MTAT.07.017
Applied Cryptography

Online Certificate Status Protocol (OCSP)

University of Tartu

Spring 2018

Online Certificate Status Protocol

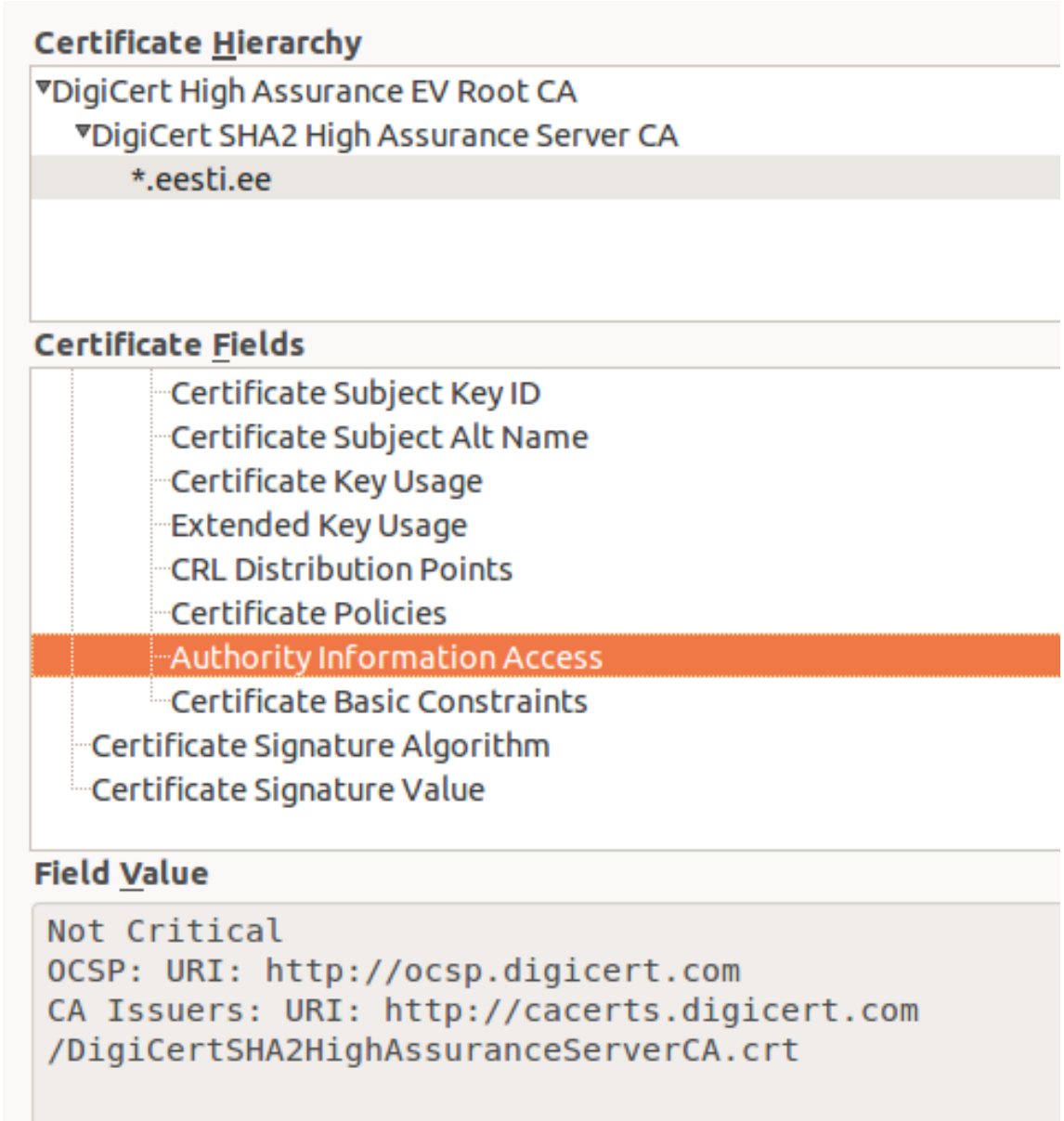
CRL shortcomings:

