INFS 766

Internet Security Protocols

Lecture 6

Digital Certificates

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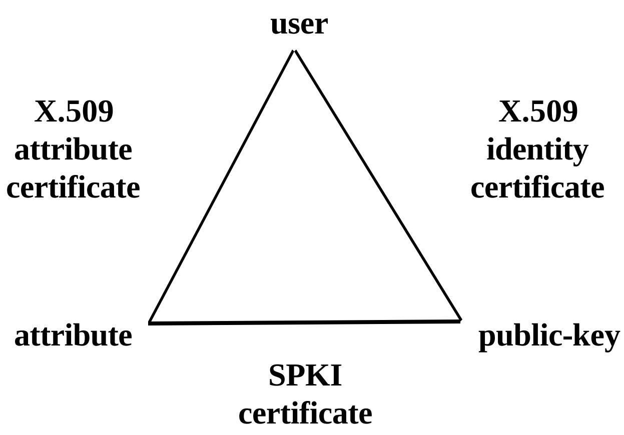
PUBLIC-KEY CERTIFICATES

- ❖ 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

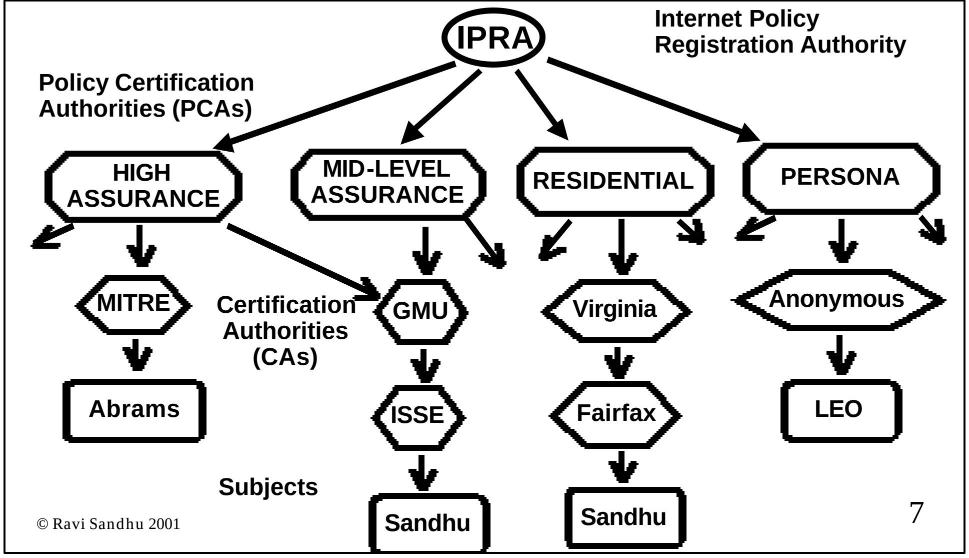
X.509 CERTIFICATE

0
1234567891011121314
RSA+MD5, 512
C=US, S=VA, O=GMU, OU=ISSE
5/1/97-5/1/98
C=US, S=VA, O=GMU, OU=ISSE, CN=Ravi Sandhu
RSA, 1024, xxxxxxxxxxxxxxxxxxxxxxxxx
SIGNATURE

