INFS 766
Internet Security Protocols

Lecture 6
Digital Certificates

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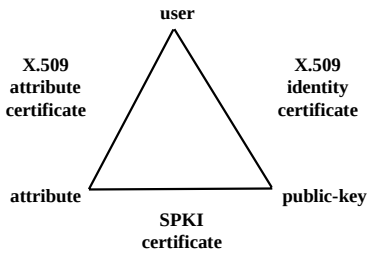
PUBLIC-KEY CERTIFICATES

- reliable distribution of public-keys
- public-key encryption
  - sender needs public key of receiver
- public-key digital signatures
  - receiver needs public key of sender
- public-key key agreement
  - both need each other's public keys

THE CERTIFICATE TRIANGLE



X.509 CERTIFICATE

VERSION
SERIAL NUMBER
SIGNATURE ALGORITHM
ISSUER
VALIDITY
SUBJECT
SUBJECT PUBLIC KEY INFO
SIGNATURE

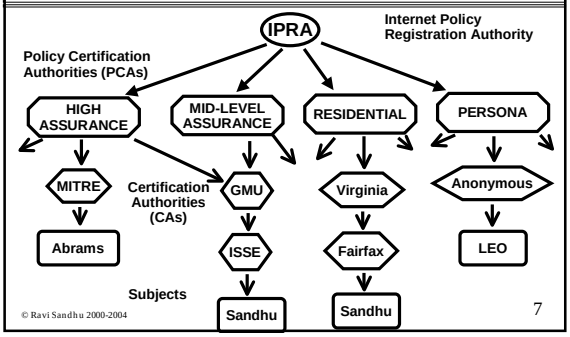
X.509 CERTIFICATE

0
1234567891011121314
RSA+MD5, 512
C=US, S=VA, O=GMU, OU=ISE
9/9/99-1/1/1
C=US, S=VA, O=GMU, OU=ISSE, CN=Ravi Sandhu
RSA, 1024, xxxxxxxxxxxxxxxxxxxxxxxxx
SIGNATURE

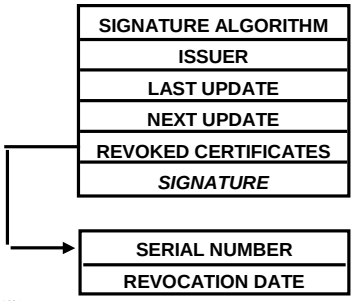
CERTIFICATE TRUST

- how to acquire public key of the issuer to verify signature
- whether or not to trust certificates signed by the issuer for this subject

PEM CERTIFICATION GRAPH



CRL FORMAT



PGP BOTTOM UP TRUST MODEL

- **How does Alice get Bob's public key**
  - **directly from Bob through some secure channel (e.g., post, phone, floppy)**
  - **from Chuck, who is known to both Alice and Bob and introduces Bob to Alice**
  - **from a trusted certifying authority**
- **PGP has mechanisms to support these, and related, alternatives**

X.509 CERTIFICATES

- **X.509v1**
  - **very basic**
- **X.509v2**
  - **adds unique identifiers to prevent against reuse of X.500 names**
- **X.509v3**
  - **adds many extensions**
  - **can be further extended**

SEPARATE KEYS FOR SEPARATE PURPOSES

- **RSA is the only known public-key cryptosystem in which the same public-private key pair can be used for**
  - **digital signatures**
  - **encryption**
- **perceived as a major advantage**

SIGNATURE KEYS

- **private key: must be private for entire life, may never leave smart card**
  - **needs to be securely destroyed after lifetime**
  - **no need for backup or archiving (would conflict with above)**
  - **no need to weaken or escrow due to law**
- **public key: must be archive possibly for a long time**

ENCRYPTION KEY

- private key: backup or archive required for recovery
  - should not be destroyed after lifetime
  - may be weakened/escrowed due to law
- public key:
  - no need to backup RSA or other encryption keys
  - need to backup Diffie-Hellman key agreement keys

X.509 INNOVATIONS

- distinguish various certificates
  - signature, encryption, key-agreement
- identification info in addition to X.500 name
- name other than X.500 name
  - email address
- issuer can state policy and usage
  - good enough for casual email but not good enough for signing checks
- limits on use of signature keys for further certification

