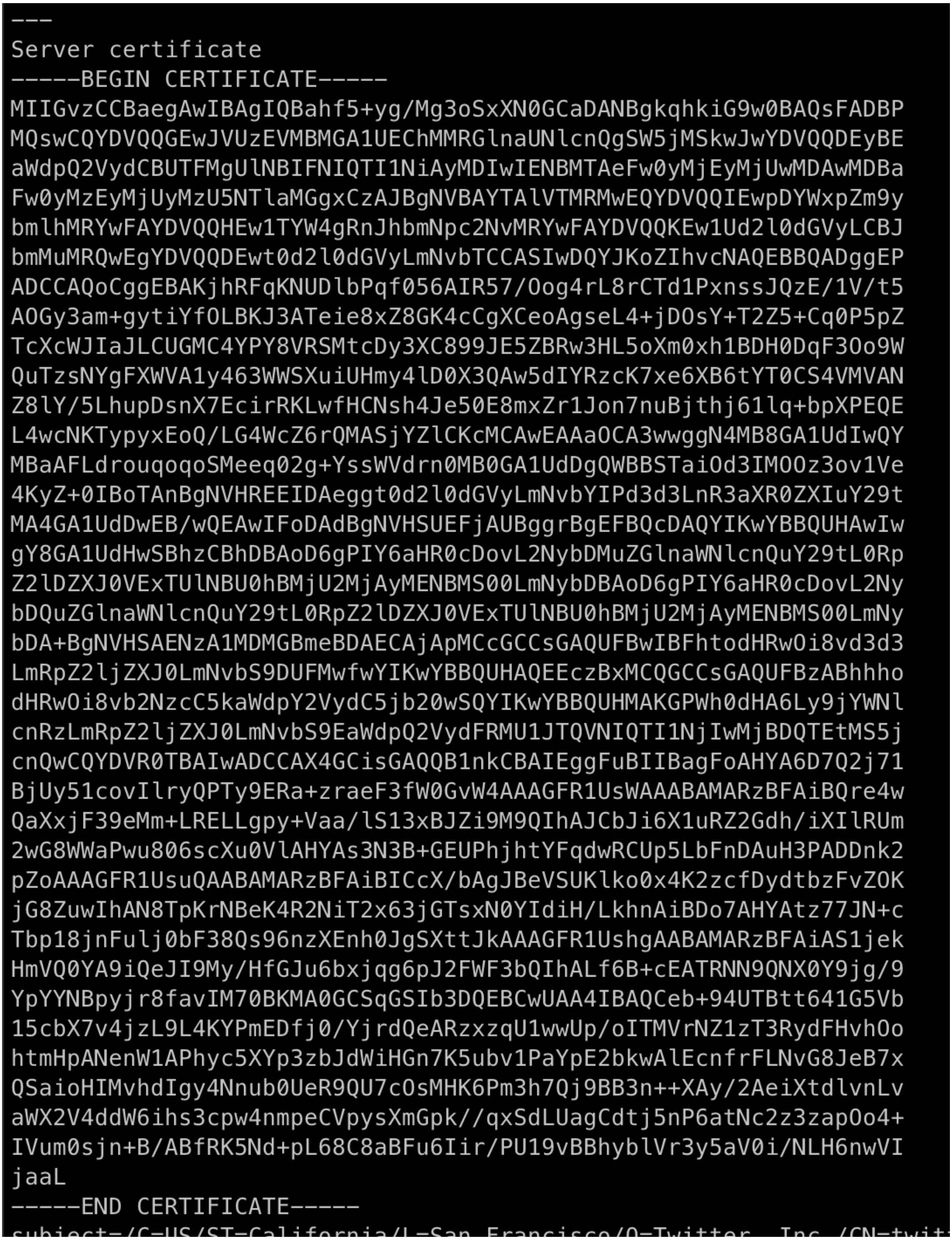
Active Public Key Infrastructure Pirawat Wareetanyarat 6238150221

1. From the 2 given commands, What is the difference ?

Ans. The primary difference between the two commands is the manner in which OpenSSL calculates the set of trusted root CA certificates that can be used to verify the server's certificate during an SSL/TLS handshake.



