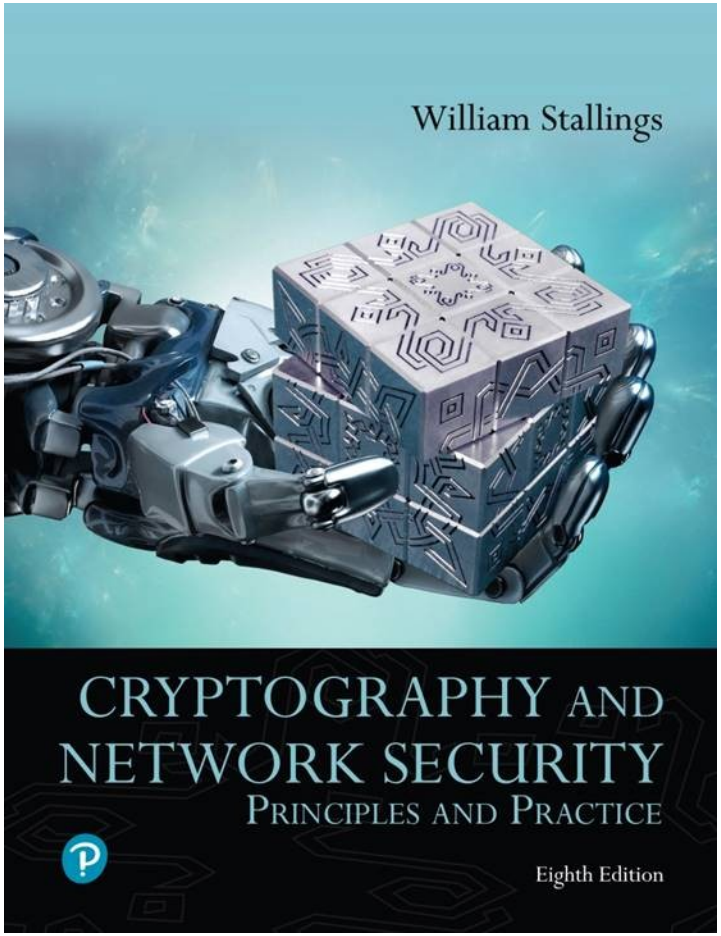
Cryptography and Network Security: Principles and Practice

Eighth Edition



Chapter 15

Cryptographic Key Management and Distribution

Cryptographic Key Management

- The secure use of cryptographic key algorithms depends on the protection of the cryptographic keys
- *Cryptographic key management* is the process of administering or managing cryptographic keys for a cryptographic system
  - It involves the generation, creation, protection, storage, exchange, replacement, and use of keys and enables selective restriction for certain keys
- In addition to access restriction, key management also involves the monitoring and recording of each key's access, use, and context
- A key management system will also include key servers, user procedures, and protocols
- The security of the cryptosystem is dependent upon successful key management

Key Distribution Technique

- Term that refers to the means of delivering a key to two parties who wish to exchange data without allowing others to see the key
- For symmetric encryption to work, the two parties to an exchange must share the same key, and that key must be protected from access by others
- Frequent key changes are desirable to limit the amount of data compromised if an attacker learns the key

Symmetric Key Distribution

- Given parties A and B, key distribution can be achieved in a number of ways:
  - A can select a key and physically deliver it to B
  - A third party can select the key and physically deliver it to A and B
  - If A and B have previously and recently used a key, one party can transmit the new key to the other, encrypted using the old key
  - If A and B each has an encrypted connection to a third party C, C can deliver a key on the encrypted links to A and B

