Public Key Infrastructure

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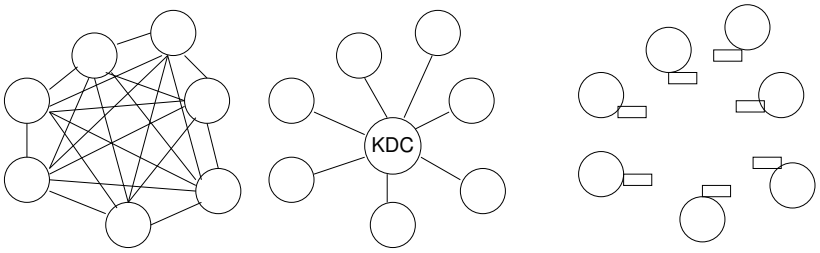
The Key Management Scaling Problem



With one symmetric key per pair, quadratic explosion

Central KDC can distribute session keys on demand (Kerberos, etc.)

Public Key approach only requires linear number of keys –

but still need reliable way to associate public key with entity...

Key Distribution Center (KDC)

Trusted third party

Should be able to authenticate requestors (at least implicitly)

Should be able to provide requestors with information that allows them to authenticate themselves to others

Should provide keys to parties as warranted over secure channel

If KDC compromised, then all is lost

Certification Authority (CA)

Trusted third party

Should be able to provide requestors with information that allows them to authenticate themselves to others

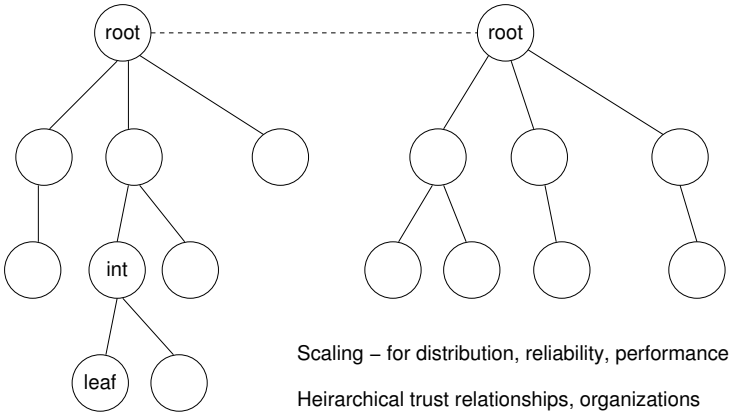
Signs certificates (that may hold keys, etc.)

Directory may use insecure channel for communication

CA need not be on–line

Compromised CA can permit spoofing, but cannot decrypt communications established between the true parties

Trusted Intermediate Hierarchies



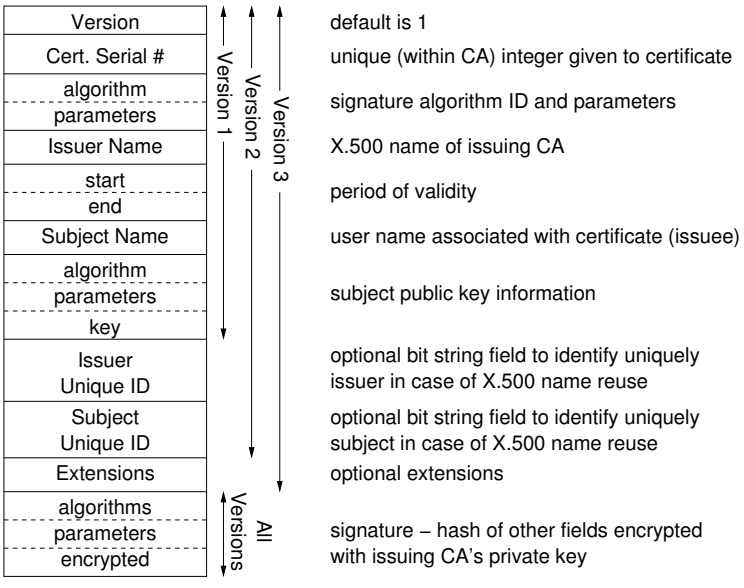
Scaling – for distribution, reliability, performance

Heirarchical trust relationships, organizations

Action at appropriate level (locality)

