50.020 Network Security Lab 4 PKI Writeup

Setup

1. As instructed in the lab manual, add

- `10.9.0.80 www.amos2025.com`

  to your `/etc/hosts` file to map the domain names to the server's IP address
- ```
  seed@seed:~/Downloads/Labsetup-arm/PKI$ cat /etc/hosts
  127.0.0.1 localhost
  127.0.1.1 seed

  # The following lines are desirable for IPv6 capable hosts
  ::1     ip6-localhost ip6-loopback
  fe00::0 ip6-localnet
  ff00::0 ip6-mcastprefix
  ff02::1 ip6-allnodes
  ff02::2 ip6-allrouters

  # For crypto pki lab4

  10.9.0.80 www.amos2025.com
  ```

Task 1: Becoming a Certification Authority

1. Following the instructions i generated a new CA certificate and private key using OpenSSL

- ```
  seed@seed:~/Downloads/Labsetup-arm/PKI$ openssl req -x509 -newkey rsa:4096 -sha256 -days 3650 \
  -keyout ca.key -out ca.crt
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  Enter PEM pass phrase:
  Verifying - Enter PEM pass phrase:
  -----
  You are about to be asked to enter information that will be incorporated
  into your certificate request.
  What you are about to enter is what is called a Distinguished Name or a DN.
  ```

```
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:SG
State or Province Name (full name) [Some-State]:
Locality Name (eg, city) []:
Organization Name (eg, company) [Internet Widgits Pty Ltd]:
Organizational Unit Name (eg, section) []:
Common Name (e.g. server FQDN or YOUR name) []:
Email Address []:
```

2. Then I run `openssl x509 -in ca.crt -text -noout` and see this output:
    -

```
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            39:86:0a:0f:bd:56:39:35:a2:58:d3:e4:86:49:67:a2:12:2e:1d:10
        Signature Algorithm: sha256WithRSAEncryption
        Issuer: C = SG, ST = Some-State, O = Internet Widgits Pty Ltd
        Validity
            Not Before: Oct 19 09:54:05 2025 GMT
            Not After : Oct 17 09:54:05 2035 GMT
        Subject: C = SG, ST = Some-State, O = Internet Widgits Pty Ltd
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (4096 bit)
                Modulus:
                    00:b0:53:f6:2e:34:9d:72:5c:69:ad:6a:d8:db:f4:
                    42:31:48:72:39:c2:0f:54:d6:22:64:05:7b:b7:d9:
                    f8:1b:ea:df:b0:1c:97:31:7c:12:9c:f9:19:f3:2c:
                    f5:42:a4:5b:14:89:47:a5:a6:a8:f0:bd:64:72:d1:
                    7c:4d:b7:76:38:79:ac:ed:f9:03:13:0d:fb:f5:79:
                    9d:26:b4:7d:19:d9:bc:03:3d:60:3e:fe:db:ff:cf:
                    5b:c5:f8:71:00:65:9e:1d:98:73:f1:77:1c:bb:43:
                    d9:5a:2c:e1:4a:f2:89:5f:02:72:87:dd:6c:74:e5:
                    96:50:5a:f6:ce:f4:9a:9e:e9:00:36:22:bf:d4:be:
                    c8:5c:26:d0:a1:6f:27:c4:64:fa:87:98:50:95:33:
                    4d:86:f3:fe:47:c4:0a:3d:db:d7:e1:90:3f:e9:38:
                    97:2d:34:2f:68:a3:67:34:69:63:3d:7a:2c:e4:d6:
                    66:a2:50:1a:36:95:b2:b5:42:7d:34:93:7b:b8:c4:
                    1b:43:6a:89:d3:df:b3:07:bd:5a:25:b3:38:56:4d:
                    e2:91:c5:ee:79:2c:85:de:33:61:16:7d:9b:8d:f9:
                    09:b5:15:54:79:7f:fa:95:87:00:75:fb:f9:50:c2:
                    7f:89:26:73:9b:7b:47:d8:73:53:e4:37:b5:27:95:
                    96:89:98:75:32:ae:ca:6a:68:a8:f0:f7:93:26:2b:
                    94:20:f4:ae:31:6a:af:4c:40:6b:89:7d:8e:99:e8:
                    de:0c:e2:cc:75:8f:4f:0b:97:a6:13:9f:c3:0f:6a:
                    27:26:a5:d0:fe:ad:2d:98:bd:a0:2e:f0:76:68:d6:
                    89:2c:3c:7d:fc:71:fe:75:df:49:92:0d:b1:3b:3e:
                    12:66:80:05:11:a3:8f:b2:6c:b0:bb:1d:22:15:99:
                    72:44:56:e3:b0:a5:f3:61:39:02:83:93:fe:a5:6b:
                    5b:a8:f7:cd:cf:b8:8f:d4:3e:b3:0f:9f:59:52:09:
                    05:89:45:d9:43:e3:0d:01:31:52:3f:8b:9c:0b:18:
                    59:48:3d:9a:2e:12:73:85:61:51:63:2c:e2:db:71:
```

```
                    e5:44:f5:5d:b7:cb:f5:e4:92:26:b0:a1:ea:87:86:
                    11:dc:a0:f2:03:84:47:ab:2a:88:32:60:27:1a:fb:
                    0d:25:df:f7:86:9e:07:99:38:8d:4d:20:3e:77:c4:
                    ee:10:06:e2:6c:8b:ad:e4:74:70:9b:3f:93:10:48:
                    94:11:a0:3c:e2:fb:c0:1f:fa:0a:05:a4:91:ef:07:
                    ff:34:40:99:ec:7a:02:0e:39:b3:d1:2c:eb:af:d7:
                    27:42:6c:52:2f:3e:f1:14:e4:e2:5c:8c:9e:7c:8b:
                    91:60:1b
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Subject Key Identifier:
                89:93:57:E7:58:22:9D:A0:93:14:45:93:F5:35:CD:2D:6E:B3:58:C6
            X509v3 Authority Key Identifier:
                89:93:57:E7:58:22:9D:A0:93:14:45:93:F5:35:CD:2D:6E:B3:58:C6
            X509v3 Basic Constraints: critical
                CA:TRUE
    Signature Algorithm: sha256WithRSAEncryption
    Signature Value:
        af:95:d0:24:27:1e:e2:2d:72:98:d5:52:1d:48:f0:b1:49:89:
        c0:38:20:09:8f:d2:ac:79:6e:7d:ce:ec:3e:1e:42:fb:06:b8:
        4f:4a:b0:1f:d7:85:94:32:9b:d8:04:1f:df:ac:50:fb:7c:86:
        d7:e6:01:e5:0f:f3:b9:c2:a9:8c:90:ad:c9:6d:4c:52:0f:52:
        01:81:95:bc:5e:ea:a0:7e:8a:72:b4:2b:96:01:08:d2:c4:d3:
        ae:8d:77:63:df:79:37:c0:ba:df:e2:c2:b7:2b:cb:b7:13:70:
        ca:e3:9c:a3:59:3b:b1:d5:91:71:c7:37:1e:d5:15:6a:bd:92:
        80:fe:46:ed:21:87:52:c6:93:a2:00:d7:4d:f9:ed:e7:dd:e5:
        2e:7d:88:93:79:f8:5d:13:5a:69:f4:a8:da:92:0c:64:57:31:
        34:f8:e5:2e:fa:32:11:d5:32:69:3e:e7:0b:df:c7:51:3e:d3:
        35:c2:eb:a3:a0:89:08:60:87:14:02:64:7c:12:89:9a:50:3c:
        86:ae:23:22:10:90:76:83:96:d3:27:4f:6b:cc:41:f7:04:5e:
        3e:ed:92:1b:d3:50:ba:3b:d7:de:f9:0d:36:b1:31:54:07:5a:
        30:4a:55:17:4f:7a:44:46:71:52:ea:32:52:be:b9:ee:ce:96:
        99:c2:30:39:87:45:69:04:e9:de:eb:c8:ef:dc:33:07:2b:16:
        13:46:7b:8a:1a:42:35:d6:7e:0e:4a:f6:8d:95:3e:6f:80:c4:
        f2:1b:73:91:23:68:79:23:a5:e5:8a:ca:49:dc:79:53:be:b6:
        9b:5e:d2:bf:74:4d:24:bb:ae:f1:d9:0a:cb:70:9c:b4:83:27:
        35:ef:f5:36:32:ff:a7:4a:89:42:60:31:7a:b5:63:02:ce:78:
        49:c3:93:c9:db:64:d1:0f:f3:b6:0e:69:dc:3f:95:c0:eb:e4:
        ad:4d:8b:69:dd:32:d2:8f:5f:f7:73:bd:9b:13:14:70:f7:e1:
        9d:ef:b1:10:00:30:fc:92:a6:b4:ec:b7:9c:09:98:f2:0e:bf:
        42:c6:18:6d:52:ac:b9:7d:dc:22:fc:c8:ca:fc:e8:ab:6c:3b:
        34:d3:3b:a7:b5:34:91:c5:02:fc:74:97:f3:84:4f:56:88:da:
```

```
15:08:49:c1:a5:a1:86:41:ec:0a:3c:de:e5:95:38:4d:89:bc:
ed:a3:f5:57:aa:f4:d1:c4:b7:96:87:78:1b:de:a5:f8:77:9a:
cb:c9:9c:0a:e3:dd:64:6d:37:b5:4d:a7:ed:d7:cc:b4:77:2d:
7f:58:cb:c5:18:1b:bd:d2:a0:bb:3a:c0:74:70:55:a3:79:a4:
f4:44:a1:c9:25:f7:4a:ed
```