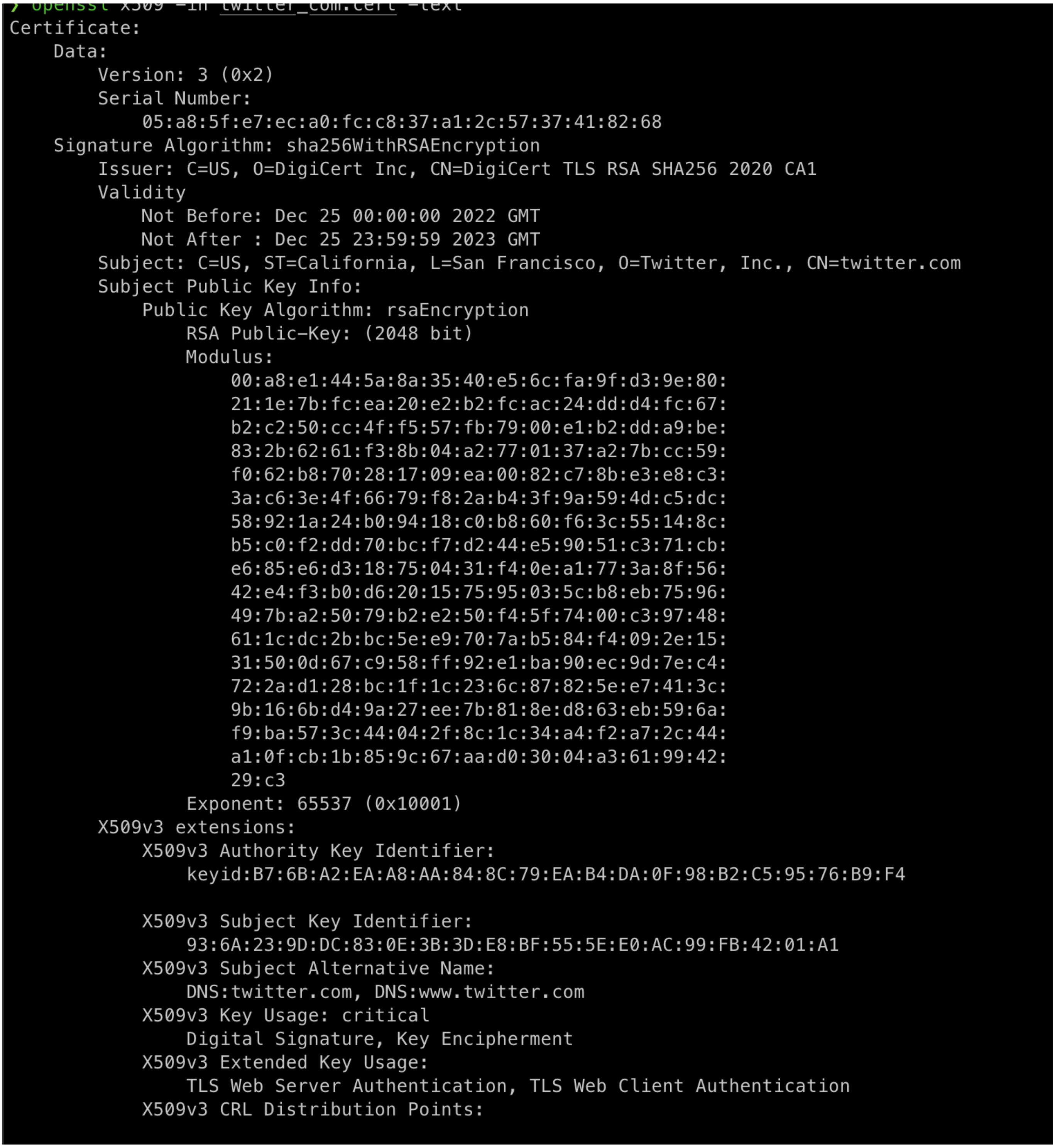
```
---
Server certificate
-----BEGIN CERTIFICATE-----
MIIGvzCCBaegAwIBAgIQBahf5+yg/Mg3oSxXN0GCaDANBgkqhkiG9w0BAQsFADBP
MQswCQYDVQQGEwJVUzEVMBMGA1UEChMMRGlnaUNlcnQgSW5jMSkwJwYDVQQDEyBE
aWdpQ2VydCBUTFMgUlNBIFNIQTI1NiAyMDIwIENBMTAeFw0yMjEyMjUwMDAwMDBa
Fw0yMzEyMjUyMzU5NTlaMGgxCzAJBgNVBAYTAlVTMRMwEQYDVQQIEwpDYWxpZm9y
bmlhMRYwFAYDVQQHEw1TYW4gRnJhbmNpc2NvMRYwFAYDVQQKEw1Ud2l0dGVyLCBJ
bmMuMRQwEgYDVQQDEwt0d2l0dGVyLmNvbTCCASIwDQYJKoZIhvcNAQEBBQADggEP
ADCCAQoCggEBAKjhRFqKNUDlbPqf056AIR57/Oog4rL8rCTd1PxnssJQzE/1V/t5
AOGy3am+gytiYfOLBKJ3ATeie8xZ8GK4cCgXCeoAgseL4+jDOsY+T2Z5+Cq0P5pZ
TcXcWJIaJLCUGMC4YPY8VRSMtcDy3XC899JE5ZBRw3HL5oXm0xh1BDH0DqF3Oo9W
QuTzsNYgFXWVA1y463WWSXuiUHmy4lD0X3QAw5dIYRzcK7xe6XB6tYT0CS4VMVAN
Z8lY/5LhupDsnX7EcirRKLwfHCNsh4Je50E8mxZr1Jon7nuBjthj61lq+bpXPEQE
L4wcNKTypyxEoQ/LG4WcZ6rQMASjYZlCKcMCAwEAAaOCA3wwggN4MB8GA1UdIwQY
MBaAFLdrouqoqoSMeeq02g+YssWVdrn0MB0GA1UdDgQWBBSTaiOd3IMOOz3ov1Ve
4KyZ+0IBoTAnBgNVHREEIDAeggt0d2l0dGVyLmNvbYIPd3d3LnR3aXR0ZXIuY29t
MA4GA1UdDwEB/wQEAwIFoDAdBgNVHSUEFjAUBggrBgEFBQcDAQYIKwYBBQUHAwIw
gY8GA1UdHwSBhzCBhDBAoD6gPIY6aHR0cDovL2NybDMuZGlnaWNlcnQuY29tL0Rp
Z2lDZXJ0VExTUlNBU0hBMjU2MjAyMENBMS00LmNybDBAoD6gPIY6aHR0cDovL2Ny
bDQuZGlnaWNlcnQuY29tL0RpZ2lDZXJ0VExTUlNBU0hBMjU2MjAyMENBMS00LmNy
