CERTIFICATES : THE BASICS

This chapter will focus on **public** certificate and their use in digital cinema

PREFACE

The certificates are the essential part of security workflow in digital cinema and are standardized by SMPTE and DCI.

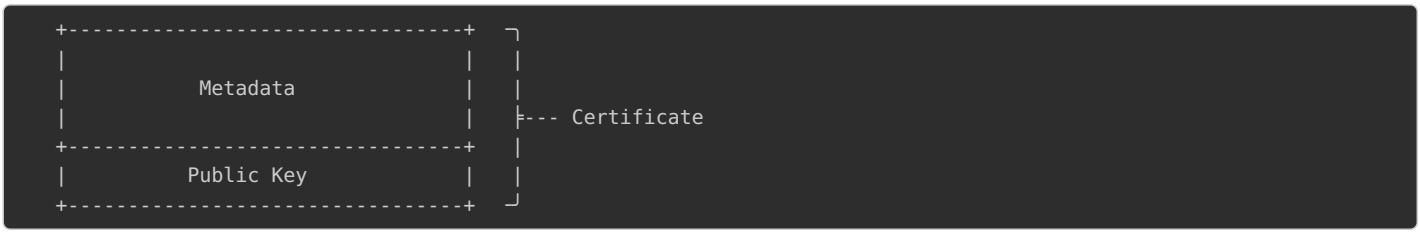
The DCI specification and SMPTE standards define that the asymmetric cryptography used in digital cinema is the asymmetric cryptography RSA.

As a reminder, the **asymmetric cryptography** needs to create two type of keys, each having a specific role : one private key and one public key. The **private key used for decryption** (or signing), and the **public key used for encryption** (or to verify the signature of a signed document with the private key)

To distribute the public key, you can :

- distribute the public key in raw format, without any embellishment. It includes the cryptographic values useful for encryption (called the modulus and the exponent, which we will see in this chapter but which are detailed in the RSA chapter),
- integrate this public key in a container and include extensive informations - the metadata - such as identification, validity timestamps, parent's name or any other details, that help describe or even manage the public key.

This type of container is known as a **certificate**.



The metadata contains sometimes much more data than the public key itself :)

To sum up: a certificate is like an information sheet that includes metadata and the public key. Picture this like an envelope : inside the envelope, your (public) key. Outside the envelope, you have the recipient's address, the sender's address, and so on.

WHO USES THESE CERTIFICATS AND WHY ?

Certificates are used in many ways in the DCI workflow :

- **CompositionPlaylist** (CPL) : For authentication and integrity - using signature.
- **PackingList** (PKL) : For authentication and integrity - using signature.
- **KDM** : For authentication, integrity, and above all, confidentiality: encryption !
- **Certificats** : Creating and signing the entire certification chain (we will see this principle in this chapter).

Certificates are used by all devices complying with the DCI specification (and thus SMPTE). So, you have - mainly - certificates for DCP players, DCP encoders and KDM generators.

Certificates are exchanged between laboratories and theater owners to encrypt and sign the KDMs. [1]

AND IN WHICH CONTEXTS ?

We use the certificates in the following use cases :

- **During KDM creation** : to encrypt the KDM part (CipherValue) that will be decrypted by the receiver [2], we use the receiver's public certificate. The certificate is integrated into the KDM.
- **During DCP creation** : PKL and CPL are signed with the encoder's private key. Consequently, its public certificate is embedded in both the PKL and the CPL.

CAN WE USE ANY TYPE OF CERTIFICATE ?

Quick answer: no ! :)

A DCI/SMPTE certificate complies with standardized data structure defined by the X509 standard and its version 3, which adds useful extensions for our specific needs.

The specification of x509v3 is defined in RFC 5280 - Internet X509 Public Key Infrastructure Certificate. In addition, the SMPTE 430-2 - Digital Certificate provides modifications and parameters that allow compliance with the DCI workflow.

For the following chapters on certificates, I will refer to any certificate that complies with SMPTE standards and DCI specification as an **X509 DCI Certificate** or a **DCI Certificate**, in order to clearly distinguish it from other types of X509 certificates used in different domains.