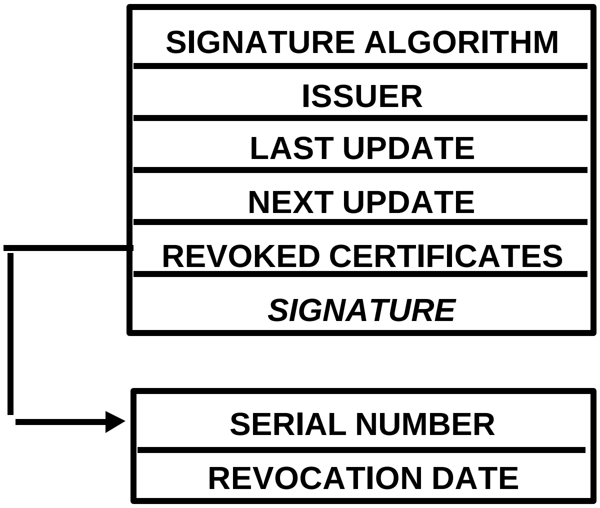
CERTIFICATE TRUST

- **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



SIGNATURE ALGORITHM

ISSUER

LAST UPDATE

NEXT UPDATE

REVOKED CERTIFICATES

SIGNATURE

SERIAL NUMBER

REVOCATION DATE

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

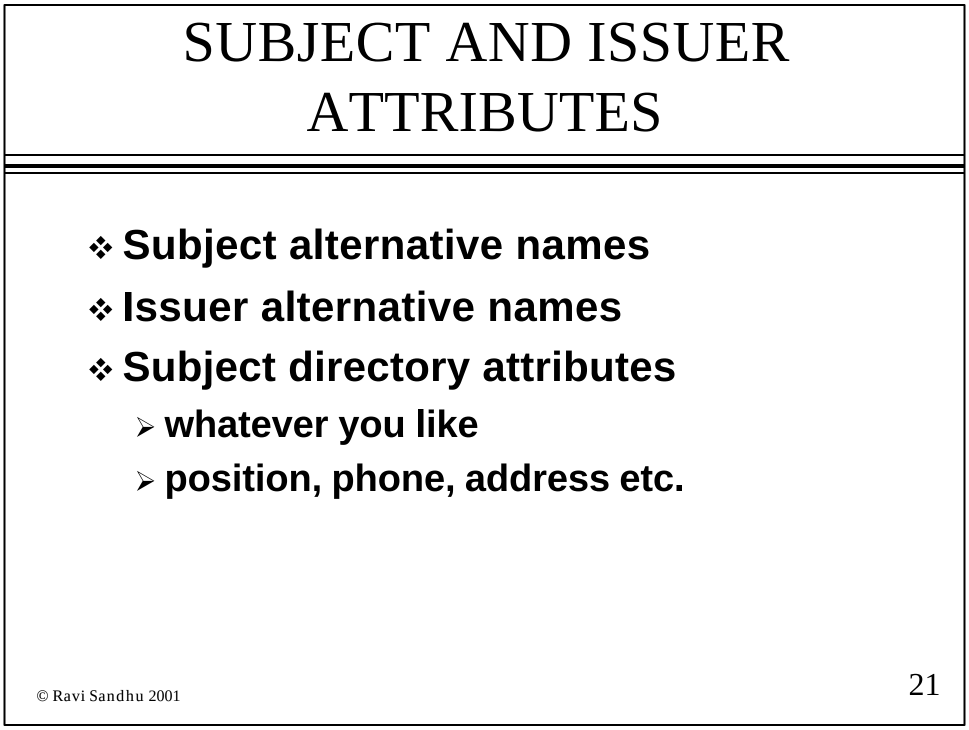
- internet email address
- internet domain name
- web uri (url's are subset of uri)
- IP address
- X.400 email address
- X.500 directory name
- registered identifier
- other name