bDA+BgNVHSAENzA1MDMGBmeBDAECAjApMCcGCCsGAQUFBwIBFhtodHRwOi8vd3d3
LmRpZ2ljZXJ0LmNvbS9DUFMwfwYIKwYBBQUHAQEEczBxMCQGCCsGAQUFBzABhhho
dHRwOi8vb2NzcC5kaWdpY2VydC5jb20wSQYIKwYBBQUHMAKGPWh0dHA6Ly9jYWNl
cnRzLmRpZ2ljZXJ0LmNvbS9EaWdpQ2VydFRMU1JTQVNIQTI1NjIwMjBDQTEtMS5j
cnQwCQYDVR0TBAIwADCCAX4GCisGAQQB1nkCBAIEggFuBIIBagFoAHYA6D7Q2j71
BjUy51covIlryQPTy9ERa+zraeF3fW0GvW4AAAGFR1UsWAAABAMARzBFAiBQre4w
QaXxjF39eMm+LRELLgpy+Vaa/lS13xBJZi9M9QIhAJCbJi6X1uRZ2Gdh/iXIlRUm
2wG8WWaPwu806scXu0VlAHYAs3N3B+GEUPhjhtYFqdwRCUp5LbFnDAuH3PADDnk2
pZoAAAGFR1UsuQAABAMARzBFAiBICcX/bAgJBeVSUKlko0x4K2zcfDydtbzFvZOK
jG8ZuwIhAN8TpKrNBeK4R2NiT2x63jGTsxN0YIdiH/LkhnAiBDo7AHYAtz77JN+c
Tbp18jnFulj0bF38Qs96nzXEnh0JgSXttJkAAAGFR1UshgAABAMARzBFAiAS1jek
HmVQ0YA9iQeJI9My/HfGJu6bxjqg6pJ2FWF3bQIhALf6B+cEATRNN9QNX0Y9jg/9
YpYYNBpyjr8favIM70BKMA0GCSqGSIb3DQEBCwUAA4IBAQCeb+94UTBtt641G5Vb
15cbX7v4jzL9L4KYPmEDfj0/YjrdQeARzxzqU1wwUp/oITMVrNZ1zT3RydFHvhOo
htmHpANenW1APhyc5XYp3zbJdWiHGn7K5ubv1PaYpE2bkwAlEcnfrFLNvG8JeB7x
QSaioHIMvhdIgy4Nnub0UeR9QU7cOsMHK6Pm3h7Qj9BB3n++XAy/2AeiXtdlvnLv
aWX2V4ddW6ihs3cpw4nmpeCVpysXmGpk//qxSdLUagCdtj5nP6atNc2z3zapOo4+
IVum0sjn+B/ABfRK5Nd+pL68C8aBFu6Iir/PU19vBBhyblVr3y5aV0i/NLH6nwVI
jaaL
-----END CERTIFICATE-----
subject=/C=US/ST=California/L=San Francisco/O=Twitter, Inc./CN=twit
```

