Public-Key Infrastructure (PKI) Lab

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Instruction: https://seedsecuritylabs.org/Labs_16.04/PDF/Crypto_PKI.pdf

Task 1

Copy the configuration file into current directory:

```
cp /usr/lib/ssl/openssl.cnf ./openssl.cnf
```

create new sub-directories and files according to what it specifies in its `[ CA_default ]` section:

```
dir = ./demoCA # Where everything is kept
certs = $dir/certs # Where the issued certs are kept
crl_dir = $dir/crl # Where the issued crl are kept
new_certs_dir = $dir/newcerts # default place for new certs.
database = $dir/index.txt # database index file.
serial = $dir/serial # The current serial number
```

Simply create an empty file for `index.txt`, put a single number in string format in `serial`:

```
mkdir ./demoCA
cd ./demoCA
mkdir certs
mkdir crl
mkdir newcerts
touch index.txt
echo "1000" > serial
```

Start to generate the self-signed certificate for the CA:

```
# return to the parent directory
# cd ..
openssl req -new -x509 -keyout ca.key -out ca.crt -config
    openssl.cnf
```

Notice that we apply `policy_match` in `openssl.cnf`, so we should keep some fields the same when creating certificates for CA and servers:

```
[ policy_match ]
countryName     = match
stateOrProvinceName = match
organizationName    = match
organizationalUnitName  = optional
commonName      = supplied
emailAddress        = optional
```

When asked to type PEM pass phrase, remember the password you typed (e.g. I use `114514`). It will then ask you to fill in some information, you can skip it by Enter, except for those required by `policy_match`.

> The output of the command are stored in two files: `ca.key` and `ca.crt`. The file `ca.key` contains the CA's **private key**, while `ca.crt` contains the **public-key certificate**.

Task 2

As a root CA, we are ready to sign a digital certificate for `SEEDPKILab2018.com`.

Step 1: Generate public/private key pair

Generate an RSA key pair. Provide a pass phrase (e.g. I use `soudayo`) to encrypt the private key in `server.key` using AES-128 encryption algorithm.

```
openssl genrsa -aes128 -out server.key 1024
```

To see the actual content in `server.key` (pass phrase required):

```
openssl rsa -in server.key -text
```

Step 2: Generate a Certificate Signing Request (CSR)

Use `SEEDPKILab2018.com` as the common name of the certificate request

```
openssl req -new -key server.key -out server.csr -config
    openssl.cnf
```

Skip the unnecessary information as well, keep the necessary information (required by `policy_match` consistent with the `CA.crt` created in Task 1).

Now, the new Certificate Signing Request is saved in `server.csr`, which basically includes the company's public key.

> The CSR will be sent to the CA, who will generate a certificate for the key (usually after ensuring that identity information in the CSR matches with the server's true identity)

Step 3: Generating Certificates

In this lab, we will use our own trusted CA to generate certificates.

Use `ca.crt` and `ca.key` to convert `server.csr` to `server.crt`:

```
openssl ca -in server.csr -out server.crt -cert ca.crt -keyfile
    ca.key \
-config openssl.cnf
```

Task 3

Step 1: Configuring DNS

Open and edit `/etc/hosts`:

```
sudo gedit /etc/hosts
```

Add one line:

```
127.0.0.1 SEEDPKILab2018.com
```

Step 2: Configuring the web server

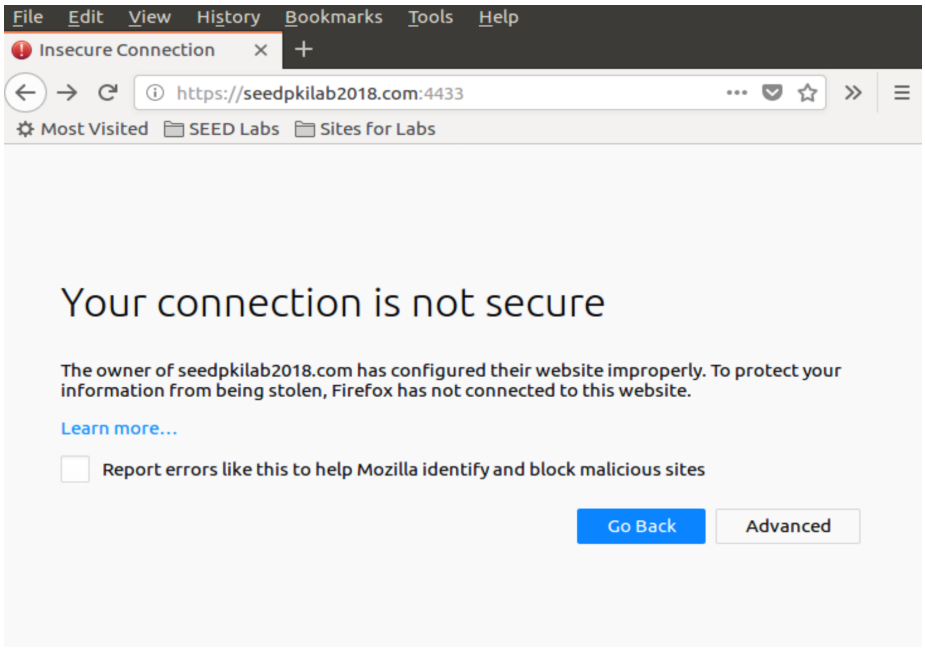
Combine the secret key and certificate into one single file `server.pem`:

```
cp server.key server.pem
cat server.crt >> server.pem
```

