INFS 766
Internet Security Protocols

Lecture 6
Digital Certificates

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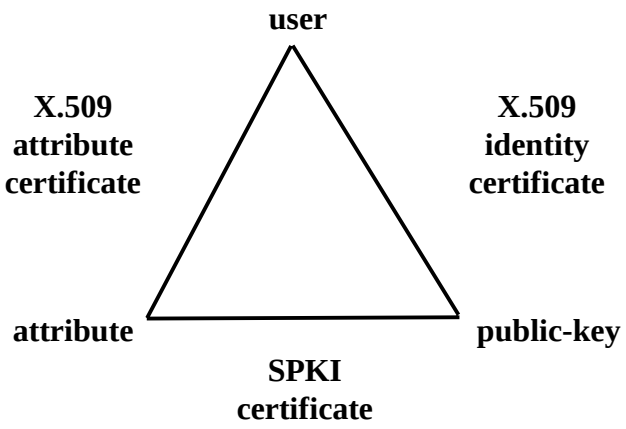
PUBLIC-KEY CERTIFICATES

- **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

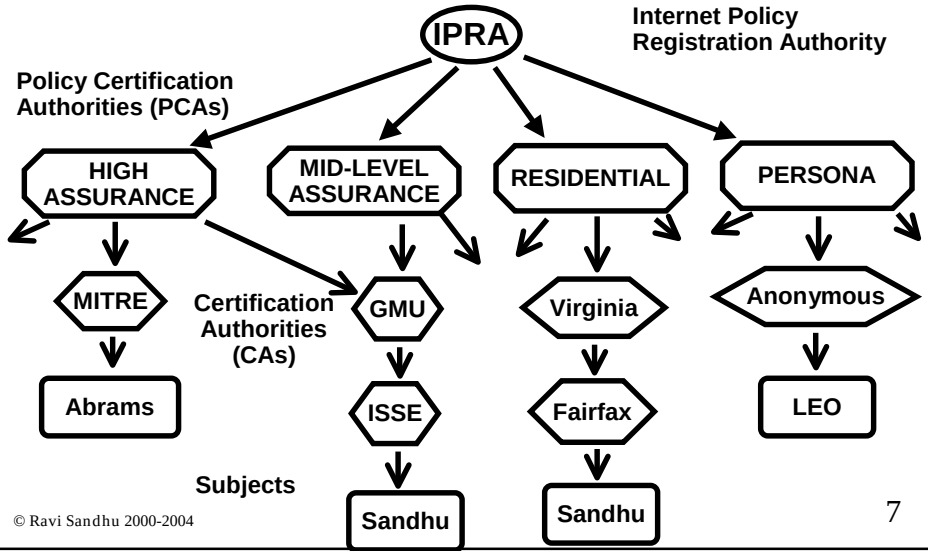
X.509 CERTIFICATE

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

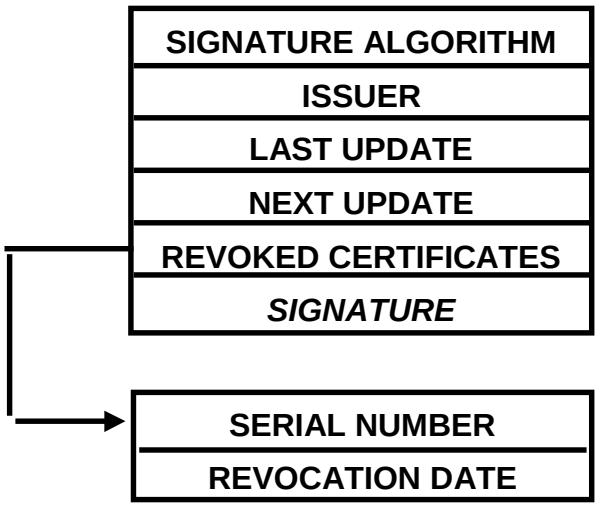