2. What does the error (verify error) in the first command mean? Please explain.

Ans. The client will raise a verify error if the server's supplied certificate cannot be confirmed for some reason. This issue may happen for a number of reasons, including a certificate that is out-of-date or revoked, a domain name that is inaccurate or mismatched, or a problem with the chain of trust between the server's certificate and the root CA.

3. Copy the server certificate (beginning with -----BEGIN CERTIFICATE----- and ending with -----END CERTIFICATE-----) and store it as twitter_com.cert. Use the command openssl x509 -in twitter_com.cert -text to show a text representation of the certificate content. Briefly explain what is stored in an X.509 certificate (i.e. data in each field).

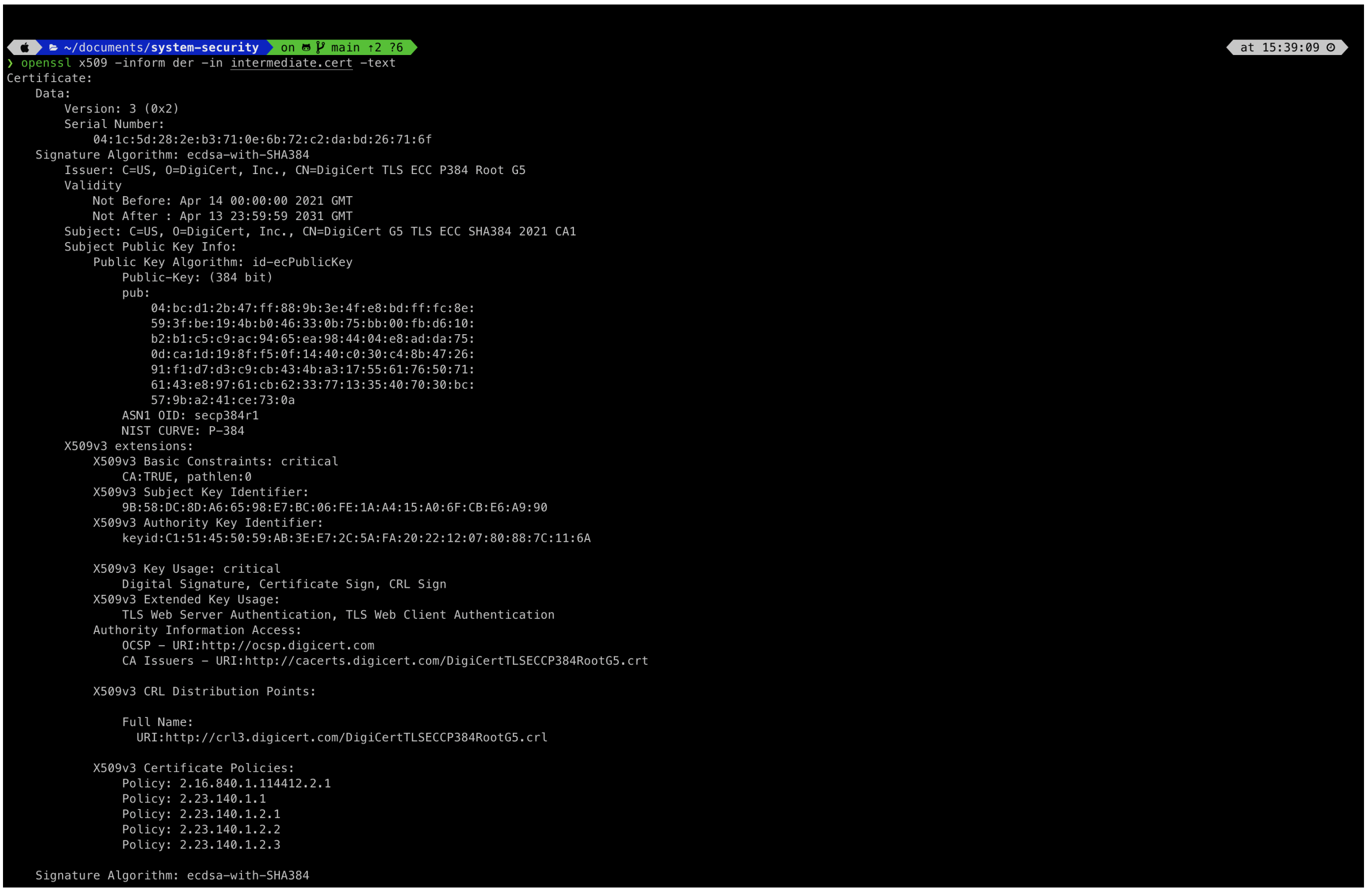
Ans.This is a TLS (Transport Layer Security) server certificate granted by DigiCert Inc in 2022 for the domain twitter.com. The validity period for this certificate is from Dec 25 00:00:00 2022 GMT to Dec 25 23:59:59 2023 GMT. The public key in the certificate is a 2048-bit RSA key that is used for server-client key exchange and authentication. The certificate has been signed using the SHA256withRSA technique. The certificate has a number of extensions that provide additional information and capabilities. The X509v3 extensions consist of the subject alternative name, key usage, extended key usage, certificate policies, fundamental constraints, and access to authority information.



```
❯ openssl x509 -in twitter_com.cert -text
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            05:a8:5f:e7:ec:a0:fc:c8:37:a1:2c:57:37:41:82:68
    Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=US, O=DigiCert Inc, CN=DigiCert TLS RSA SHA256 2020 CA1
        Validity
            Not Before: Dec 25 00:00:00 2022 GMT
            Not After : Dec 25 23:59:59 2023 GMT
        Subject: C=US, ST=California, L=San Francisco, O=Twitter, Inc., CN=twitter.com
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                RSA Public-Key: (2048 bit)
                Modulus:
                    00:a8:e1:44:5a:8a:35:40:e5:6c:fa:9f:d3:9e:80:
                    21:1e:7b:fc:ea:20:e2:b2:fc:ac:24:dd:d4:fc:67:
                    b2:c2:50:cc:4f:f5:57:fb:79:00:e1:b2:dd:a9:be:
                    83:2b:62:61:f3:8b:04:a2:77:01:37:a2:7b:cc:59:
                    f0:62:b8:70:28:17:09:ea:00:82:c7:8b:e3:e8:c3:
                    3a:c6:3e:4f:66:79:f8:2a:b4:3f:9a:59:4d:c5:dc:
                    58:92:1a:24:b0:94:18:c0:b8:60:f6:3c:55:14:8c:
                    b5:c0:f2:dd:70:bc:f7:d2:44:e5:90:51:c3:71:cb:
                    e6:85:e6:d3:18:75:04:31:f4:0e:a1:77:3a:8f:56:
                    42:e4:f3:b0:d6:20:15:75:95:03:5c:b8:eb:75:96:
                    49:7b:a2:50:79:b2:e2:50:f4:5f:74:00:c3:97:48:
                    61:1c:dc:2b:bc:5e:e9:70:7a:b5:84:f4:09:2e:15:
                    31:50:0d:67:c9:58:ff:92:e1:ba:90:ec:9d:7e:c4:
                    72:2a:d1:28:bc:1f:1c:23:6c:87:82:5e:e7:41:3c:
                    9b:16:6b:d4:9a:27:ee:7b:81:8e:d8:63:eb:59:6a:
                    f9:ba:57:3c:44:04:2f:8c:1c:34:a4:f2:a7:2c:44:
                    a1:0f:cb:1b:85:9c:67:aa:d0:30:04:a3:61:99:42:
                    29:c3
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Authority Key Identifier:
                keyid:B7:6B:A2:EA:A8:AA:84:8C:79:EA:B4:DA:0F:98:B2:C5:95:76:B9:F4

            X509v3 Subject Key Identifier:
                93:6A:23:9D:DC:83:0E:3B:3D:E8:BF:55:5E:E0:AC:99:FB:42:01:A1
            X509v3 Subject Alternative Name:
                DNS:twitter.com, DNS:www.twitter.com
            X509v3 Key Usage: critical
                Digital Signature, Key Encipherment
            X509v3 Extended Key Usage:
                TLS Web Server Authentication, TLS Web Client Authentication
            X509v3 CRL Distribution Points:
```