INSIDE A DCI CERTIFICATE

Most certificates are provided as files with the `.pem` extension [3], they can be read with a text editor :

```
-----BEGIN CERTIFICATE-----
MIIEejCCA2KgAwIBAgICAoMwDQYJKoZIhvcNAQELBQAwgYIxITAfBgNVBAoTGERD
Mi5TTVBURS5ET1JFTUlMQUJTLkNPTTEaMBgGA1UECxMRREMuRE9SRU1JTEFCUy5D
T00xGjAYBgNVBAMTES5EQy5ETVMuREMyLlNNUFRFMSUwIwYDVQQuExwrTEx2dVlO
TzRZQkpTcDlKam1sdjhvaXBwelE9MB4XDTA3MDEwMTAwMDAwMFoXDTI1MTIzMTIz
NTk1OVowgY4xITAfBgNVBAoTGERDMi5TTVBURS5ET1JFTUlMQUJTLkNPTTEaMBgG
A1UECxMRREMuRE9SRU1JTEFCUy5DT00xJjAkBgNVBAMTHUNTLkRNU0pQMkstODAx
MTkuREMuREMyLlNNUFRFMSUwIwYDVQQuExxTUUZZU1NxV3dqZWZwcHFhc01KbWZk
bVM2bEk9MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAvGKl+zNPc1gq
agM3K1JiThcaQW9u9MOYtTJMTVRixOfu5sGIOYAFf6FmSf5VneEGG9td/iN6GplI
1e5upTvkyw1CTmiuAp3pqcqLhM8vyPntzloICTNxe9AIiuOnJQO1khLGUQ1pgD5M
vpfya/4Iiqnq8upR84PoLnnsEKvoxeuXa1iLrCyDZykP7Ybn8U5muzdAqr9YRuFz
Fzbbq8Fcrz1uPhyKeK0i6+ZQVdfT8xy4BuNGQcucimPGoImu+2yfNbEcfFQffDA5
bGzR2/XDJTLEaqNwe/WXZyGokZtIRzmFJYGb4Zy+pYGWIK5umuhjNFETufNI48my
bNZtelpjIwIDAQABo4HrMIHoMAwGA1UdEwEB/wQCMAAwCwYDVR0PBAQDAgSwMB0G
A1UdDgQWBBRJAVhJKpbCN5+mmpqwwmZ92ZLqUjCBqwYDVR0jBIGjMIGggBT4su+5
g07hgElKn0mOaW/yiKmnNKGBhKSBgTB/MSEwHwYDVQQKExhEQzIuU01QVEUuRE9S
RU1JTEFCUy5DT00xGjAYBgNVBAsTEURDLkRPUkVNSUxBQlMuQ09NMRcwFQYDVQQD
Ew4uRE1TLkRDMi5TTVBURTElMCMGA1UELhMcUlEvNTNSbXVMc2J6Z2ZQWEdsUllt
SnJ1d01zPYIBAjANBgkqhkiG9w0BAQsFAAOCAQEAPBpZ6Tkg9TZg2LamLaOCPE6i
ngBvqmsQHR5V4b99sNU/EvdGL2eJjZFw4YLsxaEmPppIGFdMIE+QJHrED5YLaJ9i
1VvTbD1jNfrclW4Sbc6+mlQKFC6vOD5/go3hLYC8A5w92ea75iX77SuD0DCD1GIs
6FL3EGSrMXC59HFK4ahnIkxcUyhV75Cn14ujaOQpiO+zBxr/Vai/PDZoy6KSm0yY
JEh97q4+vQYQlRWSP1cF9IjLusrYBTjU30f7rygOR4vcqL8xnNQhYprBlJBn+KS3
FqNKtrUoHTF0YtLl4I5l90octl+vtQNGWxq4xU33Du9qXOBXBE9heSfG3CsmVw==
-----END CERTIFICATE-----
```

This format is known as **ASN.1 PEM**

- The PEM Format means base64 encoding :-)
- The ASN.1 is a standardized structure used to describe and store information (serialization) in a binary format of the x509 certificate, known as DER (Distinguished Encoding Rules).