CERTIFICATE TRUST

- **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**

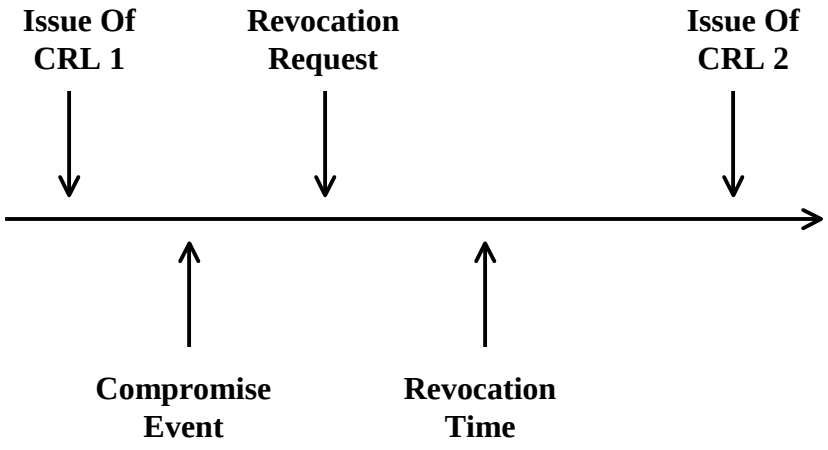
CERTIFICATE REVOCATION LISTS

- **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**

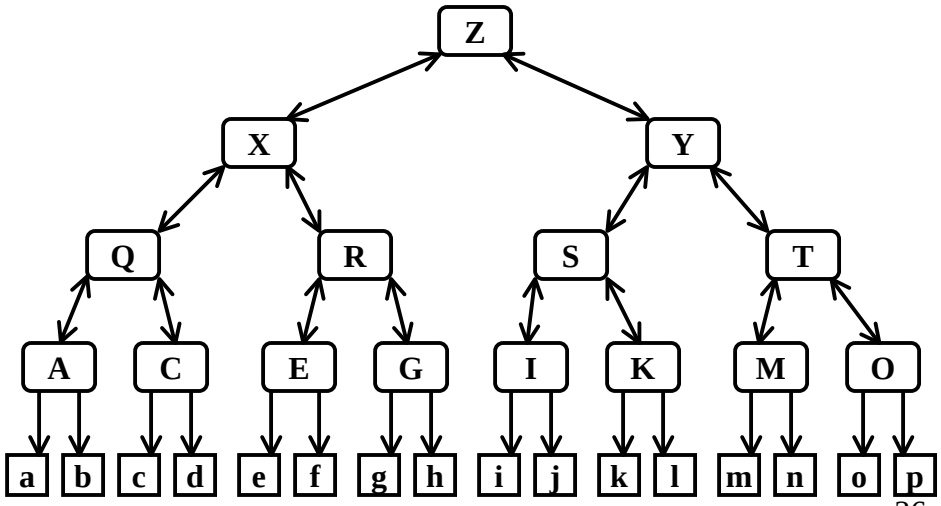
INDIRECT-CRL

- **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)**

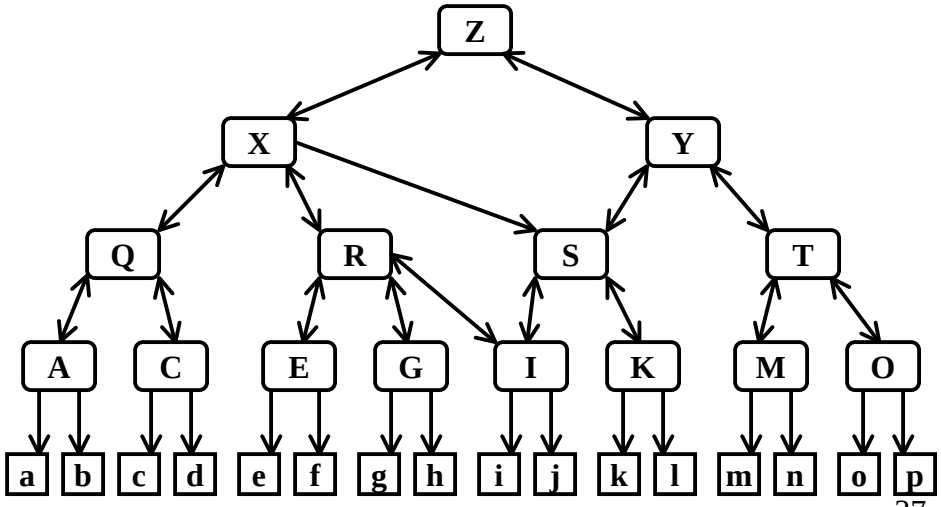
