MONASH University
Information Technology

FIT3031 INFORMATION & NETWORK SECURITY

MONASH University
Information Technology

FIT3031 INFORMATION & NETWORK SECURITY

Lecture 4:
Authentication Applications

Unit Structure: Lecture Topics

- ✓ OSI security architecture
  - **common security standards and protocols for network security applications**
  - **common information risks and requirements**
- ✓ operation of private key encryption techniques
- ✓ operation of public encryption techniques
- ✓ concepts and techniques for digital signatures, authentication and non-repudiation
- security threats of web servers, and their possible countermeasures
- Wireless Security Issues
- security threats of email systems and their possible countermeasures
- IP security
- intrusion detection techniques for security purpose
- risk of malicious software, virus and worm threats, and countermeasures
- firewall deployment and configuration to enhance protection of information assets
- network management protocol for security purpose

Review of Last Lecture

- **Concept of asymmetric encryption: use of key pair**
- **Operation of asymmetric encryption in encryption and authentication mode**
- **Asymmetric encryption uses longer keys**
- **Operation of RSA algorithm**
- **Operation of Diffie-Hellman algorithm**
- **Message Authentication Code (MAC): a small block of data generated, appended and transmitted with the message**
  - MAC is a function of message as well as key
- **Hash function is a one way function that accepts a message M and produces a fixed-size message digest**
  - is a function of message
- **Both MAC and Hash are used to verify the integrity of the transmitted message**
  - Both are one way function
  - SHA-512, HMAC, CMAC, CCM
- **Symmetric encryption is faster, but key distribution is an issue**
  - One solution is to use asymmetric encryption to share symmetric encryption key, used to share session key in communication between web server and client

Lecture 4: Objectives

- **Appreciate the importance of authentication tools and protocols**
- **Understand Kerberos authentication protocol**
- **Be familiar with X.509 directory authentication service and public key infrastructure**
- **Appreciate the concept of federated identity management**

Lecture 4: Outline

- **Authentication protocol**
  - Requirements
  - Access control to services
  - Simple authentication dialogue
  - More secure authentication dialogue
  - Kerberos v.4 authentication
- **X.509 authentication services**
  - certificates
  - Different authentication procedure
- **Public Key Infrastructure**
- **Federated Identity Management**

Access Control

- **In today's organizations, we mostly have open distributed architecture consisting of**
  - workstations (clients)
  - distributed/centralized servers.
- **Enforcement of access restriction to the services on servers is crucial for security**
- **Three threats exist:**
  - User pretends to be another user
  - User alters the network address of a workstation
  - User eavesdrops on exchanges and uses a replay attack
- **A workstation cannot be trusted for access control purpose**

Access Control …

- **Three approaches to security can be considered:**
  1. rely on **client workstations** to assure user(s) identity and rely on **server to enforce a security policy** based on **user id**
  2. require that **client systems** authenticate themselves to **servers**, but trust the **client systems** to assure **user(s) identity**
  3. **require the user** to prove identity for **each service** on the **server** and also the **server to prove its identity to clients**
- **The first or second strategy may be suitable for a small closed environment**
  – inadequate for larger open environment
- **The third approach is needed**
  – supported by Kerberos authentication protocol

Kerberos

In Greek mythology, a many headed dog, the guardian of the entrance of Hades

Kerberos …

- **Provides a centralized authentication server to authenticate <u>users to servers</u> and <u>servers to users</u>**
  - > **allows users access to services distributed through network**
  - > **without needing to trust all workstations**
  - > **rather all trust a central authentication server**
- **Relies on conventional/Symmetric encryption**
  - – makes no use of public-key/Asymmetric encryption
- **Two versions: version 4 and 5**
- **Version 4 makes use of DES**

Kerberos Requirement

- **The first published report identified its requirements as:**
  - **Security** - secure enough to prevent eavesdropping
  - **Reliability** - highly reliable to ensure the availability
  - **Transparency** - user should not be aware of authentication taking place
  - **Scalability** - capable of supporting large number of clients and servers

Kerberos Overview

- **Its a basic third-party authentication scheme**
- **Employs an Authentication Server (AS)**
  - users initially negotiate with **AS** to **identify** self
  - **AS** provides a non-corruptible authentication credential (ticket granting ticket **TGT**)
- **Employs a Ticket Granting server (TGS)**
  - users subsequently request access to other services from TGS on basis of users TGT
- ***Before going into details, we consider a simple authentication dialogues***

Why Authentication Server?

- When a request is made by a client for a network service, the server must be able **to confirm the identity of the clients**
- This places a **substantial burden on the server** where each client/server interaction requires authentication
- An alternative is to use an Authentication Server (**AS**)
- **AS** stores the password of all users in a **centralized database** and shares a unique key with **each server**

A Simple Authentication Dialogue(1)

- **Consider the following notations:**
  - **C** = Client
  - **AS** = authentication server
  - **V** = server
  - $\mathbf{ID_C}$ = identifier of user on C
  - $\mathbf{ID_V}$ = identifier of V
  - $\mathbf{P_C}$ = password of user on C
  - $\mathbf{AD_C}$ = network address of C
  - **K_V = secret encryption key shared by AS an V**
  - **TS** = timestamp
  - **||** = concatenation

A Simple Authentication Dialogue(2)

- **C send a message to AS**
- **AS checks the database for user ID and password match, and whether the user has access permission to (Server) V.**
  - If passed, it takes the user as authentic
  - AS creates a ticket.
    - > The ticket contains **user ID, server ID and network address**, all encrypted by a secret key shared by AS and V.
- **C sends a message to V with C's ID and the ticket.**
- **V decrypts the ticket**
  - verifies whether the user ID in the ticket is the same as the unencrypted user ID
  - If those matches, the server grants requested service

