Lecture Plan

- Distribution of Public Keys
- Public-Key Authority
- Certificate Management and Public Key Infrastructure.

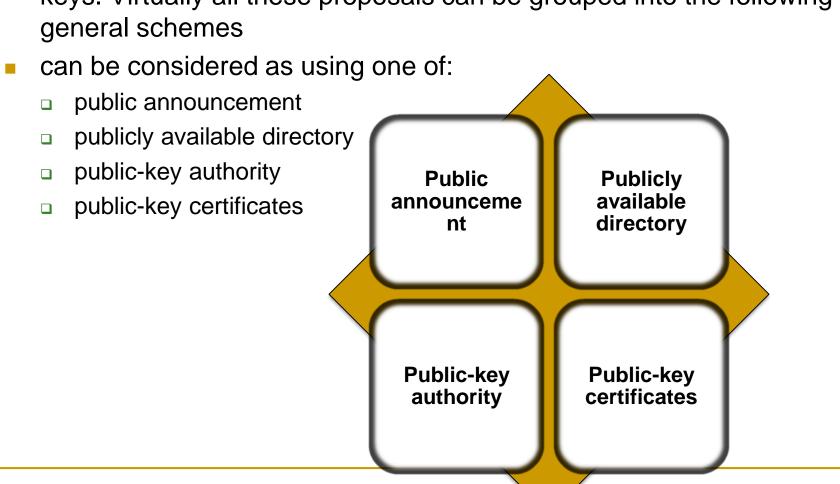
What is the main problem?

- Public key schemes allow two entities to securely communicate over public channel without having to meet in advance.
- How do they obtain public keys?
- Public-Key Authority
- Certificate Management and Public Key Infrastructure.



Distribution of Public Keys

 Several techniques have been proposed for the distribution of public keys. Virtually all these proposals can be grouped into the following general schemes



Notation

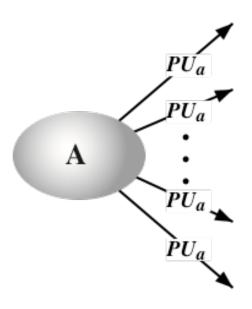
- We use the conventions associated with RSA schemes while explaining public key protocols.
- Public Address: PU
 Private Address: PR
- Public Key Encryption/Decryption:
 - Encryption: E(PU,M) = C;
 - □ Decryption: M = E(PR,C)
- Public Key Signature/Verification
- Signing:
 - \neg s = E(PR,M); (M,s) is a signature pair
- Verification
 - M eq E(PU,s)?

NOTE: the notation E(key, message) is used for symmetric key encryption also; the meaning depends on the context.



Public Announcement

- Users distribute public keys to recipients or broadcast to community at large
 - eg. append PGP keys to email messages or post to news groups or email list
- Major weakness is forgery
 - anyone can create a key claiming to be someone else and broadcast it
 - until forgery is discovered can masquerade as claimed user



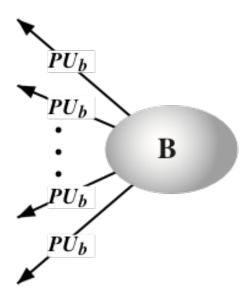


Figure 14.10 Uncontrolled Public Key Distribution



Publicly Available Directory

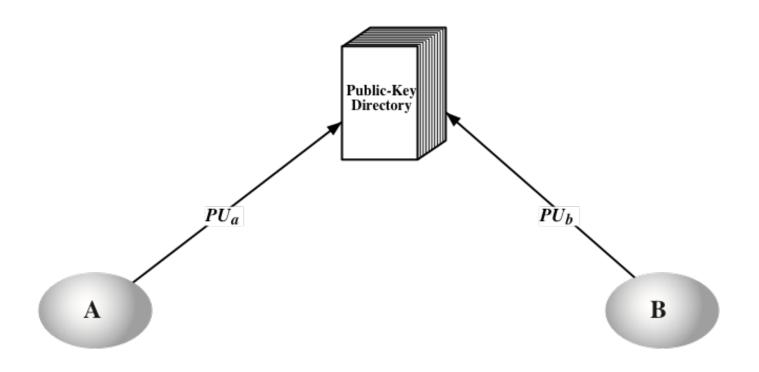


Figure 14.11 Public Key Publication

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Publicly Available Directory

- Can obtain greater security by registering keys with a public directory
- Directory must be trusted with properties:
 - contains {name,public-key} entries
 - participants register securely with directory
 - participants can replace key at any time
 - directory is periodically published
 - directory can be accessed electronically
- Still vulnerable to tampering or forgery