If we remove the base64 encoding, here is what we find :

```
$ openssl base64 -d -in certificate.pem \
    | xxd -c 32   # affichage

00000000: 3082 047a 3082 0362 a003 0201 0202 0202 8330 0d06 092a 8648 86f7 0d01 010b 0500  0..z0..b.........0...*.H.
00000020: 3081 8231 2130 1f06 0355 040a 1318 4443 322e 534d 5054 452e 444f 5245 4d49 4c41  0..1!0...U....DC2.SMPTE.DO
00000040: 4253 2e43 4f4d 311a 3018 0603 5504 0b13 1144 432e 444f 5245 4d49 4c41 4253 2e43  BS.COM1.0...U....DC.DOREMI
00000060: 4f4d 311a 3018 0603 5504 0313 112e 4443 2e44 4d53 2e44 4332 2e53 4d50 5445 3125  OM1.0...U.....DC.DMS.DC2.S
00000080: 3023 0603 5504 2e13 1c2b 4c4c 7675 594e 4f34 5942 4a53 7039 4a6a 6d6c 7638 6f69  0#..U....+LLvuYNO4YBJSp9Jj
000000a0: 7070 7a51 3d30 1e17 0d30 3730 3130 3130 3030 3030 305a 170d 3235 3132 3331 3233  ppzQ=0...070101000000Z..25
000000c0: 3539 3539 5a30 818e 3121 301f 0603 5504 0a13 1844 4332 2e53 4d50 5445 2e44 4f52  5959Z0..1!0...U....DC2.SMP
000000e0: 454d 494c 4142 532e 434f 4d31 1a30 1806 0355 040b 1311 4443 2e44 4f52 454d 494c  EMILABS.COM1.0...U....DC.D
00000100: 4142 532e 434f 4d31 2630 2406 0355 0403 131d 4353 2e44 4d53 4a50 324b 2d38 3031  ABS.COM1&0$..U....CS.DMSJP
00000120: 3139 2e44 432e 4443 322e 534d 5054 4531 2530 2306 0355 042e 131c 5351 4659 5353  19.DC.DC2.SMPTE1%0#..U....
00000140: 7157 776a 6566 7070 7161 734d 4a6d 6664 6d53 366c 493d 3082 0122 300d 0609 2a86  qWwjefppqasMJmfdmS6lI=0..'
00000160: 4886 f70d 0101 0105 0003 8201 0f00 3082 010a 0282 0101 00bc 62a5 fb33 4f73 582a  H.............0.........b
00000180: 6a03 372b 5262 4e17 1a41 6f6e f4c3 98b5 324c 4d54 62c4 e7ee e6c1 8839 8005 7fa1  j.7+RbN..Aon....2LMTb....
000001a0: 6649 fe55 9de1 061b db5d fe23 7a1a 9948 d5ee 6ea5 3be4 cb0d 424e 68ae 029d e9a9  fI.U.....].#z..H..n.;...BN
000001c0: ca8b 84cf 2fc8 f9ed ce5a 0809 3371 7bd0 088a e3a7 2503 b592 12c6 510d 6980 3e4c  ..../....Z..3q{.....%....
000001e0: be97 f26b fe08 8aa9 eaf2 ea51 f383 e82e 79ec 10ab e8c5 eb97 6b58 8bac 2c83 6729  ...k.......Q....y.......kX
00000200: 0fed 86e7 f14e 66bb 3740 aabf 5846 e173 1736 dbab c15c af3d 6e3e 1c8a 78ad 22eb  .....Nf.7@..XF.s.6...\.=n>
00000220: e650 55d7 d3f3 1cb8 06e3 4641 cb9c 8a63 c6a0 89ae fb6c 9f35 b11c 7c54 1f7c 3039  .PU.......FA...c.....l.5.
00000240: 6c6c d1db f5c3 2532 c46a a370 7bf5 9767 21a8 919b 4847 3985 2581 9be1 9cbe a581  ll....%2.j.p{..g!...HG9.%
00000260: 9620 ae6e 9ae8 6334 5113 b9f3 48e3 c9b2 6cd6 6d7a 5a63 2302 0301 0001 a381 eb30  . .n..c4Q...H...l.mzZc#..
00000280: 81e8 300c 0603 551d 1301 01ff 0402 3000 300b 0603 551d 0f04 0403 0204 b030 1d06  ..0...U.......0.0...U....
000002a0: 0355 1d0e 0416 0414 4901 5849 2a96 c237 9fa6 9a9a b0c2 667d d992 ea52 3081 ab06  .U......I.XI*..7......f}.
000002c0: 0355 1d23 0481 a330 81a0 8014 f8b2 efb9 834e e180 494a 9f49 8e69 6ff2 88a9 a734  .U.#...0.........N..IJ.I.i
000002e0: a181 84a4 8181 307f 3121 301f 0603 5504 0a13 1844 4332 2e53 4d50 5445 2e44 4f52  ......0.1!0...U....DC2.SMP
00000300: 454d 494c 4142 532e 434f 4d31 1a30 1806 0355 040b 1311 4443 2e44 4f52 454d 494c  EMILABS.COM1.0...U....DC.D
00000320: 4142 532e 434f 4d31 1730 1506 0355 0403 130e 2e44 4d53 2e44 4332 2e53 4d50 5445  ABS.COM1.0...U.....DMS.DC2
00000340: 3125 3023 0603 5504 2e13 1c52 512f 3533 526d 754c 7362 7a67 6650 5847 6c52 596d  1%0#..U....RQ/53RmuLsbzgfP
00000360: 4a72 7577 4d73 3d82 0102 300d 0609 2a86 4886 f70d 0101 0b05 0003 8201 0100 3c1a  JruwMs=...0...*.H........
00000380: 59e9 3920 f536 60d8 b6a6 2da3 823c 4ea2 9e00 6faa 6b10 1d1e 55e1 bf7d b0d5 3f12  Y.9 .6`...-..<N...o.k...U
000003a0: f746 2f67 898d 9170 e182 ecc5 a126 3e9a 4818 574c 204f 9024 7ac4 0f96 0b68 9f62  .F/g...p.....&>.H.WL O.$z
000003c0: d55b d36c 3d63 35fa dc95 6e12 6dce be9a 540a 142e af38 3e7f 828d e12d 80bc 039c  .[.l=c5...n.m...T....8>..
000003e0: 3dd9 e6bb e625 fbed 2b83 d030 83d4 622c e852 f710 64ab 3170 b9f4 714a e1a8 6722  =....%..+..0..b,.R..d.1p.
00000400: 4c5c 5328 55ef 90a7 d78b a368 e429 88ef b307 1aff 55a8 bf3c 3668 cba2 929b 4c98  L\S(U......h.).....U..<6h
00000420: 2448 7dee ae3e bd06 1095 1592 3f57 05f4 88cb baca d805 38d4 df47 fbaf 280e 478b  $H}..>......?W........8..(
00000440: dca8 bf31 9cd4 2162 9ac1 9490 67f8 a4b7 16a3 4ab6 b528 1d31 7462 d2e5 e08e 65f7  ...1..!b....g.....J..(.1tb
00000460: 4a1c b65f afb5 0346 5b1a b8c5 4df7 0eef 6a5c e057 044f 6179 27c6 dc2b 2657       J.._...F[...M...j\.W.Oay'
```

We observe several things :

- It hurts !
- We can see some readable content in the right column.
- It begins with `0x3082` which is a typical header for an **ASN.1 DER** structure [4]