C $\rightarrow$ AS: $ID_c \| P_c \| ID_v$

AS $\rightarrow$ C: Ticket

C $\rightarrow$ V: $ID_c \| Ticket$

Ticket = $E_{K_V}[IDc \| AD_c \| IDv]$

The ticket is encrypted to prevent forgery

AD_c is included to counter replay attack

A Simple Authentication Dialogue(3)

- **There are a few problems with this scheme:**
  - – the user needs to enter password every time a service is accessed
    - > each attempt for the same service requires reentering the password
  - – a new ticket for every different service
  - – password is transmitted in plaintext format
    - > easy for an eavesdropper to capture the password

$$\mathbf{C \rightarrow AS: ID_c \,||\, P_c \,||\, ID_v}$$

A more **secure** authentication Dialogue (1)

- **An improved scheme:**
  - avoiding plaintext password
  - Employ another server, called **ticket-granting server** (TGS)
    - >TGS satisfies two requirements
      - **only one password query per session**
      - **protection of the user’s password**

A more **secure** authentication Dialogue (2)

Once per user logon session:

(1) $C \rightarrow AS$: $ID_C \| ID_{tgs}$

(2) $AS \rightarrow C$: $E(K_c, Ticket_{tgs})$

Once per type of service:

(3) $C \rightarrow TGS$: $ID_C \| ID_V \| Ticket_{tgs}$

(4) $TGS \rightarrow C$: $Ticket_v$

Once per service session:

(5) $C \rightarrow V$: $ID_C \| Ticket_v$

$$Ticket_{tgs} = E(K_{tgs}, [ID_C \| AD_C \| ID_{tgs} \| TS_1 \| Lifetime_1])$$

$$Ticket_v = E(K_v, [ID_C \| AD_C \| ID_v \| TS_2 \| Lifetime_2])$$

The client requests a **ticket-granting ticket** from **AS**

- **AS** sends a ticket encrypted with a key $\mathbf{K}_c$ derived from the user's password **no password** is transmitted.
- ticket is **reusable - timestamp** is include to counter ticker **spoofing**

The client **C** requests a **service using granting ticket (TGS)** decrypts the ticket using secret shared key $\mathbf{K}_v$ checks lifetime, used id, network address

Client requests access to service V using service granting ticket

A more **secure** authentication Dialogue (3)

- **Problem still remains:**
  - *Lifetime*$_{1\ \&\ 2}$ associated with the ticket-granting ticket
  - If too short → repeatedly asked for password
  - If too long → greater opportunity to replay
- **The threat is that an opponent will steal the ticket and use it before it expires**

- **<u>Kerberos authentication dialogue addresses these problems</u>**

Kerberos v4 Overview

- **a basic third-party authentication scheme**
- **have an Authentication Server (AS)**
  - users initially negotiate with AS to identify self
  - AS provides a non-corruptible authentication credential (ticket granting ticket TGT)
- **have a Ticket Granting server (TGS)**
  - users subsequently request access to other services from TGS on basis of users TGT
- **using a complex protocol using DES**

Kerberos V.4 Authentication dialogue

Table 4.1 Summary of Kerberos Version 4 Message Exchanges

(1) C → AS $ID_c \| ID_{tgs} \| TS_1$

(2) AS → C $E(K_c, [K_{c,tgs} \| ID_{tgs} \| TS_2 \| Lifetime_2 \| Ticket_{tgs}])$

$$Ticket_{tgs} = \mathrm{E}(\mathrm{K}_{tgs}, [\mathrm{K}_{c,tgs} \| \mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{ID}_{tgs} \| \mathrm{TS}_2 \| \mathrm{Lifetime}_2])$$

(a) Authentication Service Exchange to obtain ticket-granting ticket

(3) C → TGS $ID_v \| Ticket_{tgs} \| Authenticator_c$

(4) TGS → C $E(K_{c,tgs}, [K_{c,v} \| ID_v \| TS_4 \| Ticket_v])$

$$Ticket_{tgs} = \mathrm{E}(\mathrm{K}_{tgs}, [\mathrm{K}_{c,tgs} \| \mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{ID}_{tgs} \| \mathrm{TS}_2 \| \mathrm{Lifetime}_2])$$

$$Ticket_v = \mathrm{E}(\mathrm{K}_v, [\mathrm{K}_{c,v} \| \mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{ID}_v \| \mathrm{TS}_4 \| \mathrm{Lifetime}_4])$$

$$Authenticator_c = \mathrm{E}(\mathrm{K}_{c,tgs}, [\mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{TS}_3])$$

(b) Ticket-Granting Service Exchange to obtain service-granting ticket

(5) C → V $Ticket_v \| Authenticator_c$

(6) V → C $E(K_{c,v}, [TS_5 + 1])$ (for mutual authentication)

$$Ticket_v = \mathrm{E}(\mathrm{K}_v, [\mathrm{K}_{c,v} \| \mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{ID}_v \| \mathrm{TS}_4 \| \mathrm{Lifetime}_4])$$