Public-Key Authority

Next level of Improvement:

- improve security by tightening control over distribution of keys from directory
- has properties of directory
- and requires users to know public key for the directory
- then users interact with directory to obtain any desired public key securely
 - does require real-time access to directory when keys are needed
 - may be vulnerable to tampering

Public-Key Authority: A simple scenario

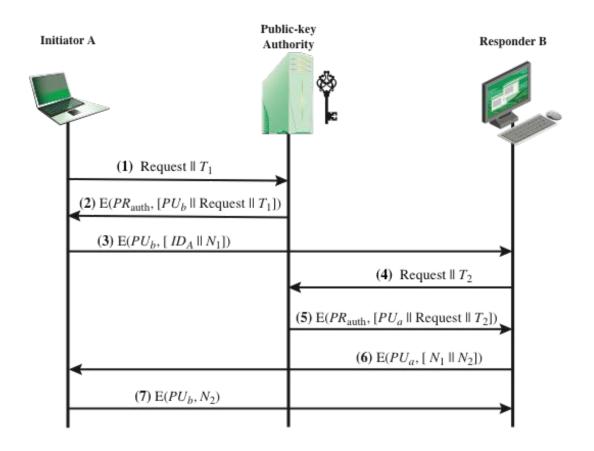


Figure 14.12 Public-Key Distribution Scenario

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Public-Key Certificates: Another Improvement

- certificates allow key exchange without realtime access to public-key authority
- a certificate binds identity to public key
 - usually with other info such as period of validity, rights of use etc
- with all contents signed by a trusted Public-Key or Certificate Authority (CA)
- can be verified by anyone who knows the public-key authorities public-key



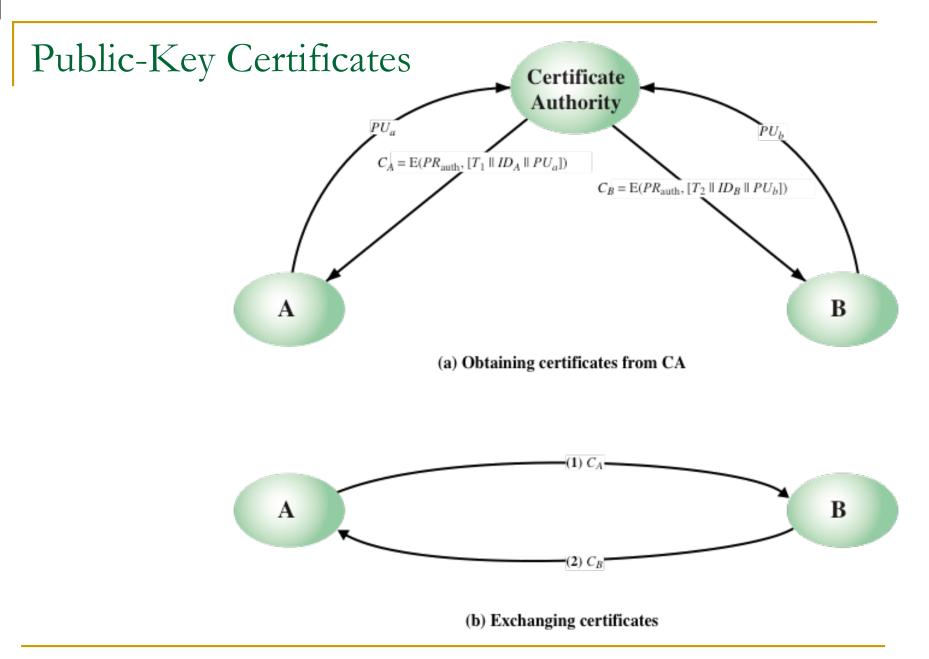


Figure 14.13 Exchange of Public-Key Certificates



X.509 Certificates

- Part of the X.500 series of recommendations that define a directory service
 - The directory is, in effect, a server or distributed set of servers that maintains a database of information about users
- X.509 defines a framework for the provision of authentication services by the X.500 directory to its users
 - Was initially issued in 1988 with the latest revision in 2000
 - Based on the use of public-key cryptography and digital signatures
 - Does not dictate the use of a specific algorithm but recommends RSA
 - Does not dictate a specific hash algorithm
- Each certificate contains the public key of a user and is signed with the private key of a trusted certification authority
- X.509 defines alternative authentication protocols based on the use of public-key certificates

