Public Key Infrastructure

Cryptography Four

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Topics

- Public Key Infrastructure
- Intro
- PKI Architecture
- Trust Models
- Components
- X.509 Certificates
- X.500
- LDAP

Public Key Infrastructure Defied

A public key infrastructure (PKI):

- Binds public keys to entities
- Enables other entities to verify public key bindings
- Provides the services needed for ongoing management of keys in a distributed system.

  -- NIST 800-32

Provides confidence that:

- The person or process identified as sending the transaction is actually the originator.
- The person or process receiving the transaction is the intended recipient.
- Data integrity has not been compromised.

Public Key Infrastructure

- Public key infrastructure enables enterprises to protect the security of their communications and business transactions on networks.
  - An enterprise-wide network security architecture, PKI integrates:
    - Digital certificates
    - Public key cryptography
    - Certification authorities.
  - Facilitates specific security services including:
    - Public key exchange
    - User authentication
    - Nonrepudiation.

Public Key Infrastructure Issues

Specific Public Key Infrastructure (PKI) issues include:

- Key Authentication and Non-repudiation
  - Nothing about a key proves to whom it belongs
- Revoking keys
  - Nothing about a key indicates whether it has been revoked
- Policy enforcement
  - Any organization utilizing PKI needs to create and enforce a local policy.

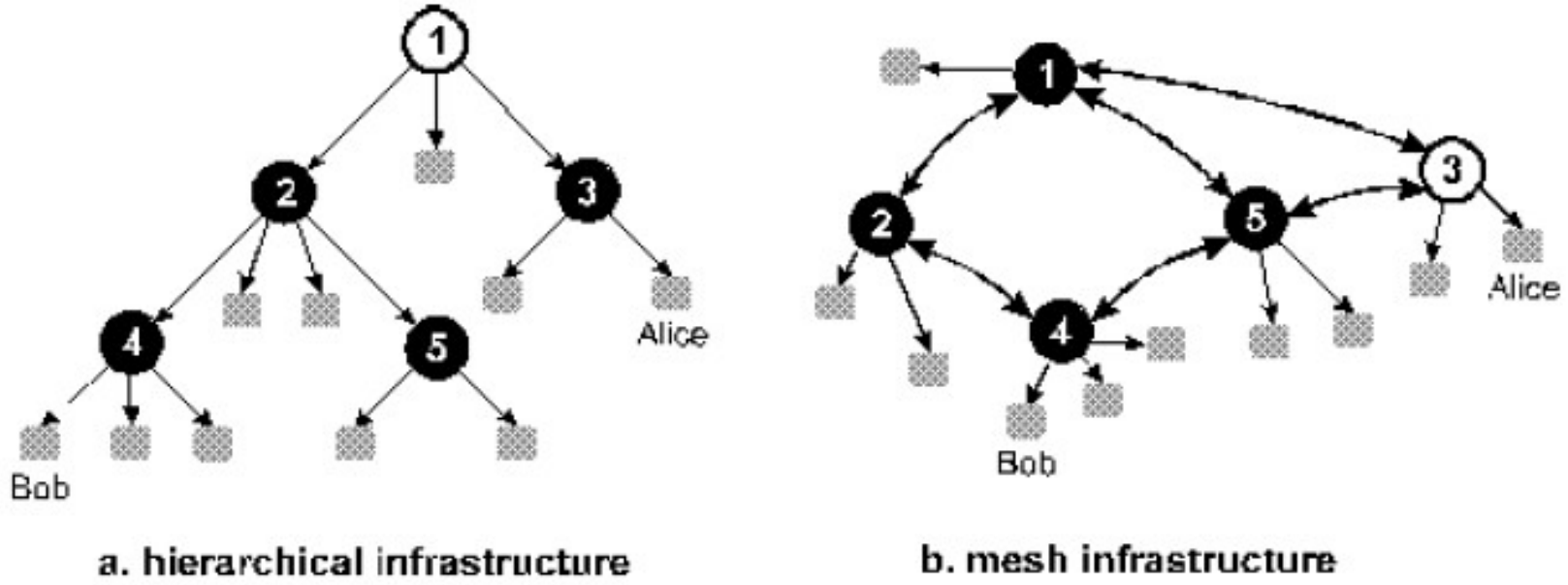
PKI Architecture Overview

- PKI architecture consists of:
  - A Trust Model
  - Servers (Certificate, Revocation, Registration)
  - Certificates/Data format standards
    - Public key mechanism standards
  - Related infrastructure including
    - Programs
    - Protocols
    - Policies and Procedures
- All components work together to enable trusted and secure communications.