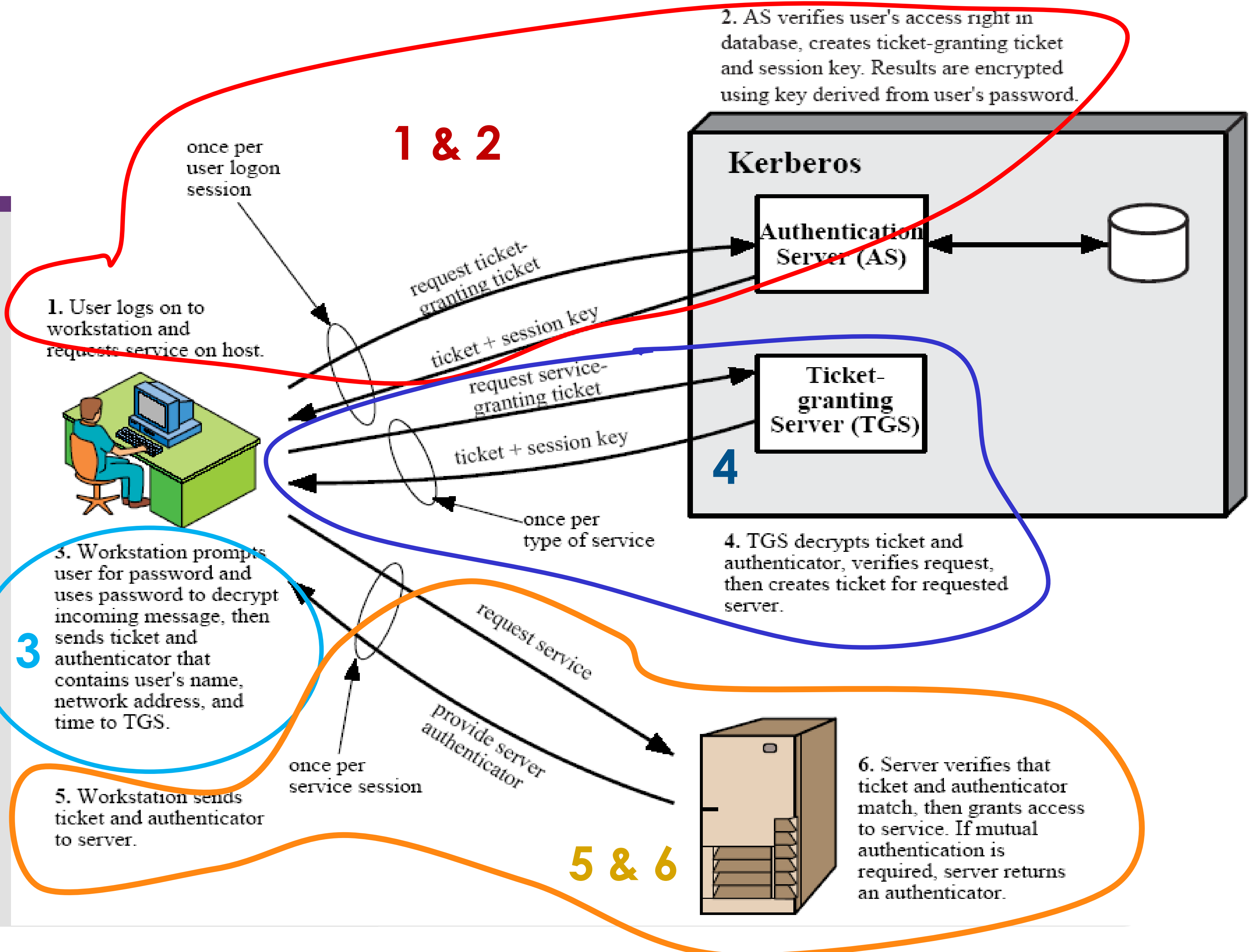
$$Authenticator_c = \mathrm{E}(\mathrm{K}_{c,v}, [\mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{TS}_5])$$

(c) Client/Server Authentication Exchange to obtain service

Kerberos V.4 (1)

- **A session key $K_{c,tgs}$ is introduced**
- **The ticket contains the session key**
- **The authenticator proves client's identity**
  - can be used only once
  - has a short lifetime
  - threat of stealing both the ticket and authenticator for later presentation is removed
- **The authenticator is encrypted by the session key**

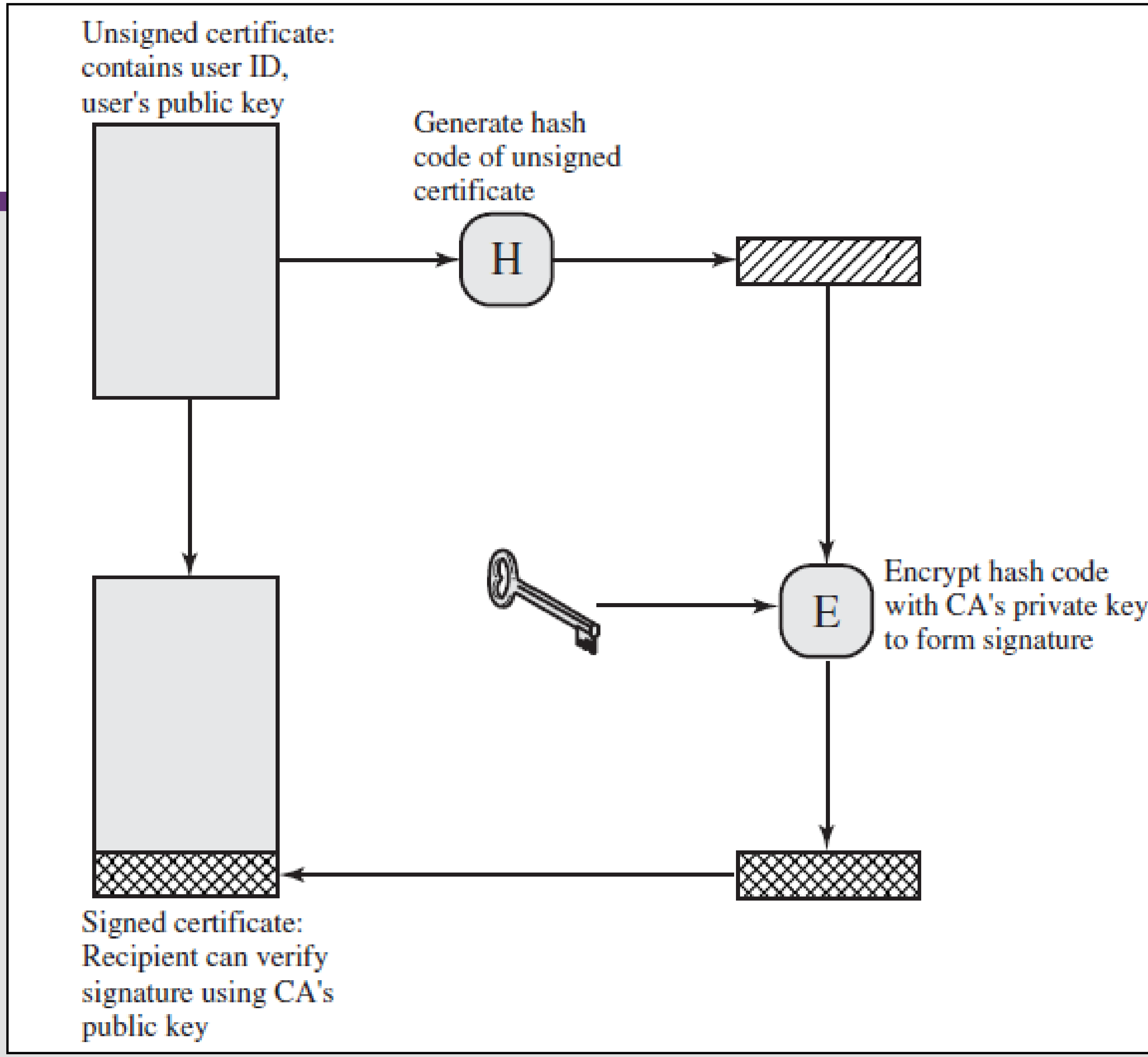
Kerberos V.4 (2)