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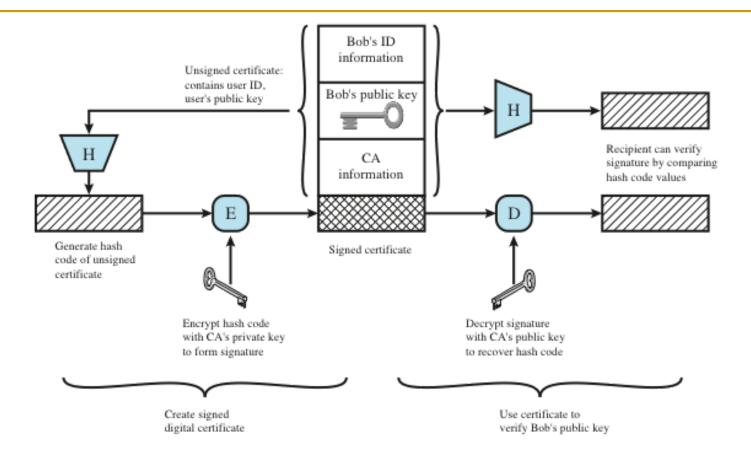


Figure 14.14 Public-Key Certificate Use



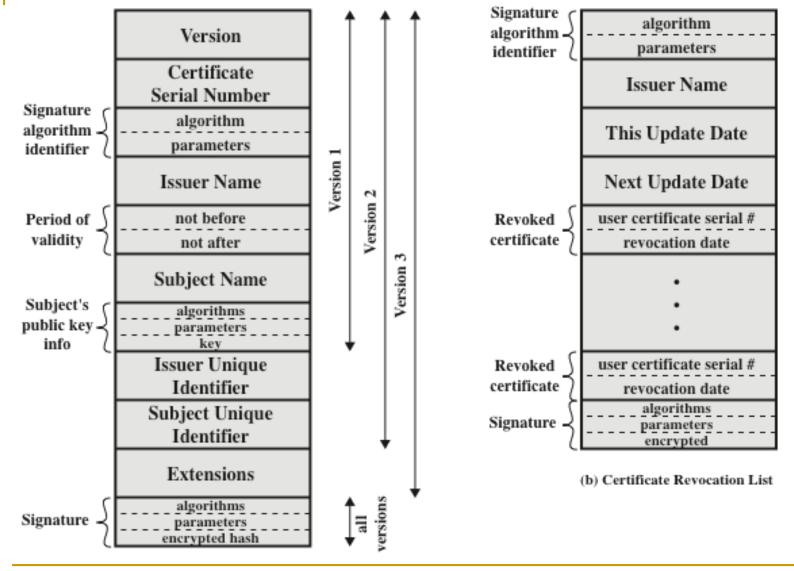
X.509 Certificates

Created by a trusted Certification Authority (CA) and have the following elements:

- Version
- Serial number
- Signature algorithm identifier
- Issuer name
- Period of validity
- Subject name
- Subject's public-key information
- Issuer unique identifier
- Subject unique identifier
- Extensions
- Signature



X.509 Certificates





Obtaining a Certificate

User certificates generated by a CA have the following characteristics:

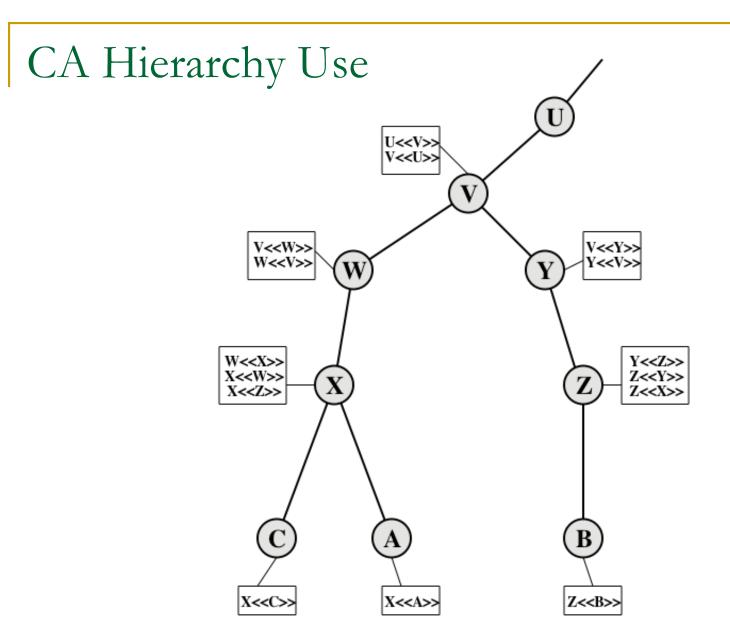
- Any user with access to the public key of the CA can verify the user public key that was certified
- No party other than the certification authority can modify the certificate without this being detected
- Because certificates are unforgeable, they can be placed in a directory without the need for the directory to make special efforts to protect them
 - In addition, a user can transmit his or her certificate directly to other users
- Once B is in possession of A's certificate, B has confidence that messages it encrypts with A's public key will be secure from eavesdropping and that messages signed with A's private key are unforgeable