- Size of CRLs
- Client side complexity
- Outdated status information

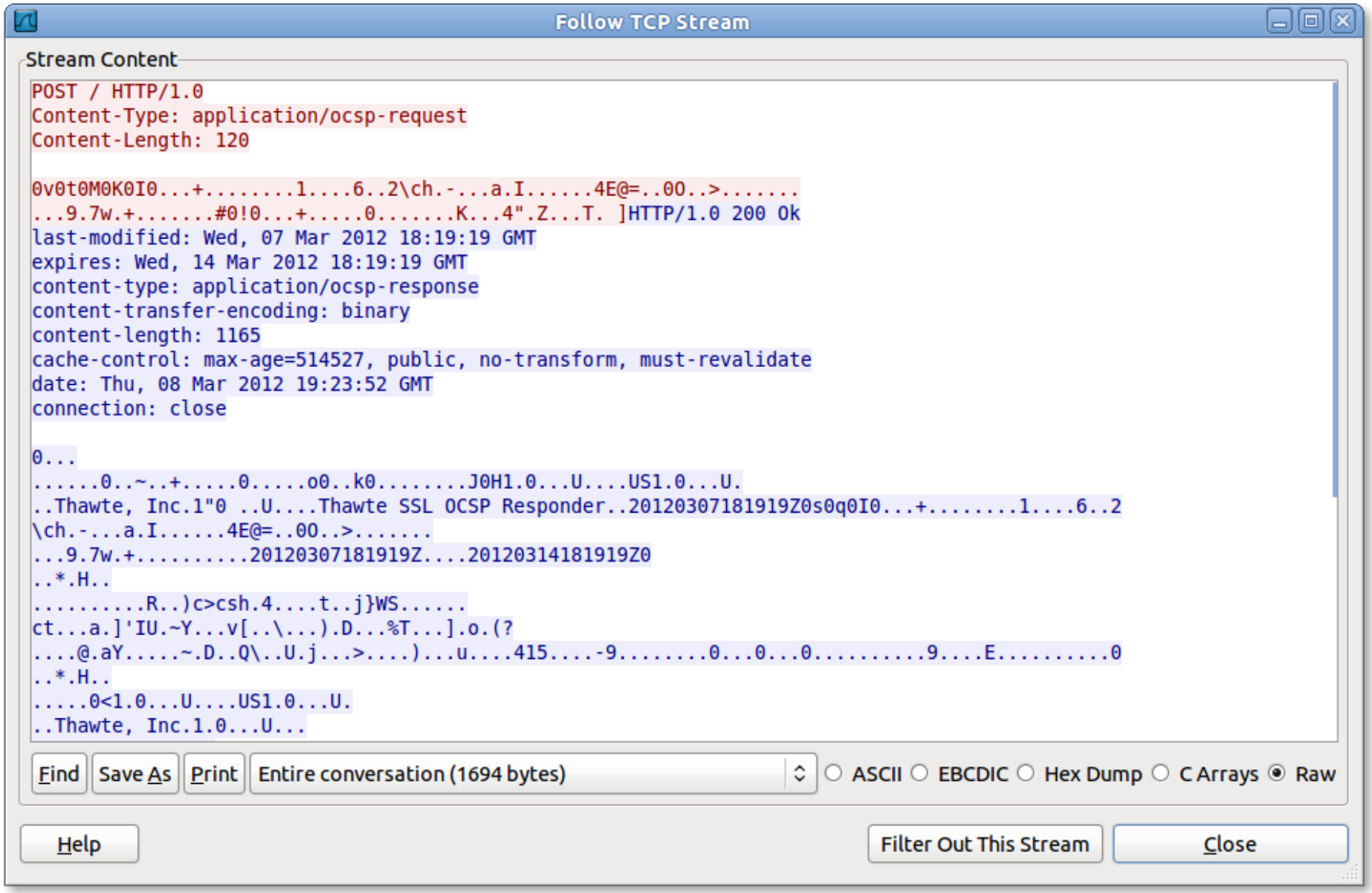
"The Online Certificate Status Protocol (OCSP) enables applications to determine the (revocation) state of an identified certificate."

- Where can the relying party find the OCSP responder?
- How is the certificate identified in the OCSP request?
- How is the integrity of OCSP response assured?
- How to ensure the freshness of OCSP response?
- At which point OCSP must be checked?