3. Then i run `openssl rsa -in ca.key -text -noout` and enter the passphrase `dees` to see this output:
    -

```
Private-Key: (4096 bit, 2 primes)
modulus:
    00:b0:53:f6:2e:34:9d:72:5c:69:ad:6a:d8:db:f4:
    42:31:48:72:39:c2:0f:54:d6:22:64:05:7b:b7:d9:
    f8:1b:ea:df:b0:1c:97:31:7c:12:9c:f9:19:f3:2c:
    f5:42:a4:5b:14:89:47:a5:a6:a8:f0:bd:64:72:d1:
    7c:4d:b7:76:38:79:ac:ed:f9:03:13:0d:fb:f5:79:
    9d:26:b4:7d:19:d9:bc:03:3d:60:3e:fe:db:ff:cf:
    5b:c5:f8:71:00:65:9e:1d:98:73:f1:77:1c:bb:43:
    d9:5a:2c:e1:4a:f2:89:5f:02:72:87:dd:6c:74:e5:
    96:50:5a:f6:ce:f4:9a:9e:e9:00:36:22:bf:d4:be:
    c8:5c:26:d0:a1:6f:27:c4:64:fa:87:98:50:95:33:
    4d:86:f3:fe:47:c4:0a:3d:db:d7:e1:90:3f:e9:38:
    97:2d:34:2f:68:a3:67:34:69:63:3d:7a:2c:e4:d6:
    66:a2:50:1a:36:95:b2:b5:42:7d:34:93:7b:b8:c4:
    1b:43:6a:89:d3:df:b3:07:bd:5a:25:b3:38:56:4d:
    e2:91:c5:ee:79:2c:85:de:33:61:16:7d:9b:8d:f9:
    09:b5:15:54:79:7f:fa:95:87:00:75:fb:f9:50:c2:
    7f:89:26:73:9b:7b:47:d8:73:53:e4:37:b5:27:95:
    96:89:98:75:32:ae:ca:6a:68:a8:f0:f7:93:26:2b:
    94:20:f4:ae:31:6a:af:4c:40:6b:89:7d:8e:99:e8:
    de:0c:e2:cc:75:8f:4f:0b:97:a6:13:9f:c3:0f:6a:
    27:26:a5:d0:fe:ad:2d:98:bd:a0:2e:f0:76:68:d6:
    89:2c:3c:7d:fc:71:fe:75:df:49:92:0d:b1:3b:3e:
    12:66:80:05:11:a3:8f:b2:6c:b0:bb:1d:22:15:99:
    72:44:56:e3:b0:a5:f3:61:39:02:83:93:fe:a5:6b:
    5b:a8:f7:cd:cf:b8:8f:d4:3e:b3:0f:9f:59:52:09:
    05:89:45:d9:43:e3:0d:01:31:52:3f:8b:9c:0b:18:
    59:48:3d:9a:2e:12:73:85:61:51:63:2c:e2:db:71:
    e5:44:f5:5d:b7:cb:f5:e4:92:26:b0:a1:ea:87:86:
    11:dc:a0:f2:03:84:47:ab:2a:88:32:60:27:1a:fb:
    0d:25:df:f7:86:9e:07:99:38:8d:4d:20:3e:77:c4:
    ee:10:06:e2:6c:8b:ad:e4:74:70:9b:3f:93:10:48:
    94:11:a0:3c:e2:fb:c0:1f:fa:0a:05:a4:91:ef:07:
    ff:34:40:99:ec:7a:02:0e:39:b3:d1:2c:eb:af:d7:
    27:42:6c:52:2f:3e:f1:14:e4:e2:5c:8c:9e:7c:8b:
    91:60:1b
publicExponent: 65537 (0x10001)
privateExponent:
    07:05:58:d4:8f:28:c3:c0:75:3e:bf:f5:e1:90:30:
    c0:88:9b:6f:bc:4f:e2:f7:61:c8:2c:c5:b7:d4:d8:
    81:b8:10:ef:10:bc:5e:6e:8b:c9:2f:4b:fe:b8:48:
```

```
    0d:be:c0:97:a9:3d:ae:95:5b:bd:b6:34:d5:33:8d:
    29:05:08:92:88:19:c0:21:fd:a2:d9:18:32:b6:84:
    70:e1:97:e7:9b:19:56:e1:af:3e:e2:e3:fc:a4:13:
    89:e6:f2:0c:eb:7e:e7:bb:c5:c6:14:11:93:4d:48:
    ce:c3:e1:b6:9b:c0:a7:85:4f:ed:23:fe:69:0b:29:
    38:8a:de:af:ef:e2:66:38:6d:d7:39:fb:fc:6b:1a:
    4c:3d:09:6a:9c:23:ef:b8:7b:97:41:93:d7:d5:02:
    9d:c0:82:5b:f6:2c:d8:38:b4:38:59:87:89:f0:44:
    68:ba:de:b6:62:67:3e:19:82:27:95:01:4b:9d:53:
    d9:db:a9:a7:89:bf:63:63:41:dc:01:91:58:12:8a:
    e9:5c:c9:1f:24:15:9b:55:c9:4c:9d:fd:bc:c5:fe:
    23:02:c8:13:90:17:c6:78:b2:41:74:7f:e8:9f:c5:
    68:ad:f0:3e:a4:3f:64:8b:cb:13:67:94:8e:48:28:
    4e:dc:36:97:36:c9:ee:0e:ed:84:b5:49:23:c9:db:
    84:0f:1e:68:07:57:6c:25:bf:a3:7c:d1:5b:6c:72:
    b1:ef:43:a3:32:79:7c:0d:46:fe:5d:bb:00:f1:5c:
    45:9d:94:29:a9:87:98:81:55:f9:66:e3:3c:23:0d:
    70:32:4e:fa:56:98:be:15:1d:9a:78:95:62:23:95:
    52:a8:1a:07:e7:6d:ce:12:c0:66:f9:da:aa:de:6f:
    a0:5f:aa:6d:e2:58:54:79:86:b0:39:49:cd:b7:37:
    58:60:88:d4:11:a4:72:af:a3:e9:bc:7d:0c:da:b8:
    78:8f:5e:bb:5b:8e:5f:7b:71:07:3b:18:bc:58:b0:
    9d:86:41:ea:42:c0:5e:54:b2:7d:3f:9a:45:22:3e:
    78:b7:f7:a4:bc:bd:e6:b8:85:cc:e6:58:a9:7a:15:
    05:2a:a8:3d:e0:c2:55:59:c1:9c:1f:5e:8b:0b:b3:
    c2:8a:10:a4:ae:4e:30:7d:40:73:1a:19:a0:b1:17:
    f8:d3:36:f9:c8:97:3c:72:32:ed:0d:2a:fa:42:ed:
    4e:06:d9:ee:fe:55:2e:06:d6:8f:d0:77:be:87:88:
    e7:74:16:d9:0a:db:33:0b:5a:8a:cb:d8:29:b3:35:
    56:98:ae:db:9a:57:e8:f7:30:02:55:04:19:3d:24:
    c1:e0:af:36:83:86:1b:da:c4:47:19:a5:93:b6:e4:
    4f:39
prime1:
    00:da:7d:71:f5:d9:db:ed:69:7d:64:aa:3c:02:bf:
    d3:c2:43:5b:77:64:c2:d0:42:d3:d8:ec:07:52:5f:
    d5:c7:e8:0b:89:85:96:95:6d:f1:93:9f:f3:0a:8c:
    35:6e:00:7d:a2:81:82:c6:a3:00:9b:8d:85:f2:84:
    b6:11:90:dc:ec:1c:5b:9f:54:6c:b2:f5:a4:8a:b8:
    9f:c5:3b:a2:c4:49:b1:5b:b0:fd:0f:c5:94:07:fb:
    22:74:bf:e8:a2:1e:e6:8a:41:51:c7:33:77:c6:00:
    56:2a:7b:84:37:25:39:8e:9d:fd:35:94:7f:ff:6c:
    29:d1:e7:d1:d7:e3:bb:68:2f:37:dc:26:be:b0:65:
```

```
    93:dd:5c:60:b5:72:44:db:87:55:e8:92:60:f9:6d:
    94:66:07:92:6d:2e:c8:98:d3:2b:c1:f4:cd:4a:88:
    7f:f9:f4:b4:e3:81:cd:b8:58:ad:f4:68:99:5b:05:
    ac:15:ab:83:43:fa:ef:43:18:48:1a:a2:11:c2:70:
    d0:f8:4f:c0:d9:9c:20:cf:5b:18:79:60:60:c9:a8:
    73:82:ee:68:cd:a9:2e:1b:2d:24:ed:9d:0e:85:3f:
    1c:4c:b8:6b:82:b3:4e:50:ba:f7:2d:13:5b:7f:be:
    49:d3:8c:26:21:07:94:1a:6d:da:29:5f:34:fa:82:
    df:63
prime2:
    00:ce:99:82:a5:dd:08:fe:d3:38:78:95:99:fa:b5:
    8e:c8:68:ed:30:96:77:4f:fa:0c:25:e6:0c:ef:8c:
    b0:14:af:37:f8:9d:a6:8e:b4:74:90:ce:e3:0d:95:
    6c:8e:f6:42:65:43:32:2e:f0:45:9c:e1:f2:bc:d4:
    38:6b:50:02:af:43:20:53:a1:32:47:64:73:85:3e:
    21:40:07:b9:41:a6:5b:ec:89:a6:9b:9b:af:22:9a:
    57:9b:4a:08:07:b4:12:af:48:d5:8b:2f:03:7b:ec:
    e1:82:31:e6:09:e7:7c:57:d6:6a:8b:e9:77:b1:1d:
    27:40:97:94:ce:07:c3:27:ad:43:39:95:e5:01:08:
    10:8c:be:a3:f9:9c:e5:70:fd:44:ed:0b:ad:2a:79:
    d2:d4:5c:6b:ce:e3:8c:64:2a:15:16:a2:d6:b5:1a:
    f8:e6:0d:46:19:1b:eb:ec:09:1f:cf:b0:4d:43:f1:
    82:35:71:ee:1b:1d:49:ec:19:ce:e8:aa:ec:b6:f1:
    80:c5:4b:37:c2:ba:db:d3:54:b9:2b:62:b5:0f:6e:
    c8:59:37:cd:73:14:d8:68:58:85:a3:18:3d:21:f7:
    c9:45:9a:f0:89:df:52:c2:c3:6e:b8:a1:05:fb:7c:
    e2:48:b6:6a:f3:91:90:cb:3a:1a:1c:8b:e9:64:06:
    65:e9
exponent1:
    00:9e:1e:12:8e:dd:2e:ef:cd:5b:d5:b1:ec:e4:00:
    76:fb:2b:4b:d2:47:b5:44:8a:58:4d:af:e2:4c:96:
    d6:5b:69:6e:90:03:81:4a:7a:da:4c:ff:80:1f:ae:
    00:2c:af:66:3c:68:85:7f:c3:0e:f9:83:9d:e0:38:
    72:9a:9b:bf:85:8f:b0:2e:ca:26:30:0c:dd:1b:17:
    29:68:cf:13:a8:01:bc:bc:a2:85:41:18:b7:5c:5f:
    3e:3c:47:75:cf:7d:95:51:90:9b:e2:11:39:28:ad:
    ad:ad:e8:dd:72:1b:1a:60:3f:ad:b3:4c:d8:a4:bc:
    5e:37:6e:10:ca:b0:20:3b:f1:8f:f7:5e:82:b9:9d:
    89:38:b5:55:b7:7a:0e:a2:e0:7a:27:69:67:8c:9a:
    e4:be:41:d4:91:f7:3d:6c:7b:c6:3b:03:32:5e:32:
    12:8b:8d:b0:2a:c5:11:5f:cb:ad:78:27:0a:74:78:
    d2:64:8c:4e:de:af:86:df:83:7f:0a:e7:26:fb:14:
```

```
    31:e6:c1:b0:ca:ca:d6:63:b9:85:28:b1:ba:d9:b5:
    72:82:da:8e:35:e7:ad:5a:35:7d:78:08:25:2e:00:
    d2:36:23:70:8a:91:c0:a7:63:e6:e5:54:10:ef:8d:
    82:57:fa:20:cd:de:72:2b:fe:3b:d7:9c:f2:f6:28:
    28:09
exponent2:
    00:b1:db:1f:c8:f0:4f:45:28:cb:0d:ac:24:81:db:
    79:0e:f8:9d:70:dd:a7:db:36:f4:ec:4f:6e:c5:6e:
    c5:4b:19:48:c3:03:dd:16:2f:2d:c6:58:04:c9:75:
    e0:9d:f6:4c:54:66:93:b6:2a:ec:92:d1:45:29:e0:
    3c:ad:cd:94:72:13:04:aa:5a:34:31:97:bd:87:70:
    64:29:7e:3c:b2:d2:a7:82:2b:42:3d:e5:b9:d0:bd:
    34:3c:20:70:67:49:53:68:88:f8:25:39:14:f3:c3:
    8a:a3:8d:97:6e:e1:54:7f:3d:bc:3d:b4:80:70:fe:
    1b:03:95:3a:ea:5f:6e:57:22:e6:a3:95:72:2f:00:
    25:57:34:eb:6f:00:ed:d8:e6:80:46:dd:6d:77:0a:
    a7:40:60:4c:03:30:8b:74:d3:71:92:2a:1f:52:8b:
    e4:c8:0f:97:50:18:64:72:af:ac:2e:1c:a5:77:9f:
    5a:ab:ed:e7:c0:79:e7:60:95:1b:35:db:a7:ab:1a:
    9e:f3:b9:fc:47:ec:9b:40:04:48:e0:9b:ba:29:8e:
    02:76:23:fe:ff:5a:6b:ae:f0:be:23:18:c3:d0:11:
    43:b9:63:58:3e:28:fe:53:62:f1:57:8a:6f:de:ff:
    b4:c2:4a:20:2a:8d:1f:2c:85:59:63:47:e3:65:53:
    c8:b9
coefficient:
    00:ab:24:1c:a1:40:6a:e7:15:1a:97:84:b3:bc:82:
    4b:10:dc:bc:f2:95:90:35:1d:0c:a8:8c:c5:78:ac:
    ec:e2:89:70:cc:a1:86:0e:26:9c:03:ae:26:f7:16:
    b1:85:ef:3b:c2:7f:17:f1:c3:a1:69:f8:52:73:d0:
    89:2e:7f:ae:16:50:b4:45:b0:c3:45:ff:5c:15:38:
    e0:51:11:1d:04:43:b9:78:30:8e:e7:0b:36:0b:60:
    f7:23:18:48:9a:e7:1c:b3:2b:87:5e:94:67:a7:3e:
    5d:2c:55:e9:ea:13:af:f8:61:84:60:69:4a:7c:8f:
    76:c4:dc:90:b8:93:c6:39:ff:04:01:b2:a1:0c:45:
    4a:4e:a8:cf:e0:45:a3:80:c4:a8:91:fa:38:9f:43:
    d0:33:f3:67:14:33:15:63:b2:43:11:90:2c:3e:f6:
    32:ca:cc:35:5d:43:cf:43:83:51:f2:2c:16:87:16:
    dc:6c:78:42:6a:7d:02:13:05:c2:2f:b6:e9:58:80:
    78:51:65:9f:83:69:8b:fc:47:ff:f4:c0:e1:5e:7d:
    c7:2d:f3:81:ef:f0:97:a2:f5:42:d6:a2:b5:ef:06:
    58:1b:d3:b4:a9:28:ce:6a:4d:a7:9d:86:a9:09:bf:
    bc:be:ce:a1:db:10:c8:89:4a:d4:8a:88:0c:96:1b:
```

```
64:0b
```