X.509v3 STANDARD EXTENSIONS

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

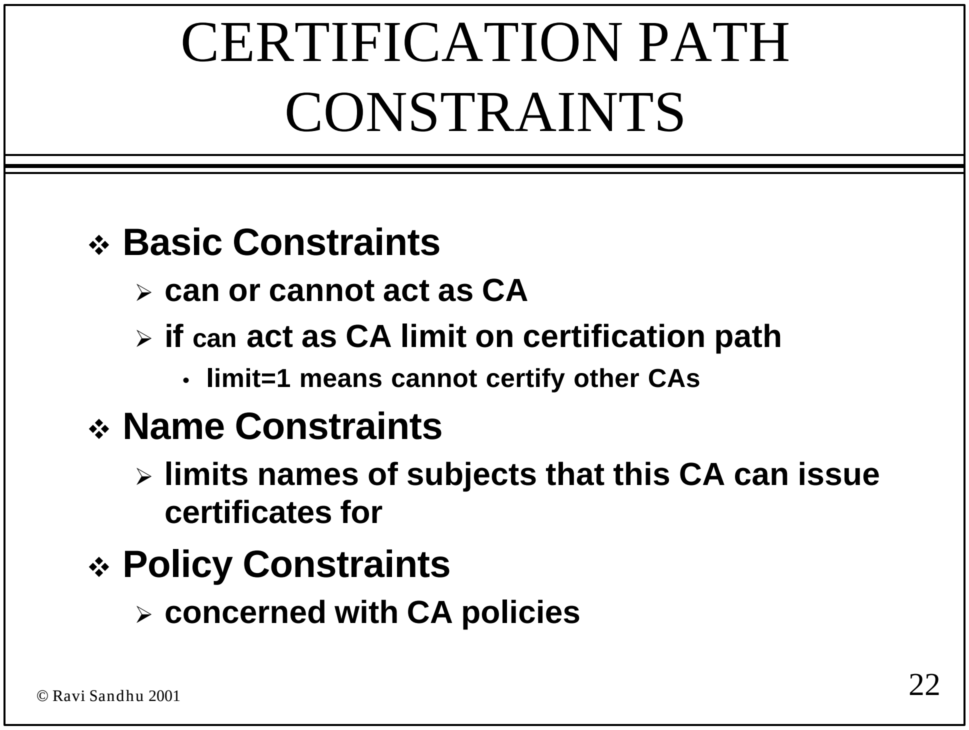
KEY AND POLICY INFORMATION

- 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**

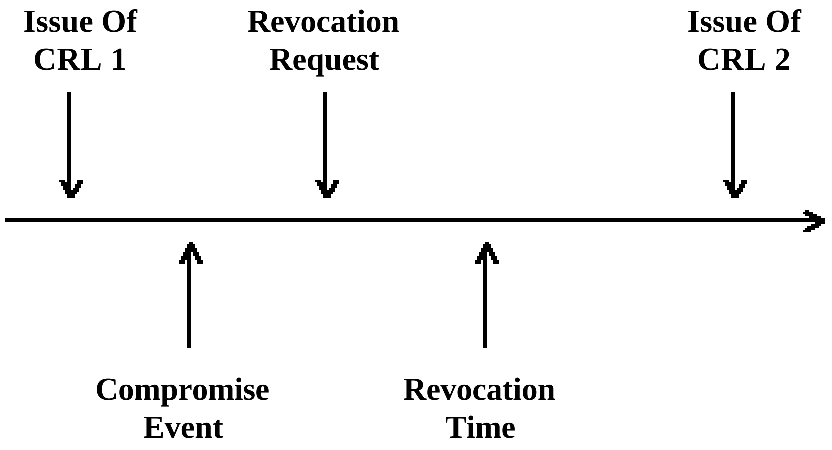
CERTIFICATE REVOCATION LISTS

- **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



Issue Of CRL 1

Revocation Request

Issue Of CRL 2

Compromise Event

Revocation Time

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

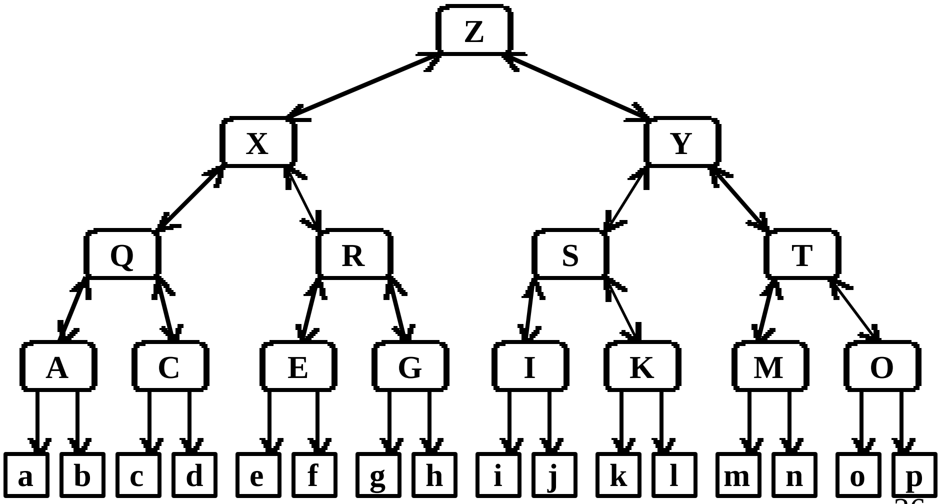
INDIRECT-CRL

- 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)