Launch the web server using `server.pem`:

```
openssl s_server -cert server.pem -www
```

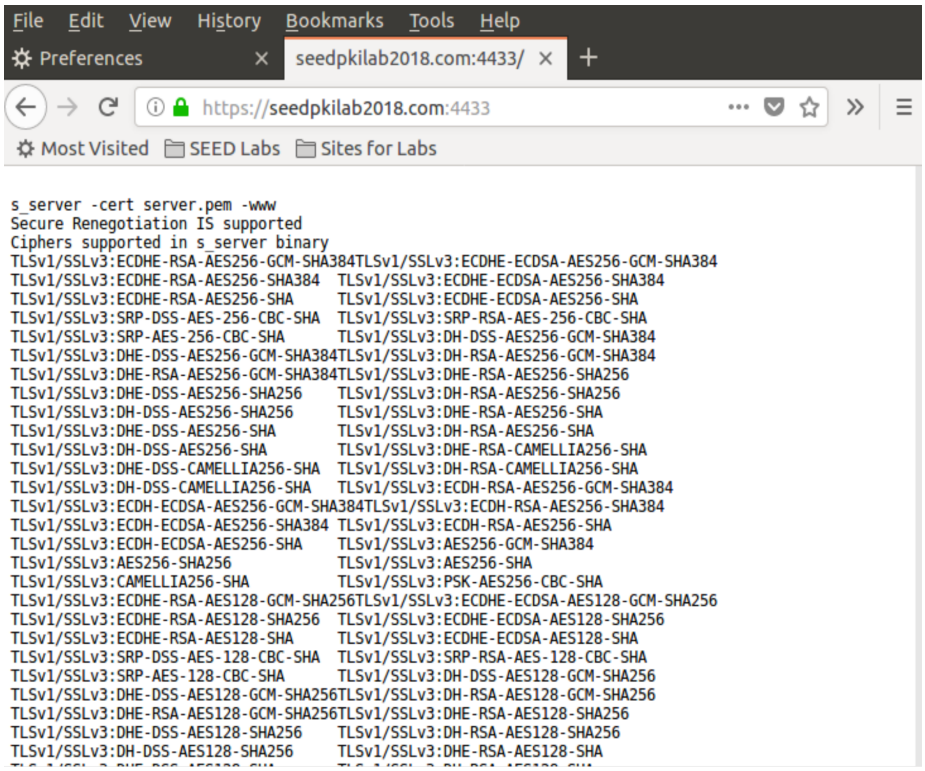
Now, the server is listening on port 4433. Browser https://seedpkilab2018.com:4433/



Step 3: Getting the browser to accept our CA certificate.

Search for "certificate" in Firefox's Preferences page, click on "View Certificates" and enter "certificate manager", click on "Authorities tab" and import `CA.crt`. Check "Trust this CA to identify web sites".

Reload https://seedpkilab2018.com:4433/.



