x.509

Christian Grothoff

Berner Fachhochschule

4.06.2018

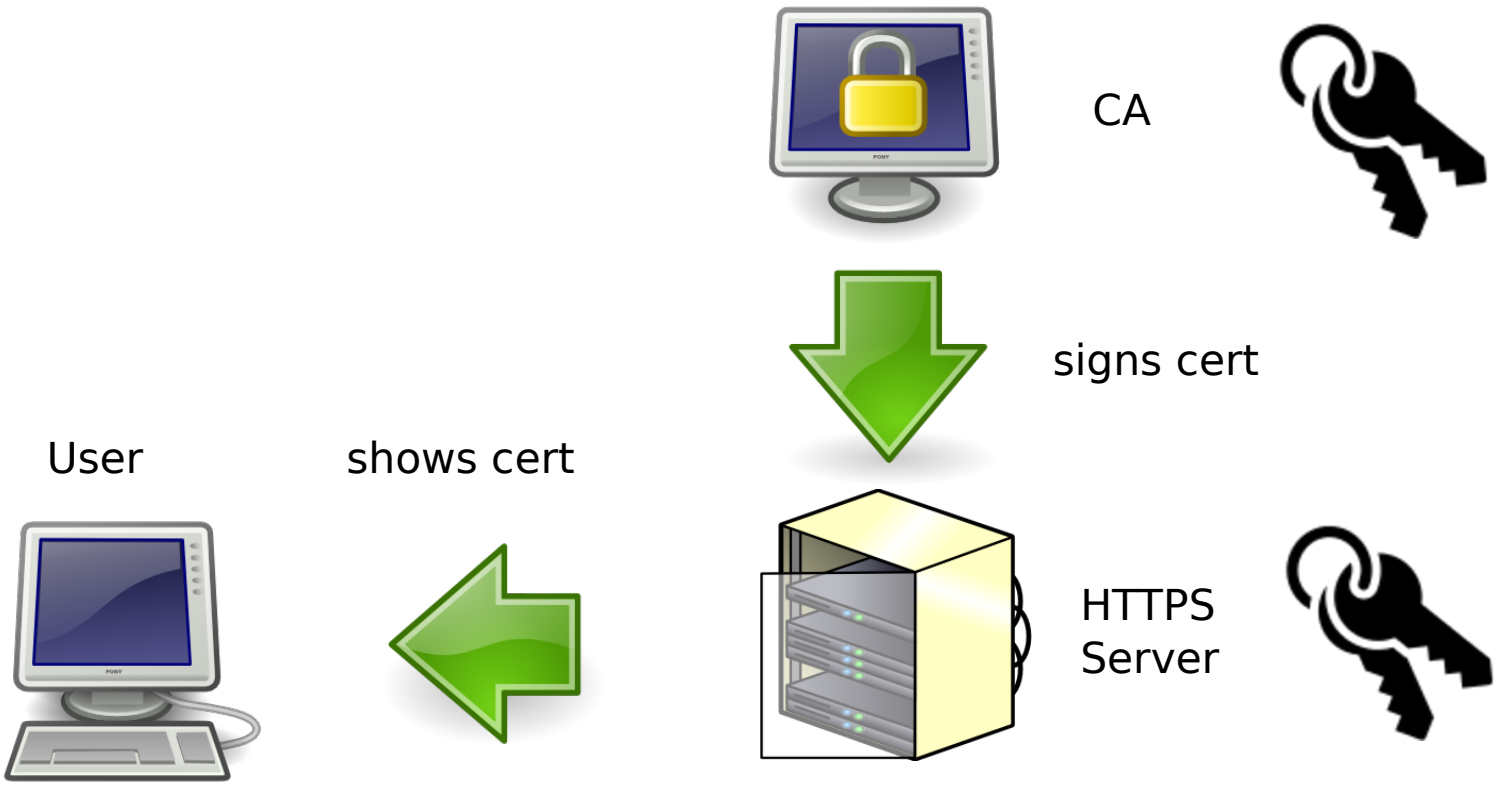
X.509 and TLS

X.509 is an ITU standard (but also RFC 5280).