If we pass our **ASN.1 DER** output through an **ASN.1 parser**, we can see all the entries of the certificate :

```
openssl base64 -d -in certificate.pem \
    | openssl asn1parse \
        -inform DER \    # our input is a DER format
        -i \             # indentation
        -dump            # dump hex form
```

```
    0:d=0  hl=4 l=1146 cons: SEQUENCE
    4:d=1  hl=4 l= 866 cons:  SEQUENCE
    8:d=2  hl=2 l=   3 cons:   cont [ 0 ]
   10:d=3  hl=2 l=   1 prim:    INTEGER           :02
   13:d=2  hl=2 l=   2 prim:   INTEGER           :0283
   17:d=2  hl=2 l=  13 cons:   SEQUENCE
   19:d=3  hl=2 l=   9 prim:    OBJECT            :sha256WithRSAEncryption
   30:d=3  hl=2 l=   0 prim:    NULL
   32:d=2  hl=3 l= 130 cons:   SEQUENCE
   35:d=3  hl=2 l=  33 cons:    SET
   37:d=4  hl=2 l=  31 cons:     SEQUENCE
   39:d=5  hl=2 l=   3 prim:      OBJECT            :organizationName
   44:d=5  hl=2 l=  24 prim:      PRINTABLESTRING   :DC2.SMPTE.DOREMILABS.COM
   70:d=3  hl=2 l=  26 cons:    SET
   72:d=4  hl=2 l=  24 cons:     SEQUENCE
```

```
  74:d=5  hl=2 l=   3 prim:      OBJECT            :organizationalUnitName
  79:d=5  hl=2 l=  17 prim:      PRINTABLESTRING   :DC.DOREMILABS.COM
  98:d=3  hl=2 l=  26 cons:    SET
 100:d=4  hl=2 l=  24 cons:     SEQUENCE
 102:d=5  hl=2 l=   3 prim:      OBJECT            :commonName
 107:d=5  hl=2 l=  17 prim:      PRINTABLESTRING   :.DC.DMS.DC2.SMPTE
 126:d=3  hl=2 l=  37 cons:    SET
 128:d=4  hl=2 l=  35 cons:     SEQUENCE
 130:d=5  hl=2 l=   3 prim:      OBJECT            :dnQualifier
 135:d=5  hl=2 l=  28 prim:      PRINTABLESTRING   :+LLvuYNO4YBJSp9Jjmlv8oippzQ=
 165:d=2  hl=2 l=  30 cons:   SEQUENCE
 167:d=3  hl=2 l=  13 prim:    UTCTIME           :070101000000Z
 182:d=3  hl=2 l=  13 prim:    UTCTIME           :251231235959Z
 197:d=2  hl=3 l= 142 cons:   SEQUENCE
 200:d=3  hl=2 l=  33 cons:    SET
 202:d=4  hl=2 l=  31 cons:     SEQUENCE
 204:d=5  hl=2 l=   3 prim:      OBJECT            :organizationName
 209:d=5  hl=2 l=  24 prim:      PRINTABLESTRING   :DC2.SMPTE.DOREMILABS.COM
 235:d=3  hl=2 l=  26 cons:    SET
 237:d=4  hl=2 l=  24 cons:     SEQUENCE
 239:d=5  hl=2 l=   3 prim:      OBJECT            :organizationalUnitName
 244:d=5  hl=2 l=  17 prim:      PRINTABLESTRING   :DC.DOREMILABS.COM
 263:d=3  hl=2 l=  38 cons:    SET
 265:d=4  hl=2 l=  36 cons:     SEQUENCE
 267:d=5  hl=2 l=   3 prim:      OBJECT            :commonName
 272:d=5  hl=2 l=  29 prim:      PRINTABLESTRING   :CS.DMSJP2K-80119.DC.DC2.SMPTE
 303:d=3  hl=2 l=  37 cons:    SET
 305:d=4  hl=2 l=  35 cons:     SEQUENCE
 307:d=5  hl=2 l=   3 prim:      OBJECT            :dnQualifier
 312:d=5  hl=2 l=  28 prim:      PRINTABLESTRING   :SQFYSSqWwjefppqasMJmfdmS6lI=
 342:d=2  hl=4 l= 290 cons:   SEQUENCE
 346:d=3  hl=2 l=  13 cons:    SEQUENCE
 348:d=4  hl=2 l=   9 prim:     OBJECT            :rsaEncryption
 359:d=4  hl=2 l=   0 prim:     NULL
 361:d=3  hl=4 l= 271 prim:    BIT STRING
    0000 - 00 30 82 01 0a 02 82 01-01 00 bc 62 a5 fb 33 4f   .0.........b..3O
    0010 - 73 58 2a 6a 03 37 2b 52-62 4e 17 1a 41 6f 6e f4   sX*j.7+RbN..Aon.
    0020 - c3 98 b5 32 4c 4d 54 62-c4 e7 ee e6 c1 88 39 80   ...2LMTb......9.
    0030 - 05 7f a1 66 49 fe 55 9d-e1 06 1b db 5d fe 23 7a   ...fI.U.....].#z
    0040 - 1a 99 48 d5 ee 6e a5 3b-e4 cb 0d 42 4e 68 ae 02   ..H..n.;...BNh..
    0050 - 9d e9 a9 ca 8b 84 cf 2f-c8 f9 ed ce 5a 08 09 33   ......./....Z..3
    0060 - 71 7b d0 08 8a e3 a7 25-03 b5 92 12 c6 51 0d 69   q{.....%.....Q.i
    0070 - 80 3e 4c be 97 f2 6b fe-08 8a a9 ea f2 ea 51 f3   .>L...k.......Q.
    0080 - 83 e8 2e 79 ec 10 ab e8-c5 eb 97 6b 58 8b ac 2c   ...y.......kX..,
    0090 - 83 67 29 0f ed 86 e7 f1-4e 66 bb 37 40 aa bf 58   .g).....Nf.7@..X
    00a0 - 46 e1 73 17 36 db ab c1-5c af 3d 6e 3e 1c 8a 78   F.s.6...\.=n>..x