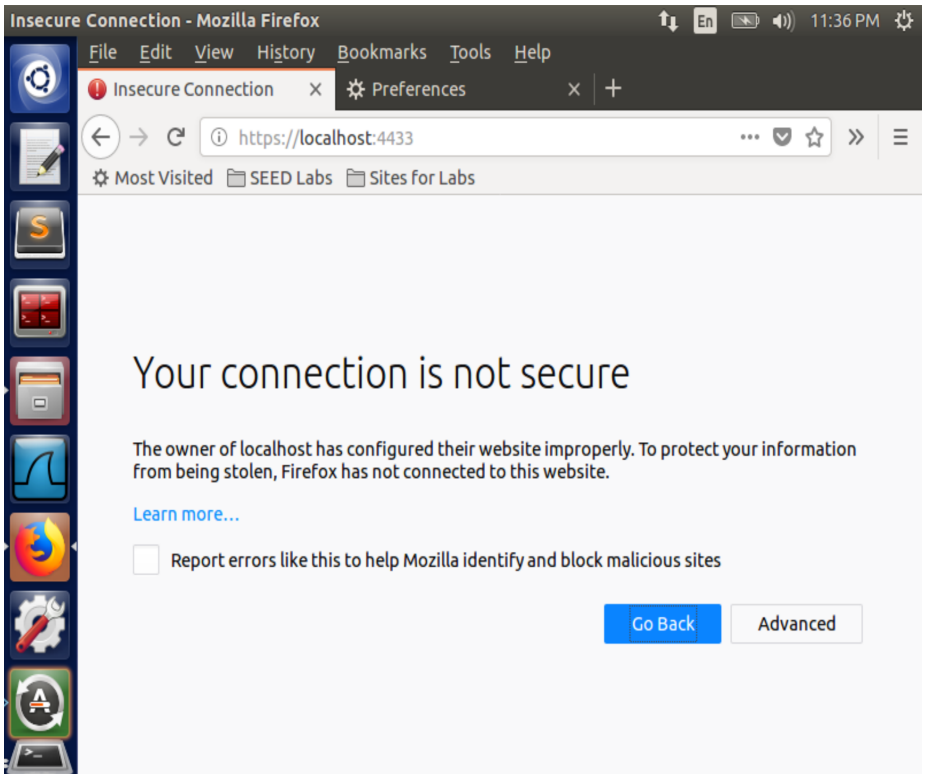
Step 4. Testing our HTTPS website

Modify one byte in `server.pem`

It's up to which byte you modify. Most bytes make no differences after corrupted. But some will make the certificate invalid.

Use localhost

When browsing `https://localhost:4433`, it is reported unsafe HTTPS



Because the `localhost` has no certificate, the website is using a certificate identified for `seedpkilab2018.com`.

Task 4

Open configuration file of Apache HTTPS server:

```
sudo gedit /etc/apache2/sites-available/default-ssl.conf
```

Add the entry and save:

```
<VirtualHost *:443>
        ServerName SEEDPKILab2018.com
        DocumentRoot /var/www/pki
        DirectoryIndex index.html

        SSLEngine On
        SSLCertificateFile /var/www/pki/server.crt
        SSLCertificateKeyFile /var/www/pki/server.pem
</VirtualHost>
```

Copy the server certificate and private key to the folder:

```
sudo mkdir /var/www/pki
sudo cp server.pem server.crt /var/www/pki
```

Test the Apache configuration file for errors:

```
sudo apachectl configtest
```

Enable the SSL module:

```
sudo a2enmod ssl
```

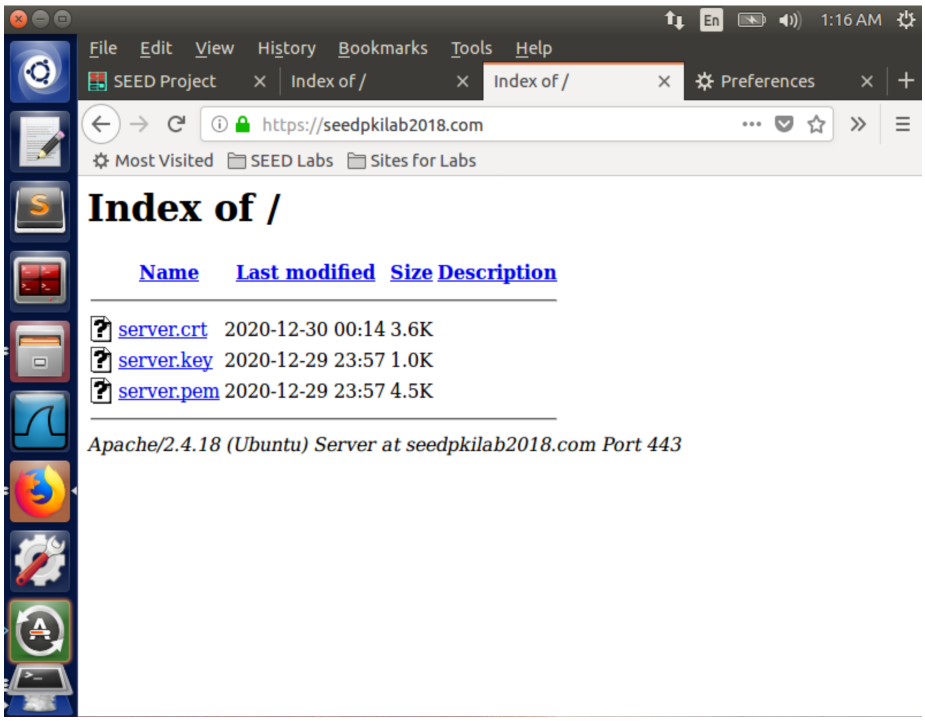
Enable the site we have just edited:

```
sudo a2ensite default-ssl
```

Restart `Apache`:

```
sudo service apache2 restart
```

Once `Apache` runs properly, open https://seedpkilab2018.com/



Task 5

Suppose we still use this VM (`10.0.2.10`) as the malicious server, start another VM (`10.0.2.4`) as the victim.