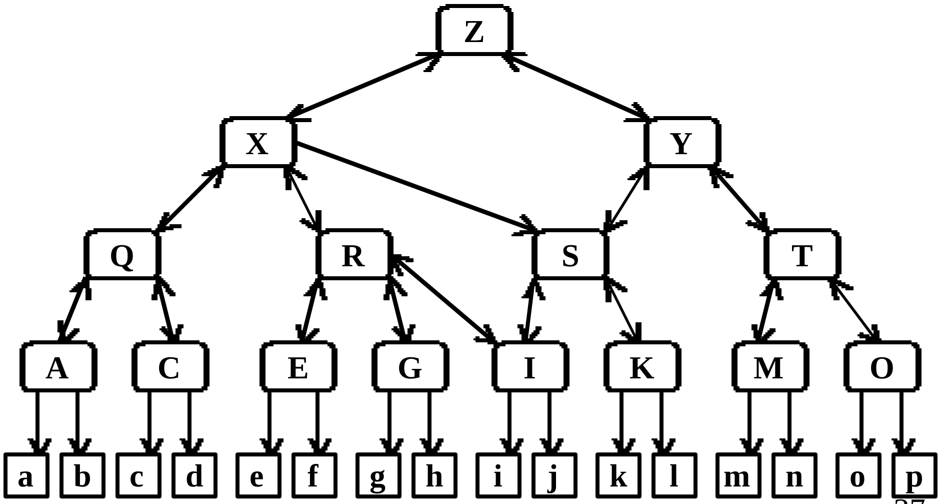
CERTIFICATE SUSPENSION

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

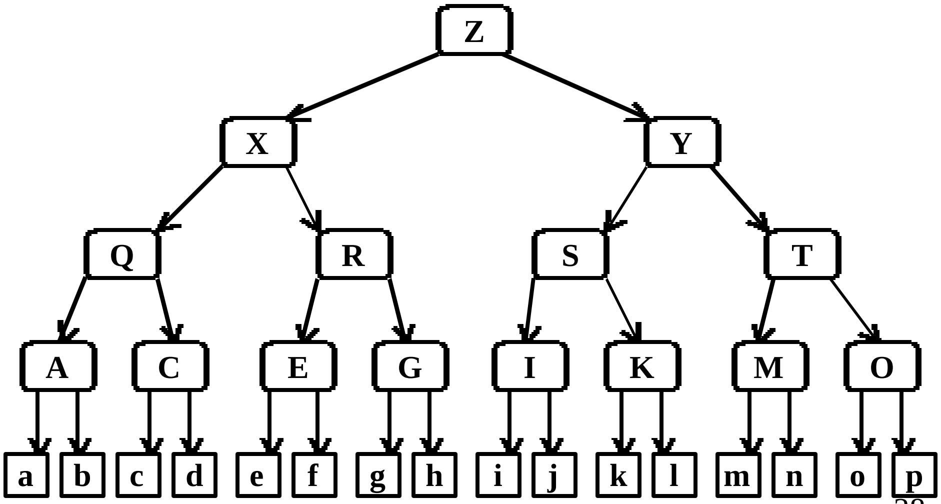
GENERAL HIERARCHICAL STRUCTURE



GENERAL HIERARCHICAL STRUCTURE WITH ADDED LINKS



TOP-DOWN HIERARCHICAL STRUCTURE



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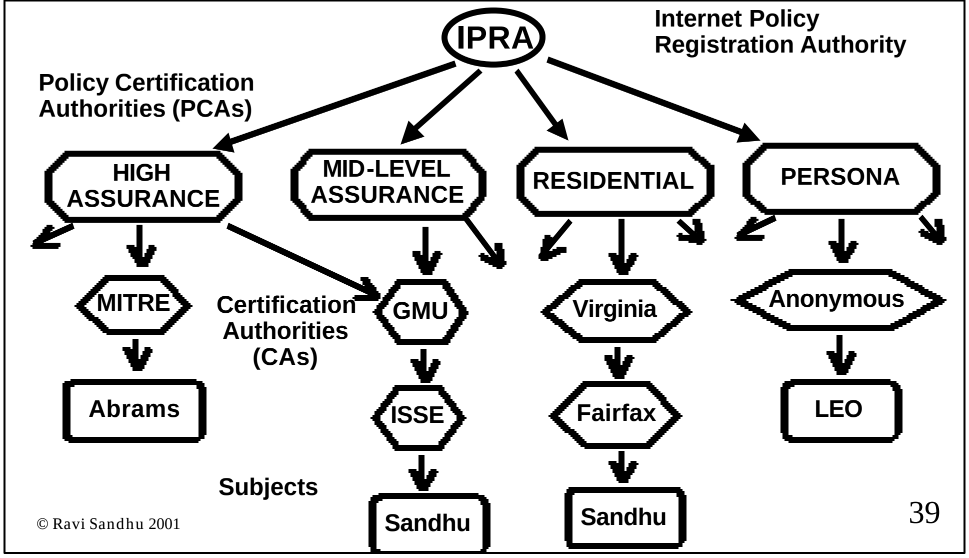

IPRA