Task 1: Questions

1. What part of the certificate indicates this is a CA's certificate?
    - From the x509v3 extensions section, the `X509v3 Basic Constraints: critical CA:TRUE` indicates that this is a CA's certificate.
2. What part of the certificate indicates this is a self-signed certificate?
    - Similarly from the x509v3 extensions section, the Issuer section, `Issuer: C = SG, ST = Some-State, O = Internet Widgits Pty Ltd` and the Subject section, `Subject: C = SG, ST = Some-State, O = Internet Widgits Pty Ltd` are the same, indicating that this is a self-signed certificate.
3. In the RSA algorithm, we have a public exponent e, a private exponent d, a modulus n, and two secret numbers p and q, such that n = pq. Please identify the values for these elements in your certificate and key files.
    - From the `ca.key` file, the modulus is the value under `modulus`,
        -

```
modulus:
    00:b0:53:f6:2e:34:9d:72:5c:69:ad:6a:d8:db:f4:
    42:31:48:72:39:c2:0f:54:d6:22:64:05:7b:b7:d9:
    f8:1b:ea:df:b0:1c:97:31:7c:12:9c:f9:19:f3:2c:
    f5:42:a4:5b:14:89:47:a5:a6:a8:f0:bd:64:72:d1:
    7c:4d:b7:76:38:79:ac:ed:f9:03:13:0d:fb:f5:79:
    9d:26:b4:7d:19:d9:bc:03:3d:60:3e:fe:db:ff:cf:
    5b:c5:f8:71:00:65:9e:1d:98:73:f1:77:1c:bb:43:
    d9:5a:2c:e1:4a:f2:89:5f:02:72:87:dd:6c:74:e5:
    96:50:5a:f6:ce:f4:9a:9e:e9:00:36:22:bf:d4:be:
    c8:5c:26:d0:a1:6f:27:c4:64:fa:87:98:50:95:33:
    4d:86:f3:fe:47:c4:0a:3d:db:d7:e1:90:3f:e9:38:
    97:2d:34:2f:68:a3:67:34:69:63:3d:7a:2c:e4:d6:
    66:a2:50:1a:36:95:b2:b5:42:7d:34:93:7b:b8:c4:
    1b:43:6a:89:d3:df:b3:07:bd:5a:25:b3:38:56:4d:
    e2:91:c5:ee:79:2c:85:de:33:61:16:7d:9b:8d:f9:
    09:b5:15:54:79:7f:fa:95:87:00:75:fb:f9:50:c2:
    7f:89:26:73:9b:7b:47:d8:73:53:e4:37:b5:27:95:
    96:89:98:75:32:ae:ca:6a:68:a8:f0:f7:93:26:2b:
    94:20:f4:ae:31:6a:af:4c:40:6b:89:7d:8e:99:e8:
    de:0c:e2:cc:75:8f:4f:0b:97:a6:13:9f:c3:0f:6a:
    27:26:a5:d0:fe:ad:2d:98:bd:a0:2e:f0:76:68:d6:
    89:2c:3c:7d:fc:71:fe:75:df:49:92:0d:b1:3b:3e:
    12:66:80:05:11:a3:8f:b2:6c:b0:bb:1d:22:15:99:
    72:44:56:e3:b0:a5:f3:61:39:02:83:93:fe:a5:6b:
    5b:a8:f7:cd:cf:b8:8f:d4:3e:b3:0f:9f:59:52:09:
    05:89:45:d9:43:e3:0d:01:31:52:3f:8b:9c:0b:18:
    59:48:3d:9a:2e:12:73:85:61:51:63:2c:e2:db:71:
    e5:44:f5:5d:b7:cb:f5:e4:92:26:b0:a1:ea:87:86:
    11:dc:a0:f2:03:84:47:ab:2a:88:32:60:27:1a:fb:
    0d:25:df:f7:86:9e:07:99:38:8d:4d:20:3e:77:c4:
    ee:10:06:e2:6c:8b:ad:e4:74:70:9b:3f:93:10:48:
    94:11:a0:3c:e2:fb:c0:1f:fa:0a:05:a4:91:ef:07:
    ff:34:40:99:ec:7a:02:0e:39:b3:d1:2c:eb:af:d7:
    27:42:6c:52:2f:3e:f1:14:e4:e2:5c:8c:9e:7c:8b:
    91:60:1b
```