Authority Information Access



OCSP over HTTP



Request Syntax

```
OCSPRequest ::= SEQUENCE {
  tbsRequest TBSRequest,
  optionalSignature [0] Signature OPTIONAL }

Signature ::= SEQUENCE {
  signatureAlgorithm AlgorithmIdentifier,
  signature          BIT STRING,
  certs              [0] SEQUENCE OF Certificate OPTIONAL }

TBSRequest ::= SEQUENCE {
  version             [0] Version DEFAULT v1(0),
  requestorName       [1] GeneralName OPTIONAL,
  requestList         SEQUENCE OF SEQUENCE {
     reqCert                    CertID,
     singleRequestExtensions  [0] Extensions OPTIONAL }
  requestExtensions  [2] Extensions OPTIONAL }

CertID ::= SEQUENCE {
  hashAlgorithm       AlgorithmIdentifier,
  issuerNameHash      OCTET STRING, -- Hash of Issuer's DN
  issuerKeyHash       OCTET STRING, -- Hash of Issuer's public key
                (i.e., hash of subjectPublicKey BIT STRING content)
  serialNumber        CertificateSerialNumber }
```

http://tools.ietf.org/html/rfc6960

Response Syntax

```
OCSPResponse ::= SEQUENCE {
      responseStatus         OCSPResponseStatus,
      responseBytes          [0] EXPLICIT ResponseBytes OPTIONAL }

   OCSPResponseStatus ::= ENUMERATED {
       successful             (0),  --Response has valid confirmations
       malformedRequest       (1),  --Illegal confirmation request
       internalError          (2),  --Internal error in issuer
       tryLater               (3),  --Try again later
                                    --(4) is not used
       sigRequired            (5),  --Must sign the request
       unauthorized           (6)   --Request unauthorized
   }

ResponseBytes ::=       SEQUENCE {
       responseType   OBJECT IDENTIFIER, --id-pkix-ocsp-basic
       response       OCTET STRING }
```

- `responseBytes` provided only if `responseStatus` is "successful"
- Note that `responseStatus` is not signed

Response Syntax

```
response ::= SEQUENCE {
    tbsResponseData      ResponseData,
    signatureAlgorithm   AlgorithmIdentifier,
    signature            BIT STRING,
    certs                [0] EXPLICIT SEQUENCE OF Certificate OPTIONAL }

ResponseData ::= SEQUENCE {
    version             [0] EXPLICIT Version DEFAULT v1,
    responderID         [1] Name,
    producedAt          GeneralizedTime,
    responses           SEQUENCE OF SEQUENCE {
          certID           CertID,
          certStatus       CertStatus,
          thisUpdate       GeneralizedTime,
          nextUpdate       [0] EXPLICIT GeneralizedTime OPTIONAL,
          singleExtensions [1] EXPLICIT Extensions OPTIONAL }
    responseExtensions  [1] EXPLICIT Extensions OPTIONAL }

CertStatus ::= CHOICE {
    good        [0]     IMPLICIT NULL,
    revoked     [1]     IMPLICIT SEQUENCE {
          revocationTime   GeneralizedTime,
          revocationReason [0] EXPLICIT CRLReason OPTIONAL }
    unknown     [2]     IMPLICIT NULL }
```

Who signs OCSP response?

The key used to sign the response MUST belong to one of the following:

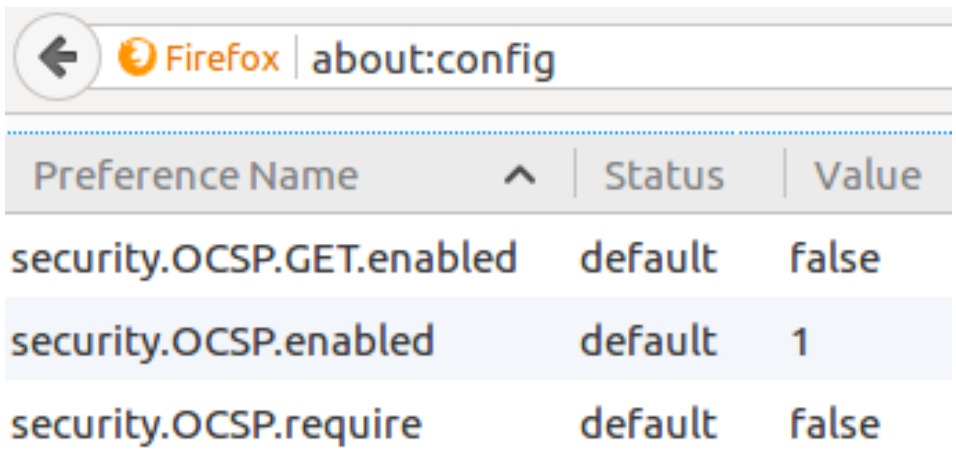
- CA who issued the certificate in question
- CA Authorized Responder who holds a specially marked certificate issued directly by the CA, indicating that the responder may issue OCSP responses for that CA
  - OCSP signing delegation SHALL be designated by the inclusion of `id-kp-OCSPSigning` flag in an `extendedKeyUsage` extension of the responder's certificate
  - How to check the revocation status of this certificate?
- Trusted Responder whose public key is trusted by the requester
  - Trust must be established by some out-of-band means

How to provide response freshness?

