21.4.7 Lab - Certificate Authority Stores

This lab has been updated for use on NETLAB+.
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Objectives

Part 1: Certificates Trusted by Your Browser

Part 2: Checking for Man-In-Middle

Background / Scenario

As the web evolved, so did the need for security. *HTTPS* (where the 'S' stands for security) along with the concept of a *Certificate Authority* was introduced by *Netscape* back in 1994 and is still used today. In this lab, you will:

- List all the certificates trusted by your browser (completed on your computer)
- Use hashes to detect if your internet connection is being intercepted (completed in the CyberOps Workstation virtual machine)

Instructions

Part 1: Certificates Trusted by Your Browser

HTTPS relies on a third-party entity for validation. Known as *Certification Authority (CA),* this third-party entity verifies if a domain name really belongs to the organization claiming its ownership. If the verification checks, the *CA* creates a digitally signed certificate containing an information about the organization, including its public key.

The entire system is based on the fact that web browsers and operating systems ship with a list of *CAs* they trust. Any certificates signed by any of the *CAs* in the list will be seen by the browser as legitimate and be automatically trusted. To make the system more secure and more scalable, *CAs* often spread the task of creating and signing certificates among many child *CAs*. The parent *CA* is known as the *Root CA*. If a browser trusts a *Root CA*, it also trusts all of its children *CAs*.

Follow the steps to display the CA store in your browser:

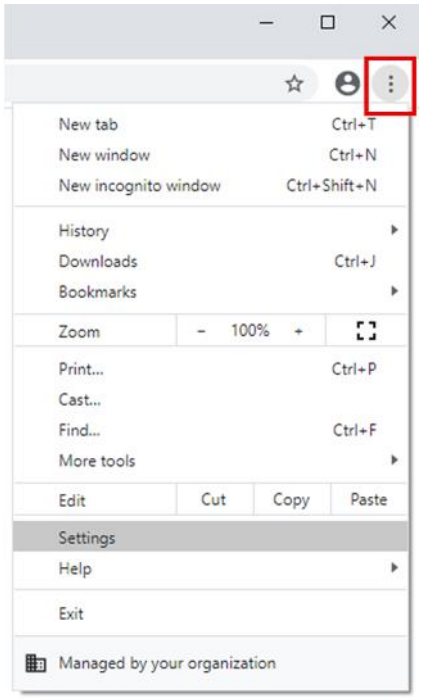
Step 1: Display the Root Certificates in Chrome.

You can do this step on your local machine or use *Firefox* in the **Workstation** VM. If you use *Firefox*, proceed to *Step 2*. If you use a browser other than *Chrome* or *Firefox*, search the internet for the steps to display your root certificates.

Note: The menu and graphics may be different for other versions of the *Chrome* browser.

a. Open the **Chrome** web browser on your PC.

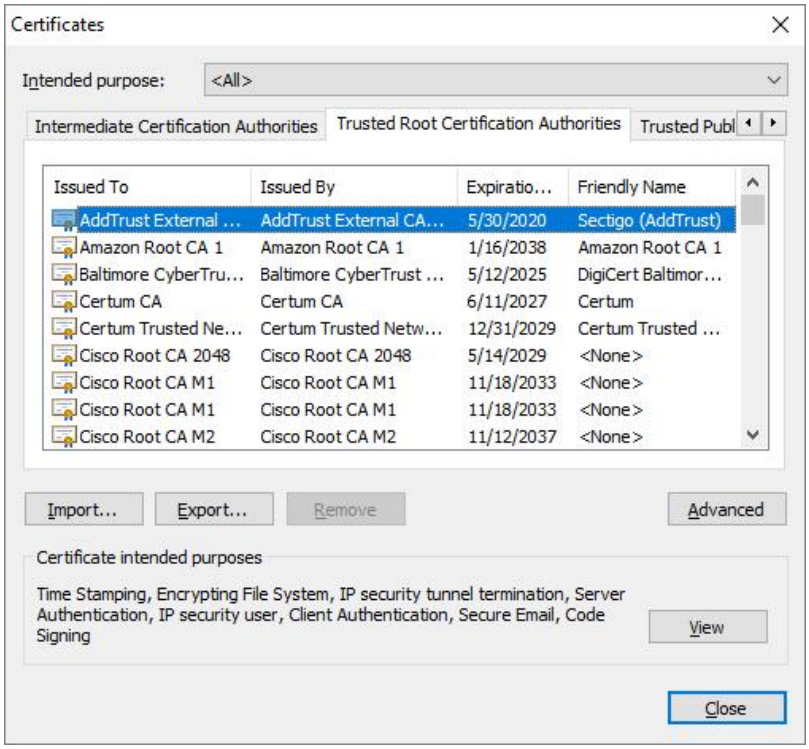
b. Click the three-dot icon on the far right of the address bar to display **Chrome**'s options. Click **Settings**.