Kerberos V.4 (3)

- **Currently two Kerberos versions:**
  - V4 and v5 version
  - Kerberos v5 is an Internet standard
  - specified in RFC1510, and used by many utilities
- **To use Kerberos:**
  - need to have a KDC on your network
  - need to have Kerberised applications running on all participating systems
  - major problem - US export restrictions
  - Kerberos cannot be directly distributed outside the US in source format (& binary versions must obscure crypto routine entry points and have no encryption)
  - else crypto libraries must be reimplemented locally

X.509 Certificate Use



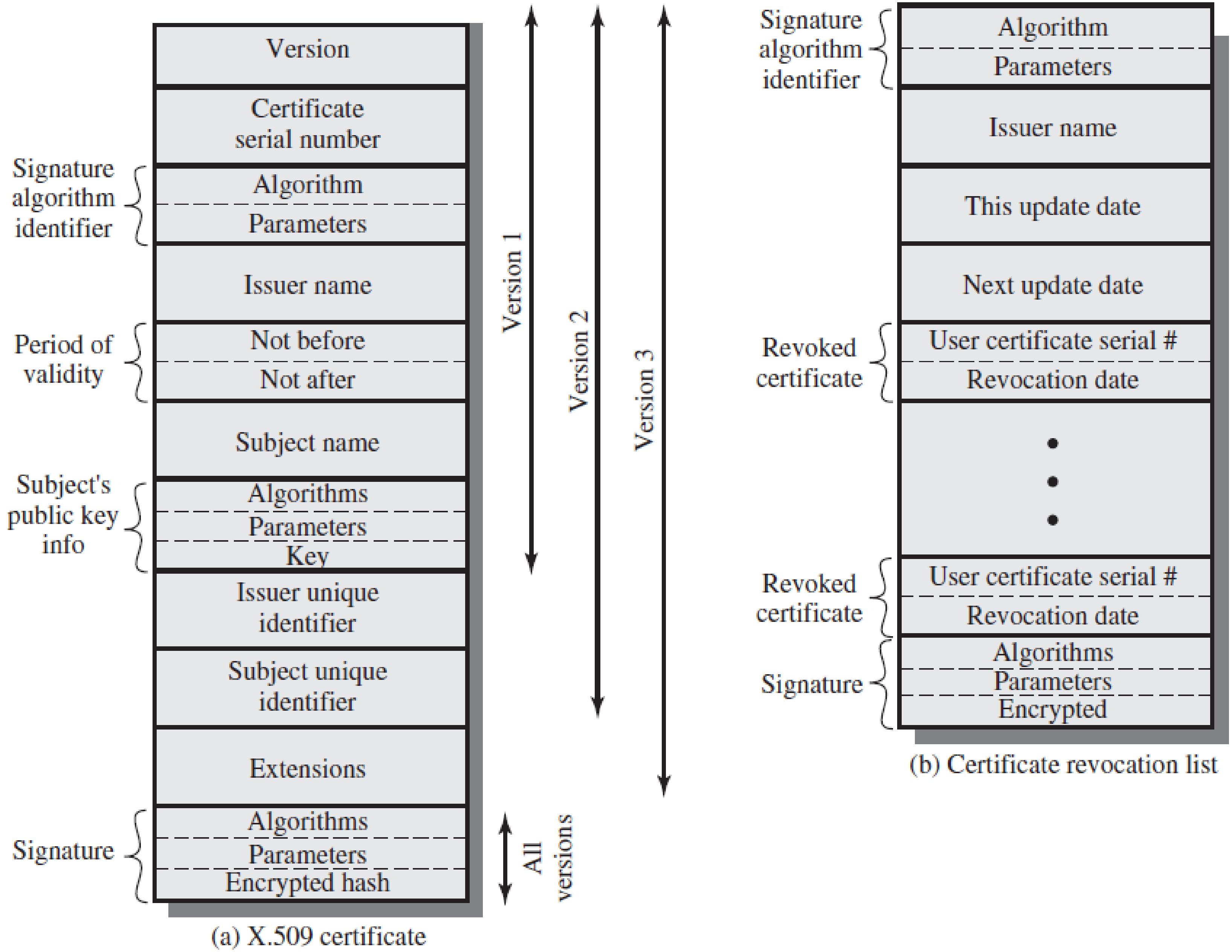
Public-Key Distribution of Secret Keys

- **Conventional encryption requires 2 parties to securely share a secret key**
- **Diffie-Hellman key exchange *does not authenticate* the 2 partners**
- **Alternative is the use of *public key certificates***
  - Encrypt session key using public-key encryption
  - Receiver obtains the sender's public key by means of ***public key certificate that provides assurance of a valid public key***