Figure 15.1 Key Distribution Between Two Communicating Entities

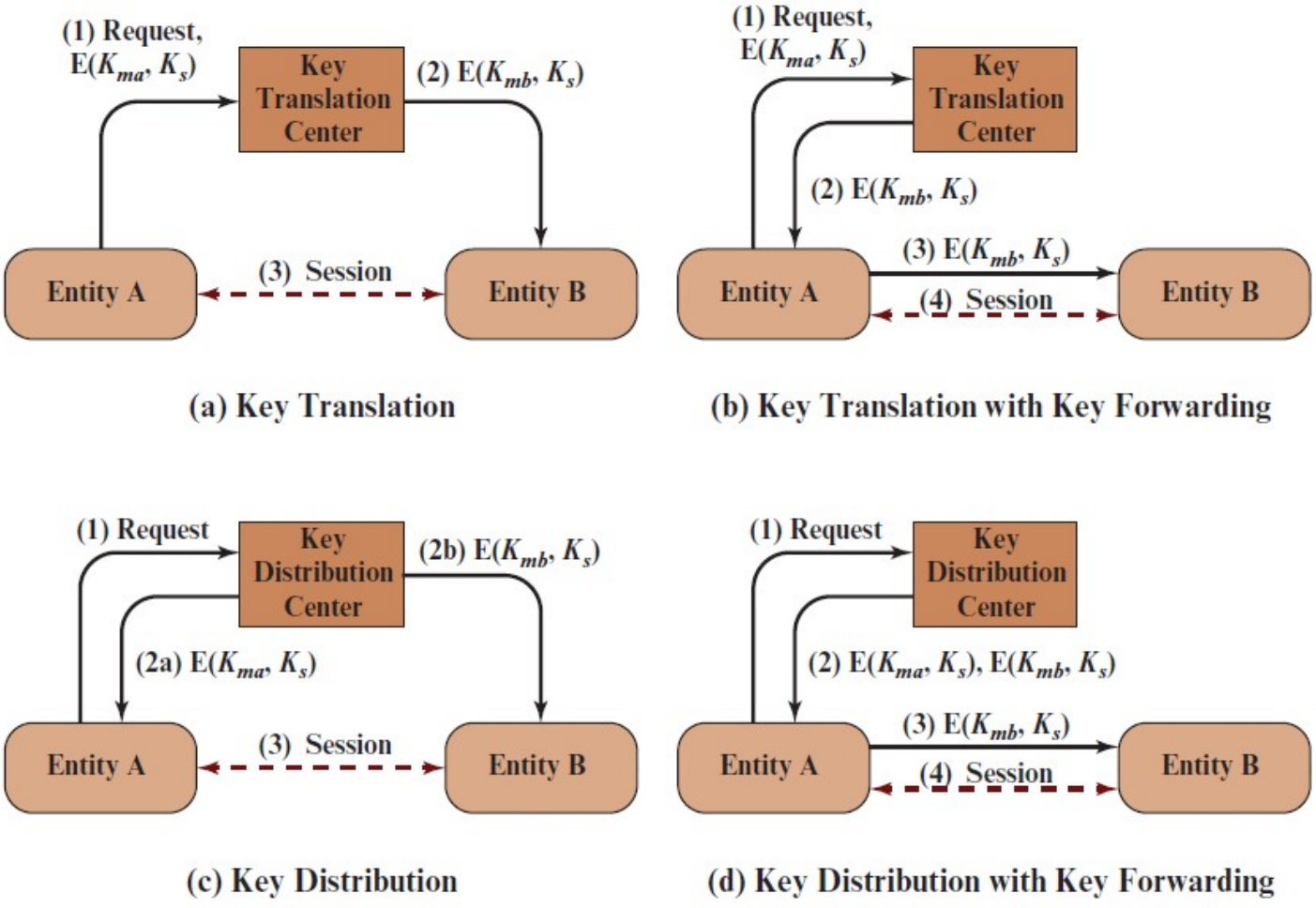


Figure 15.2 Symmetric Key Hierarchy

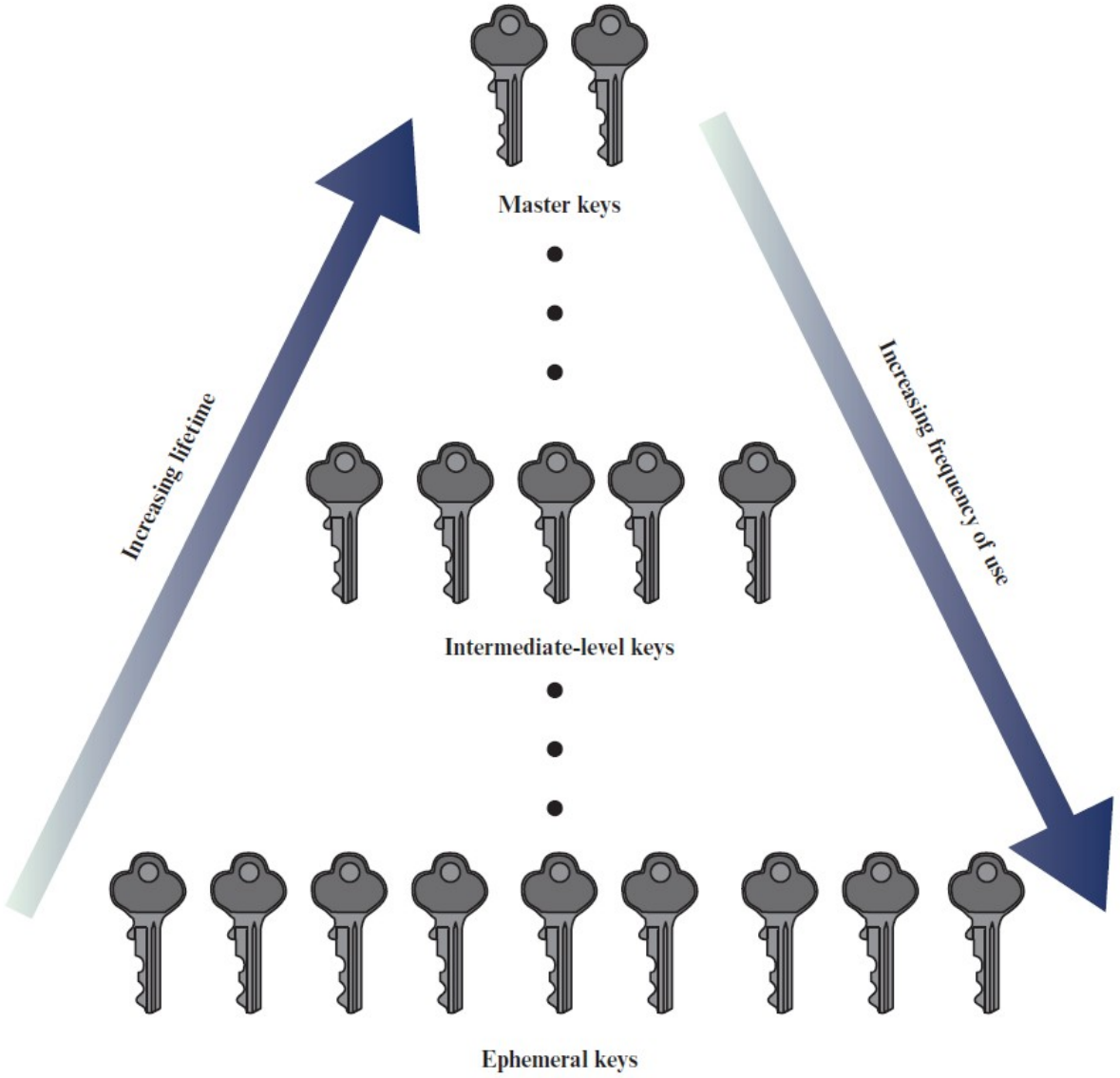