4. From the information in exercise 3, is there an intermediate certificate? If yes, what purpose does it serve? Hint: Look for an issuer and download the intermediate certificate. You may use the command openssl x509 -inform der -in intermediate.cert -text to show the details of the intermediate certificate. (Note that the -inform der is for reading the DER file. The default file format for x509 is the PEM file.)

Ans. Yes, there is an intermediate certificate, and the reason is that The trustworthy CA issues the intermediate certificate, which is used to sign the website's public TLS certificate. So, when a browser verifies a public TLS certificate, it also verifies the issuer of the intermediate certificate to ensure that it was issued by a trusted Certification Authority (CA). This establishes a trust chain from the trusted CA, through the intermediate certificate, to the website's public TLS certificate. The browser would display a security warning to the user if it were unable to verify that the public TLS certificate was issued by a trusted CA in the absence of the intermediate certificate.



```
 ~/documents/system-security on  main ↑2 ?6                                                          at 15:39:09
❯ openssl x509 -inform der -in intermediate.cert -text
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            04:1c:5d:28:2e:b3:71:0e:6b:72:c2:da:bd:26:71:6f
    Signature Algorithm: ecdsa-with-SHA384
        Issuer: C=US, O=DigiCert, Inc., CN=DigiCert TLS ECC P384 Root G5
        Validity
            Not Before: Apr 14 00:00:00 2021 GMT
            Not After : Apr 13 23:59:59 2031 GMT
        Subject: C=US, O=DigiCert, Inc., CN=DigiCert G5 TLS ECC SHA384 2021 CA1
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
                Public-Key: (384 bit)
                pub:
                    04:bc:d1:2b:47:ff:88:9b:3e:4f:e8:bd:ff:fc:8e:
                    59:3f:be:19:4b:b0:46:33:0b:75:bb:00:fb:d6:10:
                    b2:b1:c5:c9:ac:94:65:ea:98:44:04:e8:ad:da:75:
                    0d:ca:1d:19:8f:f5:0f:14:40:c0:30:c4:8b:47:26:
                    91:f1:d7:d3:c9:cb:43:4b:a3:17:55:61:76:50:71:
                    61:43:e8:97:61:cb:62:33:77:13:35:40:70:30:bc:
                    57:9b:a2:41:ce:73:0a
                ASN1 OID: secp384r1
                NIST CURVE: P-384
        X509v3 extensions:
            X509v3 Basic Constraints: critical
                CA:TRUE, pathlen:0
            X509v3 Subject Key Identifier:
                9B:58:DC:8D:A6:65:98:E7:BC:06:FE:1A:A4:15:A0:6F:CB:E6:A9:90
            X509v3 Authority Key Identifier:
                keyid:C1:51:45:50:59:AB:3E:E7:2C:5A:FA:20:22:12:07:80:88:7C:11:6A

            X509v3 Key Usage: critical
                Digital Signature, Certificate Sign, CRL Sign
            X509v3 Extended Key Usage:
                TLS Web Server Authentication, TLS Web Client Authentication
            Authority Information Access:
                OCSP - URI:http://ocsp.digicert.com
                CA Issuers - URI:http://cacerts.digicert.com/DigiCertTLSECCP384RootG5.crt

            X509v3 CRL Distribution Points:

                Full Name:
                  URI:http://crl3.digicert.com/DigiCertTLSECCP384RootG5.crl

            X509v3 Certificate Policies:
                Policy: 2.16.840.1.114412.2.1
                Policy: 2.23.140.1.1
                Policy: 2.23.140.1.2.1
                Policy: 2.23.140.1.2.2
                Policy: 2.23.140.1.2.3

    Signature Algorithm: ecdsa-with-SHA384
```