X.509 Authentication Service

- **X.500 directory is a distributed set of servers that maintains a database about users**
- **X.509 defines a framework of authentication services provided by X.500 to its users**
- **Each certificate contains the public key of a user and is signed with the private key of a CA (Certification Authority)**
- **Used in S/MIME, IP Security, SSL/TLS and SET.**
- **Use of RSA is recommended.**

X.509 Formats



Getting a Certificate

- **Any user with *access to CA* can get *any certificate* from it**
- **Only the issuing CA *can modify* a certificate**
  - any modification is detected
- **Because certificates *cannot be forged*, they can be *placed* in a public directory**

CA Hierarchy (1)

- **If both users share a common CA then it is assumed they 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**
- **Enables verification of any certificate from one CA by users of all other CAs in hierarchy**

CA Hierarchy (2)

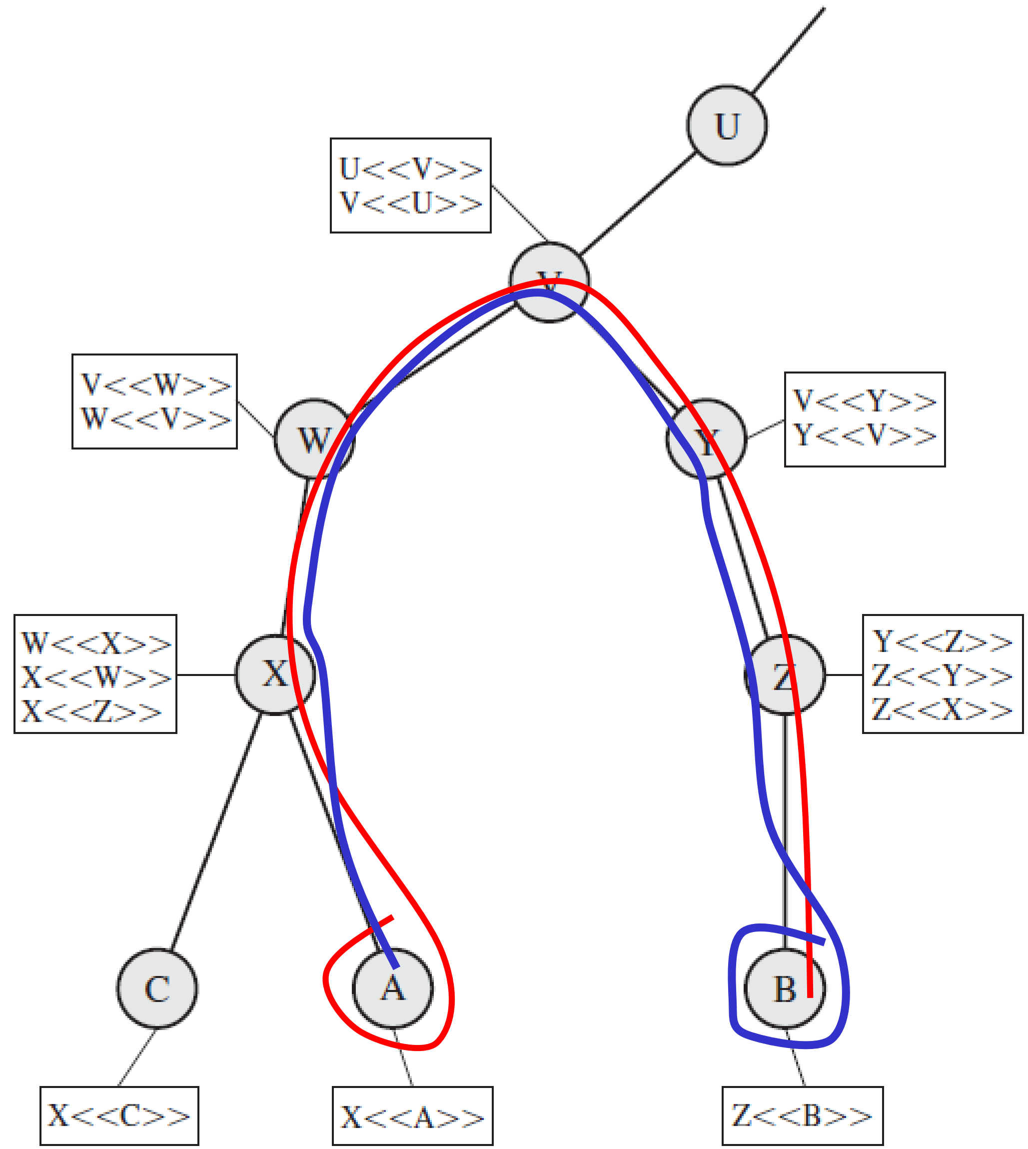
X <<C>> the certificate of user C issued by certification authority X

- A acquires B certificate using chain:

X<<W>>W<<V>>V<<Y>>Y<<Z>>Z<<B>>

- B acquires A certificate using chain:

Z<<Y>>Y<<V>>V<<W>>W<<X>>X<<A>>



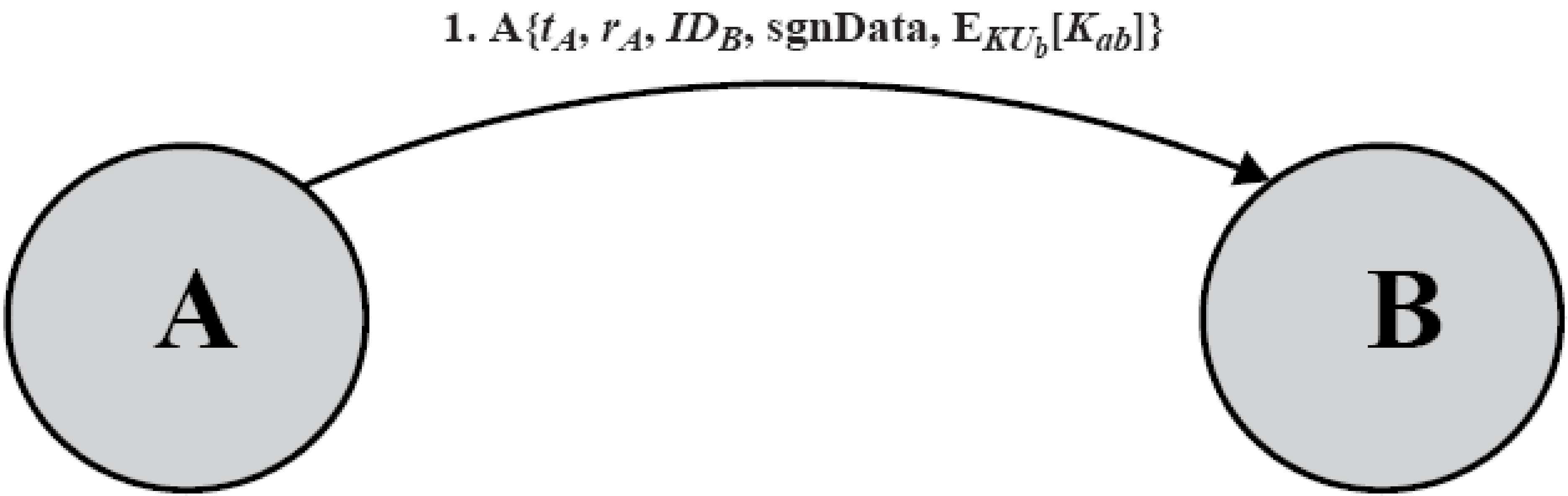
Certificate Revocation

- **Certificates have a period of validity**
- **May need to be revoked before expiry, eg:**
  – user's private key is compromised
  – user is no longer certified by this CA
  – CA's certificate is compromised
- **CA’s maintain list of revoked certificates**
  – the Certificate Revocation List (CRL)
- **Users should check certificates with CA’s CRL**

Authentication Procedure

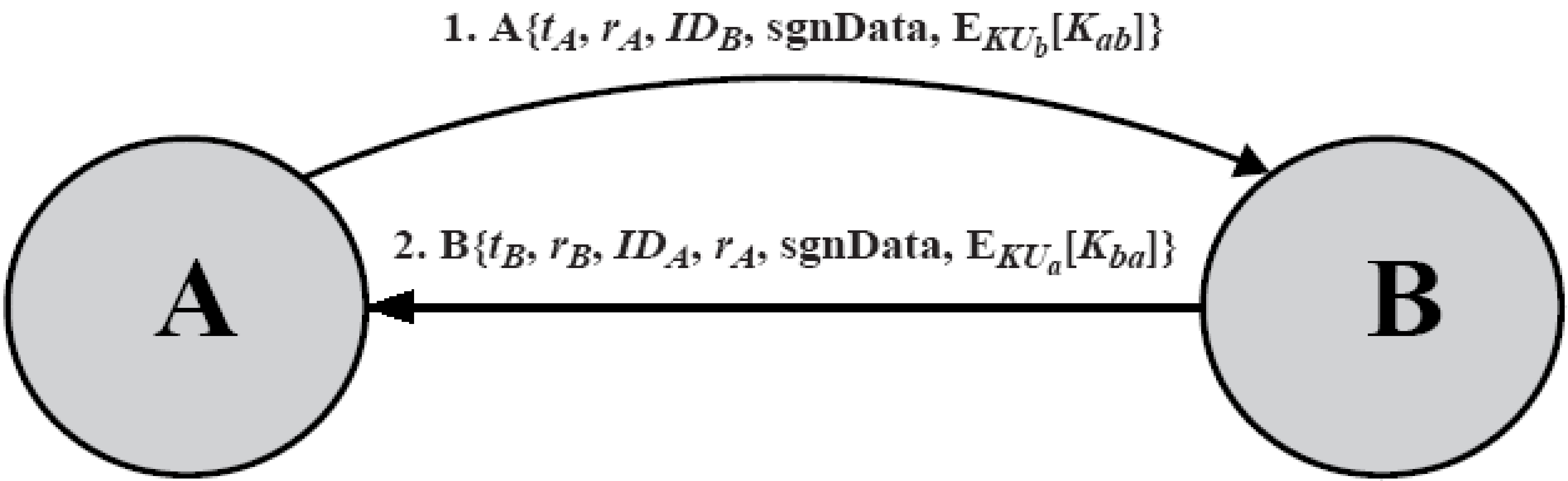
- **X.509 includes three alternative authentication procedures:**
  - One-Way Authentication
    - > for unidirectional messages (like email)
  - Two-Way Authentication
    - > for interactive sessions when timestamps are used
  - Three-Way Authentication
    - > for interactive sessions with no need for timestamps (and hence synchronised clocks).
- **all use public-key signatures**