Generate a certificate for `example.com`

use a password (e.g. I use `islander`):

```
openssl genrsa -aes128 -out example.key 1024
```

Use `example.com` as the common name of the certificate request:

```
openssl req -new -key example.key -out example.csr -config
    openssl.cnf
openssl ca -in example.csr -out example.crt -cert ca.crt
    -keyfile ca.key \
-config openssl.cnf
cp example.key example.pem
cat example.crt >> example.pem
```

Copy the certificate and private key to the website root folder:

```
sudo mkdir /var/www/example
sudo cp example.crt example.pem /var/www/example
```

Config and start the server

On the server VM, open `/etc/apache2/sites-available/default-ssl.conf` and add the following entry:

```
<VirtualHost *:443>
        ServerName example.com
        DocumentRoot /var/www/example
        DirectoryIndex index.html

        SSLEngine On
        SSLCertificateFile /var/www/example/example.crt
        SSLCertificateKeyFile /var/www/example/example.pem
</VirtualHost>
```

Restart `Apache`:

```
sudo apachectl configtest
sudo service apache2 restart
```

Config on Victim VM

On the victim VM, modify `/etc/hosts` by:

```
sudo gedit /etc/hosts
```

add one line before the ending, which emulates a DNS cache positing attack:

```
10.0.2.10    example.com
```

To get the `ca.crt`, listen on a local port like:

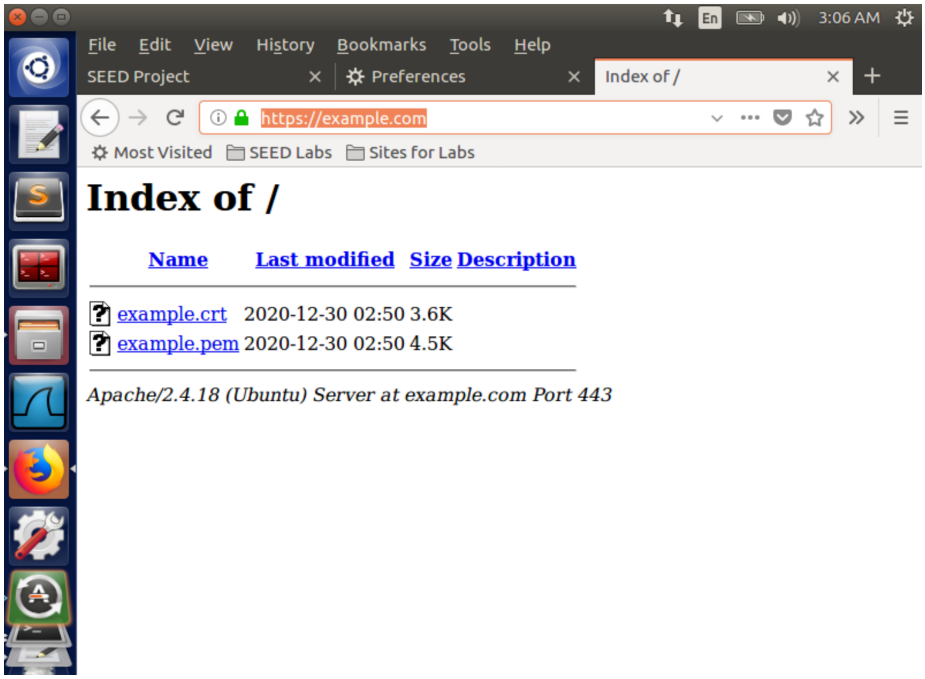
```
nc -lvp 4444 > ca.crt
```

Then on the server VM, we send `ca.crt` by:

```
cat ca.crt | nc 10.0.2.4 4444
```

Once we receive the file on the victim VM, we install it on Firefox as above.

Now, when browsing https://example.com/, the user on this VM actually visit the fake website launched by the malicious server:



Task 6

Based on Task 5, we can assume if the attacker stole `ca.key`, which indicates that he/she can easily generate the CA certificate `ca.crt` by the compromised key:

```
openssl req -new -x509 -keyout ca.key -out ca.crt -config
    openssl.cnf
```

Then, `ca.crt` can be used to sign any server's certificate, including the forged ones. The process of such attacks can be described as what we did before, except

that we don't even need to deploy the `ca.crt` on the victim machine because it has already installed the same `ca.crt`.