Distributed Systems Security

Authentication Practice - 2

Prof. Steve Wilbur
s.wilbur@cs.ucl.ac.uk

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Lecture Objectives

- Examine X.509 as a practical example of Public Key services

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X.500 Directory Service

- X.500 is a family of standards for directory services providing information about users
- Developed in late-1980s by ITU
- X.509 defines a certificate structure and protocols which are widely used, eg.:
  - S/MIME
  - IP Security
  - SSL/TLS
  - SET
- X.509:
  - V1: 1988; V2: 1993; V3: 1995

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X.509 Certificate Structure

Example of early definition of Certificate structure in ASN.1

LHS = identifier; RHS = type

```
certificate ::= SIGNED SEQUENCE {
   signature             AlgorithmIdentifier,
   issuer                Name,
   validity              Validity,
   subject               Name,
   subjectpkinfo SubjectPublicKeyInfo}

Validity ::= SEQUENCE {
   notbefore             UTCTime,
   notAfter              UTCTime}

SubjectPublicKeyInfo ::= SEQUENCE{
   algorithm             AlgorithmIdentifier,
   subjPK                BITSTRING}

AlgorithmIdentifier ::= SEQUENCE {
   algorithm             OBJECT IDENTIFIER,
   parameters            ANY DEFINED BY algorithm OPTIONAL}
```

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X.509 Certificates

- Issued by trusted Certification Authority
- Directory Service only stores and distributes them

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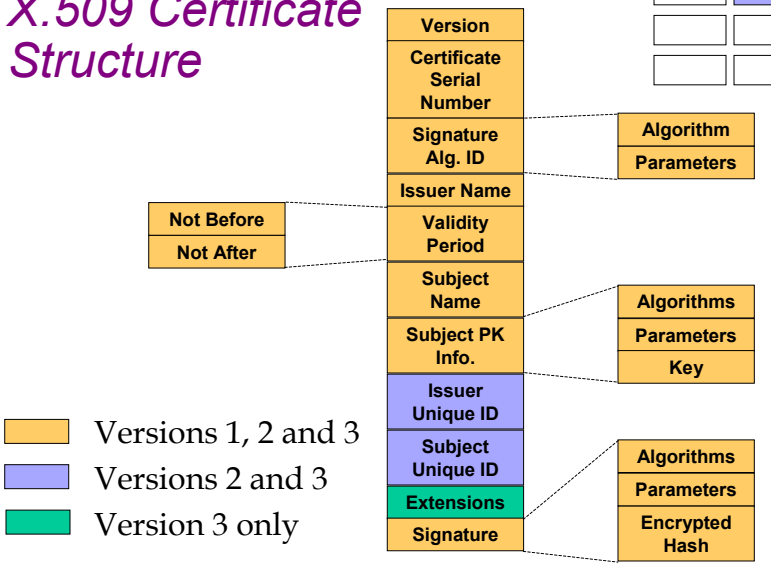
X.509 Certificate Structure



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X.509 Certificates - 2

- **Version:** Indicates format of certificate (1, 2 or 3)
- **Serial Number:** Integer associated with this C, unique in issuing CA
- **Sig. Alg. ID:** Algorithm used to sign the C and any parameters (repeated in the Signature field)
- **Issuer Name:** Name of CA that created C
- **Validity Period:** First and last dates on which C is valid
- **Subject Name:** Name of user to whom C applies
- **Subject PK Info.:** Public key, algorithm and any relevant parameters of subject
- **Issuer Unique ID:** Optional bit string to identify uniquely CA in case name is not unique
- **Subject Unique ID:** Optional bit string to identify uniquely CA in case name is not unique
- **Signature:** Covers all other fields of C

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X.509 Certificates - 3

- Inter-domain certification by CA's producing certificates for each other's Public Keys
  - **Forward Certificate:** Certificate of X generated by other Cas
  - **Reverse Certificates:** Certificates generated by X for another CA
- Generally arranged hierarchically so that easy for users to find certification chain and request relevant certificates
- Otherwise, similar to "theory"