One-Way Authentication



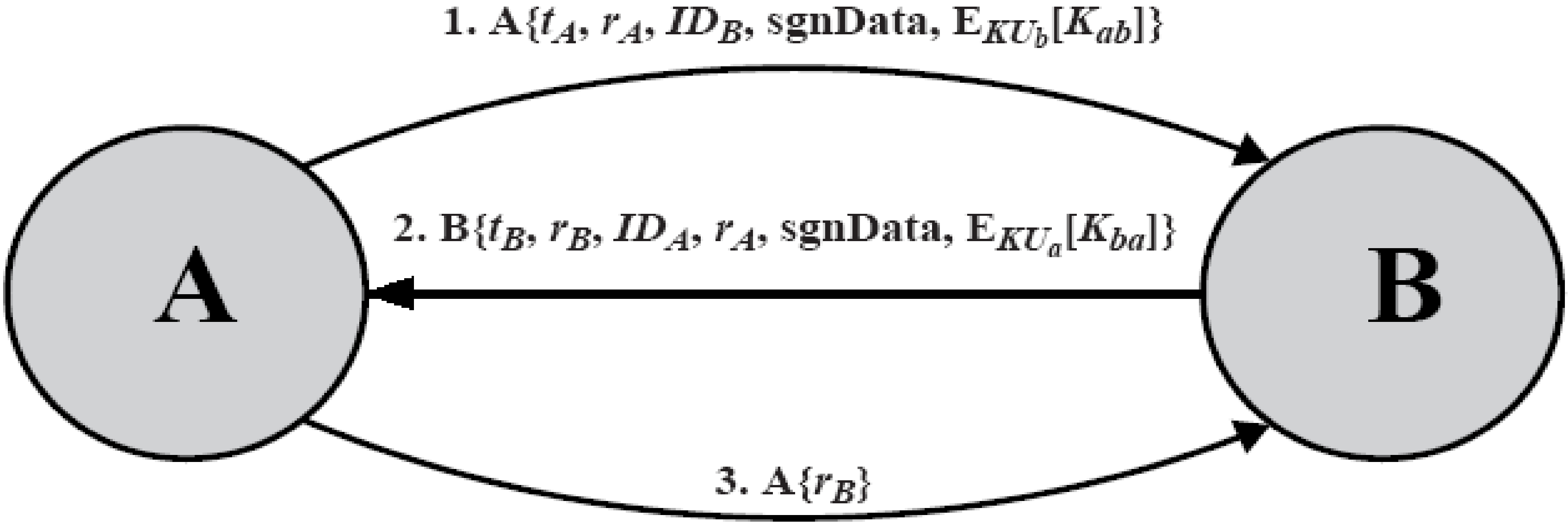
- 1 message (A → B) used to establish with **synchronized clocks**
  - the **identity** of A and that message is from A
  - message was intended for B
  - integrity & originality of message
- message must include timestamp, nonce, B's identity and is signed by A
- timestamp need to be **checked** 'or' **relied** upon

Two-Way Authentication



- 2 messages (A → B, B → A) for two way authentication, with **synchronized** clocks in addition:
  - **the identity of B and that reply is from B**
  - **that reply is intended for A**
  - **integrity & originality of reply**
- reply includes original nonce from A, also timestamp and nonce from B
- timestamp need to be checked or relied upon