c. Scroll down to **Privacy and security** and click **More**.

d. Scroll down and select **Manage certificates**.

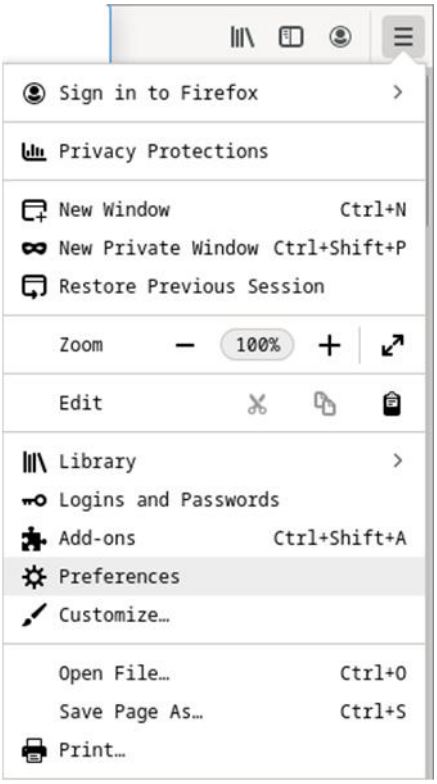
e. In the **Certificates** window, select **Trusted Root Certification Authorities** tab to show all certificates and certificate authorities trusted by **Chrome**.



Step 2: Display the Certificates in the CA Store in Firefox.

Note: The menu and graphics may be different for other versions of the Firefox browser and between different operating systems. **Firefox** on the **Workstation** VM is shown in this step.

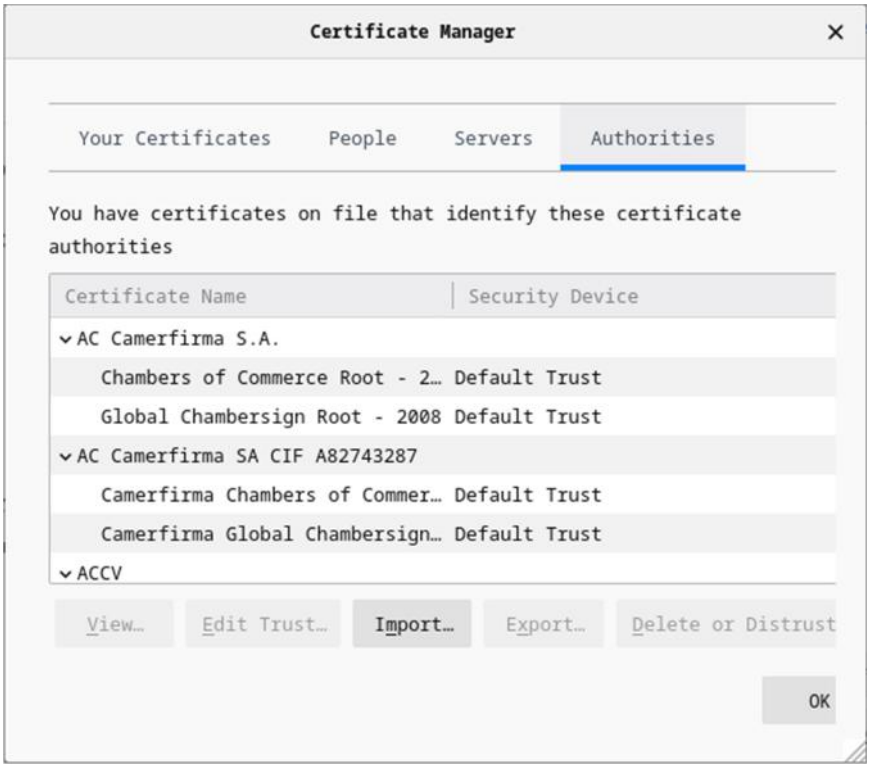
a. Launch the **Workstation** VM and log in with username **analyst** and password **cyberops**. Open **Firefox** and click the **Menu** icon. The *Menu* icon is located on the far right of the Firefox window, next to the address bar. Click **Preferences**.



