Public Key Infrastructure

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Motivation:

1. Numerous people buy/sell over the internet – hard to manage security of all possible pairs of connections with secret keys
2. US government subject to the Government Paperwork Elimination Act requiring electronic transactions with the public (from 2003)
3. Agencies are required to use electronic authentication technology to verify identity of the sender and the integrity of electronic content
4. This is especially important when doing classified work or working with contractors who do classified work
5. The Health Insurance Portability and Accountability Act of 1996 mandates security and privacy standards to protect health information that is exchanged electronically.

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2. enables other entities to verify public key bindings
3. provides services for management of keys in a distributed system

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Integrates:

1. Digital certificates
2. Public key cryptography
3. Certification authorities

for an enterprise-wide network security architecture

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5. Certificates
   - includes public key, information about the identity of the party holding the corresponding private key, the operational period for the certificate, and the CA's own digital signature
   - may contain other information about the signing party or information about the recommended uses for the public key

Public Key Infrastructure

X.509 certificate standard:

- version
- serial number
- algorithm ID
- issuer
- validity – not before, not after
- subject
- subject key key info – algorithm and public key
- extensions
  - basic constraints – includes public
  - key usage – crypto operations that key can be used for
    Ex: signing but not encryption
  - extended key usage – indicates allowed usage per application
    Ex: may be used on the server end of a TLS connection
    may be used to protect email
- certificate signature algorithm
- certificate signature

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3. Performs four basic PKI functions:
   - issues certificates (creates and signs them)
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   - publishes its current (e.g., unexpired) certificates and CRLs, so users can obtain the information they need to implement security services
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8. CA *must* provide adequate protection for its own private key

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7. RAs must provide adequate protection for their private keys

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Repositories:

1. Directory service for distribution of certificates and certificate status
   - provides means of storing and distributing certificates
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4. Lightweight Directory Access Protocol (LDAP) for client-server communications
5. Directory servers need to be *interoperable* to be able to retrieve CRLs and certificates from remote sites for signature verification

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6. This permits the verification of signatures on old documents (such as wills) at a later date.

Public Key Infrastructure

Trust Models:

Monopoly model: One organization is trusted by all others to issue certificates. All software contains public key of that CA

Monopoly + Registration Authorities: Use other organizations to check identities and vouch for public keys

Delegated CAs: Trust anchor (TA) issues certificates to other CAs. Users can get a certificate from one of the other CAs.

Oligarchy (Browsers): Many trust anchors, certificate from one is sufficient

Anarchy (PGP): Each user responsible for configuring TAs.

Public Key Infrastructure

Monopoly:

There is no one universally trusted organization
Infeasible to change the key in all software if it is compromised
CA could charge whatever it wants to issue certificates

Monopoly + RAs:

More convenient than above – many places to get certified

Delegated CAs:

Recipient may see a chain of certificates vs. one for Mon+RAs

Oligarchy (e.g. browsers):

Worse than monopoly since *any* of trust anchors could be comp.
Trust anchors may be trusted by vendor but not user!
It is easy to trick a naive user into accepting a bogus trust anchor
Users do not understand what's up: ex: use of public terminal
Unlikely a user will check trust anchor list to see if it's tampered

Anarchy (PGP):

Trust of a single certificate varies so create a trust score from several then make a decision

Public Key Infrastructure

Name Constraints:

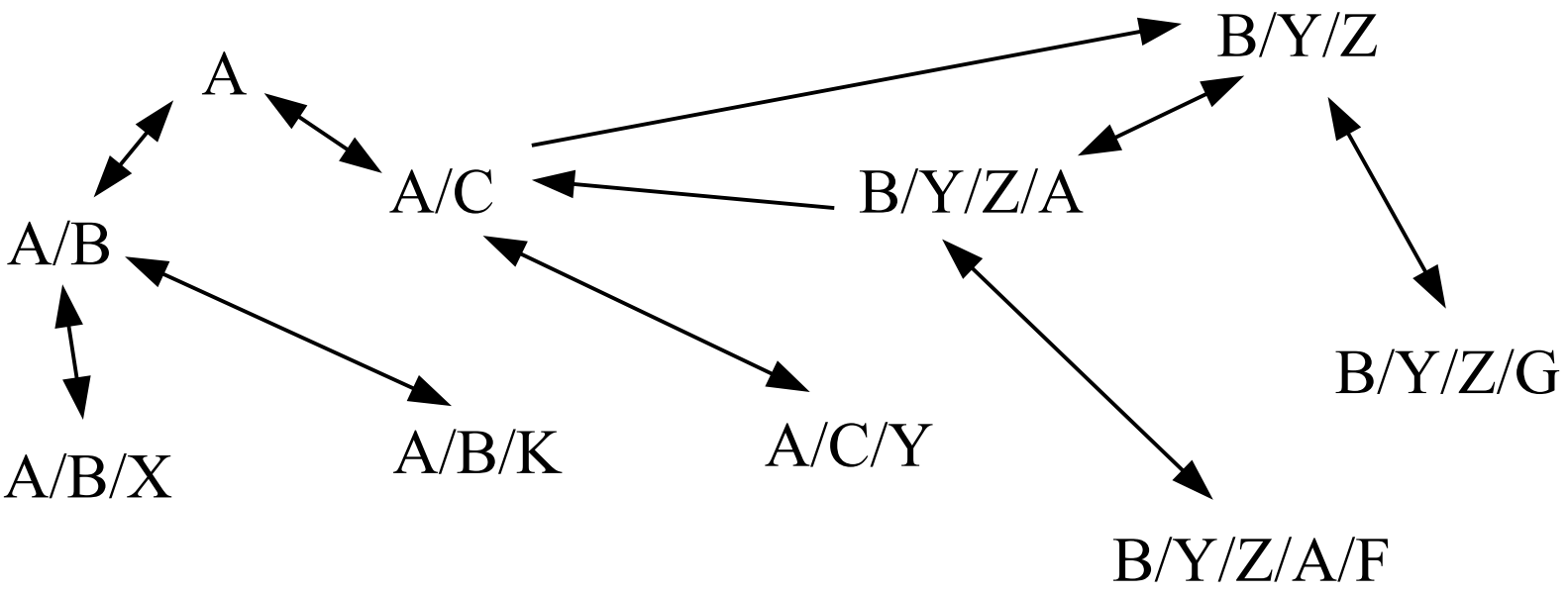
Assume CA trusted to issue certs for only some users or domains

Top-Down with Name Constraints:

Tree of CAs, each can only issue certs in their domain.

Bottom-Up with Name Constraints:

Each org creates its own PKI and links to the WWW of PKIs



Public Key Infrastructure

Top-Down with Name Constraints:

Like Monopoly with delegated CAs where delegates are restricted to parts of the name hierachy

Public Key Infrastructure

Bottom-Up with Name Constraints:

1. Easy to determine whether path exists
2. Hierarchy corresponding to the name of the principal is intuitive
3. PKI can be deployed in any org, no need to pay someone to do it
   Can have a PKI in your org even if lots of other orgs do not
4. Damage due to compromised CA is limited to that org
   No one can impersonate you from a compromised CA outside of your org
5. Configuration is easy: all CAs can be reached beginning with your key pair - new employee gets a key just like a badge

Public Key Infrastructure

Relative Names:

Certificates carry relative names, not absolute names
e.g. Use *cs* instead of *cs.uc.edu*

If an entire subtree of names has to be moved, no certificates need to be reissued

Do not use name A/B/C/D but only D on certificates from A/B/C - then if that moves to H/Y, say, only certificates between H/Y and ancestors need be reissued.

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Name Constraints in Certificates:

Field in certificate stating names

Allows issuer to specify names that subject is trusted to certify

Can also disallow names.

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Policies in Certificates:

Statement of how carefully the identity of requester is checked.
If not obeyed, no certificate is issued.
Can deny certificates to users not at high level of security.

Example of policy: certificate can be used only for signing

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Expiration and Revocation:

Revocation important – someone may realize their key is stolen.

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Hence, security is down the tubes.

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Certificate Revocation Lists (CRL):

CA periodically issues a timestamped, signed list of revoked certs

Delta CRL – just the changes since a particular time/day

On-Line Revocation Server (OLRS):

System that can be queried over the net

Can this service be trusted?

Not security-sensitive -
Contains no vulnerable database of secrets
Worst thing it can do is to claim an invalid cert is still valid
– damage from this is limited