X.509v3 EXTENSIONS

- X.509v3 same as X.509v2 but adds extensions
- provides a general extension mechanism
  - extension type: registered just like an algorithm is registered
  - standard extension types: needed for interoperability

X.509v3 EXTENSIONS CRITICALITY

- non-critical: extension can be ignored by certificate user
  - alternate name can be non-critical
- critical : extension should not be ignored by certificate user
  - limit on use of signatures for further certification

X.509v3 EXTENSIONS CRITICALITY

- criticality is flagged by certificate issuer
  - certificate user may consider non-critical extensions more important than critical ones
  - certificate user may refuse to use certificate if some extensions are missing
- critical extensions should be few and should be standard

X.509v3 NAMES

- internet email address
- internet domain name
- web uri (url's are subset of uri)
- IP address
- X.400 email address
- X.500 directory name
- registered identifier
- other name

X.509v3 STANDARD EXTENSIONS

- Key and policy information
- Subject and issuer attributes
- Certification path constraints
- Extensions related to CRLs
  - will be discussed with CRLs

KEY AND POLICY INFORMATION

- key usage
  - critical: intended only for that purpose, limits liability of CA
  - non-critical: advisory to help find the correct key, no liability implication
- private-key usage period
  - certificate valid for 2 years for verifying signature
  - key valid only for one year for signing
- certificate policies
  - for CAs

SUBJECT AND ISSUER ATTRIBUTES

- Subject alternative names
- Issuer alternative names
- Subject directory attributes
  - whatever you like
  - position, phone, address etc.

CERTIFICATION PATH CONSTRAINTS

- Basic Constraints
  - can or cannot act as CA
  - if can act as CA limit on certification path
    - limit=1 means cannot certify other CAs
- Name Constraints
  - limits names of subjects that this CA can issue certificates for
- Policy Constraints
  - concerned with CA policies

CERTIFICATE REVOCATION LISTS

- CRLs issued periodically as per CA policy
  - off-cycle CRLs may also be needed
  - blank CRLs can be issued

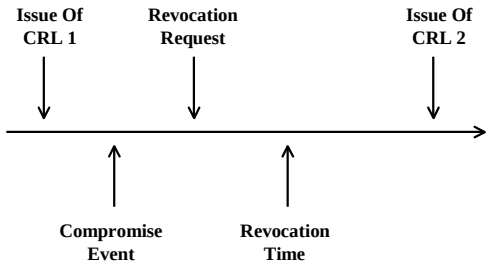
CERTIFICATE REVOCATION LISTS

- CRL distribution
  - pull method
  - push method
- DMS example
  - pull method with push for compromised key list (CKL) which is broadcast via secure email, single CKL for entire system

CERTIFICATE REVOCATION LISTS

- **immediate or real-time revocation**
  - **needs query to CA on every certificate use**
  - **maybe ok for small closed communities**

REVOCATION TIME-LINE



OCSP

ON-LINE CERTIFICATE STATUS PROTOCOL

- **consult authoritative server**
- **the server in turn can look up CRLs**

SHORT-LIVED CERTIFICATES

- **Authorization certificates can be short lived**
  - **minutes, hours, days instead of**
  - **months, years**

X.509 CRL EXTENSIONS

- **General Extensions**
- **CRL distribution points**
- **Delta-CRLs**
- **Indirect-CRLs**
- **Certificate Suspension**

GENERAL EXTENSIONS

- **Reason Code**
  - **Key Compromise**
  - **CA Compromise**
  - **Affiliation changed**
  - **Superseded**
  - **Cessation of operation**
  - **Remove from CRL: defer till Delta-CRL**
  - **Certificate hold: defer**
- **Invalidity Date**

CRL DISTRIBUTION POINTS

- CRLs can get very big
  - version 1 CRL (1988, 1993)
    - each CA has two CRLs: one for end users, one for CAs
    - end user CRL can still be very big
  - version 2 CRL
    - can partition certificates, each partition associated with one CRL
    - distribution point
    - also can have different distribution points for different revocation reasons