b. Click **Privacy & Security** in the left panel.

c. Scroll down to the Security section and click **View Certificates**.

d. A window opens that shows the certificates and certification authorities trusted by Firefox.



Part 2: Checking for Man-In-Middle

This part is completed using the **Workstation** VM.

A common use for hashes is to verify data integrity, but they can also be used to detect *HTTPS* man-in-the-middle attacks.

To protect user data, more and more websites are switching to encrypted traffic. Known as *HTTPS*, sites use protocols such as *TLS/SSL* to encrypt user traffic from end to end. After the traffic is properly encrypted, it is very difficult for any party other than the user and the site in question to see the contents of the encrypted message. This is good for the users, but it creates a problem for organizations that want to look into that traffic. Companies and organizations often choose to peek into employee-generated traffic for monitoring purposes. They needed to be able to look into *TLS/SSL*-encrypted traffic. This is done by using an *HTTPS* proxy.

Web browsers trust the identity of a visited web site if the certificate presented by that web site is signed by one of the *CAs* installed in the browser's certificate store. To be able to peek into its users' *TLS/SSL*-encrypted traffic, a company or organization simply adds another *CA* into the user's browser list of installed *CA*.

Consider the following scenario: Company X hires a new employee and provides him with a new company laptop. Before handing over the laptop, the company IT department installs all the software necessary for the work. Among the software and packages that are installed, the IT department also includes one extra *CA* to the list of trusted *CAs*. This extra *CA* points to a company-controlled computer known as the *HTTPS* proxy. Because the company controls traffic patterns, the *HTTPS* proxy can be placed in the middle of any connection. It works like this:

1. The user attempts to establish a secure connection to *HTTPS* web site H, hosted on the internet. H can be any *HTTPS* site: a bank, online store, email server, etc.

2. Because the company controls traffic patterns, it makes it so that all user traffic must traverse the *HTTPS* proxy. The *HTTPS* proxy then *impersonates* web site H and presents a self-signed certificate to prove it is H. The *HTTPS* proxy essentially says "Hi there, I am *HTTPS* site H. Here's my certificate. It's has been signed by… myself."
3. Because the presented certificate is signed by one of the *CAs* included in the laptop's *CA* store (remember, it was added by IT), the web browser mistakenly believes it is indeed communicating with H. Notice that, had the extra *CA* not been added to the *CA* store, the laptop would not trust the certificate and immediately realize that someone else was trying to *impersonate* H.
4. The laptop trusts the connection and establishes a secure channel with the *HTTPS* proxy, mistakenly believing it is communicating securely with H.
5. The *HTTPS* proxy now establishes a second secure connection to H, the web site the user was trying to access from the beginning.
6. The *HTTPS* proxy is now the end point of two separate secure connections; one established with the user and another established with H. Because the *HTTPS* is the end point of both connections, it can now decrypt traffic from both connections.
7. The *HTTPS* proxy can now receive *TLS/SSL*-encrypted user traffic destined to H, decrypt it, inspect it, re-encrypt it using *TLS/SSL* and send it to H. When H responds, the *HTTPS* proxy reverses the process before forwarding the traffic to the user.