Figure 15.3 Simple Use of Public-Key Encryption to Establish a Session Key

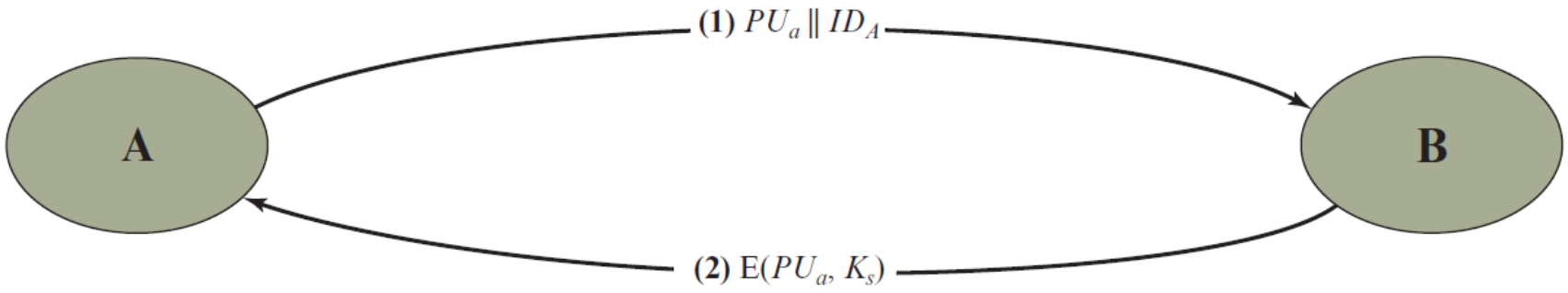


Figure 15.4 Another Man-in-the-Middle Attack

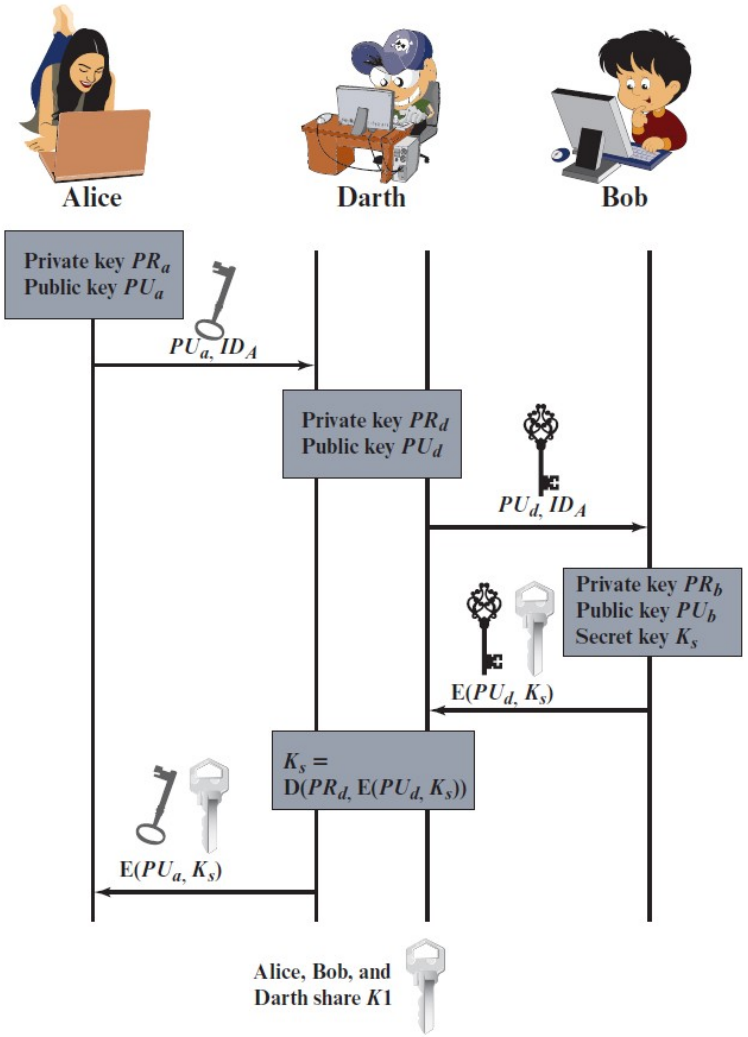