- the public exponent e is the value under `publicExponent`,
  - `publicExponent: 65537 (0x10001)`
- the private exponent d is the value under `privateExponent`,
  -

```
privateExponent:
07:05:58:d4:8f:28:c3:c0:75:3e:bf:f5:e1:90:30:
c0:88:9b:6f:bc:4f:e2:f7:61:c8:2c:c5:b7:d4:d8:
81:b8:10:ef:10:bc:5e:6e:8b:c9:2f:4b:fe:b8:48:
0d:be:c0:97:a9:3d:ae:95:5b:bd:b6:34:d5:33:8d:
29:05:08:92:88:19:c0:21:fd:a2:d9:18:32:b6:84:
70:e1:97:e7:9b:19:56:e1:af:3e:e2:e3:fc:a4:13:
89:e6:f2:0c:eb:7e:e7:bb:c5:c6:14:11:93:4d:48:
ce:c3:e1:b6:9b:c0:a7:85:4f:ed:23:fe:69:0b:29:
38:8a:de:af:ef:e2:66:38:6d:d7:39:fb:fc:6b:1a:
4c:3d:09:6a:9c:23:ef:b8:7b:97:41:93:d7:d5:02:
9d:c0:82:5b:f6:2c:d8:38:b4:38:59:87:89:f0:44:
68:ba:de:b6:62:67:3e:19:82:27:95:01:4b:9d:53:
d9:db:a9:a7:89:bf:63:63:41:dc:01:91:58:12:8a:
e9:5c:c9:1f:24:15:9b:55:c9:4c:9d:fd:bc:c5:fe:
23:02:c8:13:90:17:c6:78:b2:41:74:7f:e8:9f:c5:
68:ad:f0:3e:a4:3f:64:8b:cb:13:67:94:8e:48:28:
4e:dc:36:97:36:c9:ee:0e:ed:84:b5:49:23:c9:db:
84:0f:1e:68:07:57:6c:25:bf:a3:7c:d1:5b:6c:72:
b1:ef:43:a3:32:79:7c:0d:46:fe:5d:bb:00:f1:5c:
45:9d:94:29:a9:87:98:81:55:f9:66:e3:3c:23:0d:
70:32:4e:fa:56:98:be:15:1d:9a:78:95:62:23:95:
52:a8:1a:07:e7:6d:ce:12:c0:66:f9:da:aa:de:6f:
a0:5f:aa:6d:e2:58:54:79:86:b0:39:49:cd:b7:37:
58:60:88:d4:11:a4:72:af:a3:e9:bc:7d:0c:da:b8:
78:8f:5e:bb:5b:8e:5f:7b:71:07:3b:18:bc:58:b0:
9d:86:41:ea:42:c0:5e:54:b2:7d:3f:9a:45:22:3e:
78:b7:f7:a4:bc:bd:e6:b8:85:cc:e6:58:a9:7a:15:
05:2a:a8:3d:e0:c2:55:59:c1:9c:1f:5e:8b:0b:b3:
c2:8a:10:a4:ae:4e:30:7d:40:73:1a:19:a0:b1:17:
f8:d3:36:f9:c8:97:3c:72:32:ed:0d:2a:fa:42:ed:
4e:06:d9:ee:fe:55:2e:06:d6:8f:d0:77:be:87:88:
e7:74:16:d9:0a:db:33:0b:5a:8a:cb:d8:29:b3:35:
56:98:ae:db:9a:57:e8:f7:30:02:55:04:19:3d:24:
c1:e0:af:36:83:86:1b:da:c4:47:19:a5:93:b6:e4:
4f:39
```

- the two secret numbers p and q are the values under `prime1` and `prime2` respectively,
    -

prime1:
00:da:7d:71:f5:d9:db:ed:69:7d:64:aa:3c:02:bf:
d3:c2:43:5b:77:64:c2:d0:42:d3:d8:ec:07:52:5f:
d5:c7:e8:0b:89:85:96:95:6d:f1:93:9f:f3:0a:8c:
35:6e:00:7d:a2:81:82:c6:a3:00:9b:8d:85:f2:84:
b6:11:90:dc:ec:1c:5b:9f:54:6c:b2:f5:a4:8a:b8:
9f:c5:3b:a2:c4:49:b1:5b:b0:fd:0f:c5:94:07:fb:
22:74:bf:e8:a2:1e:e6:8a:41:51:c7:33:77:c6:00:
56:2a:7b:84:37:25:39:8e:9d:fd:35:94:7f:ff:6c:
29:d1:e7:d1:d7:e3:bb:68:2f:37:dc:26:be:b0:65:
93:dd:5c:60:b5:72:44:db:87:55:e8:92:60:f9:6d:
94:66:07:92:6d:2e:c8:98:d3:2b:c1:f4:cd:4a:88:
7f:f9:f4:b4:e3:81:cd:b8:58:ad:f4:68:99:5b:05:
ac:15:ab:83:43:fa:ef:43:18:48:1a:a2:11:c2:70:
d0:f8:4f:c0:d9:9c:20:cf:5b:18:79:60:60:c9:a8:
73:82:ee:68:cd:a9:2e:1b:2d:24:ed:9d:0e:85:3f:
1c:4c:b8:6b:82:b3:4e:50:ba:f7:2d:13:5b:7f:be:
49:d3:8c:26:21:07:94:1a:6d:da:29:5f:34:fa:82:
df:63

- prime2:
00:ce:99:82:a5:dd:08:fe:d3:38:78:95:99:fa:b5:
8e:c8:68:ed:30:96:77:4f:fa:0c:25:e6:0c:ef:8c:
b0:14:af:37:f8:9d:a6:8e:b4:74:90:ce:e3:0d:95:
6c:8e:f6:42:65:43:32:2e:f0:45:9c:e1:f2:bc:d4:
38:6b:50:02:af:43:20:53:a1:32:47:64:73:85:3e:
21:40:07:b9:41:a6:5b:ec:89:a6:9b:9b:af:22:9a:
57:9b:4a:08:07:b4:12:af:48:d5:8b:2f:03:7b:ec:
e1:82:31:e6:09:e7:7c:57:d6:6a:8b:e9:77:b1:1d:
27:40:97:94:ce:07:c3:27:ad:43:39:95:e5:01:08:
10:8c:be:a3:f9:9c:e5:70:fd:44:ed:0b:ad:2a:79:
d2:d4:5c:6b:ce:e3:8c:64:2a:15:16:a2:d6:b5:1a:
f8:e6:0d:46:19:1b:eb:ec:09:1f:cf:b0:4d:43:f1:
82:35:71:ee:1b:1d:49:ec:19:ce:e8:aa:ec:b6:f1:
80:c5:4b:37:c2:ba:db:d3:54:b9:2b:62:b5:0f:6e:
c8:59:37:cd:73:14:d8:68:58:85:a3:18:3d:21:f7:
c9:45:9a:f0:89:df:52:c2:c3:6e:b8:a1:05:fb:7c:
e2:48:b6:6a:f3:91:90:cb:3a:1a:1c:8b:e9:64:06:
65:e9

Task 2: Generating certificate request for webserver

1. Using the command provided in the lab instructions, I generate a new CSR for the webserver `www.amos2025.com` and sign it with my CA certificate.

   - `openssl req -newkey rsa:2048 -sha256 -keyout server.key -out server.csr -subj`