5. Is there an intermediate CA, i.e. is there more than one organization involved in the certification? Say why you think so.

Ans. Yes there is an intermediate CA, and there should be at least one for sure because of the certificate chain which are Twitter inc in server certificate and Digicert

6.What is the role of ca-certificates.crt?

Ans. certificates issued by the Certification Authority. crt file plays a crucial role in establishing secure connections over TLS/SSL protocols by providing the client with a list of trusted root CAs against which to validate SSL certificates.

7.Explore the ca-certificates.crt. How many certificates are in there? Give the command/method you have used to count.

Ans. There are 127 certificates in it. I use open file and then count every time the line starts with -----BEGIN CERTIFICATE-----\n

```
def main():
    with open('../ca-certificates.cert', 'r') as cert_file:
        # Read the contents of the file
        cert_content = cert_file.readlines()
        cert_num = 0
        for e in cert_content:
        if (e == '-----BEGIN CERTIFICATE-----\n'):
            cert_num += 1
        print(cert_num)
```

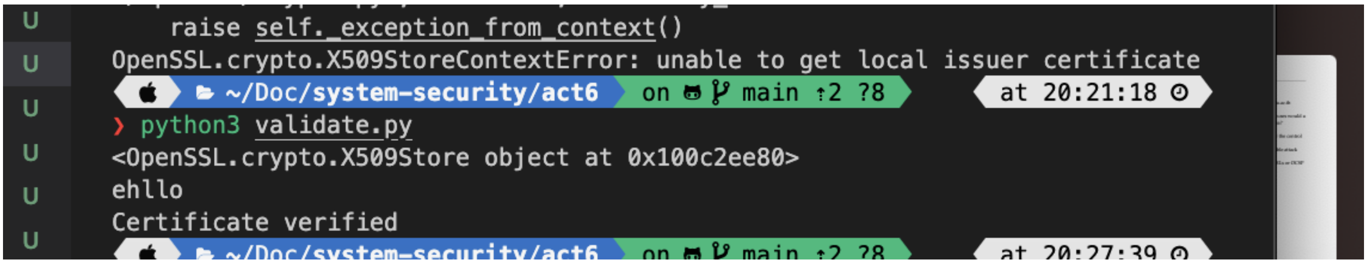
8. Extract a root certificate from ca-certificates.crt. Use the openssl command to explore the details. Do you see any Issuer information? Please compare it to the details of twitter's certificate and the details of the intermediate certificate.