Cross–hierarchy trusts

X.509 Certificates



default is 1

unique (within CA) integer given to certificate

signature algorithm ID and parameters

X.500 name of issuing CA

period of validity

user name associated with certificate (issuee)

subject public key information

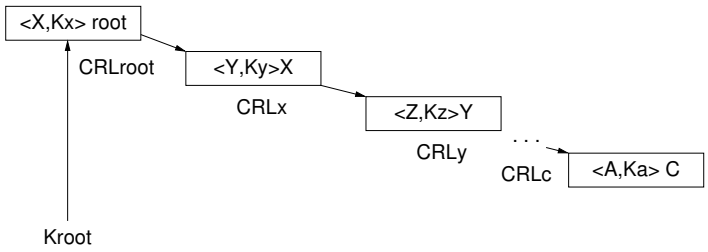
optional bit string field to identify uniquely issuer in case of X.500 name reuse

optional bit string field to identify uniquely subject in case of X.500 name reuse

optional extensions

signature – hash of other fields encrypted with issuing CA's private key

Certificate Chains



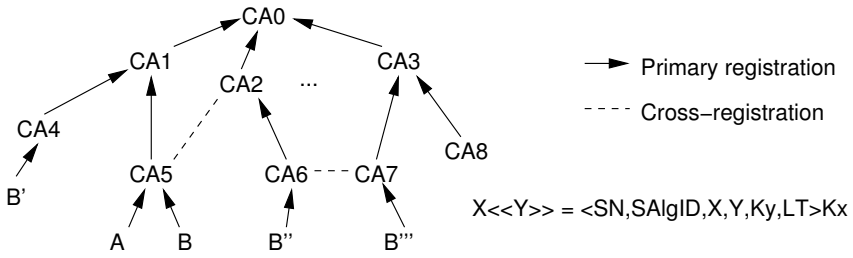
To get B's public key reliably, A must

Obtain copy of B's certificate from a directory service

Build certification path (certificate chain) from root CA to certificate
Verify temporal validity of all certificates along certificate chain
Verify all signatures along certificate chain

Check all CRLs to ensure no certificate on chain was revoked
A has the root's public key from the start

X.509 Certificate Binding Hierarchy



A−>B: CA5<<A>>

A−>B': CA5<<A>>,CA1<<CA5>>,CA4<<CA1>>

A−>B'': CA5<<A>>,CA1<<CA5>>,CA0<<CA1>>,CA2<<CA0>>,CA6<<CA2>>
...or... CA5<<A>>,CA2<<CA5>>,CA6<<CA2>>

certification path can use X.500 Directory Information Tree (DIT) or
DIT plus cross−registration short−cuts

X.509 Certificate Revocation

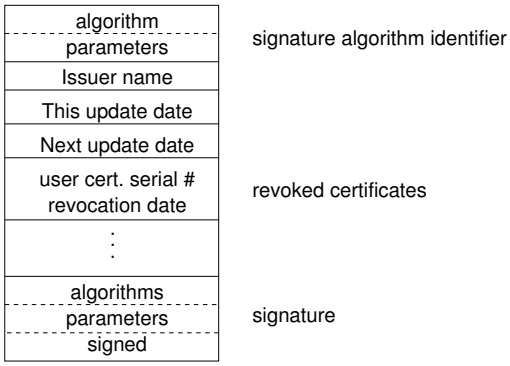
Each CA maintains a CRL (Certificate Revocation List)

May have ICRL (individual) and CACRL (CAs)

vulnerability in specification – look the same

Must check the CRL for each CA on certification path

Certificate Revocation Lists



X.509 Certificate Version 3 Extensions

May need more info than subject field alone gives

May need security policy information

Need to limit damage from fault CA

Need to be able to identify separate keys used by same subject (encrypt, verify)

Extension fields provide this in a flexible way

- Extension identifier
- Extension criticality – can this be ignored safely?
- Extension value

Three main categories –

- Key and policy info
- Subject and issuer attributes
- Certification path constraints

Certification Path Constraint Extensions

Constraints included in CA certificates for other CAs

May restrict types of certificates that can be issued by the subject CA, or that may occur later in the chain

Include:

- Basic constraints – indicates if subject can act as a CA; may constrain certification path length
- Name constraints – constrains name space of all subject names in rest of certification path
- Policy constraints – may specify explicit policy identification or may inhibit policy mapping for rest of path

Key and Policy Extensions

Certificate Policy = named set of rules that indicates applicability of a certificate to a particular community or class of application with common security requirements.

Includes:

- Authority key identifier – distinguishes among multiple signing keys for the CA
- Subject key identifier – distinguishes among multiple keys for subject (e.g., verification key, encryption key; useful for updating keys also)
- Key usage – restricts ways in which the key should be used: digital signature, non–repudiation, key encryption, data encryption, key agreement, CA signature verification on certificates, CA signature verification on CRLs
- Private key usage period – signing key usually shorter lived than verification key
- Certificate policies – list of policies the certificate supports, along with optional qualifying information
- Policy mappings – used only in certificates issued by CAs for other CAs; allows issuer to indicate equivalencies between policies of issuer and subject CA domains

Certificate Subject and Issuer Attribute Extensions

Support for alternative names, alternative formats

Can provide additional information about a subject for identification purposes (e.g., email address, postal address, position title, photograph, etc.)

Includes:

- Subject alternative name – one or more alternative names in a variety of forms; supports IPSEC, email, EDI, etc.
- Issuer alternative name – ditto for issuer
- Subject directory attributes – any X.500 directory attribute values for subject