Three PKI Trust Models

1. Hierarchical Trust
   - Sets up an independent certificate authority (CA) with authority to sign digital certificates.
   - A CA can revoke a certificate
   - Facilitates enforcement of a local policy
   - Most complex, most efficient trust model
1. Web of Trust
   - Random trust chains produce a network of signed keys.
   - Invented by Phil Zimmerman -- Used by PGP
1. Direct Trust
   - Each person confirms their authenticity by personally delivering their public keys

Traditional PKI Trust Architectures



a. hierarchical infrastructure **b. mesh infrastructure**

Figure 1. Traditional PKI Architectures

PKI Web Model

- A form of hierarchical trust, in which there are many independent CAs.
- Cross Certification
  - Allows two CAs to exchange certificates with one another.
  - An alternative to cross certification is a CA hierarchy with a root authority at the top

PKI Support Infrastructure

- Includes
  - Certificates
    - X.509 Standard
  - Certificate Authority
    - Trusted entity that maintains and issues digital certificates.
  - Registration Authorities
    - Performs certificate registration duties
    - Acts as a broker between users and CA
  - Certificate revocation process
    - CA maintains a Certificate Revocation List (CRL)
  - Local Policies and Procedures
  - Non-repudiation service
    - Digital Signature

Certificate Servers

- Certificate servers validate, or certify, keys.
- A certificate server holds a large number of:
  - Certificates
  - Associated data sets
  - Revocation lists
- Three data structures
  1. Certificates
  2. Certificate revocation lists
  3. Attribute certificates.
- Include:
  - Certificate Authorities
  - Registration Authorities

Directory Services

- A directory server could hold and make available data such as email addresses, telephone numbers etc. ready for retrieval by company employees.
- X.500 is a directory services standard based on the ISO/OSI model developed by the ITU.
  - Many organizations choose the TCP/IP based LDAP

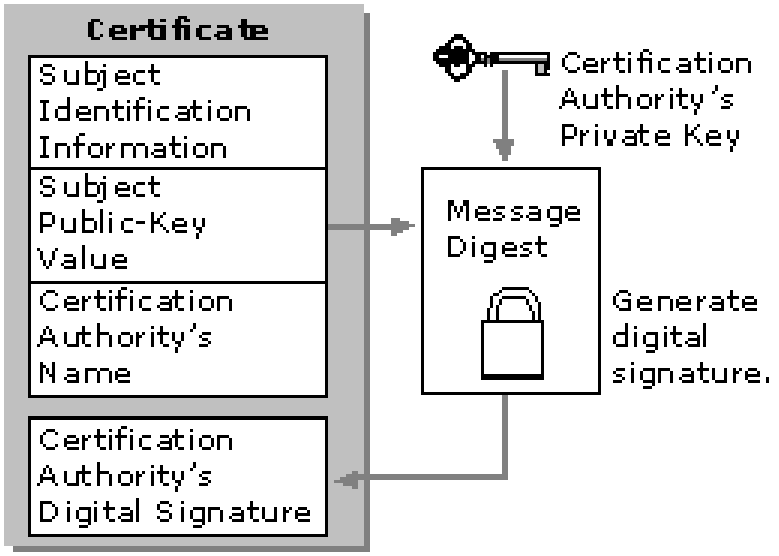
X.509 Certificate Standard

- ITU/CCITT X.509
  - X.500 component
  - Initially intended to provide X.500 authentication
    - Produced by a ISO and ITU collaboration
- Describes digital certificate format.
  - Several versions.
- PKIX – IETF working group
  - Specifies protocols for managing digital certificates as well as protocols for their use.
  - RFC 2459