Notice that process is mostly transparent to the user, who sees the connection as *TLS/SSL*-encrypted (green marks on the browser). While the connection is secure (*TLS/SSL*-encrypted), it has been established to a spurious web site.

Even though their presence is mostly transparent to the user, *TLS* proxies can be easily detected with the help of hashes. Considering the example above, because the *HTTPS* proxy has no access to the site H private keys, the certificate it presents to the user is different than the certificate presented by H. Included in every certificate is a value known as a *fingerprint.* Essentially a hash calculated and signed by the certificate issuer, the fingerprint acts as a unique summary of all the contents of the certificate. If as much as one letter of the certificate is modified, the fingerprint will yield a completely different value when calculated. Because of this property, fingerprints are used to quickly compare certificates. Returning to the example above, the user can request H's certificate and compare the fingerprint included in it with the one provided when the connection to the web site H was established. If the fingerprints match, the connection is indeed established to H. If the fingerprints do not match, the connection has been established to some other end point.

Follow the steps below to assess if there's a *HTTPS* proxy in your connection.

Step 1: Gathering the correct and unmodified certificate fingerprint.

The table below contains a few site certificate fingerprints from popular sites.

Note: The SHA-1 fingerprints shown in Table 1 may no longer be valid as organizations regularly renew their certificates. A fingerprint is also called a thumbprint in Windows-based machines.

Table 1 - Popular Sites and Their SHA-1 Certificate Fingerprints

Site	Domains Covered By Certificate	Certificate SHA-1 Fingerprint (as of May 2020)
www.cisco.com	www.cisco.com	E2:BD:0B:58:C6:B4:FF:91:D6:23:AB:44:0D:8F:64:76:29:4E:30:0B
www.facebook.com	*.facebook.com	BB:E7:A0:97:C7:92:B2:2D:00:38:12:69:E4:64:E9:04:96:4B:C7:41
www.wikipedia.org	*.wikipedia.org	A8:F9:F7:79:BE:DB:3E:EB:59:F0:1D:A6:34:08:A1:64:5D:28:48:44
twitter.com	twitter.com	73:33:BB:96:1D:DB:9C:0C:4F:E5:1C:FF:68:26:CF:5E:3F:50:AB:96

Site	Domains Covered By Certificate	Certificate SHA-1 Fingerprint (as of May 2020)
www.linkedin.com	www.linkedin.com	04:BC:C5:09:DD:AE:99:40:7E:99:A5:65:32:68:EC:5D:2D:D7:5A:19

What are the fingerprints? Why are they important?

Who calculates fingerprints? How to find them?

Step 2: Gather the certificate fingerprint in use by the CyberOps Workstation VM.

Now that we have the actual fingerprints, it is time to fetch fingerprints from a local host and compare the values. If the fingerprints do not match, the certificate in use does NOT belong to the *HTTPS* site being verified, which means there's an *HTTPS* proxy in between the host computer and the *HTTPS* site being verified. Matching fingerprints means no *HTTPS* proxy is in place.