    00b0 - ad 22 eb e6 50 55 d7 d3-f3 1c b8 06 e3 46 41 cb   ."..PU.......FA.
    00c0 - 9c 8a 63 c6 a0 89 ae fb-6c 9f 35 b1 1c 7c 54 1f   ..c.....l.5..|T.
    00d0 - 7c 30 39 6c 6c d1 db f5-c3 25 32 c4 6a a3 70 7b   |09ll....%2.j.p{
    00e0 - f5 97 67 21 a8 91 9b 48-47 39 85 25 81 9b e1 9c   ..g!...HG9.%....
    00f0 - be a5 81 96 20 ae 6e 9a-e8 63 34 51 13 b9 f3 48   .... .n..c4Q...H
    0100 - e3 c9 b2 6c d6 6d 7a 5a-63 23 02 03 01 00 01      ...l.mzZc#.....
 636:d=2  hl=3 l= 235 cons:   cont [ 3 ]
 639:d=3  hl=3 l= 232 cons:    SEQUENCE
 642:d=4  hl=2 l=  12 cons:     SEQUENCE
 644:d=5  hl=2 l=   3 prim:      OBJECT            :X509v3 Basic Constraints
 649:d=5  hl=2 l=   1 prim:      BOOLEAN           :255
 652:d=5  hl=2 l=   2 prim:      OCTET STRING
    0000 - 30 00                                             0.
 656:d=4  hl=2 l=  11 cons:     SEQUENCE
 658:d=5  hl=2 l=   3 prim:      OBJECT            :X509v3 Key Usage
 663:d=5  hl=2 l=   4 prim:      OCTET STRING
    0000 - 03 02 04 b0                                       ....
 669:d=4  hl=2 l=  29 cons:     SEQUENCE
 671:d=5  hl=2 l=   3 prim:      OBJECT            :X509v3 Subject Key Identifier
 676:d=5  hl=2 l=  22 prim:      OCTET STRING
    0000 - 04 14 49 01 58 49 2a 96-c2 37 9f a6 9a 9a b0 c2   ..I.XI*..7......
    0010 - 66 7d d9 92 ea 52                                 f}...R
 700:d=4  hl=3 l= 171 cons:     SEQUENCE
 703:d=5  hl=2 l=   3 prim:      OBJECT            :X509v3 Authority Key Identifier
 708:d=5  hl=3 l= 163 prim:      OCTET STRING
    0000 - 30 81 a0 80 14 f8 b2 ef-b9 83 4e e1 80 49 4a 9f   0.........N..IJ.
    0010 - 49 8e 69 6f f2 88 a9 a7-34 a1 81 84 a4 81 81 30   I.io....4......0
    0020 - 7f 31 21 30 1f 06 03 55-04 0a 13 18 44 43 32 2e   .1!0...U....DC2.
    0030 - 53 4d 50 54 45 2e 44 4f-52 45 4d 49 4c 41 42 53   SMPTE.DOREMILABS
```

```
    0040 - 2e 43 4f 4d 31 1a 30 18-06 03 55 04 0b 13 11 44   .COM1.0...U....D
    0050 - 43 2e 44 4f 52 45 4d 49-4c 41 42 53 2e 43 4f 4d   C.DOREMILABS.COM
    0060 - 31 17 30 15 06 03 55 04-03 13 0e 2e 44 4d 53 2e   1.0...U.....DMS.
    0070 - 44 43 32 2e 53 4d 50 54-45 31 25 30 23 06 03 55   DC2.SMPTE1%0#..U
    0080 - 04 2e 13 1c 52 51 2f 35-33 52 6d 75 4c 73 62 7a   ....RQ/53RmuLsbz
    0090 - 67 66 50 58 47 6c 52 59-6d 4a 72 75 77 4d 73 3d   gfPXGlRYmJruwMs=
    00a0 - 82 01 02                                          ...
874:d=1  hl=2 l=  13 cons:  SEQUENCE
876:d=2  hl=2 l=   9 prim:   OBJECT            :sha256WithRSAEncryption
887:d=2  hl=2 l=   0 prim:   NULL
889:d=1  hl=4 l= 257 prim:  BIT STRING
    0000 - 00 3c 1a 59 e9 39 20 f5-36 60 d8 b6 a6 2d a3 82   .<.Y.9 .6`...-..
    0010 - 3c 4e a2 9e 00 6f aa 6b-10 1d 1e 55 e1 bf 7d b0   .H.WL O.$z....
    0040 - 68 9f 62 d5 5b d3 6c 3d-63 35 fa dc 95 6e 12 6d   h.b.[.l=c5...n.m
    0050 - ce be 9a 54 0a 14 2e af-38 3e 7f 82 8d e1 2d 80   ...T....8>....-.
    0060 - bc 03 9c 3d d9 e6 bb e6-25 fb ed 2b 83 d0 30 83   ...=....%..+..0.
    0070 - d4 62 2c e8 52 f7 10 64-ab 31 70 b9 f4 71 4a e1   .b,.R..d.1p..qJ.
    0080 - a8 67 22 4c 5c 53 28 55-ef 90 a7 d7 8b a3 68 e4   .g"L\S(U......h.
    0090 - 29 88 ef b3 07 1a ff 55-a8 bf 3c 36 68 cb a2 92   ).......U..<6h...
    00a0 - 9b 4c 98 24 48 7d ee ae-3e bd 06 10 95 15 92 3f   .L.$H}..>......?
    00b0 - 57 05 f4 88 cb ba ca d8-05 38 d4 df 47 fb af 28   W........8..G..(
    00c0 - 0e 47 8b dc a8 bf 31 9c-d4 21 62 9a c1 94 90 67   .G....1..!b....g
    00d0 - f8 a4 b7 16 a3 4a b6 b5-28 1d 31 74 62 d2 e5 e0   .....J..(.1tb...
    00e0 - 8e 65 f7 4a 1c b6 5f af-b5 03 46 5b 1a b8 c5 4d   .e.J.._...F[...M
    00f0 - f7 0e ef 6a 5c e0 57 04-4f 61 79 27 c6 dc 2b 26   ...j\.W.Oay'..+&
    0100 - 57                                                W
```