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X.509 Certificate Revocation

- Certificates usually issued for appropriate length of time, eg. students: 1 academic year
- May need to nullify C earlier if:
  - user's secret key compromised
  - user no longer within jurisdiction of CA, eg. left job
  - CA's certificate has been compromised
- Each CA keeps a list of all revoked but not expired certificates
- Periodically published to directory via Certificate Revocation List (CRL)
- If end user caches C's they must also cache relevant CRL's

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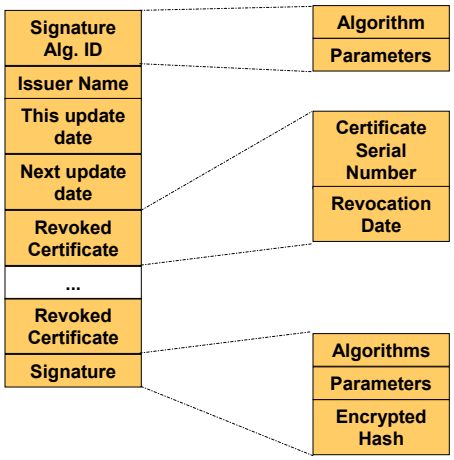
X.509 Certificate Revocation List



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X.509 Certificates V.3 Limitations of V.2

- Subject field inadequate to fully convey identity of owner (which j smith in that domain esp. if domain is broad eg. ISP)
- May be several different identities for a given user, eg. mail address, URL, etc. - need to specify and relate them
- Need to indicate security policy information, so protocols can relate specific Certificate for this
- Need to limit damage from faulty or malicious CA
- Important to keep separate keys used by same owner at different times - key life cycle management

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X.509 Certificates V.3

- Flexible structure to deal with these and other needs: extensions
- Each extension consists of:
  - extension identifier
  - criticality indicator
  - extension value
- Criticality indicator indicates whether this extension can safely be ignored
  - if indicator is TRUE and application/protocol cannot deal with this extension type, then the certificate must be treated as invalid

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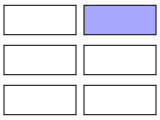
X.509 Certificates V.3 Key and Policy Information -1



- Authority Key Identifier: Identifies which of CAs keys to use to validate C. Allows CAs key pairs to be updated
- Subject Key Identifier: Similar to above.
- Key Usage: Policy restrictions on key, eg. digital signature, data encryption, key encryption etc.

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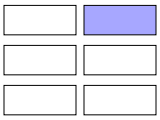
X.509 Certificates V.3 Key and Policy Information -2



- Private-key Usage Period: Private key may be valid for a much shorter period than the public key, eg. signing (private) key validity less than verifying (public) key
- Certificate Policies: Lists policies this certificate supports and optional qualifier information
- Policy Mappings: For Certificates for CAs issued by other CAs. Indicates policies in issuer domain which are equivalent in the subject CAs domain

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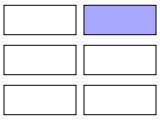
X.509 Certificates V.3 Subject & Issuer Attributes



- Provide alternative names in alternative formats
- Increase user's confidence that C relates to particular person or entity
- Examples:
  - postal address
  - position within organisation
  - picture
- Subject Alternative Name: One or more alternative names. Some apps use their own name forms

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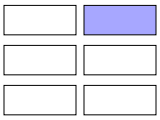
X.509 Certificates V.3 Subject & Issuer Attributes -2



- Subject Alternative Name: One or more alternative names. Some apps use their own name forms
- Issuer Alternative Name: Similar to above, but for issuer
- Subject Directory Attributes: X.500 directory attributes for the subject

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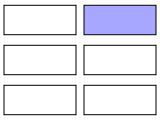
X.509 Certificates V.3 Certification Path Constraints



- May provide constraints on which cross-certificates may appear in certification chains
- May constrain the types of certificates that the subject CA can issue

- Basic Constraints: Indicates if subject may act as CA. May include a max. certification path length.
- Name Constraints: Limits name space for all subject names in subsequent Cs in a path
- Policy Constraints: May enforce explicit policy specification in the rest of the certification path

