifying X.509 certificates

Each AC directory should have the following structure:



Configuration of AC1 (Root CA)

1. Generate the directory structure necessary for AC1 and initialize the files serial and index.txt.

```
# AC1> mkdir solicitudes crls nuevoscerts
privado # AC1> echo '01' > serial
# AC1> touch index.txt
```

2. Generate the RSA key pair and the self signed certificate for AC1. Analyze the output.

```
# AC1> openssl req -x509 -newkey rsa:2018 -days 360 -out
ac1cert.pem -outform PEM -config openssl_AC1.cnf
# AC1> openssl x509 -in ac1cert.pem -text -noout
```

Configuration ofAC2 (subordinate CA)

3. Generate the directory structure necessary for AC2 and initialize the files serial and index.txt.

```
# AC2> mkdir solicitudes crls nuevoscerts
privado # AC2> echo '01' > serial
# AC2> touch index.txt
```

4. Generate the RSA key pair for AC2 and the certificate request which will be sent to AC1 and 'send' it to AC1. Analyze the results.

```
# AC2> openssl req -newkey rsa:2048 -days 360 -out
ac2req.pem - outform PEM -config openssl_AC2.cnf
```

   As it happened in AC1, a passphrase will be required. This has to be remembered for each operation that involves AC2's private key

```
# AC2> openssl req -in ac2req.pem -text
-noout # AC2> cp ac2req.pem
../AC1/solicitudes
```

Generation of AC2's certificate by AC1

5. Verify the request "sent" by AC2.

```
# AC1> openssl req -in ./solicitudes/ac2req.pem -text -noout
```

6. Generate the corresponding certifycate for AC2 and 'send' it back to AC2. Rename 01.pem into ac2cert.pem, because AC2 as this same in its configuration file.

```
# AC1> openssl ca -in ./solicitudes/ac2req.pem -
notext - extensions v3_subca -config
openssl_AC1.cnf
# AC1> cp ./nuevoscerts/01.pem ../AC2/ac2cert.pem
```

Generation of keys for entity A as well as its corresponding certificate request

7. For entity A, generate an RSA key pair as well as a certificate request and “send” it to AC2 (when generating the certificate requests, fill in ALL the requested fields and indicate “ES” as country, “MADRID” as province, “UC3M” as organization, and common name is XXXXX (as described before) and your email is your student email.

```
# A> openssl req -newkey rsa:1024 -days 360 -sha1
-keyout Akey.pem -out Areq.pem
# A> openssl req -in Areq.pem -text
-noout # A> cp Areq.pem
../AC2/solicitudes
```

Generation of A certificate by AC2

8. Verify the request “sent” by A.

```
# AC2> openssl req -in ./solicitudes/Areq.pem -text -noout
```

9. Generate certificate for A and “send” it back to this ntity.

```
# AC2> openssl ca -in ./solicitudes/Areq.pem -notext -config
./openssl_AC2.cnf
# AC2> cp ./nuevoscerts/01.pem ../A/Acert.pem
```

10. Analyze changes in AC2 directory and check the resulting certificate:

```
# A> openssl x509 -in Acert.pem -text -noout
```

Verification of A certificate

11. Obtain a copy of the public key certificates of AC1 and AC2 and verify (you need to concatenate both AC1 and AC2 certificates in a single file).

```
# A> cp
../AC1/ac1cert.pem ./
# A> cp
../AC2/ac2cert.pem ./
# A> cat ac1cert.pem ac2cert.pem > certs.pem
# A> openssl verify -CAfile certs.pem Acert.pem
```

Joining the certificate and the private key to sign in common applications (Word/ Email)

12. Export the certificate of entity A, its private key and both AC1 and AC2 certificates (file certs.pem) to PKCS12 format.

```
# A> openssl pkcs12 -export -in Acert.pem -inkey
Akey.pem - certfile certs.pem -out Acert.p12
```

NOTE: First, A's passphrase is requested to export the private key, and then a new passphrase to protect the.*p12* certificate

EJERCICIOS

Exercise 1 :

a) What is the purpose of "serial" and "index.txt" files?