- TLS servers (and sometimes clients) are identified by public key
- Public keys are *certified* by certificate authorities
- X.509 certificates are the format used for certificates
- Any certificate authority can certify keys for any domain

TLS is not the only major protocol using X.509!
There is also S/MIME for e-mail!

X.509 overview (reminder)



What is a certificate?

- A public-key certificate is a digitally signed statement that binds the identity of the entity to a public key
- If A trusts B, and knows B's public key, then A can learn C's public key if B issues a public key certification of C

Contents of X.509 certificates

- X.509 version
- CA serial number
- A digital signature algorithm identifier
- The identity of the signer
- Validity period
- The identity of the subject (common name, org. unit, org., state, country)
- The public key of the subject
- Optional: URL to revocation center (OCSP!)
- Auxiliary information (identity address, alternative names)
- The digital signature

Certificate Authorities

- Entities that *claim* to be trustworthy to verify identities and issuing public key certificates ("let's encrypt")
- CAs can be organized into a directed graph
- X.509: Tree depth can be limited for a subtree
- X.509: Certificates of CAs signing intermediate-level CAs have the special "CA" bit set

Self-signed certificates

- Signer is self
- Allowed by TLS
- Used to sign CA tree roots

X.509 CA challenges

- Must trust a CA
  - Which one?
  - What is it trusted to do?
- Certificate bindings must be correct
  - Which John Smith is this?
  - Who authorizes attributes in a certificate?
  - How long are these values valid?
  - What process is used to verify the key holder?

CA: creates a self-signed certificate

```
# create certificate:
$ openssl req -x509 -out cert.pem -outform PEM -days 3650
# private key will now be in privkey.pem
# convert to certificate request:
$ openssl x509 -x509toreq -in cert.pem -out req.pem \
    -signkey privkey.pem
# generate config
$ cp /usr/lib/ssl/openssl.cnf .
# self-sign using:
$ openssl x509 -req -in req.pem -extfile openssl.cnf \
  -extensions v3_ca  -signkey privkey.pem -out selfcert.pem
# view using:
$ openssl x509 -in cacert.pem -text -noout
```

PEM encoding is Base64 of DER bytestream with "begin certificate" and "end certificate" markers.

Client: creates a certificate request

```
# create private key using:
$ openssl genpkey -algorithm RSA -out key.pem \
  -aes-128-cbc -pkeyopt rsa_keygen_bits:2048
# create CSR using:
$ openssl req -new -key key.pem -keyform PEM \
  -out req.pem -outform PEM
```

CA: signs certificate request

```
# Prepare CA directory structure
$ wget https://grothoff.org/christian/teaching/ca.conf
$ mkdir dir certdir
$ touch dir/index.txt dir/index.txt.attr
$ echo 1 > dir/serial.txt
# sign CSR using:
$ openssl ca -in req.pem -out cert.pem -config ca.conf
```