a. Open a **terminal** and change to the **/home/analyst/lab.support.files/pems/** directory:

```
[analyst@secOps]$ cd lab.support.files/pems/
```

b. Issue the **ls -l** command to view the available files.

```
[analyst@secOps pems]$ ls -l
total 20
-rw-r--r-- 1 analyst analyst 2431 Apr 12 16:00 cisco.pem
-rw-r--r-- 1 analyst analyst 2382 Apr 12 16:01 facebook.pem
-rw-r--r-- 1 analyst analyst 1862 Apr 12 16:03 linkedin.pem
-rw-r--r-- 1 analyst analyst 2455 Apr 12 16:02 twitter.pem
-rw-r--r-- 1 analyst analyst 3296 Apr 12 16:02 wikipedia.pem
```

c. Optionally, use the **cat** command to list the contents of the fetched certificate and stored in the **cisco.pem** text file:

```
[analyst@secOps ~]$ cat cisco.pem
-----BEGIN CERTIFICATE-----
MIIG1zCCBL+gAwIBAgIUKBO9xTQoMemc9zFHNkdMW+SgFO4wDQYJKoZIhvcNAQEL
BQAwXjELMAkGA1UEBhMCVVMxMDAuBgNVBAoTJ0h5ZHJhbnRJRCAoQXZhbGFuY2hl
IENsb3VkIENvcnBvcmF0aW9uKTEdMBsGA1UEAxMUSHlkcmFudElEIFNTTCBJQ0Eg
RzIwHhcNMTcxMjA3MjIxODU1WhcNMTkxMjA3MjIyODAwWjBjMQswCQYDVQQGEwJV
UzELMAkGA1UECAwCQ0ExETAPBgNVBAcMCFNhbiBKb3NlMRwwGgYDVQQKDBNDaXNj
byBTeXN0ZW1zLCBJbmMuMRYwFAYDVQQDDA13d3cuY2lzY28uY29tMIIBIjANBgkq
yvo6dWpJdSircYy8HG0nz4+936+2waIVf1BBQXZUjNVuws74Z/eLIpl2c6tANmE0
q1i7fiWgItjDQ8rfjeX0oto6rvp8AXPjPY6X7PT1ulfhkLYnxqXHPETRwr8l5COO
MDEh95cRxATXNAlWAwLcBT7lDmrGron6rW6hDtuUPPG/rjZeZbNww5p/nT3EXX2L
Rh+m0R4j/tuvy/77YRWyp/VZhmSLrvZEYiVjM2MgCXBvqR+aQ9zWJkw+CAm5Z414
Eiv5RLctegYuBUMGTH1al9r5cuzfwEg2mNkxl4I/mtDro2kDAv7bcTm8T1LsZAO/
```

```
1bWvudsrTA8jksw+1WGAEd9bHi3ZpJPYedlL
-----END CERTIFICATE-----
[analyst@secOps ~]$
```

d. Now that the certificate is saved in the **cisco.pem** text file, use the command below to extract and display its fingerprint:

```
[analyst@secOps ~]$ openssl x509 -noout -in cisco.pem -fingerprint -sha1
SHA1 Fingerprint=64:19:CA:40:E2:1B:3F:92:29:21:A9:CE:60:7D:C9:0C:39:B5:71:3E
[analyst@secOps ~]$
```

Note: Your fingerprint value may be different for two reasons. First, you may be using a different operating system than the **Workstation** VM. Second, certificates are regularly refreshed changing the fingerprint value.

What hash algorithm was used by OpenSSL to calculate the fingerprint?

Why was that specific algorithm chosen? Does it matter?

Step 3: Compare the Fingerprints

Use Table 1 to compare the certificate fingerprint acquired directly from the Cisco HTTPS site with the one acquired from within your network. Recall, fingerprints may change over time.

Do the fingerprints match?

What does it mean?

Is this method 100% foolproof?

Part 3: Challenges (Optional)

a. Check the fingerprints for the sites shown in Table-1 but using your web browser's GUI.

   Hints: Find a way to display the fingerprint through the browser's GUI. Remember: Google is useful in this exercise, and Windows often refers to the Fingerprint as **Thumbprint**.

b. Use the OpenSSL (Part 2, Steps 1 through 3) to check all the fingerprints listed in Table-1

Reflection Question

What would be necessary for the HTTPS proxy to work?