CRL DISTRIBUTION POINTS

- certificate extension field, says where to look
- CRL extension field
  - distribution point for this CRL and limits on scope and reason of revocation
  - protects against substitution of a CRL from one distribution point to another

DELTA-CRLs

- Delta CRL indicator
  - only carries changes from previous CRL
- Remove from CRL reason code causes purge from base CRL (stored at certificate user)
- removal due to expiry of validity period or restoration of suspension

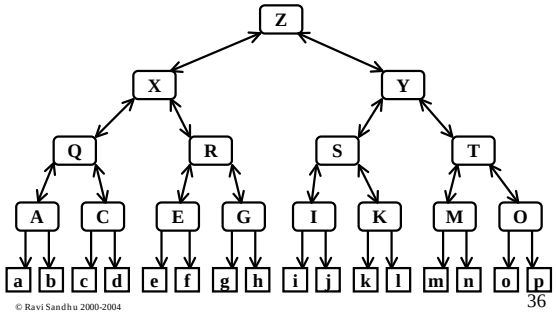
INDIRECT-CRL

- CRL can be issued by different CA than issuer of certificate
  - allows all compromise revocations to be one list
  - allows all CA revocations to be on one list (simplify certificate chasing)

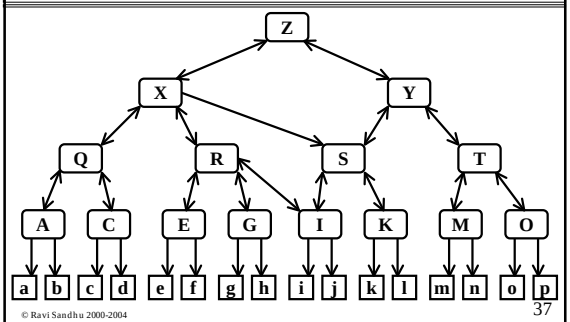
CERTIFICATE SUSPENSION

- Certificate hold reason code in CRL
- Supporting CRL entry extension
  - Instruction code: instructions on what to do with held certificate
    - call CA, repossess token

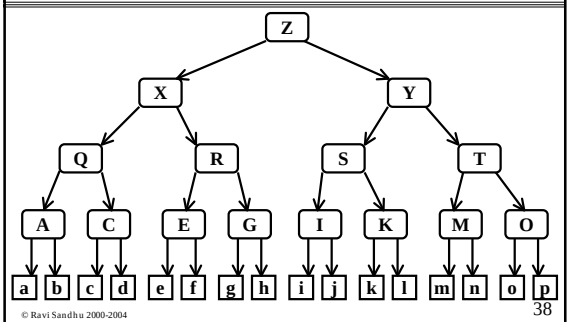
GENERAL HIERARCHICAL STRUCTURE



GENERAL HIERARCHICAL STRUCTURE WITH ADDED LINKS



TOP-DOWN HIERARCHICAL STRUCTURE



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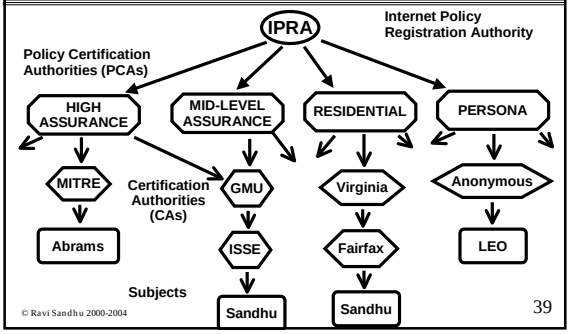
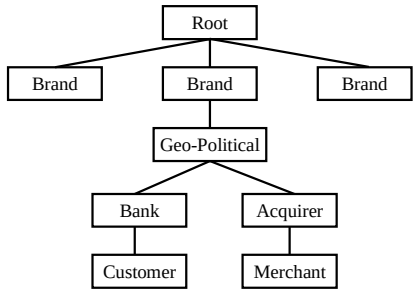


SET CA HIERARCHY



FOREST OF HIERARCHIES