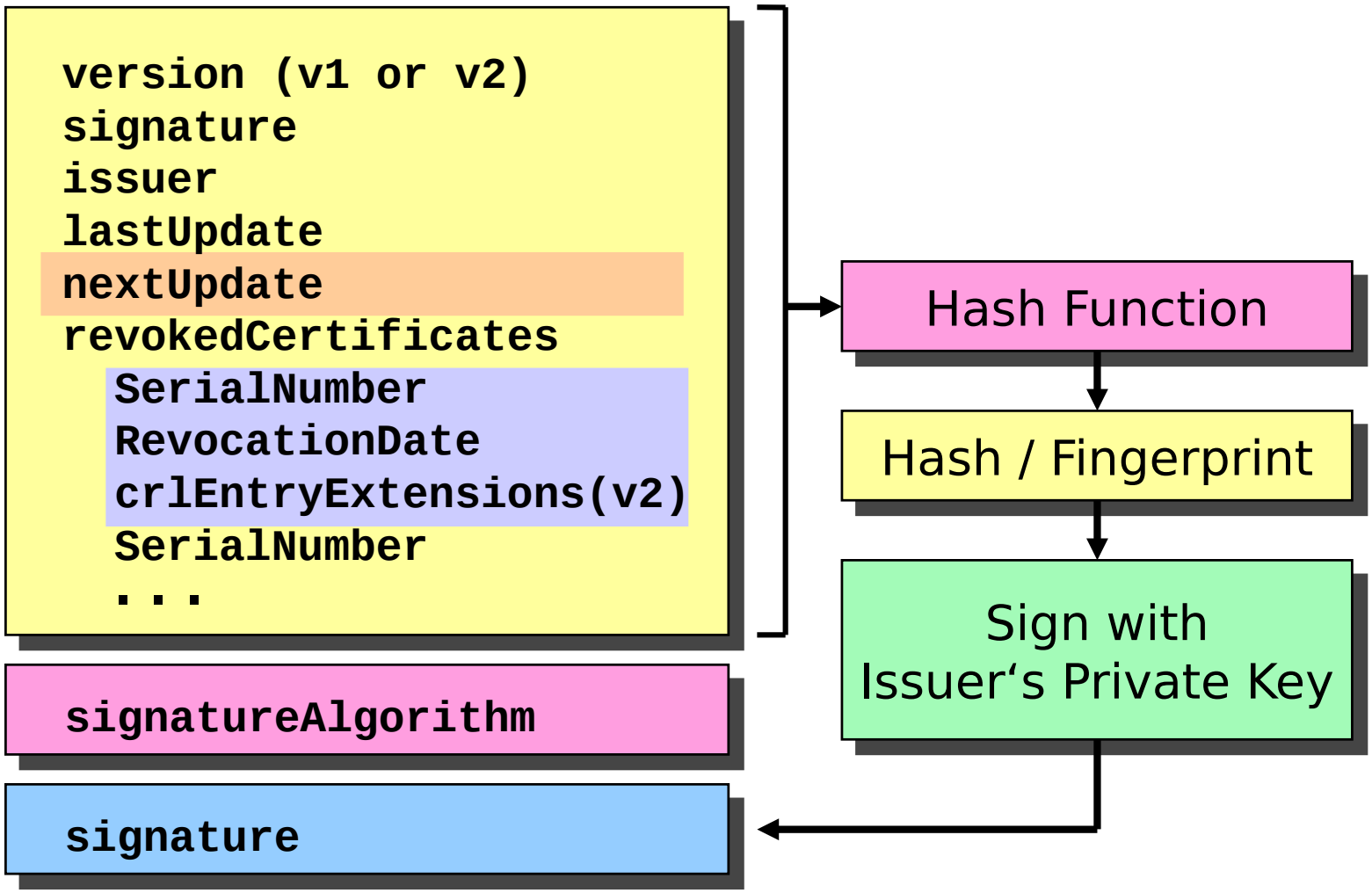
X.509v3 subjectAltNames

X.509v3 certificates can specify many subjectAltNames:

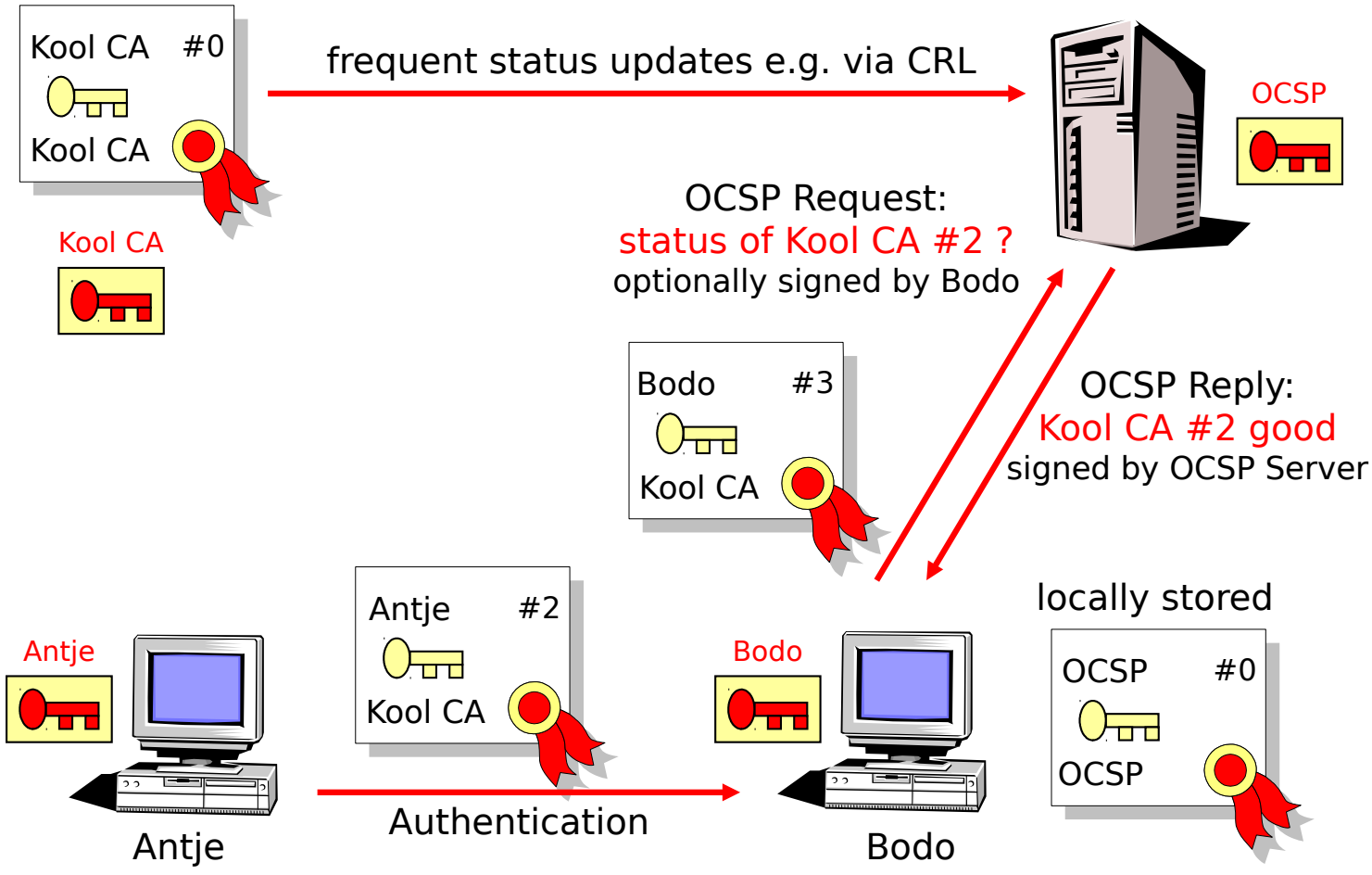
- IP:192.168.2.0
- DNS:www.example.com
- email:user@example.com

emails must be subjectAltNames and should not be used for the subject distinguished name (DN)!

X.509v3 crlDistributionPoints



Online Certificate Status Protocol (OCSP)



basicConstraints

- CA:TRUE; critical
- CA:TRUE; pathLenConstraint $= 0$
- CA:FALSE

keyUsage

CA:

- certificateSign
- crlSign

Leaf:

- digitalSignature
- nonRepudiation
- keyEncipherment
- dataEncipherment
- keyAgreement

Extended Key Usage (EKU)

- serverAuth
- clientAuth
- codeSigning
- emailProtection
- timeStamping
- ocspSigning

Legal Aspects

For what is a CA liable?

- Certificate policies (CP) define rights, duties and obligations of each party in a PKI
- These documents usually have a legal effect
- The CP should be publicly exposed by CAs on their Web site and include:
  - Registration procedures
  - Revocation procedures
  - Liability issues

Acknowledgements

- Partially based on materials and inspiration taken from talks by Andreas Steffen (ITA)