- Include signed timestamp in OCSP response (`producedAt` and `thisUpdate`)
  - What should be the allowed time difference?
  - Replay attacks
  - System clock in the Trusted Computing Base
- Include nonce in the OCSP request and check it in the response
  - OCSP nonce extension (optional)
  - Prevents replay attacks
  - Vulnerable to downgrade attacks

Revocation checking in browsers

- CRLs are not supported
- Problems with OCSP:
  - Privacy leakage
  - Slower initial page loading
  - Chrome does not use OCSP – uses CRLSets
  - Firefox is not brave enough to fail-safe:



- Solution is OCSP stapling (web server provides OCSP response to the browser)
- How frequently the OCSP status should be queried?

Server Sockets in Python

```
import socket
sserv = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
sserv.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
sserv.bind(('', 8888))
sserv.listen(0)

while True:
    (s, address) = sserv.accept()
    print "[+] Client %s:%s" % (address[0], address[1])
```

- `bind(('', 8888))` and `listen()` listens for client connections on all IPs on all network interfaces
- `accept()` will wait until client connects and returns tuple:
  - client socket (has `send()` and `recv()` methods)
  - address tuple – IP and port
- `SO_REUSEADDR` forces the kernel to reuse port even if it is in busy (`TIME_WAIT`) state (prevents error when rebinding)

`http://docs.python.org/2/howto/sockets.html`

Task: OCSP responder

Implement OCSP responder answering to HTTP POST requests.

```
$ ./ocspresponder.py
usage: ocspresponder.py --privkey privkey --cacert cacert --revoked cert [cert ...]

$ ./ocspresponder.py --privkey priv.pem --cacert rootCA.pem --revoked issued1.pem issued2.p
[+] Serial 1705406124 (issued1.pem) loaded
[+] Serial 3532215973 (issued2.pem) loaded
[+] Connection from 127.0.0.1:48318
[+] Connection from 172.17.57.208:45394

$ openssl ocsp -url http://127.0.0.1:8888/ -no_nonce -VAfile rootCA.pem
 -issuer rootCA.pem -cert issued2.pem
Response verify OK
issued2.pem: revoked
   This Update: Apr 4 10:13:37 2018 GMT
   Reason: keyCompromise
   Revocation Time: Jan 1 12:12:00 2000 GMT

$ openssl ocsp -url http://127.0.0.1:8888/ -no_nonce -VAfile rootCA.pem
 -issuer rootCA.pem -cert issued3.pem
Response verify OK
issued3.pem: good
   This Update: Apr 4 10:13:39 2018 GMT

$ openssl ocsp -url http://127.0.0.1:8888/ -no_nonce -VAfile rootCA.pem
 -issuer rootCA2.pem -cert issued3.pem
Response verify OK
issued3.pem: unknown
   This Update: Apr 4 10:13:45 2018 GMT
```

Task: OCSP responder

- Bind your HTTP server on port 8888 on all network interfaces:

```
$ netstat -na | grep 8888
tcp    0      0 0.0.0.0:8888          0.0.0.0:*          LISTEN
```

- HTTP server should be able to process sequential connections
- Must support only single certificate in OCSP request
- Signature check in `load_serials()` not required.
- Omit `nextUpdate`. Use current time for `thisUpdate` and `producedAt`.
- Return CertStatus:
  - "unknown" if not issued by CA (`issuerNameHash` or `issuerKeyHash` in CertID does not match).
  - "revoked" if certificate revoked (set arbitrary `revocationTime` and `revocatonReason`).
  - "good" otherwise.

Task: OCSP responder

```
$ openssl ocsp -url http://127.0.0.1:8888/ -no_nonce -VAfile rootCA.pem -issuer rootCA.pem
 -cert issued3.pem -text
OCSP Request Data:
    Version: 1 (0x0)
    Requestor List:
        Certificate ID:
          Hash Algorithm: sha1
          Issuer Name Hash: 8350F92D60E6122B0112EF8E5381F3190BB2C703
          Issuer Key Hash: 4396CDDBB018CC4DF32D699971706FF1639B3BFB
          Serial Number: 577DC7A1
OCSP Response Data:
    OCSP Response Status: successful (0x0)
    Response Type: Basic OCSP Response
    Version: 1 (0x0)
    Responder Id: C = EE, O = University of Tartu, OU = IT dep, CN = Arnis Root CA
    Produced At: Apr 4 10:45:20 2018 GMT
    Responses:
    Certificate ID:
      Hash Algorithm: sha1
      Issuer Name Hash: 8350F92D60E6122B0112EF8E5381F3190BB2C703
      Issuer Key Hash: 4396CDDBB018CC4DF32D699971706FF1639B3BFB
      Serial Number: 577DC7A1
    Cert Status: good
    This Update: Apr 4 10:45:20 2018 GMT

    Signature Algorithm: sha1WithRSAEncryption
         2c:30:21:51:c7:b8:98:d7:4b:5f:aa:1e:f5:62:fc:4a:6d:78:
Response verify OK
issued3.pem: good
   This Update: Apr 4 10:45:20 2018 GMT
```