Yes, it still hurts ! even with the colorimetric helper.

This is the **ASN.1 DER** structure of an x509 DCI certificate with its various tags (**SEQUENCE**, **INTEGER**, **OBJECT**, **BIT STRING**, etc.)

You might ask me why I'm showing you this. I have to show you this because it will be important for some hash calculations that we will cover later in the following chapters.

This output is still unreadable for anyone who hasn't an RFC master's and written a thesis of ASN.1.

Thankfully, OpenSSL can interpret this kind of structure and provide a more readable output :

```
openssl x509 -in certificate.pem -text
```

```
Data:
    Version: 3 (0x2)
    Serial Number: 643 (0x283)
    Signature Algorithm: sha256WithRSAEncryption
    Issuer: O = DC2.SMPTE.DOREMILABS.COM, OU = DC.DOREMILABS.COM, CN = .DC.DMS.DC2.SMPTE, dnQualifier = "+LLvuYNO4Y
    Validity
        Not Before: Jan  1 00:00:00 2007 GMT
        Not After : Dec 31 23:59:59 2025 GMT
    Subject: O = DC2.SMPTE.DOREMILABS.COM, OU = DC.DOREMILABS.COM, CN = CS.DMSJP2K-80119.DC.DC2.SMPTE, dnQualifier
    Subject Public Key Info:
        Public Key Algorithm: rsaEncryption
            Public-Key: (2048 bit)
            Modulus:
                00:bc:62:a5:fb:33:4f:73:58:2a:6a:03:37:2b:52:
                62:4e:17:1a:41:6f:6e:f4:c3:98:b5:32:4c:4d:54:
                62:c4:e7:ee:e6:c1:88:39:80:05:7f:a1:66:49:fe:
                55:9d:e1:06:1b:db:5d:fe:23:7a:1a:99:48:d5:ee:
                6e:a5:3b:e4:cb:0d:42:4e:68:ae:02:9d:e9:a9:ca:
                8b:84:cf:2f:c8:f9:ed:ce:5a:08:09:33:71:7b:d0:
                08:8a:e3:a7:25:03:b5:92:12:c6:51:0d:69:80:3e:
                4c:be:97:f2:6b:fe:08:8a:a9:ea:f2:ea:51:f3:83:
                e8:2e:79:ec:10:ab:e8:c5:eb:97:6b:58:8b:ac:2c:
                83:67:29:0f:ed:86:e7:f1:4e:66:bb:37:40:aa:bf:
                58:46:e1:73:17:36:db:ab:c1:5c:af:3d:6e:3e:1c:
                8a:78:ad:22:eb:e6:50:55:d7:d3:f3:1c:b8:06:e3:
                46:41:cb:9c:8a:63:c6:a0:89:ae:fb:6c:9f:35:b1:
                1c:7c:54:1f:7c:30:39:6c:6c:d1:db:f5:c3:25:32:
                c4:6a:a3:70:7b:f5:97:67:21:a8:91:9b:48:47:39:
                85:25:81:9b:e1:9c:be:a5:81:96:20:ae:6e:9a:e8:
                63:34:51:13:b9:f3:48:e3:c9:b2:6c:d6:6d:7a:5a:
                63:23
            Exponent: 65537 (0x10001)
    X509v3 extensions:
        X509v3 Basic Constraints: critical
            CA:FALSE
        X509v3 Key Usage:
            Digital Signature, Key Encipherment, Data Encipherment
        X509v3 Subject Key Identifier:
            49:01:58:49:2A:96:C2:37:9F:A6:9A:9A:B0:C2:66:7D:D9:92:EA:52
        X509v3 Authority Key Identifier:
            keyid:F8:B2:EF:B9:83:4E:E1:80:49:4A:9F:49:8E:69:6F:F2:88:A9:A7:34
            DirName:/O=DC2.SMPTE.DOREMILABS.COM/OU=DC.DOREMILABS.COM/CN=.DMS.DC2.SMPTE/dnQualifier=RQ\/53RmuLsbzgfP
            serial:02
Signature Algorithm: sha256WithRSAEncryption
Signature Value:
    3c:1a:59:e9:39:20:f5:36:60:d8:b6:a6:2d:a3:82:3c:4e:a2:
    9e:00:6f:aa:6b:10:1d:1e:55:e1:bf:7d:b0:d5:3f:12:f7:46:
    2f:67:89:8d:91:70:e1:82:ec:c5:a1:26:3e:9a:48:18:57:4c:
    20:4f:90:24:7a:c4:0f:96:0b:68:9f:62:d5:5b:d3:6c:3d:63:
    35:fa:dc:95:6e:12:6d:ce:be:9a:54:0a:14:2e:af:38:3e:7f:
    82:8d:e1:2d:80:bc:03:9c:3d:d9:e6:bb:e6:25:fb:ed:2b:83:
    d0:30:83:d4:62:2c:e8:52:f7:10:64:ab:31:70:b9:f4:71:4a:
    e1:a8:67:22:4c:5c:53:28:55:ef:90:a7:d7:8b:a3:68:e4:29:
    88:ef:b3:07:1a:ff:55:a8:bf:3c:36:68:cb:a2:92:9b:4c:98:
    24:48:7d:ee:ae:3e:bd:06:10:95:15:92:3f:57:05:f4:88:cb:
    ba:ca:d8:05:38:d4:df:47:fb:af:28:0e:47:8b:dc:a8:bf:31:
    9c:d4:21:62:9a:c1:94:90:67:f8:a4:b7:16:a3:4a:b6:b5:28:
    1d:31:74:62:d2:e5:e0:8e:65:f7:4a:1c:b6:5f:af:b5:03:46:
    5b:1a:b8:c5:4d:f7:0e:ef:6a:5c:e0:57:04:4f:61:79:27:c6:
    dc:2b:26:57
```