   - then `openssl req -in server.csr -text -noout` gives output:

```
seed@seed:~/Downloads/Labsetup-arm/PKI$ openssl req -in server.csr -text -noout
Certificate Request:
    Data:
        Version: 1 (0x0)
        Subject: CN = www.amos2025.com, O = Amos2025 Inc., C = US
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:bd:f9:c0:2a:13:66:55:2f:1b:e8:85:84:16:b0:
                    cf:f1:1c:2e:2d:ae:68:cd:09:63:ba:a5:df:6e:4d:
                    45:ae:80:f2:fc:bc:73:79:21:7b:ab:d1:7d:35:55:
                    fa:d0:83:48:3a:6c:90:e8:19:87:b9:03:d2:75:3e:
                    73:bd:b7:e8:58:6f:2e:81:c9:ea:cb:f4:bf:6a:2f:
                    33:38:2f:7a:9a:71:47:e8:b4:a9:56:a3:44:0e:51:
                    51:db:db:0b:00:d9:96:7d:28:4f:04:69:8a:61:90:
                    3a:59:a2:6c:6a:6d:17:bb:07:0a:4d:0b:92:77:9b:
                    09:dd:6e:16:c3:1a:0e:21:58:b0:6a:5c:da:ca:7e:
                    59:4d:d2:d9:0c:1a:f9:14:11:a7:27:de:16:b8:76:
                    f8:ae:12:41:e0:c8:50:3d:5c:72:0b:0f:0c:9c:b6:
                    de:f4:12:5b:f1:20:ab:48:b4:7e:ab:43:fe:3a:dc:
                    75:be:97:8f:7f:23:7c:9e:1e:11:19:c8:d7:e2:d2:
                    3a:51:39:77:23:9b:be:99:47:b9:ad:a2:5f:6c:b2:
                    48:ba:fb:f9:ec:1e:b0:fb:8a:cf:57:a1:c0:e7:5f:
                    a7:30:26:6d:ac:e3:44:6a:da:ca:97:d0:76:dc:c1:
                    93:b6:97:d4:6a:de:1d:94:f9:10:d5:ba:ac:ff:10:
                    d6:31
                Exponent: 65537 (0x10001)
        Attributes:
            Requested Extensions:
                X509v3 Subject Alternative Name:
                    DNS:www.amos2025.com, DNS:amos2025.org, DNS:amos2025.net
    Signature Algorithm: sha256WithRSAEncryption
    Signature Value:
        a7:ae:bc:33:c5:f1:b2:0d:fd:41:e2:7e:82:8c:90:59:6d:73:
        1b:6d:41:24:03:52:6f:af:99:29:c8:19:92:74:34:78:34:75:
        9b:8d:47:15:63:68:85:cc:fe:40:78:46:69:d7:97:1e:f1:65:
        90:f2:3d:36:e5:ac:92:5a:a2:57:98:72:6d:65:9d:0e:da:8a:
        f6:0f:9c:0c:0a:6c:b7:f6:79:8a:ae:9c:c0:51:fa:9a:42:bf:
        82:79:94:8e:8d:40:55:f2:b7:05:3c:ff:d4:37:54:e0:22:2e:
        cd:e1:1b:5b:f5:02:ea:ce:7c:04:77:47:17:82:66:81:46:2c:
        ff:4b:de:ec:00:ed:b2:fb:29:fe:46:4e:c8:35:e9:f9:8e:ff:
        8c:33:0a:9b:98:89:41:7b:5e:f3:73:34:5e:b8:b5:29:1f:df:
        3f:6d:8f:39:04:bb:d0:c6:f5:bc:cd:bc:d5:73:76:49:43:78:
        46:9e:0a:82:37:7f:73:e8:e6:09:08:0e:80:54:2b:be:4e:0c:
        44:2e:9d:83:47:a9:a9:72:91:6a:a9:74:9d:2a:d9:08:fe:a5:
        90:57:ec:ac:25:20:60:bc:bd:8b:9b:11:0f:cc:05:8e:17:ea:
        32:71:ed:34:a5:9c:7d:7a:fa:e5:b6:96:d9:e4:6b:b3:4e:9e:
        7c:30:81:bc
```

   - and `openssl rsa -in server.key -passin pass:dees -text -noout` gives output:

```
seed@seed:~/Downloads/Labsetup-arm/PKI$ openssl rsa -in server.key -passin pass:dees -text -noout
Private-Key: (2048 bit, 2 primes)
modulus:
    00:bd:f9:c0:2a:13:66:55:2f:1b:e8:85:84:16:b0:
    cf:f1:1c:2e:2d:ae:68:cd:09:63:ba:a5:df:6e:4d:
    45:ae:80:f2:fc:bc:73:79:21:7b:ab:d1:7d:35:55:
    fa:d0:83:48:3a:6c:90:e8:19:87:b9:03:d2:75:3e:
    73:bd:b7:e8:58:6f:2e:81:c9:ea:cb:f4:bf:6a:2f:
    33:38:2f:7a:9a:71:47:e8:b4:a9:56:a3:44:0e:51:
    51:db:db:0b:00:d9:96:7d:28:4f:04:69:8a:61:90:
```

```
    3a:59:a2:6c:6a:6d:17:bb:07:0a:4d:0b:92:77:9b:
    09:dd:6e:16:c3:1a:0e:21:58:b0:6a:5c:da:ca:7e:
    59:4d:d2:d9:0c:1a:f9:14:11:a7:27:de:16:b8:76:
    f8:ae:12:41:e0:c8:50:3d:5c:72:0b:0f:0c:9c:b6:
    de:f4:12:5b:f1:20:ab:48:b4:7e:ab:43:fe:3a:dc:
    75:be:97:8f:7f:23:7c:9e:1e:11:19:c8:d7:e2:d2:
    3a:51:39:77:23:9b:be:99:47:b9:ad:a2:5f:6c:b2:
    48:ba:fb:f9:ec:1e:b0:fb:8a:cf:57:a1:c0:e7:5f:
    a7:30:26:6d:ac:e3:44:6a:da:ca:97:d0:76:dc:c1:
    93:b6:97:d4:6a:de:1d:94:f9:10:d5:ba:ac:ff:10:
    d6:31
publicExponent: 65537 (0x10001)
privateExponent:
    13:fb:88:bc:84:44:df:d1:f0:38:11:8f:36:c9:cb:
    5d:9b:ae:b9:cc:5e:26:af:05:a7:f4:d9:9f:23:0e:
    a0:cf:dc:7f:3c:1d:53:50:f3:ce:bb:5e:d5:b4:e1:
    08:7c:be:a4:b2:95:bd:6c:2e:0c:06:7c:65:2b:b8:
    05:ed:29:c9:df:8b:ff:47:eb:64:1f:ae:e0:ae:ed:
    4e:cc:23:b3:ca:15:9b:c3:21:0a:c5:6a:9b:ac:ef:
    14:d6:a1:fe:29:64:fc:6e:38:7d:88:d2:6e:f7:ba:
    43:82:63:b0:00:20:9e:62:1b:b1:c5:f5:56:92:5e:
    c3:c5:58:2c:96:79:85:05:3e:3e:15:29:db:f3:47:
    d7:79:82:0e:22:af:76:04:d2:13:ab:4e:09:3e:ec:
    21:3d:68:4d:1f:7b:8e:4c:7f:6c:aa:a6:44:18:2b:
    fe:67:cc:d6:fd:bf:d9:fa:e8:7e:ff:c6:94:01:a4:
    ec:0c:47:99:12:22:a9:dc:40:75:7c:32:c1:68:2e:
    72:ec:79:9b:59:7e:de:99:fb:bb:4e:3c:1e:ae:7b:
    f2:89:dc:a6:2a:01:90:d3:34:22:c6:5f:6e:98:47:
    a5:04:1f:09:aa:9e:87:ab:45:f0:19:b7:1e:60:c5:
    2b:50:0c:b7:6f:9f:ab:5f:9b:7b:a0:0c:27:91:65:
    9f
prime1:
    00:d3:82:15:c3:25:23:16:88:f9:ae:dc:eb:12:f9:
    cd:0d:b7:44:a8:68:c2:bd:1c:58:f0:0e:36:8f:7d:
    9c:ae:5a:9e:6f:1b:81:07:0f:c9:bd:26:2c:96:1d:
    b7:c0:17:80:a4:aa:ef:cd:49:ab:74:46:fb:15:45:
    4f:23:1f:22:49:ae:a4:a6:be:6a:a6:74:a8:41:c1:
    76:70:a1:10:ac:03:8d:55:5c:ac:c8:d4:6c:79:69:
    0f:3d:5c:70:79:ea:39:26:19:99:f5:3c:e4:4b:bf:
```