Task: OCSP responder

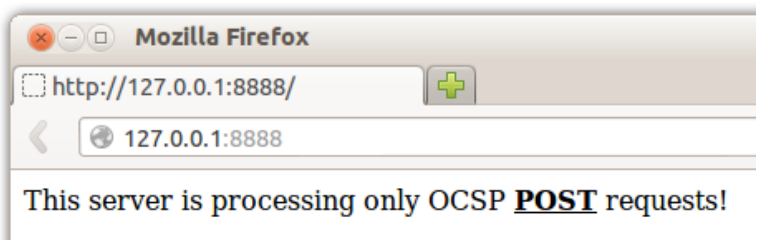
- Bonus point for supporting nonce extension:

```
$ openssl ocsp -url http://127.0.0.1:8888/ -nonce -VAfile rootCA.pem
 -issuer rootCA.pem -cert issued3.pem
Response verify OK
issued3.pem: good
This Update: Apr 4 10:29:35 2018 GMT
```

- Half bonus point for returning response status "unauthorized" to clients from non-loopback IP (127.0.0.1):

```
$ openssl ocsp -url http://172.17.57.208:8888/ -nonce -VAfile rootCA.pem
 -issuer rootCA.pem -cert issued3.pem
Responder Error: unauthorized (6)
```

- Half bonus point for serving nice response to GET requests:



Hints

- Look on `resp_revoked.der`, `resp_good.der`, `resp_unknown.der`, `resp_nonce.der` and `resp_unauthorized.der` for response examples.
- Use openssl "-respout" parameter for debugging.
- Error "bad signature" may be caused by wrong DER encoding.
- DER encoding for ENUMERATED is the same as for INTEGER, just universal tag 10 instead of 2.
- DER encoding for GeneralizedTime is the same as for UTCTime, just 4-digit year encoding and universal tag 24 instead of 23.
- Datetime object conversion to GeneralizedTime string:

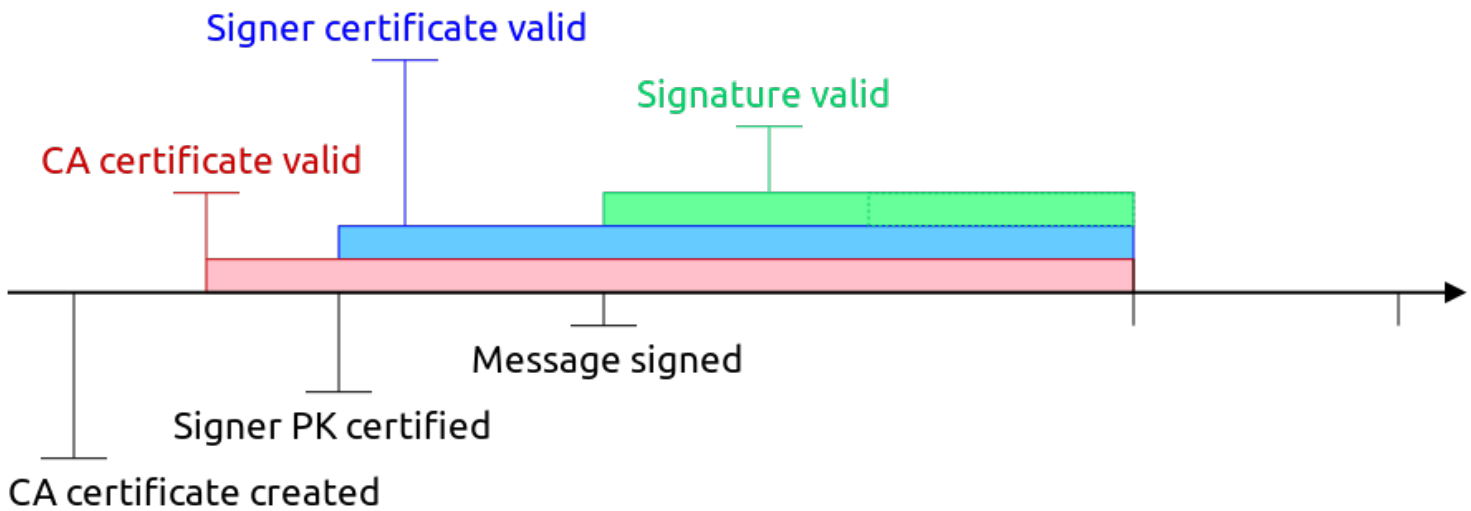
  ```
  datetime.datetime.utcnow().strftime("%Y%m%d%H%M%SZ")
  ```