Solution:

Serial number of the certificates

b) What is the purpose of the "index.txt" file?

Solution:

Is the registry of the issued certificates

c) Can AC2 create its certificate using step 2?

Solution:

No, since AC2 cannot self-sign due to not being a root CA

d) If you were a real world Certification Authority, give a reasoned explanation (i.e. pros and cons, other possible choices, etc.) for each one of the following parameters of your certification policy:

Solution:

default_days = A long value is risky (since the key might be compromised) but a short one is impractical (quick expiration date)

default_crl_days = The shorter the better

countryName = if we put a given match, we prevent being asked for requests from other countries (this makes sense for organizations such as the Spanish FNMT)

Using A's private key to sign a document

13. Create a document in Microsoft Word and sign it digitally using A's private key. First, you need to import the file Acert.p12 into your browser and then, using Microsoft Word, go to the option Office > Prepare >Add a digital signature …

Exercise 2:

e) Regarding the document Word just created and signed, you will see an "Verification Error" message. What is the cause? Could you solve this?

Solution:

It is not possible to verify the signature since the issuing entities (AC1 and AC2) are not installed in the system, and then they are untrusted. The problem would be solved by installing them

Web Browser

f) What steps does a citizen carry out to obtain a public key certificate (e.g. from Spanish FNMT? Fill the following table associating each step carried out to obtain a certificate through the FNMT with each step carried out to obtain a certificate in this assignment.

Step	Description	Step of this script where it has been performed
1	Create a key pair (public and private)	
2	Go to a registration office	
3	Create public key certificate	
4	Download certificate	

Solution:

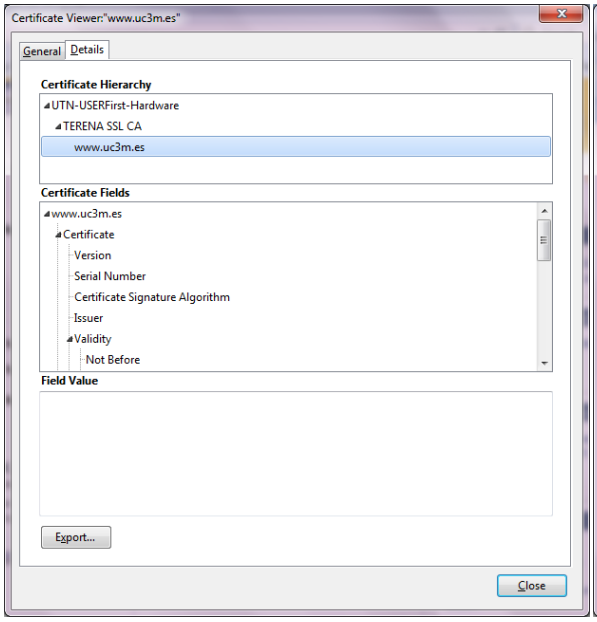
Step	Descritpion	Step of this script where it has been performed
1	Create a key pair (public and private)	7
2	Go to a registration office	None
3	Create public key certificate	8, 9 (first command)
4	Download certificate	9 (secondcommand)