2. This CSR will be used by the CA in Task 3 to generate a certificate for the webserver.

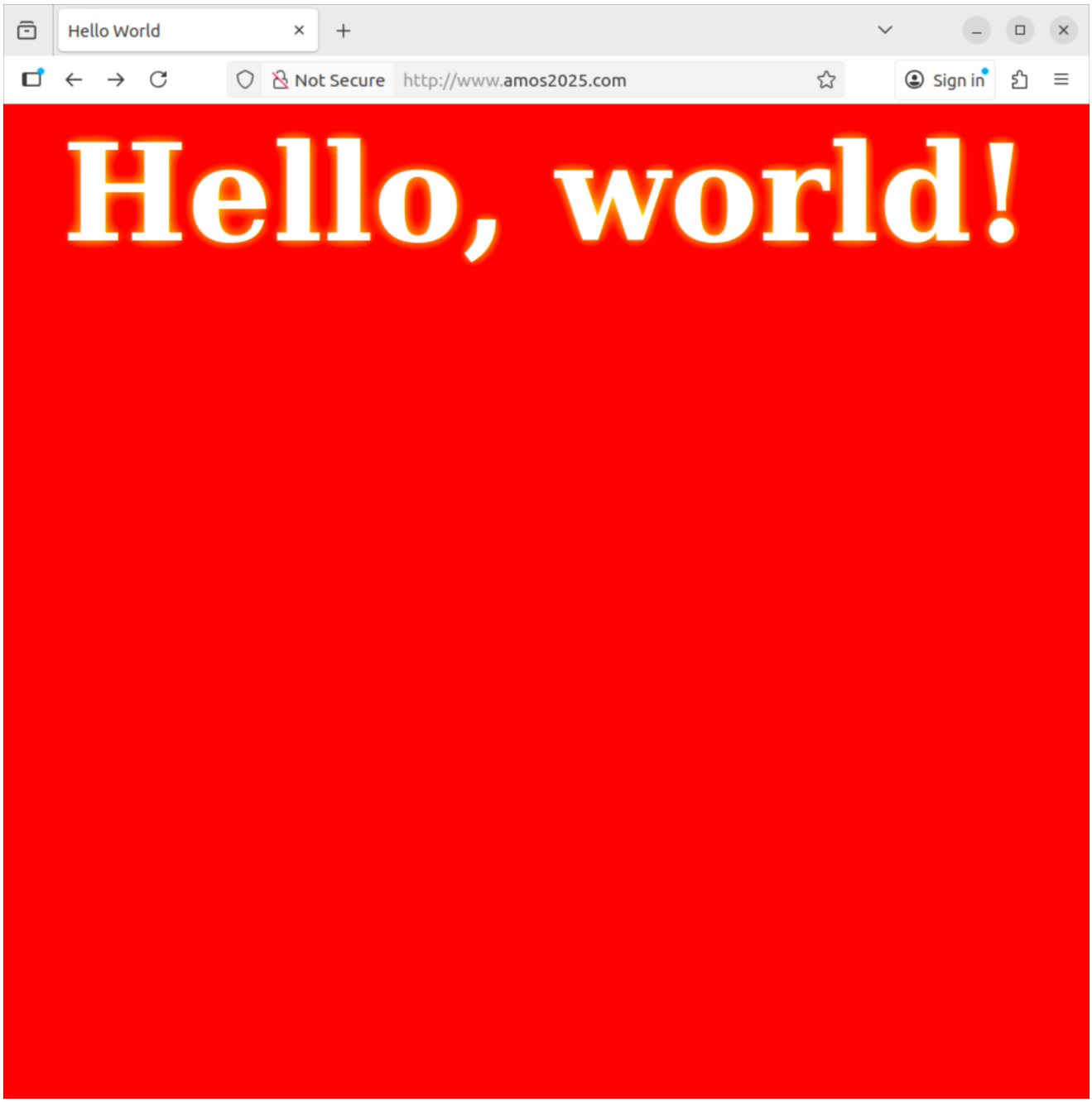
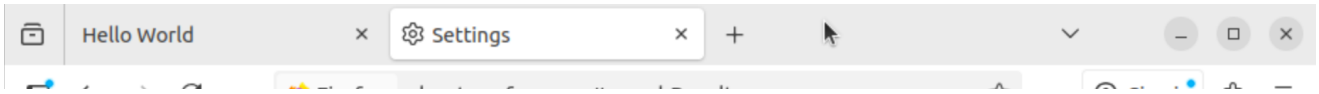
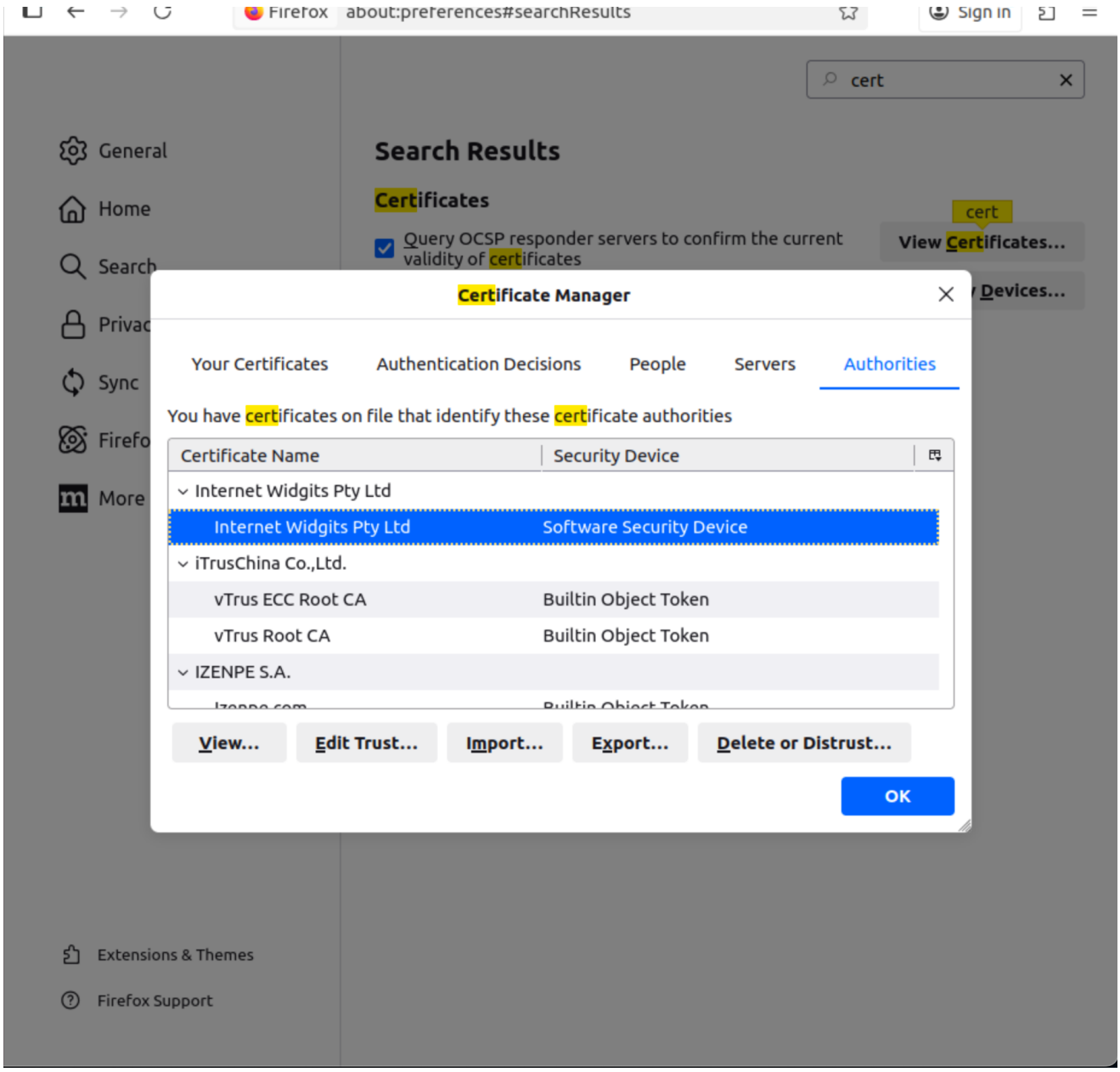
Task 3: Generating a certificate for the webserver

1. Using the command provided in the lab instructions, I generate a new certificate for the webserver `www.amos2025.com` using the CSR generated in Task 2 and sign it with my CA certificate.
   - I set the `copy_extensions = copy` in the `[ usr_cert ]` section of the `openssl.cnf` file to copy the SAN from the CSR to the issued certificate.
   - `openssl ca -config openssl.cnf -policy policy_anything -md sha256 -days 3650`
   - ```
     seed@seed:~/Downloads/Labsetup-arm/PKI$ openssl ca -config myCA_openssl.cnf -policy policy_anything -
     md sha256 -days 3650 -in server.csr -out server.crt -batch -cert ca.crt -keyfile ca.key
     Using configuration from myCA_openssl.cnf
     Enter pass phrase for ca.key:
     Check that the request matches the signature
     Signature ok
     Certificate Details:
             Serial Number: 4660 (0x1234)
             Validity
                 Not Before: Oct 19 10:03:55 2025 GMT
                 Not After : Oct 17 10:03:55 2035 GMT
             Subject:
     ```
     ```

```
            countryName               = US
            organizationName          = Amos2025 Inc.
            commonName                = www.amos2025.com
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            X509v3 Subject Key Identifier:
                9A:8F:16:CA:AE:E8:46:C9:9C:BE:08:C9:C4:FD:65:E1:0E:35:44:03
            X509v3 Authority Key Identifier:
                89:93:57:E7:58:22:9D:A0:93:14:45:93:F5:35:CD:2D:6E:B3:58:C6
            X509v3 Subject Alternative Name:
                DNS:www.amos2025.com, DNS:amos2025.org, DNS:amos2025.net
Certificate is to be certified until Oct 17 10:03:55 2035 GMT (3650 days)

Write out database with 1 new entries
Data Base Updated
```

2. then i run `openssl x509 -in server.crt -text -noout` to view the certificate details:

- ```
  seed@seed:~/Downloads/Labsetup-arm/PKI$ openssl x509 -in server.crt -text -noout
  Certificate:
      Data:
          Version: 3 (0x2)
          Serial Number: 4660 (0x1234)
          Signature Algorithm: sha256WithRSAEncryption
          Issuer: C = SG, ST = Some-State, O = Internet Widgits Pty Ltd
          Validity
              Not Before: Oct 19 10:03:55 2025 GMT
              Not After : Oct 17 10:03:55 2035 GMT
          Subject: C = US, O = Amos2025 Inc., CN = www.amos2025.com
          Subject Public Key Info:
              Public Key Algorithm: rsaEncryption
                  Public-Key: (2048 bit)
                  Modulus:
                      00:bd:f9:c0:2a:13:66:55:2f:1b:e8:85:84:16:b0:
                      cf:f1:1c:2e:2d:ae:68:cd:09:63:ba:a5:df:6e:4d:
                      45:ae:80:f2:fc:bc:73:79:21:7b:ab:d1:7d:35:55:
                      fa:d0:83:48:3a:6c:90:e8:19:87:b9:03:d2:75:3e:
                      73:bd:b7:e8:58:6f:2e:81:c9:ea:cb:f4:bf:6a:2f:
                      33:38:2f:7a:9a:71:47:e8:b4:a9:56:a3:44:0e:51:
                      51:db:db:0b:00:d9:96:7d:28:4f:04:69:8a:61:90:
                      3a:59:a2:6c:6a:6d:17:bb:07:0a:4d:0b:92:77:9b:
                      09:dd:6e:16:c3:1a:0e:21:58:b0:6a:5c:da:ca:7e:
                      59:4d:d2:d9:0c:1a:f9:14:11:a7:27:de:16:b8:76:
                      f8:ae:12:41:e0:c8:50:3d:5c:72:0b:0f:0c:9c:b6:
                      de:f4:12:5b:f1:20:ab:48:b4:7e:ab:43:fe:3a:dc:
                      75:be:97:8f:7f:23:7c:9e:1e:11:19:c8:d7:e2:d2:
                      3a:51:39:77:23:9b:be:99:47:b9:ad:a2:5f:6c:b2:
                      48:ba:fb:f9:ec:1e:b0:fb:8a:cf:57:a1:c0:e7:5f:
                      a7:30:26:6d:ac:e3:44:6a:da:ca:97:d0:76:dc:c1:
                      93:b6:97:d4:6a:de:1d:94:f9:10:d5:ba:ac:ff:10:
                      d6:31
                  Exponent: 65537 (0x10001)
          X509v3 extensions:
              X509v3 Basic Constraints:
                  CA:FALSE
              X509v3 Subject Key Identifier:
                  9A:8F:16:CA:AE:E8:46:C9:9C:BE:08:C9:C4:FD:65:E1:0E:35:44:03
              X509v3 Authority Key Identifier:
                  89:93:57:E7:58:22:9D:A0:93:14:45:93:F5:35:CD:2D:6E:B3:58:C6
              X509v3 Subject Alternative Name:
                  DNS:www.amos2025.com, DNS:amos2025.org, DNS:amos2025.net
      Signature Algorithm: sha256WithRSAEncryption
      Signature Value:
          6b:1a:bc:68:88:a7:a8:a6:53:5d:8d:6f:01:a2:c6:48:68:8f:
          82:64:d0:4c:04:57:da:69:f0:17:a4:e2:9b:5e:00:f4:5d:83:
  ```
  ```