Ans. Yes, i saw ACCV as an issuer compared to the twitter (Digicert) and intermediate (Digicert)

```
Certificate:
Data:
    Version: 3 (0x2)
    Serial Number: 6828503384748696800 (0x5ec3b7a6437fa4e0)
Signature Algorithm: sha1WithRSAEncryption
    Issuer: CN=ACCVRAIZ1, OU=PKIACCV, O=ACCV, C=ES
    Validity
        Not Before: May  5 09:37:37 2011 GMT
        Not After : Dec 31 09:37:37 2030 GMT
    Subject: CN=ACCVRAIZ1, OU=PKIACCV, O=ACCV, C=ES
    Subject Public Key Info:
        Public Key Algorithm: rsaEncryption
            RSA Public-Key: (4096 bit)
            Modulus:
                00:9b:a9:ab:bf:61:4a:97:af:2f:97:66:9a:74:5f:
                d0:d9:96:fd:cf:e2:e4:66:ef:1f:1f:47:33:c2:44:
                a3:df:9a:de:1f:b5:54:dd:15:7c:69:35:11:6f:bb:
                c8:0c:8e:6a:18:1e:d8:8f:d9:16:bc:10:48:36:5c:
                f0:63:b3:90:5a:5c:24:37:d7:a3:d6:cb:09:71:b9:
                f1:01:72:84:b0:7d:db:4d:80:cd:fc:d3:6f:c9:f8:
                da:b6:0e:82:d2:45:85:a8:1b:68:a8:3d:e8:f4:44:
                6c:bd:a1:c2:cb:03:be:8c:3e:13:00:84:df:4a:48:
                c0:e3:22:0a:e8:e9:37:a7:18:4c:b1:09:0d:23:56:
                7f:04:4d:d9:17:84:18:a5:c8:da:40:94:73:eb:ce:
                0e:57:3c:03:81:3a:9d:0a:a1:57:43:69:ac:57:6d:
                79:90:78:e5:b5:b4:3b:d8:bc:4c:8d:28:a1:a7:a3:
                a7:ba:02:4e:25:d1:2a:ae:ed:ae:03:22:b8:6b:20:
                0f:30:28:54:95:7f:e0:ee:ce:0a:66:9d:d1:40:2d:
                6e:22:af:9d:1a:c1:05:19:d2:6f:c0:f2:9f:f8:7b:
                b3:02:42:fb:50:a9:1d:2d:93:0f:23:ab:c6:c1:0f:
                    92:ff:d0:a2:15:f5:53:09:71:1c:ff:45:13:84:e6:
                    26:5e:f8:e0:88:1c:0a:fc:16:b6:a8:73:06:b8:f0:
                    63:84:02:a0:c6:5a:ec:e7:74:df:70:ae:a3:83:25:
                    ea:d6:c7:97:87:93:a7:c6:8a:8a:33:97:60:37:10:
                    3e:97:3e:6e:29:15:d6:a1:0f:d1:88:2c:12:9f:6f:
                    aa:a4:c6:42:eb:41:a2:e3:95:43:d3:01:85:6d:8e:
                    bb:3b:f3:23:36:c7:fe:3b:e0:a1:25:07:48:ab:c9:
                    89:74:ff:08:8f:80:bf:c0:96:65:f3:ee:ec:4b:68:
                    bd:9d:88:c3:31:b3:40:f1:e8:cf:f6:38:bb:9c:e4:
                    d1:7f:d4:e5:58:9b:7c:fa:d4:f3:0e:9b:75:91:e4:
                    ba:52:2e:19:7e:d1:f5:cd:5a:19:fc:ba:06:f6:fb:
                    52:a8:4b:99:04:dd:f8:f9:b4:8b:50:a3:4e:62:89:
                    f0:87:24:fa:83:42:c1:87:fa:d5:2d:29:2a:5a:71:
                    7a:64:6a:d7:27:60:63:0d:db:ce:49:f5:8d:1f:90:
                    89:32:17:f8:73:43:b8:d2:5a:93:86:61:d6:e1:75:
                    0a:ea:79:66:76:88:4f:71:eb:04:25:d6:0a:5a:7a:
                    93:e5:b9:4b:17:40:0f:b1:b6:b9:f5:de:4f:dc:e0:
                    b3:ac:3b:11:70:60:84:4a:43:6e:99:20:c0:29:71:
                    0a:c0:65
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            Authority Information Access:
                CA Issuers -
URI:http://www.accv.es/fileadmin/Archivos/certificados/raizaccv1.crt
                OCSP - URI:http://ocsp.accv.es

            X509v3 Subject Key Identifier:

D2:87:B4:E3:DF:37:27:93:55:F6:56:EA:81:E5:36:CC:8C:1E:3F:BD
            X509v3 Basic Constraints: critical
                CA:TRUE
            X509v3 Authority Key Identifier:

keyid:D2:87:B4:E3:DF:37:27:93:55:F6:56:EA:81:E5:36:CC:8C:1E:3F:BD

            X509v3 Certificate Policies:
                Policy: X509v3 Any Policy
                  User Notice:
                    Explicit Text:
                  CPS: http://www.accv.es/legislacion_c.htm

            X509v3 CRL Distribution Points:

                Full Name:

URI:http://www.accv.es/fileadmin/Archivos/certificados/raizaccv1_der.crl

            X509v3 Key Usage: critical
                Certificate Sign, CRL Sign
            X509v3 Subject Alternative Name:
                email:accv@accv.es
    Signature Algorithm: sha1WithRSAEncryption
         97:31:02:9f:e7:fd:43:67:48:44:14:e4:29:87:ed:4c:28:66:
         d0:8f:35:da:4d:61:b7:4a:97:4d:b5:db:90:e0:05:2e:0e:c6:
                79:d0:f2:97:69:0f:bd:04:47:d9:be:db:b5:29:da:9b:d9:ae:
                a9:99:d5:d3:3c:30:93:f5:8d:a1:a8:fc:06:8d:44:f4:ca:16:
                95:7c:33:dc:62:8b:a8:37:f8:27:d8:09:2d:1b:ef:c8:14:27:
                20:a9:64:44:ff:2e:d6:75:aa:6c:4d:60:40:19:49:43:54:63:
                da:e2:cc:ba:66:e5:4f:44:7a:5b:d9:6a:81:2b:40:d5:7f:f9:
                01:27:58:2c:c8:ed:48:91:7c:3f:a6:00:cf:c4:29:73:11:36:
                de:86:19:3e:9d:ee:19:8a:1b:d5:b0:ed:8e:3d:9c:2a:c0:0d:
                d8:3d:66:e3:3c:0d:bd:d5:94:5c:e2:e2:a7:35:1b:04:00:f6:
                3f:5a:8d:ea:43:bd:5f:89:1d:a9:c1:b0:cc:99:e2:4d:00:0a:
                da:c9:27:5b:e7:13:90:5c:e4:f5:33:a2:55:6d:dc:e0:09:4d:
                2f:b1:26:5b:27:75:00:09:c4:62:77:29:08:5f:9e:59:ac:b6:
                7e:ad:9f:54:30:22:03:c1:1e:71:64:fe:f9:38:0a:96:18:dd:
                02:14:ac:23:cb:06:1c:1e:a4:7d:8d:0d:de:27:41:e8:ad:da:
                15:b7:b0:23:dd:2b:a8:d3:da:25:87:ed:e8:55:44:4d:88:f4:
                36:7e:84:9a:78:ac:f7:0e:56:49:0e:d6:33:25:d6:84:50:42:
                6c:20:12:1d:2a:d5:be:bc:f2:70:81:a4:70:60:be:05:b5:9b:
                9e:04:44:be:61:23:ac:e9:a5:24:8c:11:80:94:5a:a2:a2:b9:
                49:d2:c1:dc:d1:a7:ed:31:11:2c:9e:19:a6:ee:e1:55:e1:c0:
                ea:cf:0d:84:e4:17:b7:a2:7c:a5:de:55:25:06:ee:cc:c0:87:
                5c:40:da:cc:95:3f:55:e0:35:c7:b8:84:be:b4:5d:cd:7a:83:
                01:72:ee:87:e6:5f:1d:ae:b5:85:c6:26:df:e6:c1:9a:e9:1e:
                02:47:9f:2a:a8:6d:a9:5b:cf:ec:45:77:7f:98:27:9a:32:5d:
                2a:e3:84:ee:c5:98:66:2f:96:20:1d:dd:d8:c3:27:d7:b0:f9:
                fe:d9:7d:cd:d0:9f:8f:0b:14:58:51:9f:2f:8b:c3:38:2d:de:
                e8:8f:d6:8d:87:a4:f5:56:43:16:99:2c:f4:a4:56:b4:34:b8:
                61:37:c9:c2:58:80:1b:a0:97:a1:fc:59:8d:e9:11:f6:d1:0f:
                4b:55:34:46:2a:8b:86:3b
```