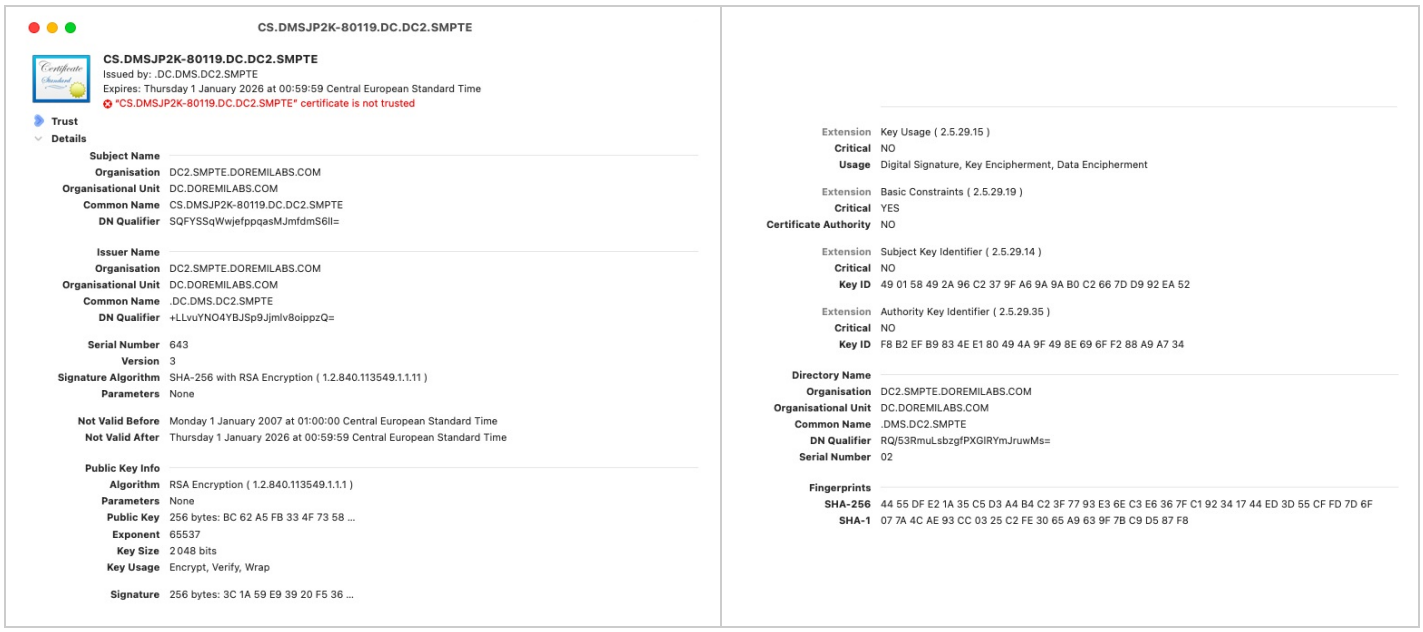
In green, we have the identification datas. In orange is the public key (the modulus and the exponent, see the RSA chapter to understand). In blue, we have x509v3 extensions, very useful for understanding the role of this certificate. At last, in pink, the certificate signature.

Each entry is named « Field »

(we will study each field, one by one, in the following chapter)

OTHER CERIFICATES VIEWERS

You have the option to view the certificat's metadata with other tools. For example, on MacOS, you have KeyChain :



Or use the online viewers :

Site	Description	Level
certificatedecoder.dev	Minimal x509 viewer	Débutant
certlogik.com/decoder	Complete x509 viewer + ASN.1 structure (standardized RFC) viewer	Intermediate
lapo.it/asn1js	ASN.1 structure viewer (binary mode, standardized RFC)	Expert