Figure 15.5 Public-Key Distribution of Secret Keys

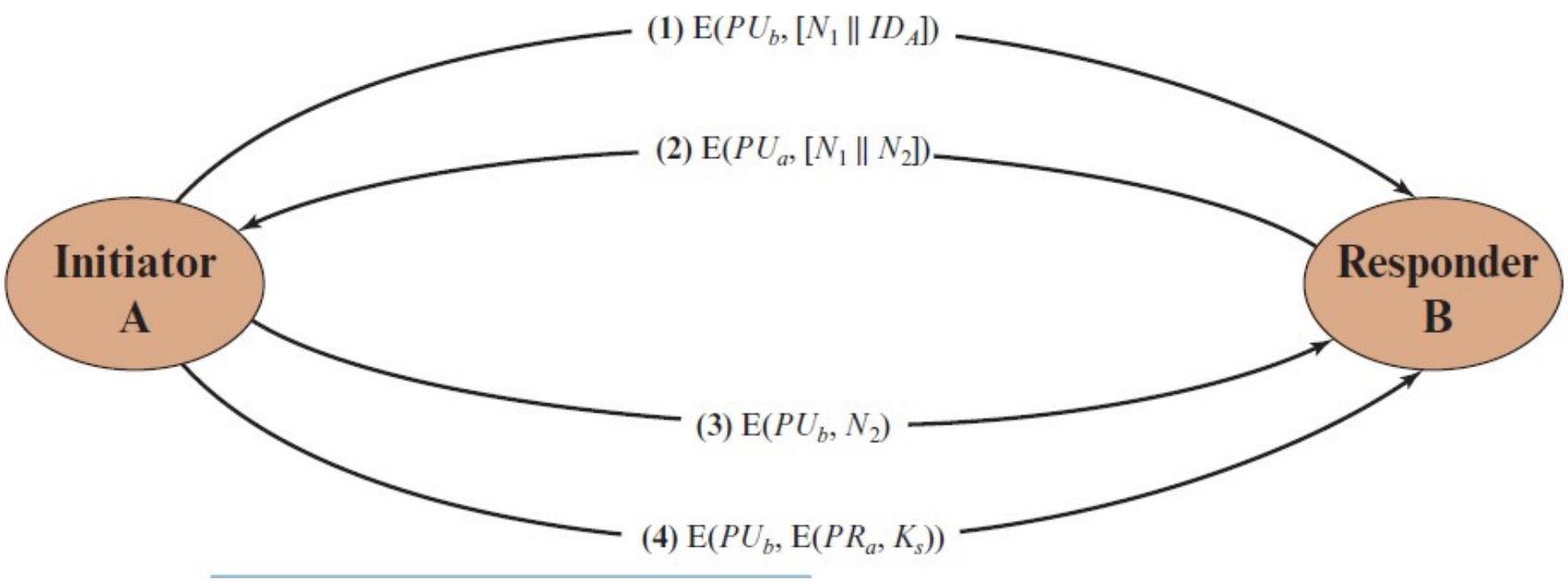


Figure 15.6 Uncontrolled Public-Key Distribution

Figure 15.7 Public-Key Publication