10. Twitter has a certificate verified.

Ans. Twitter



```
    raise self._exception_from_context()
OpenSSL.crypto.X509StoreContextError: unable to get local issuer certificate
  ~/Doc/system-security/act6  on  main ↑2 ?8          at 20:21:18
❯ python3 validate.py
<OpenSSL.crypto.X509Store object at 0x100c2ee80>
ehllo
Certificate verified
  ~/Doc/system-security/act6  on  main ↑2 ?8          at 20:27:39
```

11. Nowaday, there are root certificates for class 1 and class 3. What uses would a class 1 signed certificate have that a class 3 doesn't, and vice versa?

Ans. Class 1 and Class 3 certifications differ in the extent of identity verification and, consequently, the level of trust connected with the certificate. Class 3 certificates provide a higher level of trust than Class 1 certificates due to a more stringent identity verification process. Hence, websites that require a higher level of trust and security, such as those that handle sensitive data, should utilize an SSL/TLS certificate of Class 3. For low security, class 1 suffices.

12.

Ans.

a

- Providing counterfeit SSL/TLS certificates for websites or services, allowing an attacker to capture and alter sensitive data such as passwords and financial information.
- By issuing fake certificates for legitimate websites or services, impersonators impersonate reputable websites or services. This could enable the attacker to conduct phishing attacks and deceive victims into giving sensitive information or downloading malware.
- Conducting a man-in-the-middle (MITM) attack, intercepting traffic between users and legitimate websites or services, and perhaps stealing or modifying sensitive data.
- The manipulation of software updates or security patches, which could allow an attacker to install malware or other harmful software on a victim's system.

The attacker might use the compromised Root CA to issue fake SSL/TLS certificates for high-profile websites or services, as one conceivable attack configuration. The attacker might then use these certificates to conduct man-in-the-middle (MITM) attacks, intercepting traffic between users and legitimate websites and potentially obtaining sensitive information. Additionally, the attacker might use the counterfeit certificates to conduct phishing attacks, deceiving users into giving their credentials or downloading malware. b CRLs (Certificate Revocation Lists) and OCSP (Online Certificate Status Protocol) may not be sufficient for protection in the scenario mentioned above. CRLs and OCSP are dependent on the prompt revocation of fraudulent certificates by the CA and the consequent update of revocation information in the CRL or OCSP responder. If the compromised Root CA is not discovered for months, fake certificates issued by the attacker may not be revoked in a timely way and may not be identified by CRL or OCSP checks.