You can test them with this public certificate sample below :

```
-----BEGIN CERTIFICATE-----
MIIEejCCA2KgAwIBAgICAoMwDQYJKoZIhvcNAQELBQAwgYIxITAfBgNVBAoTGERD
Mi5TTVBURS5ET1JFTUlMQUJTLkNPTTEaMBgGA1UECxMRREMuRE9SRU1JTEFCUy5D
T00xGjAYBgNVBAMTES5EQy5ETVMuREMyLlNNUFRFMSUwIwYDVQQuExwrTEx2dVlO
TzRZQkpTcDlKam1sdjhvaXBwelE9MB4XDTA3MDEwMTAwMDAwMFoXDTI1MTIzMTIz
NTk1OVowgY4xITAfBgNVBAoTGERDMi5TTVBURS5ET1JFTUlMQUJTLkNPTTEaMBgG
A1UECxMRREMuRE9SRU1JTEFCUy5DT00xJjAkBgNVBAMTHUNTLkRNU0pQMkstODAx
MTkuREMuREMyLlNNUFRFMSUwIwYDVQQuExxTUZZU1NxV3dqZWZwcHFhc01KbWZk
bVM2bEk9MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAvGKl+zNPc1gq
agM3K1JiThcaQW9u9MOYtTJMTVRixOfu5sGIOYAFf6FmSf5VneEGG9td/iN6GplI
1e5upTvkyw1CTmiuAp3pqcqLhM8vyPntzloICTNxe9AIiuOnJQO1khLGUQ1pgD5M
vpfya/4Iiqnq8upR84PoLnnsEKvoxeuXa1iLrCyDZykP7Ybn8U5muzdAqr9YRuFz
Fzbbq8Fcrz1uPhyKeK0i6+ZQVdfT8xy4BuNGQcucimPGoImu+2yfNbEcfFQffDA5
bGzR2/XDJTLEaqNwe/WXZyGokZtIRzmFJYGb4Zy+pYGWIK5umuhjNFETufNI48my
bNZtelpjIwIDAQABo4HrMIHoMAwGA1UdEwEB/wQCMAAwCwYDVR0PBAQDAgSwMB0G
A1UdDgQWBBRJAVhJKpbCN5+mmpqwwmZ92ZLqUjCBqwYDVR0jBIGjMIGggBT4su+5
g07hgElKn0mOaW/yiKmnNKGBhKSBgTB/MSEwHwYDVQQKExhEQzIuU01QVEUuRE9S
RU1JTEFCUy5DT00xGjAYBgNVBAsTEURDLkRPUkVNSUxBQlMuQ09NMRcwFQYDVQQD
Ew4uRE1TLkRDMi5TTVBURTElMCMGA1UELhMcUlEvNTNSbXVMc2J6Z2ZQWEdsUllt
SnJ1d01zPYIBAjANBgkqhkiG9w0BAQsFAAOCAQEAPBpZ6Tkg9TZg2LamLaOCPE6i
ngBvqmsQHR5V4b99sNU/EvdGL2eJjZFw4YLsxaEmPppIGFdMIE+QJHrED5YLaJ9i
1VvTbD1jNfrclW4Sbc6+mlQKFC6vOD5/go3hLYC8A5w92ea75iX77SuD0DCD1GIs
6FL3EGSrMXC59HFK4ahnIkxcUyhV75Cn14ujaOQpiO+zBxr/Vai/PDZoy6KSm0yY
JEh97q4+vQYQlRWSP1cF9IjLusrYBTjU30f7rygOR4vcqL8xnNQhYprBlJBn+KS3
FqNKtrUoHTF0YtLl4I5l90octl+vtQNGWxq4xU33Du9qXOBXBE9heSfG3CsmVw==
-----END CERTIFICATE-----
```

CONCLUSION

We've quickly seen what a certificate is. We can look at each entry represents in the following chapters, titled Certificates Fields.

RELATED CHAPTERS

- Certificates - The basics ⬅ you are here
- Certificates - Fields
- Certificates - Identity Attributes
- Certificates - Certificate Chains
- Certificates - Certificate Thumbprint
- Certificates - Public Key Thumbprint (dnQualifier)
- Certificates - Creation : our own certificates
- RSA - The asymmetric cryptography used for encryption and signature.

REFERENCES

Links to standards and specifications :

- SMPTE 430-2 - Digital Certificate
- DCI - Digital Cinema System Specification: Compliance Test Plan - 1.3.3
- RFC 3280 - Internet X.509 Public Key Infrastructure Certificate

NOTES

1. Among others. We have other cases, such as exchange between laboratories for AES key exchanges, for example. Certificates are public, you can find them on the manufacturer's websites. ↩
2. For example, a DCP player ou another encoder - which will receive un DKDM :) ↩
3. The extension is just a naming convention. You can find files with another extensions such as `.txt`, `.crt`, `.cert`. Certificate can be delivered outside of a file. For example, via the player's API, it will provide a stream containing the certificate. So, there's no obligation to be in a file :) ↩
4. To be precise, ASN.1 complies with the TLV format which is ... like a KLV ;-) ↩

   - TLV means **Type** (or **Tag**) **Length Value**,
   - KLV means **Key Length Value**.

   The only difference between the TLV and the KLV seems to be on the size of the **Tag** (1-4 bytes for the TLV, 1-16 for the KLV)

   Here is an example of a **SEQUENCE** TLV from a x509 :

   ```
   +------+
   |  30  | Tag SEQUENCE
   +------+
   |  82  | Code indicating that the next 2 bytes will represent the size of the data (voir KLV)
   +......+
   |  LL  |
   |  LL  |--- the length (eg: 047A : 1146 bytes)
   +------+
   |  DD  |
   |  DD  |___ The data :)
   |  DD  |
   |  ..  |
   +------+
   ```

   It's the same like a KLV, you can read the KLV chapter to understand the internal binary structure of a x509 structure.