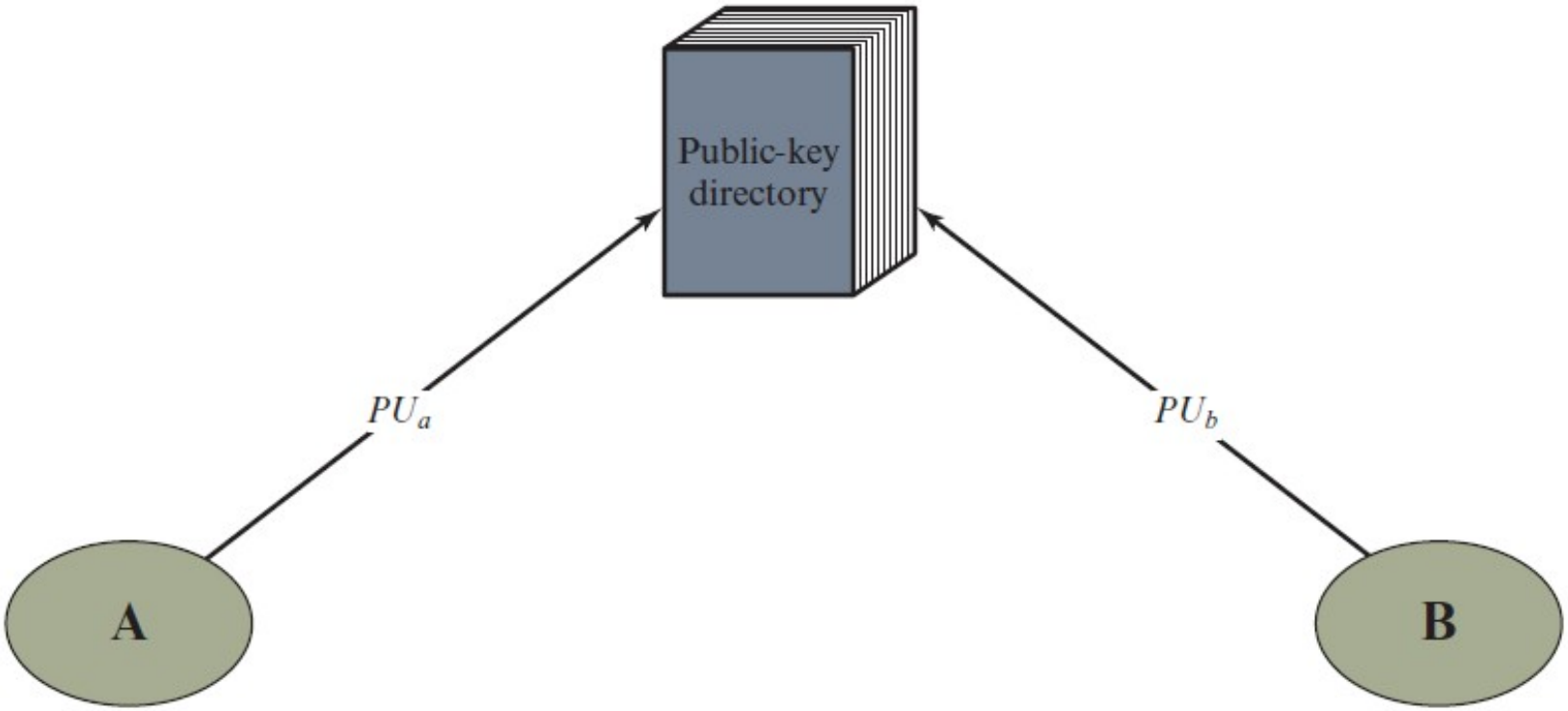


Figure 15.8 Public-Key Distribution Scenario

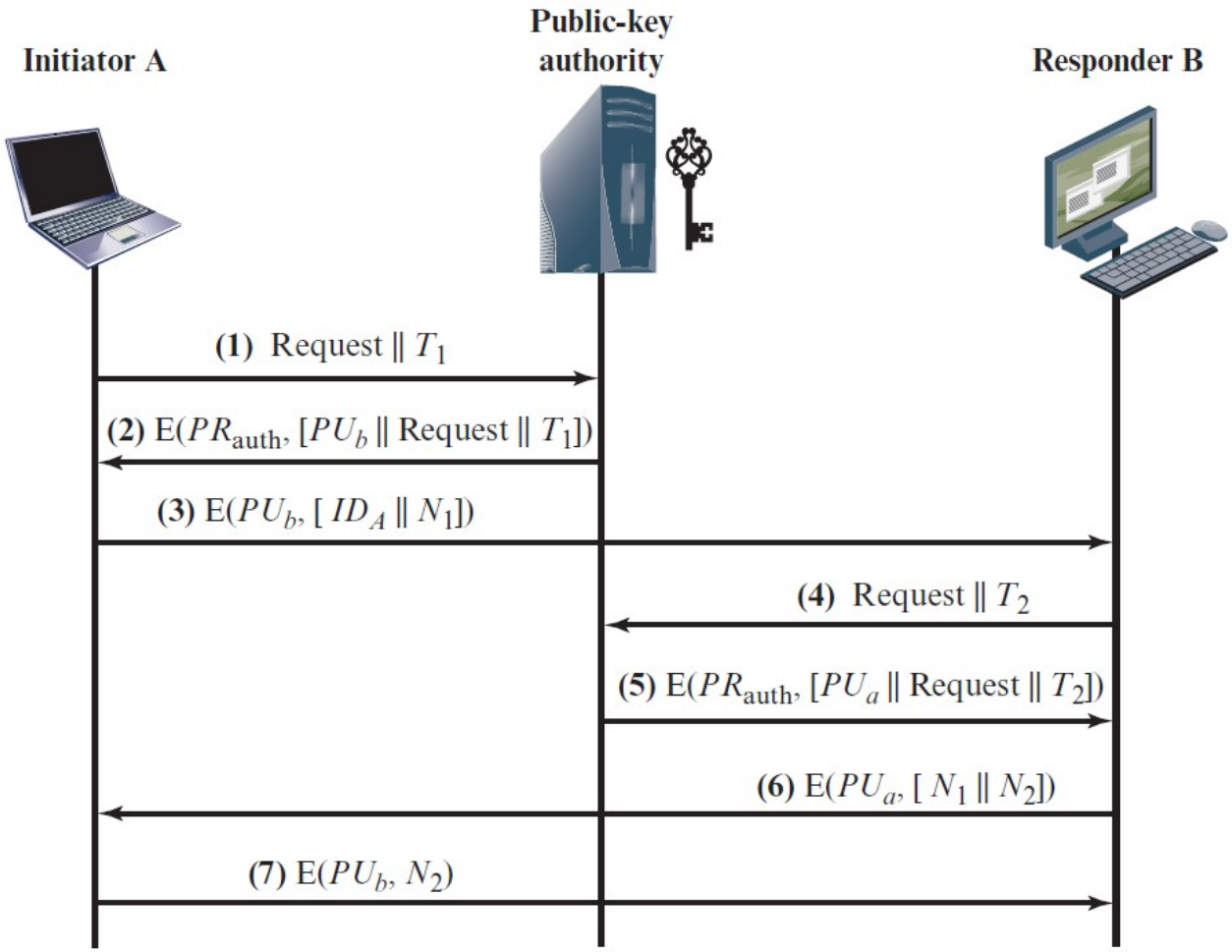
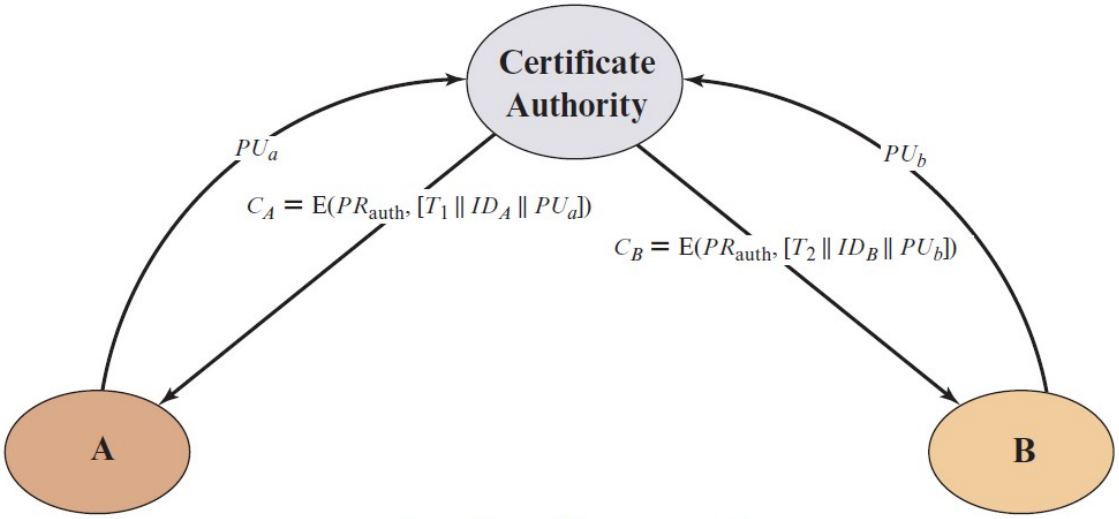
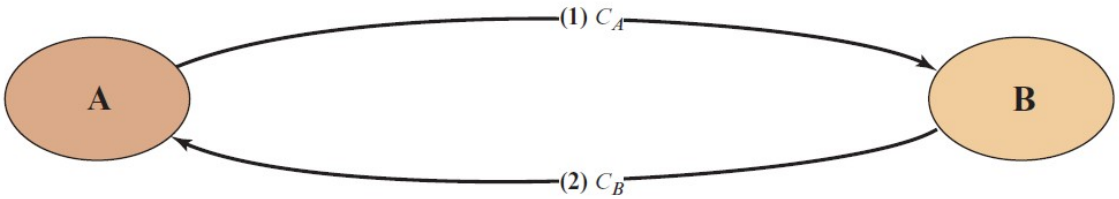