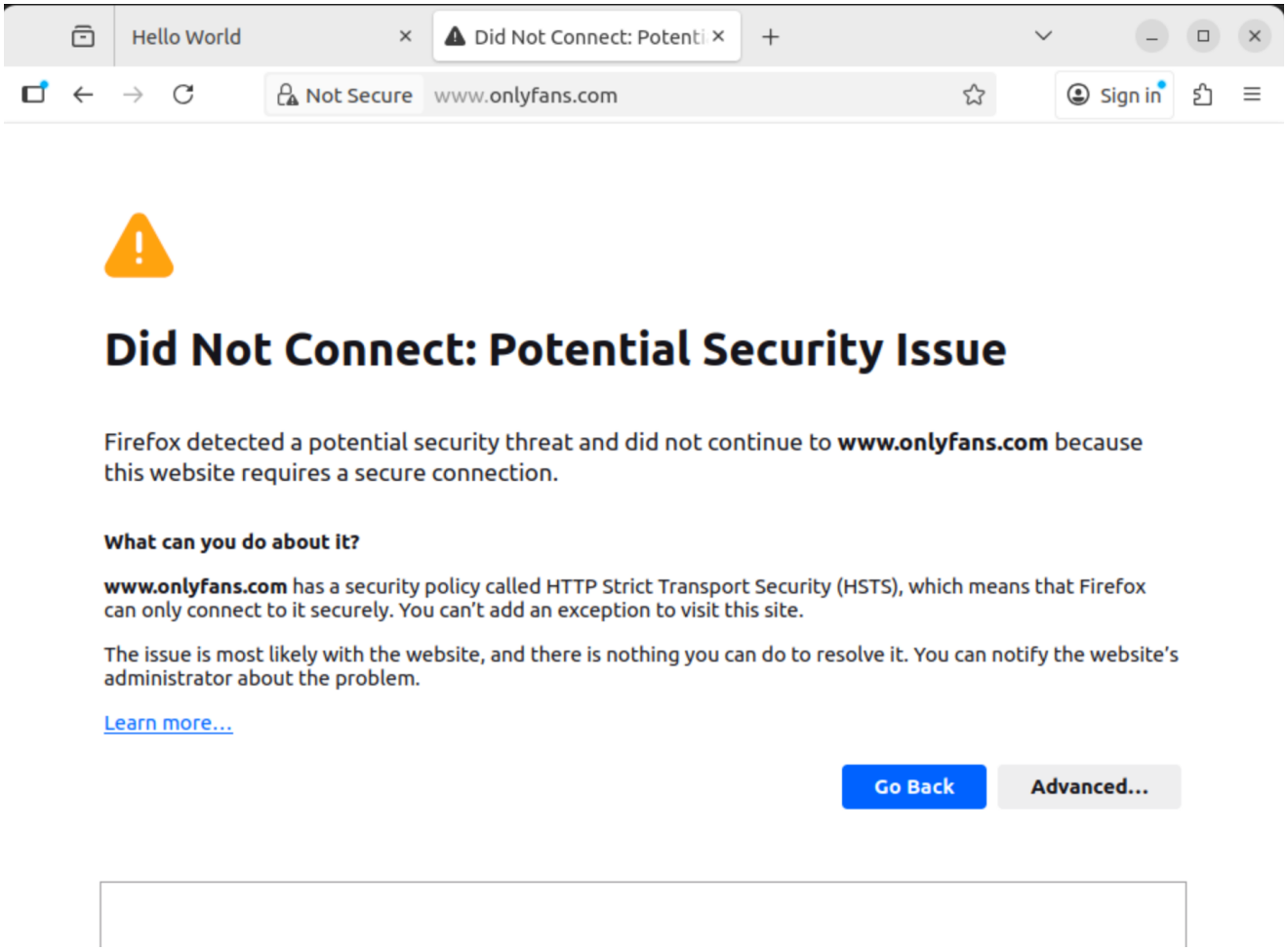
```
56:1c:5a:99:f2:82:3f:63:22:ca:28:0a:0a:b0:14:04:bb:39:
a5:0f:b5:e2:13:3c:76:c0:32:28:b7:f9:4b:b7:89:00:b5:b3:
13:2a:a9:64:bb:4f:7b:da:4e:8c:c0:ec:68:ee:35:2c:0f:bf:
6e:bc:b0:53:94:4f:d6:d1:40:6d:21:d1:d2:54:20:96:35:28:
fc:d8:94:58:8e:15:05:0a:70:0b:c6:40:6c:41:3c:ef:cb:e1:
1c:32:f1:97:18:a6:ed:8d:4e:78:04:75:bf:30:90:90:af:d2:
8a:1f:4e:97:ec:ca:25:f7:4f:9a:ec:b9:e9:68:cd:be:e3:43:
8a:8b:69:64:8a:e3:64:c9:b4:92:fa:f4:7a:1a:dc:4d:33:b8:
23:87:94:79:e0:7b:0e:15:f4:c0:d1:6a:00:5e:ab:e1:7f:46:
45:94:b0:29:f7:44:85:a0:97:11:5e:fc:c8:22:a0:99:69:c0:
88:14:70:e2:1a:00:b6:0c:87:c7:08:68:e7:c3:fd:62:a0:bc:
21:23:18:63:50:b6:9f:f9:d7:b4:84:88:a7:bd:99:12:21:44:
e7:05:4b:1c:28:93:1c:26:d3:c0:6c:8e:73:aa:56:20:f9:2c:
6e:9d:fd:c1:79:ea:7e:ee:41:06:c3:ae:31:de:55:db:ae:ef:
aa:2e:45:0b:5b:b8:11:ba:db:26:90:ff:78:25:25:58:26:85:
35:79:13:4c:a8:d6:d8:f4:46:e6:21:e4:2f:1a:74:ba:d9:95:
23:c4:2b:f1:81:9e:65:2a:13:c3:1f:f3:13:43:8d:d6:67:b0:
2b:1b:f2:a4:95:9b:e0:df:d4:7e:ab:d3:13:8a:05:2a:a2:02:
f1:64:21:2c:b7:b3:c9:81:b8:8e:79:5c:b3:b4:37:44:5b:bc:
e4:bd:4f:19:54:be:5a:4a:6d:30:09:40:21:96:d0:44:2f:61:
f9:b8:00:13:4e:3f:9a:eb:7f:7e:8f:95:2d:b9:84:ef:38:52:
4d:ac:c9:c5:b4:9a:f4:27:be:80:e3:12:12:1e:1b:bd:1d:00:
c2:fb:16:b3:cc:e9:10:51:e2:bb:6a:71:6b:c7:1f:fc:23:42:
8f:24:23:ce:f6:1e:12:9d:3f:d9:84:4a:da:5e:5a:cb:09:5a:
8a:ee:90:18:a6:3e:35:75:da:34:7a:3a:1e:83:be:3d:6a:67:
60:c0:bb:f6:10:b2:f6:25:de:63:9b:bb:e6:9c:ef:05:4a:44:
39:99:bd:c4:b6:72:1e:db
```

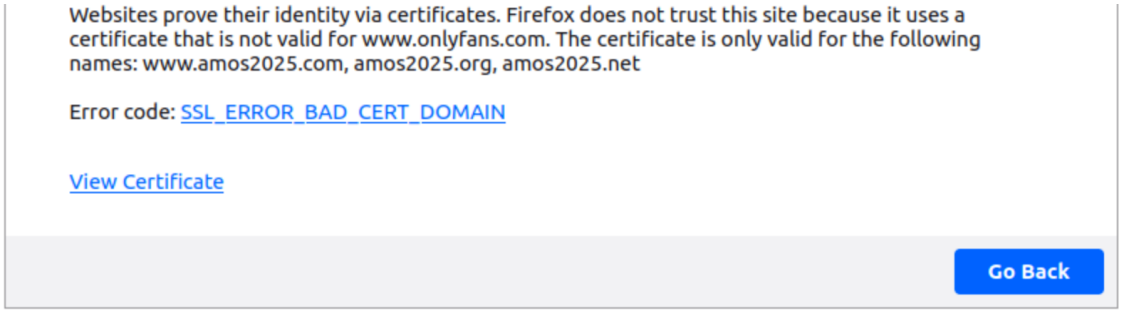
Task 4: Deploying Certificate in an Apache-Based HTTPS Website