Internet Policy Registration Authority

Policy Certification Authorities (PCAs)

HIGH ASSURANCE

MID-LEVEL ASSURANCE

RESIDENTIAL

PERSONA

MITRE

Certification Authorities (CAs)

GMU

Virginia

Anonymous

Abrams

ISSE

Fairfax

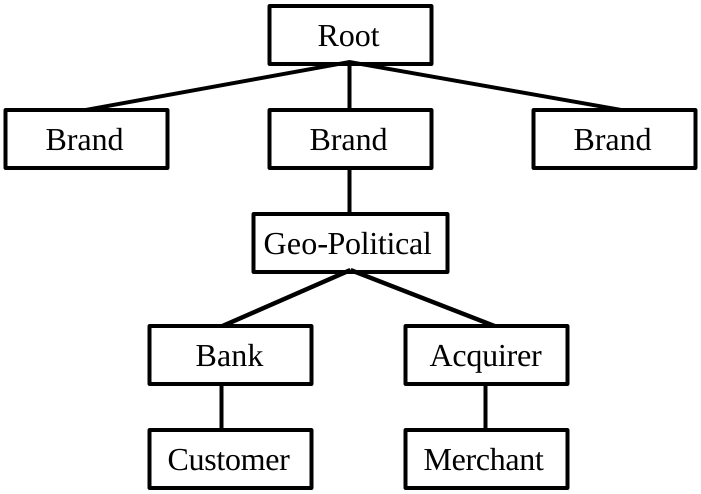
LEO

Subjects

Sandhu

Sandhu

SET CA HIERARCHY


Root

Brand

Brand

Brand

Geo-Political

Bank

Acquirer

Customer

Merchant

FOREST OF HIERARCHIES