Figure 15.9 Exchange of Public-Key Certificates



(a) Obtaining certificates from CA

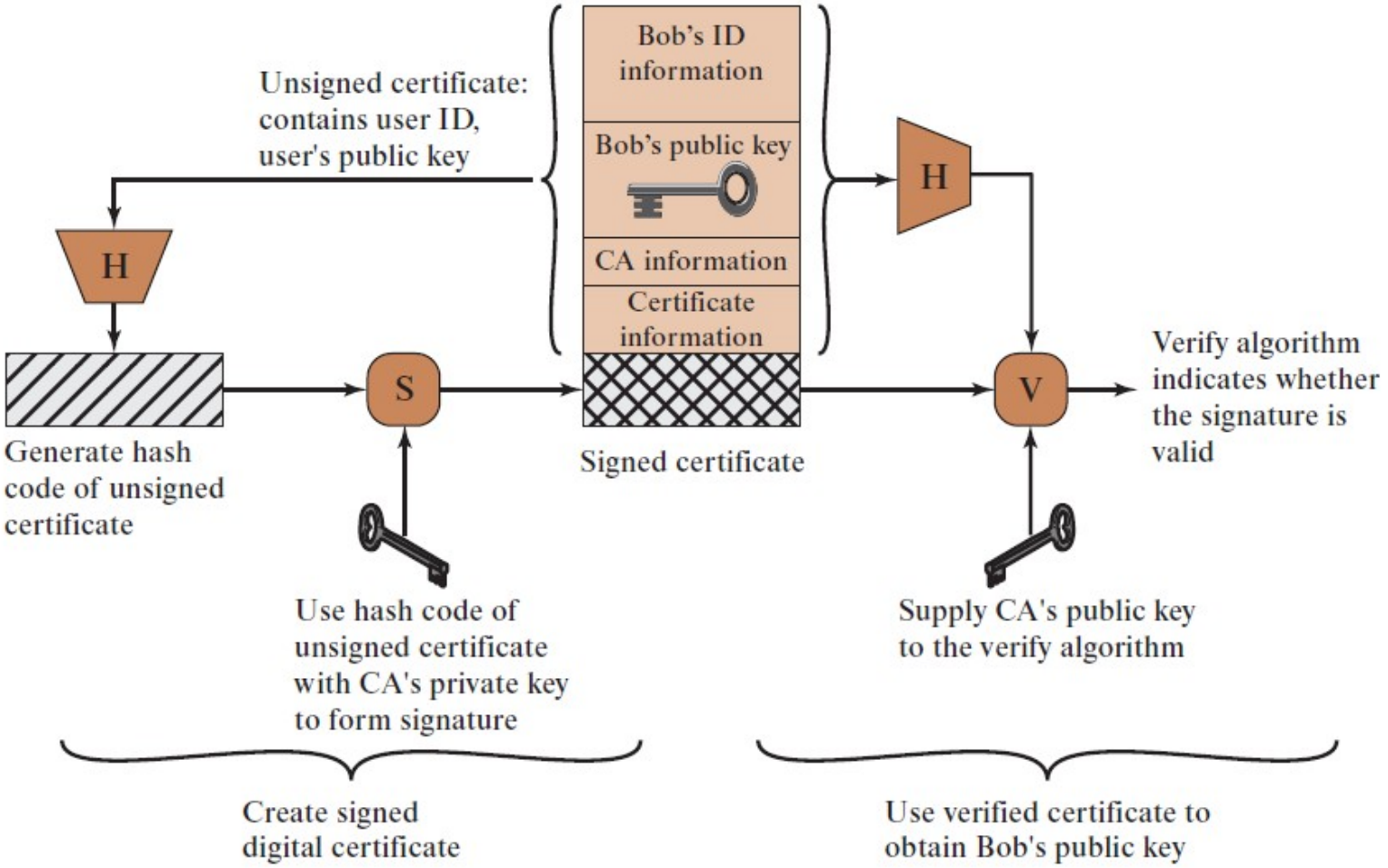


(b) Exchanging certificates

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 2016
  - 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