CA Hierarchy

- if both users share a common CA then they are assumed to know its public key
- otherwise CA's must form a hierarchy
- use certificates linking members of hierarchy to validate other CA's
 - each CA has certificates for clients (forward) and parent (backward)
- each client trusts parents certificates
- enable verification of any certificate from one CA by users of all other CAs in hierarchy







Certificate Revocation

- Each certificate includes a period of validity
 - Typically a new certificate is issued just before the expiration of the old one
- It may be desirable on occasion to revoke a certificate before it expires, for one of the following reasons:
 - The user's private key is assumed to be compromised
 - The user is no longer certified by this CA
 - The CA's certificate is assumed to be compromised
- Each CA must maintain a list consisting of all revoked but not expired certificates issued by that CA
 - These lists should be posted on the directory



X.509 Version 3

- Version 2 format does not convey all of the information that recent design and implementation experience has shown to be needed
- Rather than continue to add fields to a fixed format, standards developers felt that a more flexible approach was needed
 - Version 3 includes a number of optional extensions
- The certificate extensions fall into three main categories:
 - Key and policy information
 - Subject and issuer attributes
 - Certification path constraints



Key and Policy Information

- These extensions convey additional information about the subject and issuer keys plus indicators of certificate policy
- A certificate policy is a named set of rules that indicates the applicability of a certificate to a particular community and/or class of application with common security requirements

Included are:

- Authority key identifier
- Subject key identifier
- Key usage
- Private-key usage period
- Certificate policies
- Policy mappings



Certificate Subject and Issuer Attributes

- These extensions support alternative names, in alternative formats, for a certificate subject or certificate issuer
- Can convey additional information about the certificate subject to increase a certificate user's confidence that the certificate subject is a particular person or entity
- The extension fields in this area include:
 - Subject alternative name
 - Issuer alternative name
 - Subject directory attributes

Certification Path Constraints

- These extensions allow constraint specifications to be included in certificates issued for CAs by other CAs
- The constraints may restrict the types of certificates that can be issued by the subject CA or that may occur subsequently in a certification chain
- The extension fields in this area include:
 - Basic constraints
 - Name constraints
 - Policy constraints



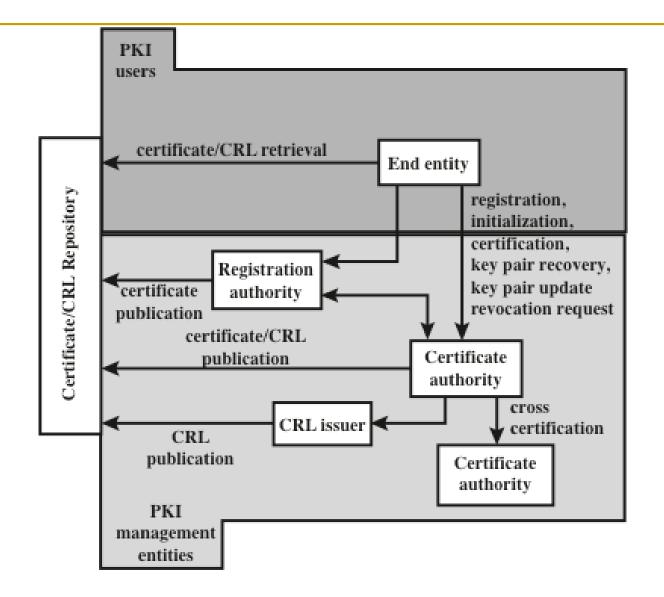


Figure 14.17 PKIX Architectural Model

PKIX Management Functions

- PKIX identifies a number of management functions that potentially need to be supported by management protocols:
 - Registration
 - Initialization
 - Certification
 - Key pair recovery
 - Key pair update
 - Revocation request
 - Cross certification



Summary

- We Have considered:
 - distribution of public keys
 - announcement, directory, Public Key authrority,
 Certificate Authority
 - X.509 authentication and certificates
 - public key infrastructure (PKIX)