- CertStatus is implicitly tagged NULL value (for good/unknown) or SEQUENCE (for revoked)
  - Implicit tagging replaces "type" byte of original value:
    - Class bits – context-defined (1 0)
    - Form bit – from value to be tagged (primitive/constructed)
    - Tag bits – tag number

Certificate Status

CRL and OCSP allows to verify if certificate valid now.

- Simple for authentication
- What about digital signature?
- Signature valid as long as certificate has not expired?



- Was the certificate valid at the time of signing?
- How to find out the time of signing?

Trusted Timestamping

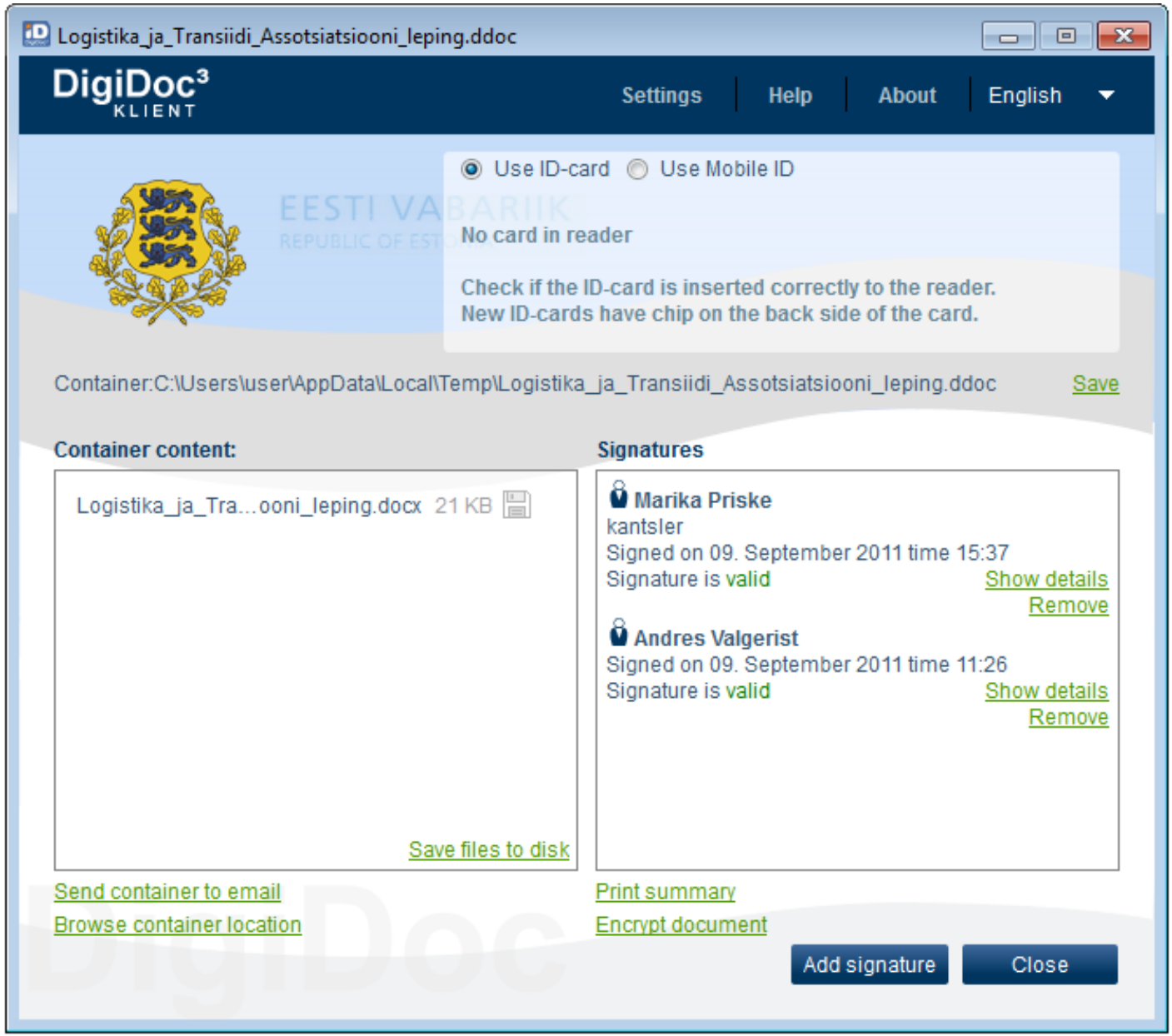
Signed statement of timestamping authority (TSA):

```
> This data [data] was presented to me at this time: [time]
> Yours,
> --
> TSA
> [signature]
```