Figure 15.10 X.509 Public-Key Certificate Use

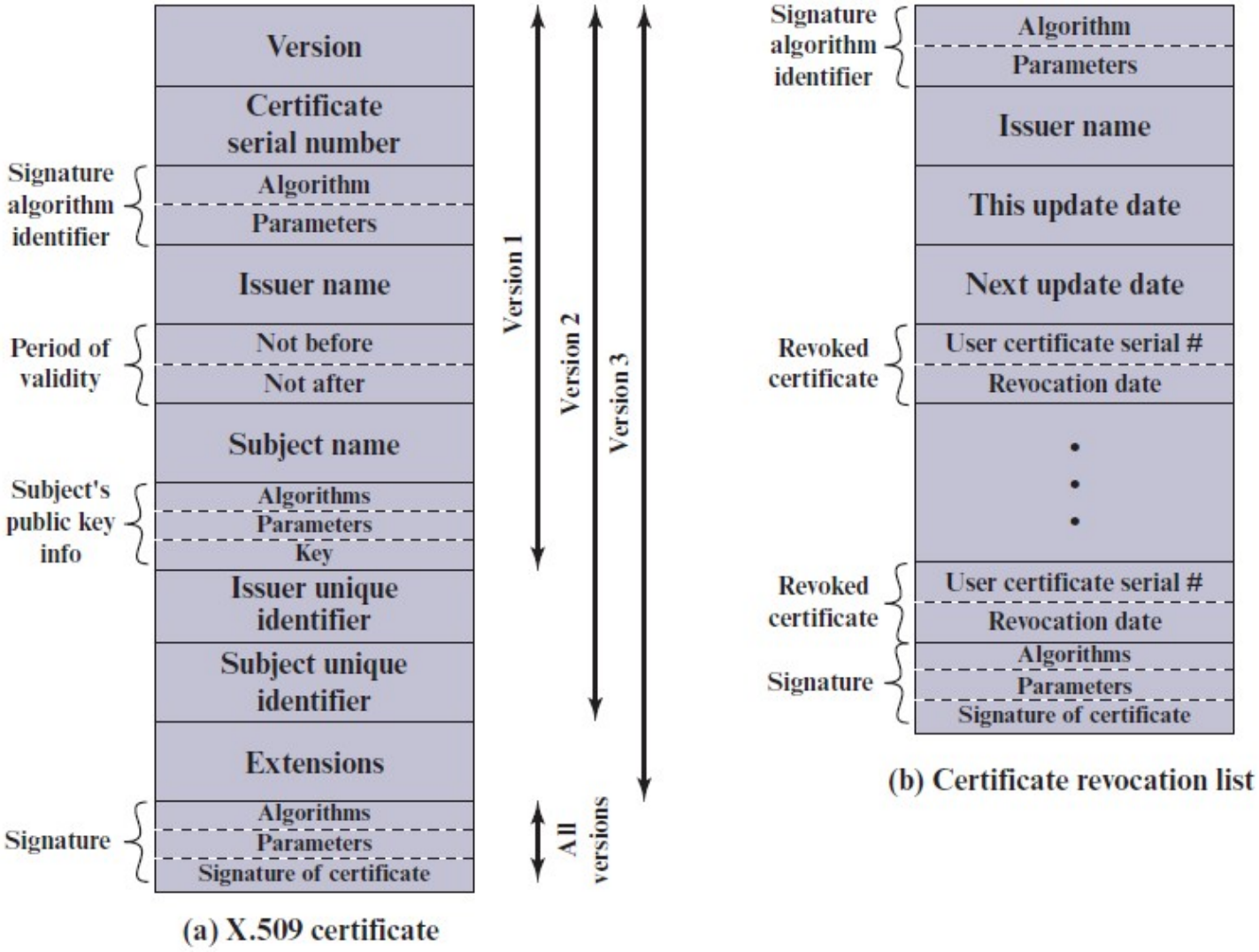


Certificates

Created by a trusted Certification Authority (C A) 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

Figure 15.11 X.509 Formats



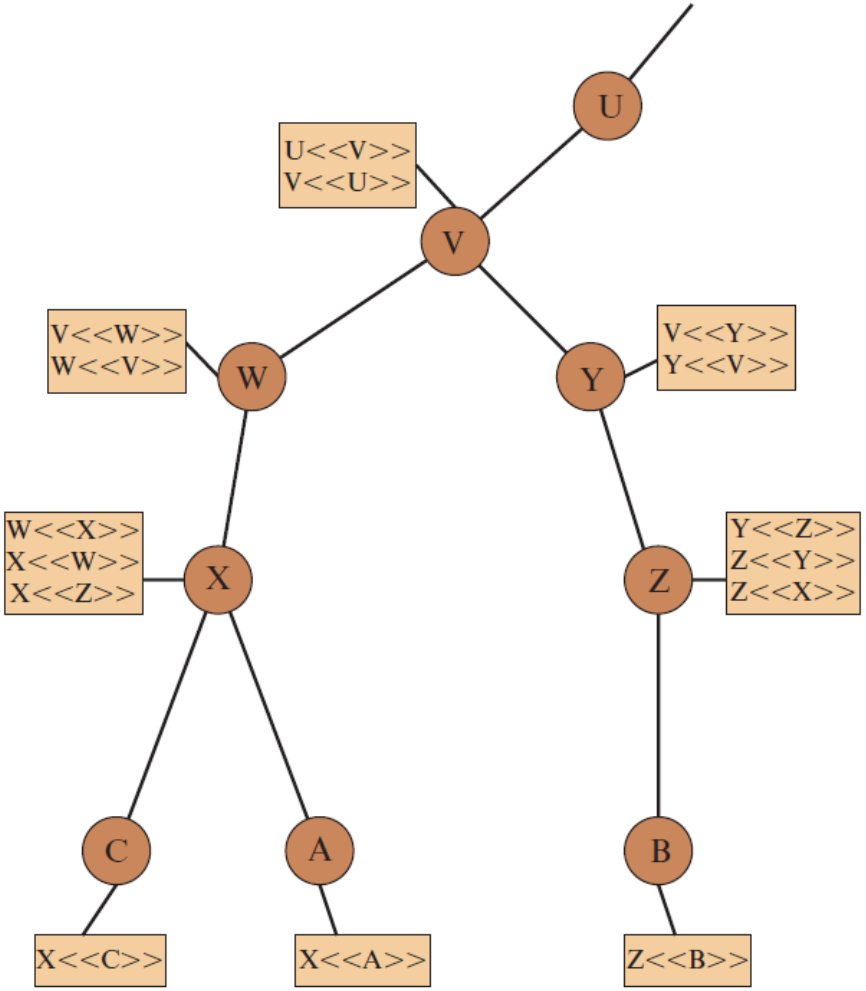
(a) X.509 certificate

(b) Certificate revocation list

Obtaining a Certificate

- User certificates generated by a C A have the following characteristics:
  - Any user with access to the public key of the C A 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