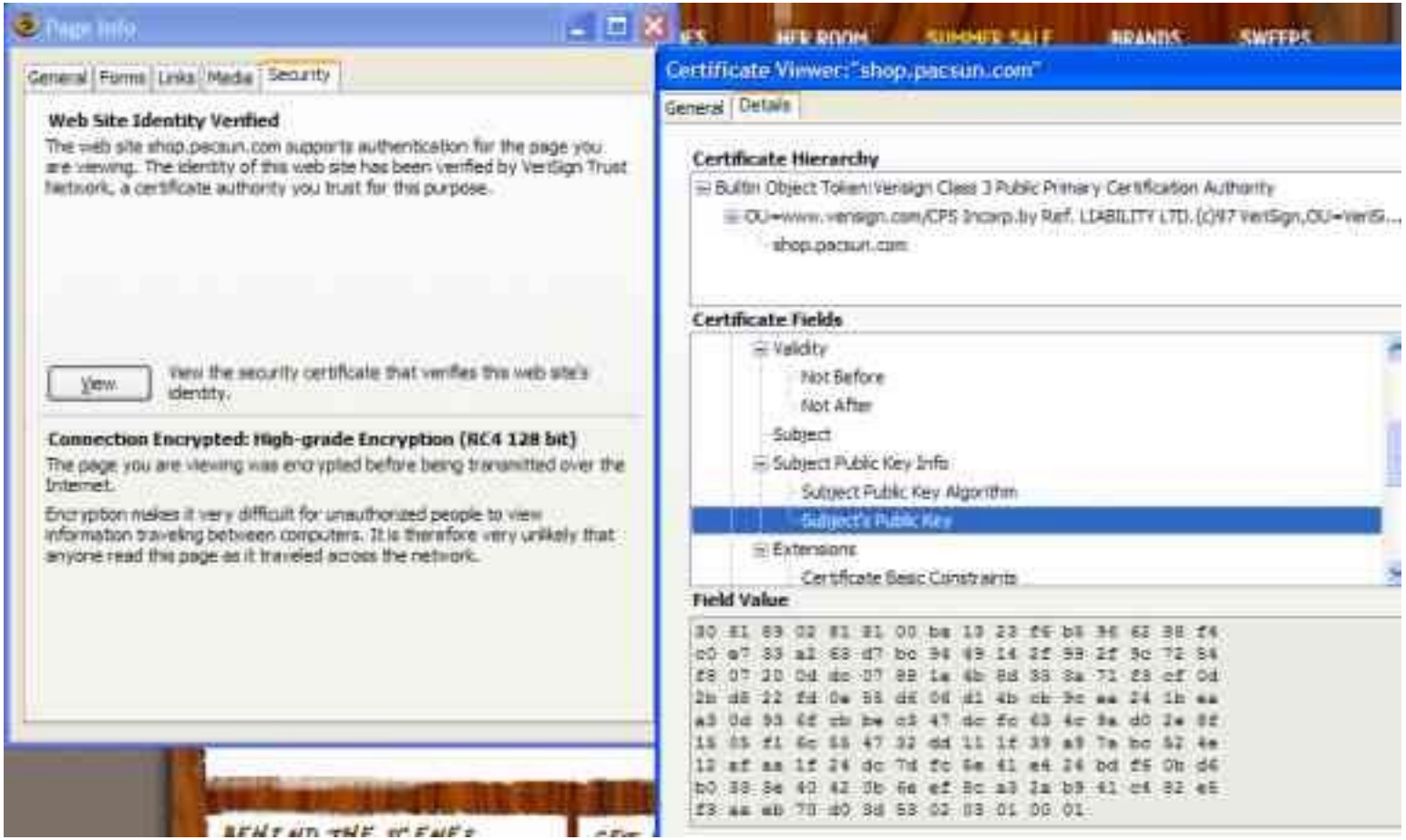
Public Key Certificates

Sample digital certificate components

1. Public key
2. Certificate attributes
   - "Identity" information about user, including name, user ID…
1. One, or more, digital signatures from the Certificate Authority.



Certificate



PKI Attributes

Can also include:

- Timestamping
- Lightweight Directory Access Protocol (LDAP)
  - Security concerns include availability and integrity of LDAP servers
- Security enabled applications
- Cross certification.

LDAP

- An OSI protocol, designed to be lighter (faster) than Directory Access Protocol (DAP).
  - TCP/IP based
  - Uses Internet address
- Evolved from a protocol to a directory services standard.
- Most important certificate server standard
  - While NDS and Active Directory may be used as certificate servers, LDAP is used most often.

Certificate Revocation Process

- Utilizes Certificate Revocation Lists (CRLs)
  - A revocation list is a signed list (usually signed by CA) in which the serial numbers of revoked certificates are detailed.
- A revocation list is replaced by an updated version from the Trust Center at regular intervals, or as necessary.
  - Validity period determined by Trust Center
  - Usually one day

Attribute Certificate

- A data structure that resembles a PKI key certificate but does not contain a public key.
- Normally an adjunct to a key certificate.
- Rarely used.

PKI Applications

- SSL
- VPN
- E-mail encryption
- File encryption
- SAP R/3
- Single Sign On (SSO)
- SET
- Others

SET

- Secure Electronic Transaction
  - Because it uses certificates, considered a PKI application
  - Level 7 protocol
    - Developed by a consortium including Cybercash, MasterCard and Visa.
- Provides confidentiality for purchases by encrypting the payment information.
- Covers end to end transactions.

Questions?

References

NIST Special Publications

`http://csrc.nist.gov/publications/PubsSPs.html`