CERTIFICATE SUSPENSION

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

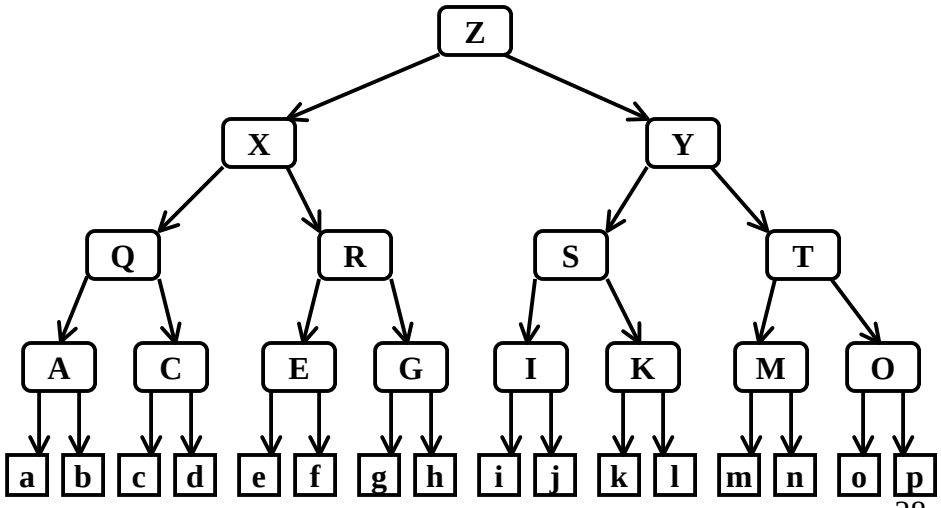
GENERAL HIERARCHICAL STRUCTURE



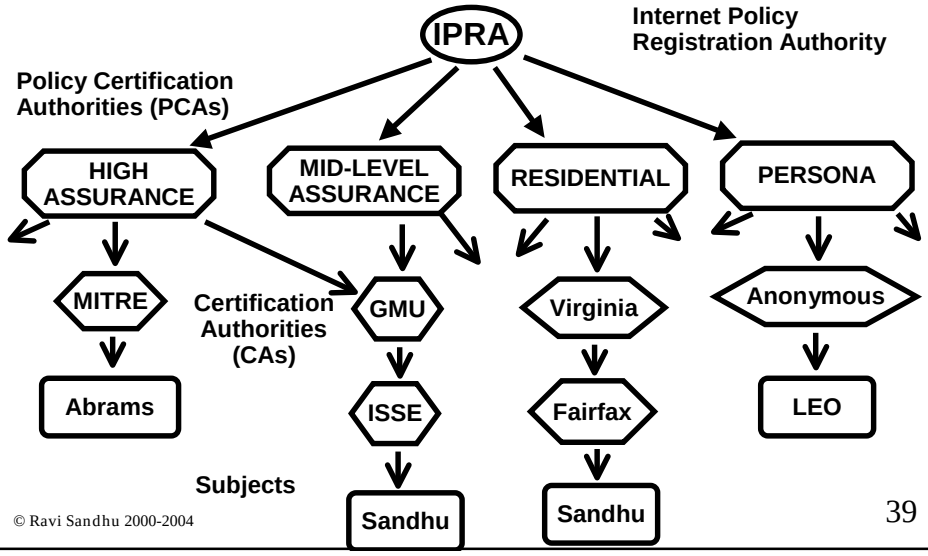
GENERAL HIERARCHICAL STRUCTURE WITH ADDED LINKS



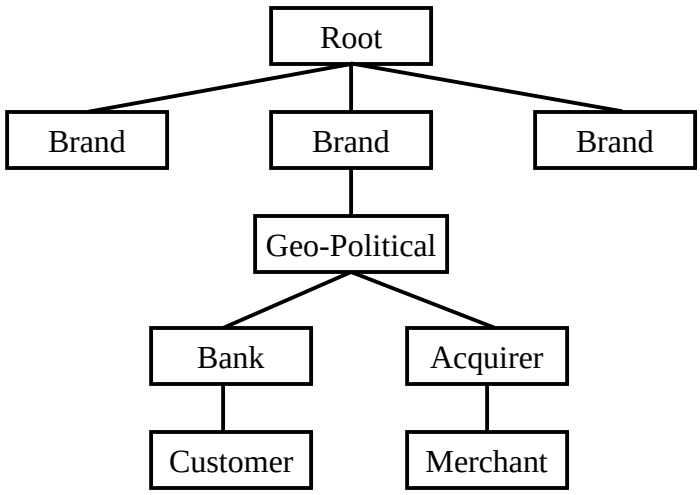
TOP-DOWN HIERARCHICAL STRUCTURE



PEM CERTIFICATION GRAPH



SET CA HIERARCHY



FOREST OF HIERARCHIES