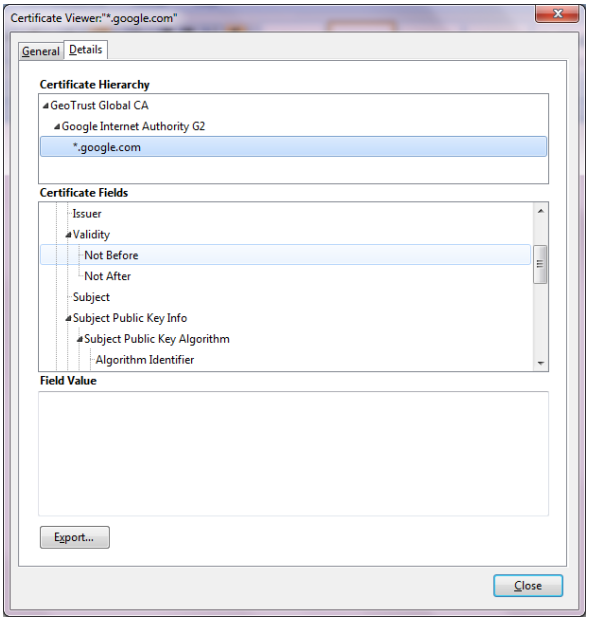
Now going to the browser, let's see how X.509 certificates are used when surfing the Internet.

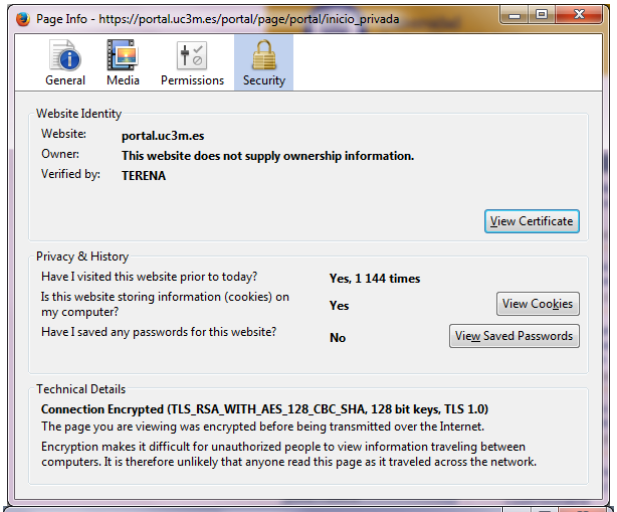
1. Open a browser and point it to aulaglobal.uc3m.es and www.google.es
    a. Which is the certificate sent by each page?
    b. Which is the certification path

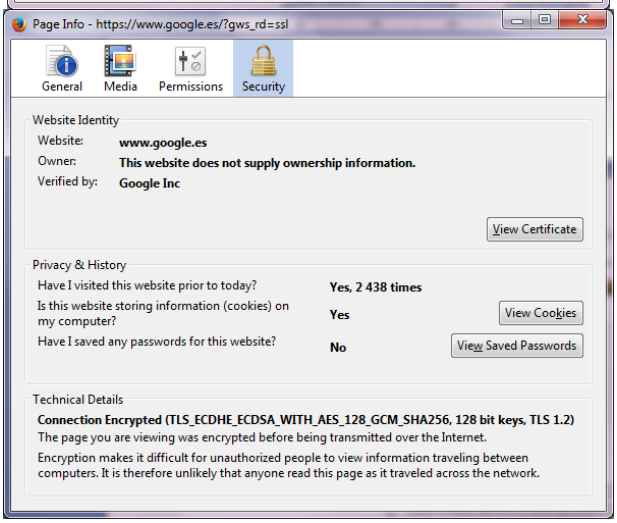
2. Repeat the process with the uc3m web page (www.uc3m.es)

With Firefox:

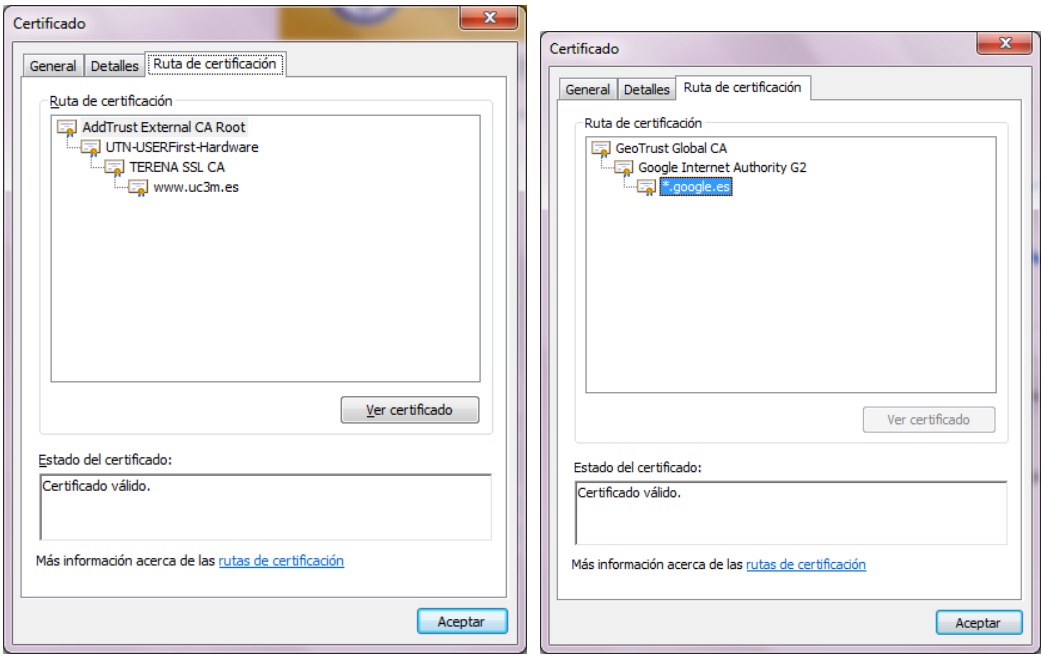


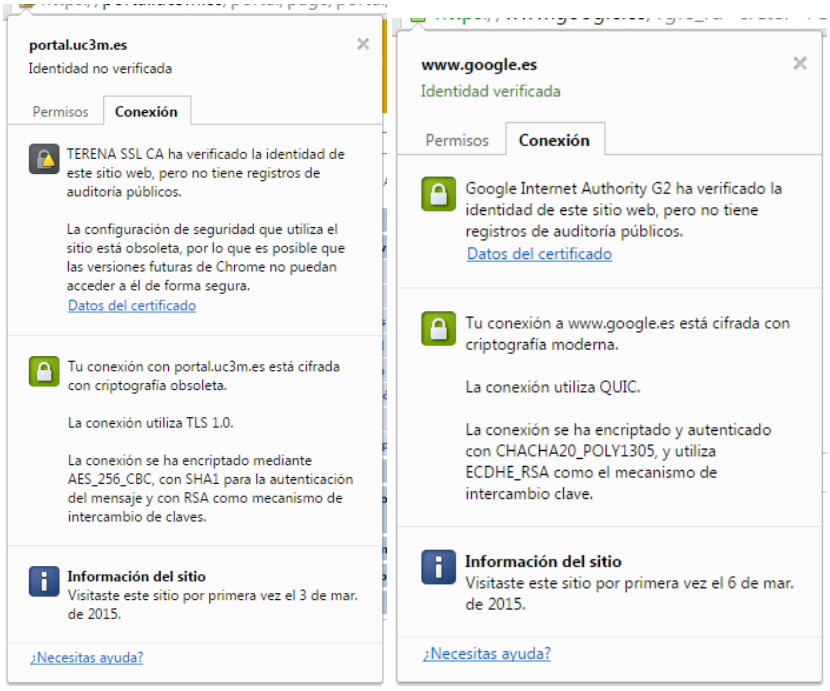




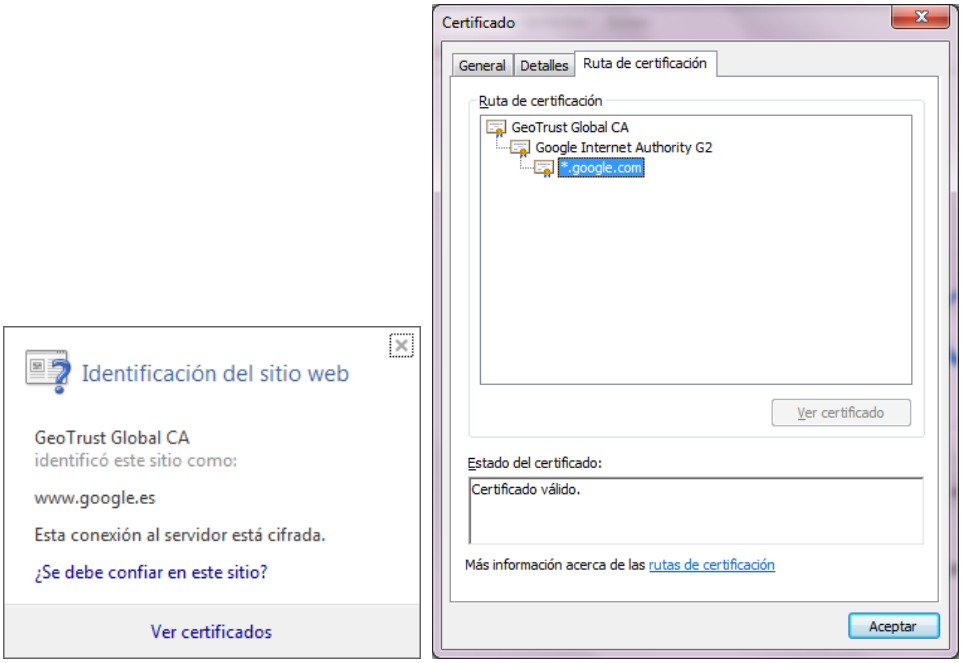


With Chrome:


Certificado
General
Detalles
Ruta de certificación
Ruta de certificación
AddTrust External CA Root
UTN-USERFirst-Hardware
TERENA SSL CA
www.uc3m.es
Ver certificado
Estado del certificado:
Certificado válido.
Más información acerca de las rutas de certificación
Aceptar
Certificado
General
Detalles
Ruta de certificación
Ruta de certificación
GeoTrust Global CA
Google Internet Authority G2
*.google.es
Ver certificado
Estado del certificado:
Certificado válido.
Más información acerca de las rutas de certificación
Aceptar


portal.uc3m.es
Identidad no verificada
Permisos
Conexión
TERENA SSL CA ha verificado la identidad de este sitio web, pero no tiene registros de auditoría públicos.
La configuración de seguridad que utiliza el sitio está obsoleta, por lo que es posible que las versiones futuras de Chrome no puedan acceder a él de forma segura.
Datos del certificado
Tu conexión con portal.uc3m.es está cifrada con criptografía obsoleta.
La conexión utiliza TLS 1.0.
La conexión se ha encriptado mediante AES_256_CBC, con SHA1 para la autenticación del mensaje y con RSA como mecanismo de intercambio de claves.
Información del sitio
Visitaste este sitio por primera vez el 3 de mar. de 2015.
¿Necesitas ayuda?
www.google.es
Identidad verificada
Permisos
Conexión
Google Internet Authority G2 ha verificado la identidad de este sitio web, pero no tiene registros de auditoría públicos.
Datos del certificado
Tu conexión a www.google.es está cifrada con criptografía moderna.
La conexión utiliza QUIC.
La conexión se ha encriptado y autenticado con CHACHA20_POLY1305, y utiliza ECDHE_RSA como el mecanismo de intercambio clave.
Información del sitio
Visitaste este sitio por primera vez el 6 de mar. de 2015.
¿Necesitas ayuda?

With Internet Explorer:



Web browser. Server side

Exercise 3:

14. Open a browser and point it to https://letsencrypt.org
    a. Which is the purpose of this webpage?
    b. Which are the pros of the server public key certificates issued y Let's encrypt?

Solution:

Free, automatic recognition in popular browsers, easy installation and transparent.