1. following the instructions i edited the apache configuration file for my `www.amos2025.com` site to use the generated certificate and private key.
   - ```
     root@d52c2cbb1e49:/etc/apache2/sites-available# cat amos2025_apache_ssl.conf
     <VirtualHost *:443>
         DocumentRoot /var/www/amos2025
         DirectoryIndex index.html
         SSLEngine On
         SSLCertificateFile /certs/server.crt
         SSLCertificateKeyFile /certs/server.key
     </VirtualHost>

     <VirtualHost *:80>
         DocumentRoot /var/www/amos2025
         ServerName www.amos2025.com
         DirectoryIndex index_red.html
     </VirtualHost>

     # Set the following gloal entry to suppress an annoying warning message
     ServerName localhost
     root@d52c2cbb1e49:/etc/apache2/sites-available#
     ```
2. then made a copy of the `server.crt` and `server.key` files to the container and moved them to the directory `/certs/` inside the container.
     ```

3. then i restarted the apache server inside the container to apply the changes, `service apache2 reload` , then `service apache2 restart` .
4. then i try to access the website `www.amos2025.com` on my firefox browser in the host vm, but i see this red page, and that the webpage is not secure.
    - 

    - This is because the browser does not trust my CA certificate yet since it is a sefl-signed certificate, not a certificate issued by a well-known CA.
    - Due to this, the browser is defaulting to `http` instead of `https` , which uses port 80 instead of port 443, and port 80 shows the `index_red.html` page.
5. to fix this, i need to import my CA certificate `ca.crt` into firefox's trusted root certificate authorities.
    - 



6. then now when we try to access the website `https://www.amos2025.com` , we see that the connection is secure and the certificate is trusted, the green website is shown as port 443 is used and the `index.html` page is displayed.

Task 5: Launch Man-in-the-Middle Attack

we are asked to set up the apache server to impersonate some social media website, i chose `www.onlyfans.com` .

1. created the apache2 configuration file for `www.onlyfans.com` site as per task 4
   - ```
     root@d52c2cbb1e49:/etc/apache2/sites-available# cat onlyfans_apache_ssl.conf
     <VirtualHost *:443>
         DocumentRoot /var/www/amos-onlyfans
         ServerName www.onlyfans.com
         DirectoryIndex index.html
         SSLEngine On
         SSLCertificateFile /certs/server.crt
         SSLCertificateKeyFile /certs/server.key
     </VirtualHost>

     <VirtualHost *:80>
         DocumentRoot /var/www/amos-onlyfans
         ServerName www.onlyfans.com
         DirectoryIndex index_red.html
     </VirtualHost>
     ```
2. then i enable this site and restart apache server inside the container.
   - ```
     root@d52c2cbb1e49:/etc/apache2/sites-available# a2enmod ssl
     Considering dependency setenvif for ssl:
     Module setenvif already enabled
     Considering dependency mime for ssl:
     Module mime already enabled
     Considering dependency socache_shmcb for ssl:
     Module socache_shmcb already enabled
     Module ssl already enabled
     root@d52c2cbb1e49:/etc/apache2/sites-available# a2enmod ssl
     Considering dependency setenvif for ssl:
     Module setenvif already enabled
     ```

```
Considering dependency mime for ssl:
Module mime already enabled
Considering dependency socache_shmcb for ssl:
Module socache_shmcb already enabled
Module ssl already enabled
root@d52c2cbb1e49:/etc/apache2/sites-available# a2ensite onlyfans_apache_ssl.conf
Site onlyfans_apache_ssl already enabled
root@d52c2cbb1e49:/etc/apache2/sites-available# service apache2 restart
 * Restarting Apache httpd web server apache2
deAH00558: apache2: Could not reliably determine the server's fully qualified domain name, using 10.9.0.8
0. Set the 'ServerName' directive globally to suppress this message
Enter passphrase for SSL/TLS keys for www.onlyfans.com:443 (RSA):
                                                                                [ OK ]
root@d52c2cbb1e49:/etc/apache2/sites-available#
```

3. then i add an entry in the `/etc/hosts` file of the host VM to map `www.onlyfans.com` to the IP address of the apache server container.
   - ```
     127.0.0.1 localhost
     127.0.1.1 seed

     # The following lines are desirable for IPv6 capable hosts
     ::1     ip6-localhost ip6-loopback
     fe00::0 ip6-localnet
     ff00::0 ip6-mcastprefix
     ff02::1 ip6-allnodes
     ff02::2 ip6-allrouters

     # For crypto pki lab4
     10.9.0.80 www.amos2025.com
     10.9.0.80 www.onlyfans.com
     ```
4. then why i try to access `https://www.onlyfans.com` on firefox browser in the host VM, i see this error that says that there is potential security issue.
   - 

     ```

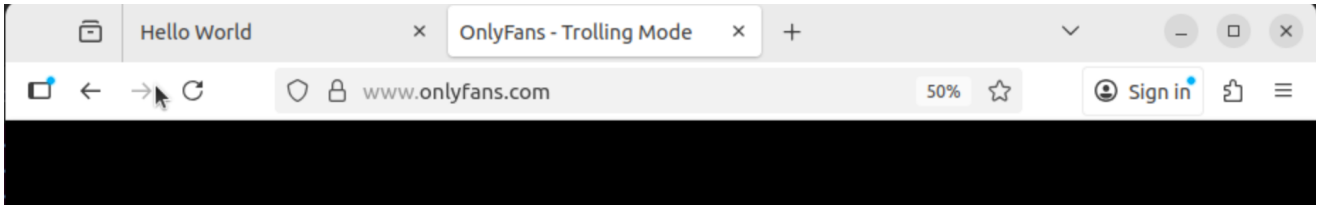



---

- this is because the public key in the certificate presented by the apache server does not match the public key expected for `www.onlyfans.com` , as the certificate was signed by my own CA and not by a well-known CA that issued a certificate for `www.onlyfans.com` . The browser detects this mismatch and raises a security warning to alert the user of a potential man-in-the-middle attack.

# Task 6: Launching a Man-In-The-Middle Attack with a Compromised CA

1. Since we have a compromised CA, i.e the CA cert we created in Task 1, we can use it to sign a certificate for `www.onlyfans.com` and have the browser trust it.
2. I generate a new CSR for `www.onlyfans.com` :
   - `openssl req -newkey rsa:2048 -sha256 -keyout onlyfans.key -out onlyfans.csr -`
   - 

3. Then i sign this CSR with my compromised CA to generate a certificate for `www.onlyfans.com` :
   - `openssl ca -config myCA_openssl.cnf -policy policy_anything -md sha256 -days`
   -
```
seed@seed:~/Downloads/Labsetup-arm/PKI$ openssl ca -config myCA_openssl.cnf -policy policy_anything -
md sha256 -days 3650 -in onlyfans.csr -out onlyfans.crt -batch -cert ca.crt -keyfile ca.key
Using configuration from myCA_openssl.cnf
Enter pass phrase for ca.key:
Check that the request matches the signature
Signature ok
Certificate Details:
        Serial Number: 4661 (0x1235)
        Validity
            Not Before: Oct 19 17:49:29 2025 GMT
            Not After : Oct 17 17:49:29 2035 GMT
        Subject:
            countryName   = GB
            organizationName   = Fenix International Limited
            commonName   = onlyfans.com
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            X509v3 Subject Key Identifier:
                C5:75:73:C5:56:94:2B:B2:E0:21:B2:28:C9:55:D1:44:63:66:10:46
            X509v3 Authority Key Identifier:
                89:93:57:E7:58:22:9D:A0:93:14:45:93:F5:35:CD:2D:6E:B3:58:C6
            X509v3 Subject Alternative Name:
                DNS:onlyfans.com, DNS:www.onlyfans.com, DNS:assets.onlyfans.com
Certificate is to be certified until Oct 17 17:49:29 2035 GMT (3650 days)

Write out database with 1 new entries
Data Base Updated
```
4. then i copy the generated `onlyfans.crt` and `onlyfans.key` files to the apache server container and move them to the `/certs/` directory.
5. then i edit the apache configuration file for `www.onlyfans.com` site to use the newly generated certificate and private key.
   -
```
root@d52c2cbb1e49:/etc/apache2/sites-available# cat onlyfans_apache_ssl.conf
<VirtualHost *:443>
    DocumentRoot /var/www/amos-onlyfans
    ServerName www.onlyfans.com
    DirectoryIndex index.html
    SSLEngine On
    SSLCertificateFile /certs/onlyfans.crt
    SSLCertificateKeyFile /certs/onlyfans.key
</VirtualHost>

<VirtualHost *:80>
    DocumentRoot /var/www/amos-onlyfans
    ServerName www.onlyfans.com
    DirectoryIndex index_red.html
</VirtualHost>
```
6. then i restart the apache server inside the container to apply the changes using `service apache2 reload` then `service apache2 restart` .
7. now when i try to access `https://www.onlyfans.com` on firefox browser i see my onlyfans website.
   -



8. With this we have successfully launched a man-in-the-middle attack using a compromised CA to impersonate `www.onlyfans.com` and have the browser trust the certificate presented by our apache server. This shows that if we can compromise a CA and issue fraudulent certificates, we can impersonate any website and intercept secure communications without raising browser security warnings.