http://tools.ietf.org/html/rfc3161

- `data` – usually a hash of the signature value
- Proves that the signature was given *before* the time specified
- Digital signature containers usually contain:
  - Signed files
  - Signature of files
  - Timestamp of the signature
  - OCSP response (acquired right after timestamping)
- How to verify digital signature after TSA/OCSP cert expires?
- Why is certificate suspension a bad idea?

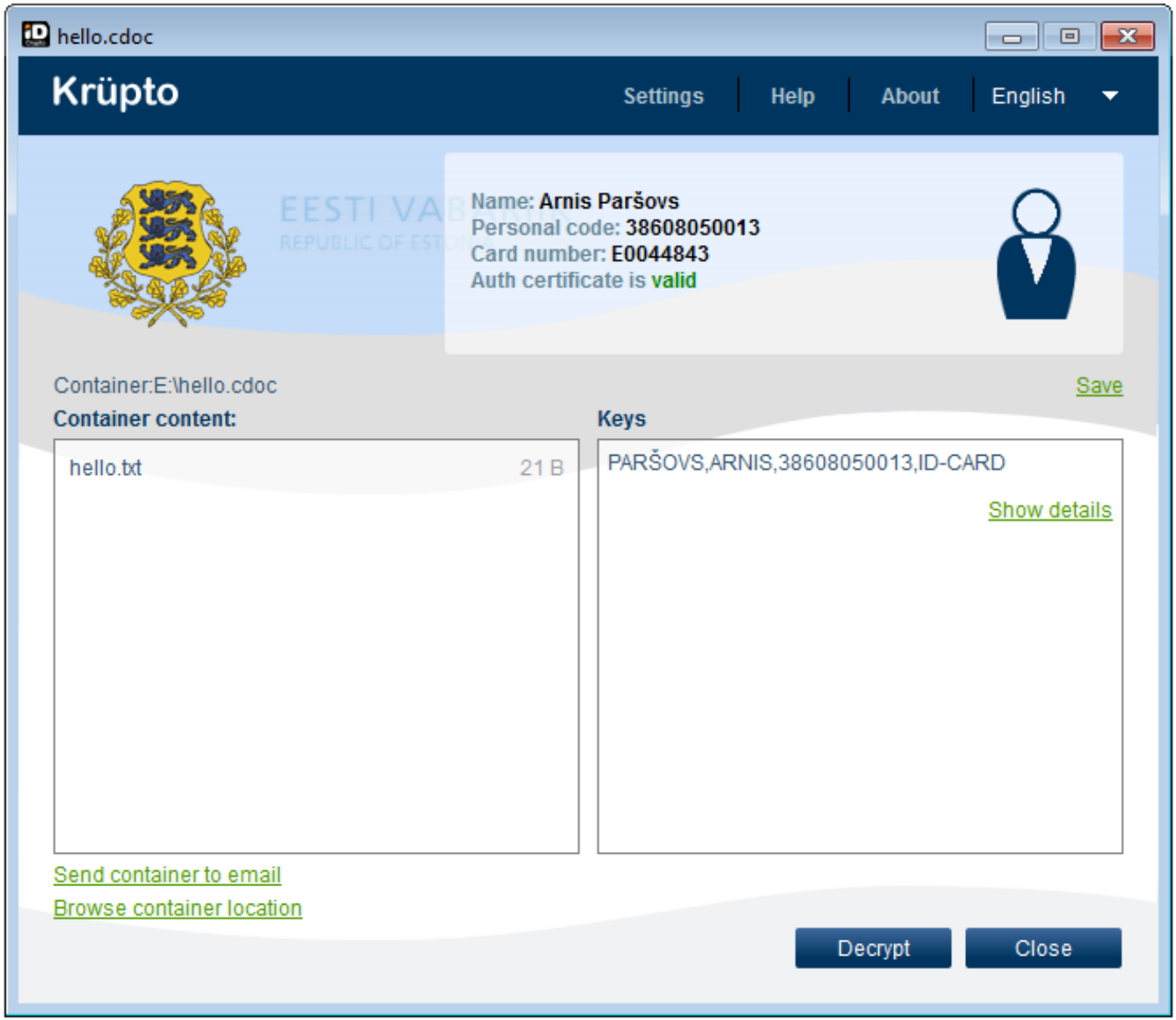
DigiDoc Client



XML Signature

```
<?xml version="1.0" encoding="UTF-8"?>
<SignedDoc format="DIGIDOC-XML" version="1.3" xmlns="http://www.sk.ee/DigiDoc/v1.3.0#">
  <DataFile Filename="document.doc" Id="D0">UEsDBBQABgA...ASlEAAAAA</DataFile>
  <Signature Id="S0">
    <SignedInfo>
      <SignatureMethod Algorithm="http://www.w3.org/2000/09/xmldsig#rsa-sha1"/>
      <Reference URI="#D0">
        <DigestMethod Algorithm="http://www.w3.org/2000/09/xmldsig#sha1"/>
        <DigestValue>Q43ti5R/wgi8qOoHsygLFTXEOqU=</DigestValue>
      </Reference>
      <Reference URI="#S0-SignedProperties">
        <DigestMethod Algorithm="http://www.w3.org/2000/09/xmldsig#sha1"/>
        <DigestValue>G0HmQqHCqMxULzfWSONIL2i0mIU=</DigestValue>
      </Reference>
    </SignedInfo>
    <SignatureValue Id="S0-SIG">kgsCQ6...M4rkcj8=</SignatureValue> - signature of <SignedInfo>
    <X509Certificate>IID4z....V8APa</X509Certificate>
    <SignedProperties Id="S0-SignedProperties">
      <SigningCertificate>
        <DigestMethod Algorithm="http://www.w3.org/2000/09/xmldsig#sha1"/>
        <DigestValue>RRFMpf0Xr5ZRyEs49m4S8M3oRnw=</DigestValue>
      </SigningCertificate>
      <SignatureProductionPlace>
        <City>Tallinn</City>
      </SignatureProductionPlace>