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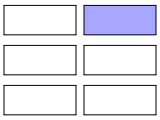
Certificate Creation



- Algorithmically, this is easy
- BUT, need to think carefully about processes within organisation or domain
- Following diagrams show schematics of Certificate issue under authority of a commercial or government issuer

- Assumes that subject's company has established its credential beforehand with issuing authority

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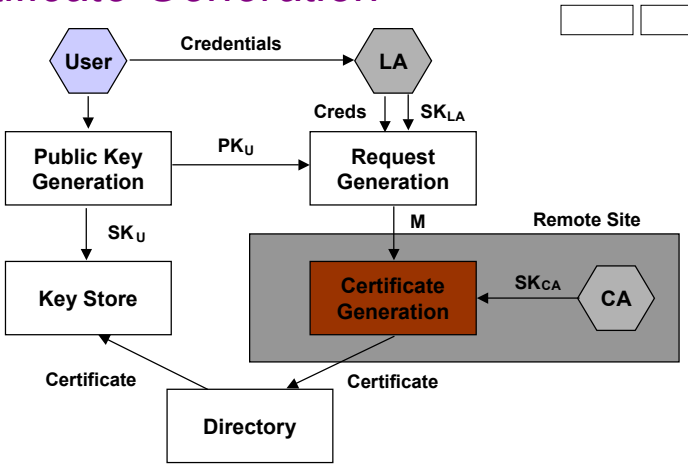
Certificate Generation



M is of form:
LA, {RQCert, LA, User, Creds, PK}SK_{LA}

CA - Certification Authority
LA - Local Authority

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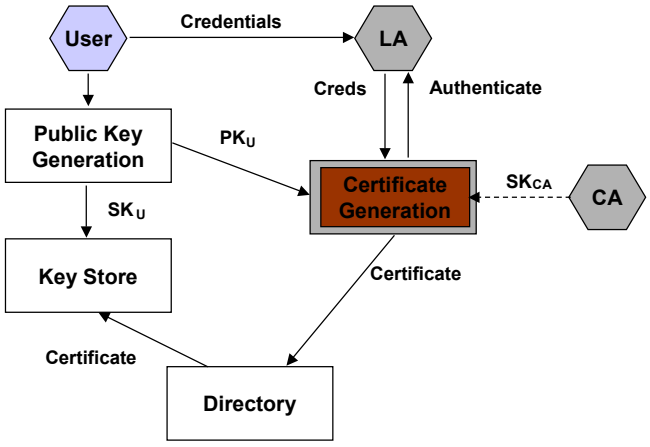
Local Certificate Generation



CA - Certification Authority
LA - Local Authority

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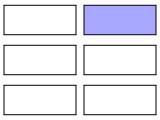
Certificate Issuing Issues



- How do you prove to someone who you are?
  - Driving licence?
  - P45?
  - Letter of reference?
  - Birth Certificate?
- How much certainty is required?
- If you buy/program key-pair generation software how do you know it is sound? What tests would you apply to it?

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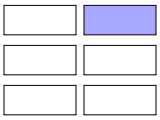
Certificate Issuing Issues - 2



- Are copies of Private Keys kept - escrowed? All of them, non, some?
- How are Private Keys stored? How secure is this?
- If PKs are encrypted while not in use (key chain) how secure is the encryption? Based on password or phrase?
- What procedures does CA expect LA to carry out? What auditing needs to be done? Does this introduce potential weaknesses

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Further Reading

- Stallings W, "Cryptography and Network Security: Principles and Practice", 2ed, Prentice Hall, 1999, 0-13-869017-0
  - **X.509 Authentication and Certificates:** pp 341-349
- Pfleeger C, "Security in Computing", 2ed, Prentice Hall, 1997, 0-13-185794-0
  - **Certificates:** pp 135-140
- Ford W, "Advances in Public-Key Certificate Standards", ACM SIGSAC Review, July 1995

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Further Reading - 2

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