Figure 15.12 X.509 Hierarchy: A Hypothetical Example



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 C A
  - The C A's certificate is assumed to be compromised
- Each C A must maintain a list consisting of all revoked but not expired certificates issued by that C A
  - These lists should be posted on the directory

X.509 Version 3

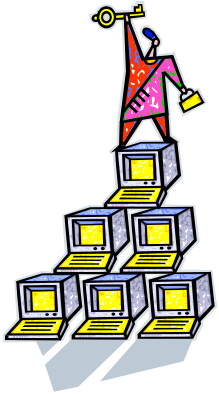
- Version 2 format does not convey all of the information that recent design and implementation experience has shown to be needed
- Rather than continue to add fields to a fixed format, standards developers felt that a more flexible approach was needed
  - Version 3 includes a number of optional extensions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

Each extension consists of:

- An extension identifier
- A criticality indicator
- An extension value

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



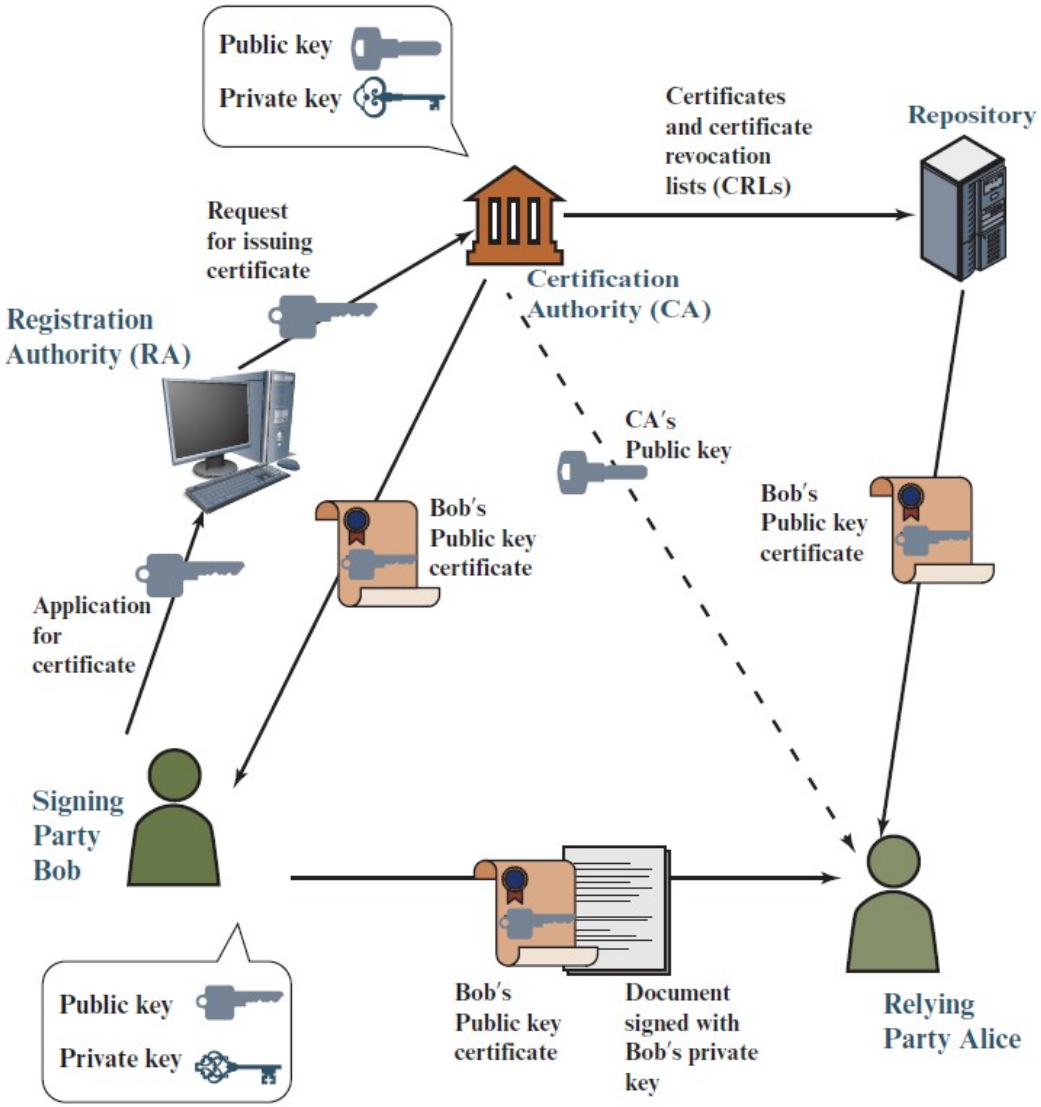
Certificate Subject and Issuer Attributes

- 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 15.13 PKI Scenario



Summary

- Discuss the concept of a key hierarchy
- Understand the issues involved in using asymmetric encryption to distribute symmetric keys
- Present an overview of public-key infrastructure concepts
- Present an overview of approaches to public-key distribution and analyze the risks involved in various approaches
- List and explain the elements in an X.509 certificate

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