    </SignedProperties>
    <OCSPValues>
    ...
  </Signature>
  ...
</SignedDoc>
```

DigiDoc Crypto



XML Encryption

```
<?xml version="1.0" encoding="UTF-8" ?>
<denc:EncryptedData xmlns:denc="http://www.w3.org/2001/04/xmlenc#">

  <denc:EncryptedKey Recipient="PARŠOVS,ARNIS,38608050013,ID-CARD">
    <denc:EncryptionMethod Algorithm="http://www.w3.org/2001/04/xmlenc#rsa-1_5"/>
    <ds:X509Certificate>A1UdEQQaM...sQkDYzTwuVzxc8OO</ds:X509Certificate>
    <denc:CipherValue>AZrhOj...QOY=</denc:CipherValue>
  </denc:EncryptedKey>


  <denc:EncryptedKey Recipient="...
  <denc:EncryptedKey Recipient="...


  <denc:EncryptionMethod Algorithm="http://www.w3.org/2001/04/xmlenc#aes128-cbc"/>
  <denc:CipherValue>QGKSSP...Wg20fGDSJal/Dr6Y1x4Fgg==</denc:CipherValue>

  <denc:EncryptionProperties>
    <denc:EncryptionProperty Name="LibraryVersion">CDigiDoc|3.8.0.1136</denc:EncryptionProperty>
    <denc:EncryptionProperty Name="DocumentFormat">ENCDOC-XML|1.0</denc:EncryptionProperty>
    <denc:EncryptionProperty Name="orig_file">hello.txt|21||D0</denc:EncryptionProperty>
  </denc:EncryptionProperties>

</denc:EncryptedData>
```

- Content encrypted using random 128-bit AES key
- Key encrypted using receivers RSA public key
- IV stored as a first ciphertext block
- Integrity protection not provided

Questions

- Where can the relying party find the OCSP responder?
- How is the certificate identified in the OCSP request?
- How is the integrity of OCSP response assured?
- How to ensure the freshness of OCSP response?
- At which point OCSP must be checked?
- What problem does the OCSP nonce extension solves?
- What is downgrade attack?
- What is needed in order to prove that the data was signed when the certificate was valid?