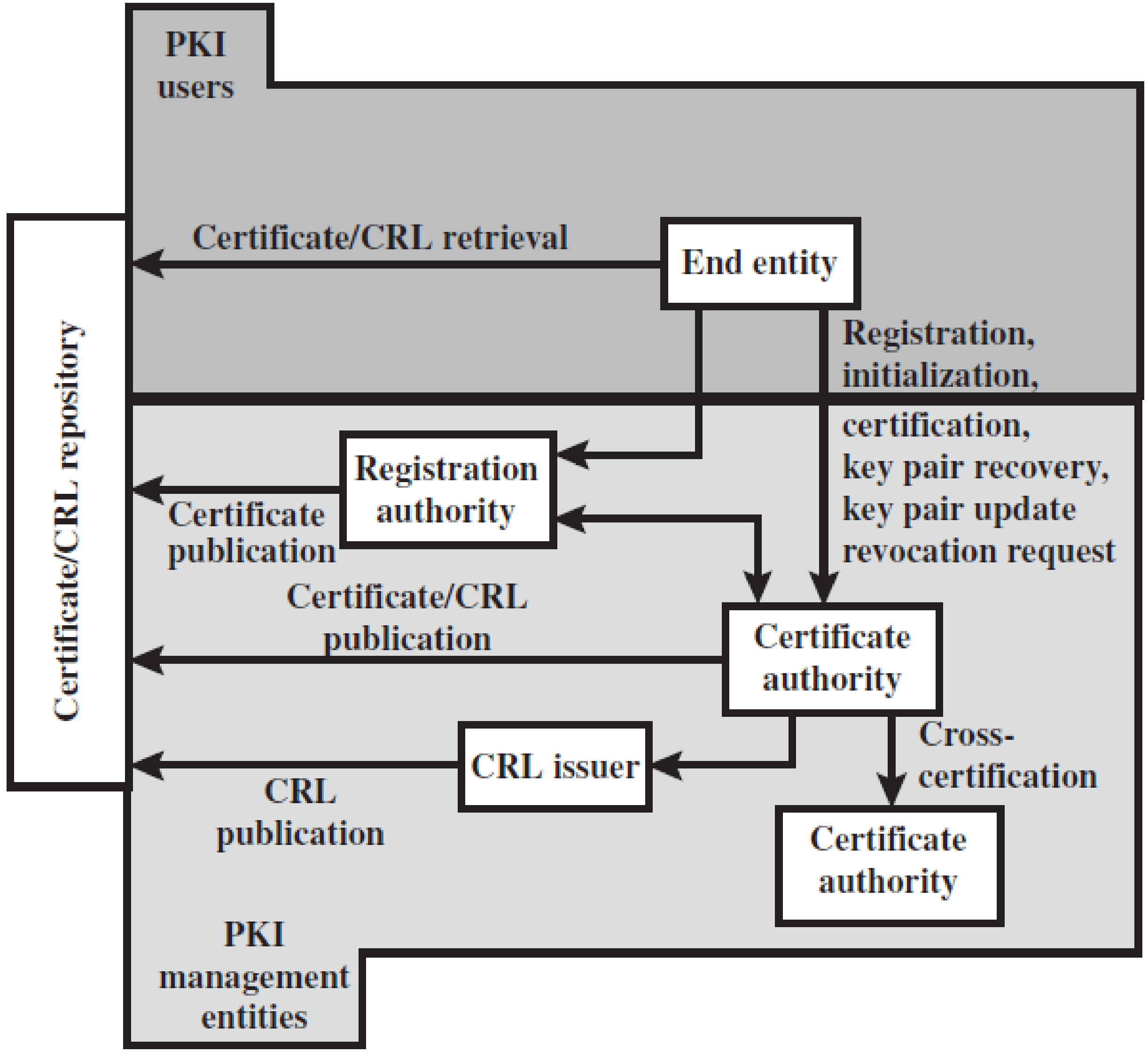
Three-Way Authentication



- 3 messages (A→B, B→A, A→B) which enables above *<u>authentication without synchronized clocks</u>*
- has reply from A back to B containing signed copy of nonce from B
- implies timestamps need not be checked or relied upon

Public Key Infrastructure

- **RFC 2822 (Internet Security Glossary) defines public-key infrastructure (PKI)**
- **Set of h/w, s/w, policies & procedures needed to create, manage, store, distribute, and revoke digital certificates based on asymmetric cryptography.**



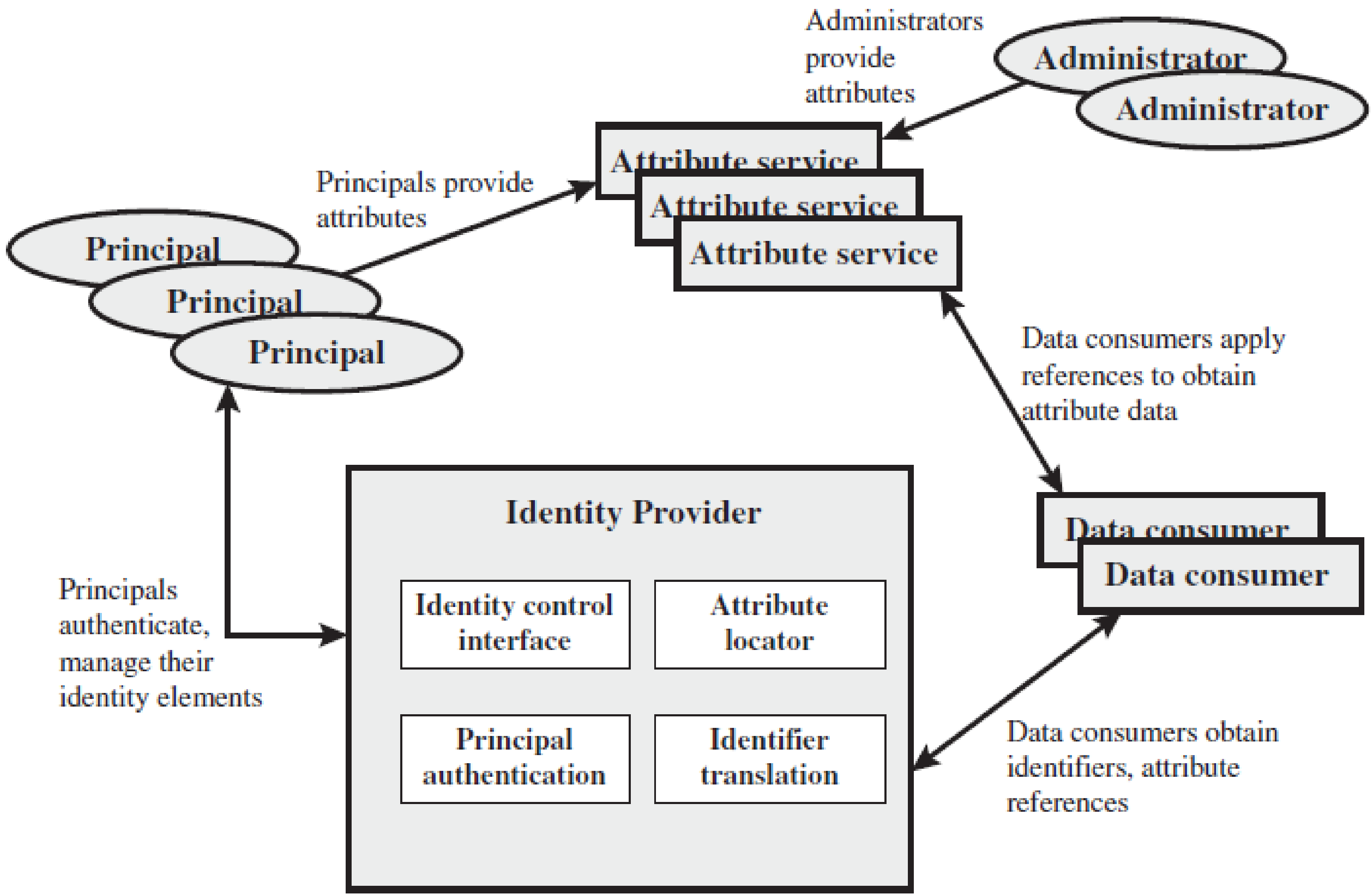
Public Key Infrastructure X.509 (PKIX) Management

- **functions:**
  - registration
  - initialization
  - certification
  - key pair recovery
  - key pair update
  - revocation request
  - cross certification
- **protocols: CMP, CMC**

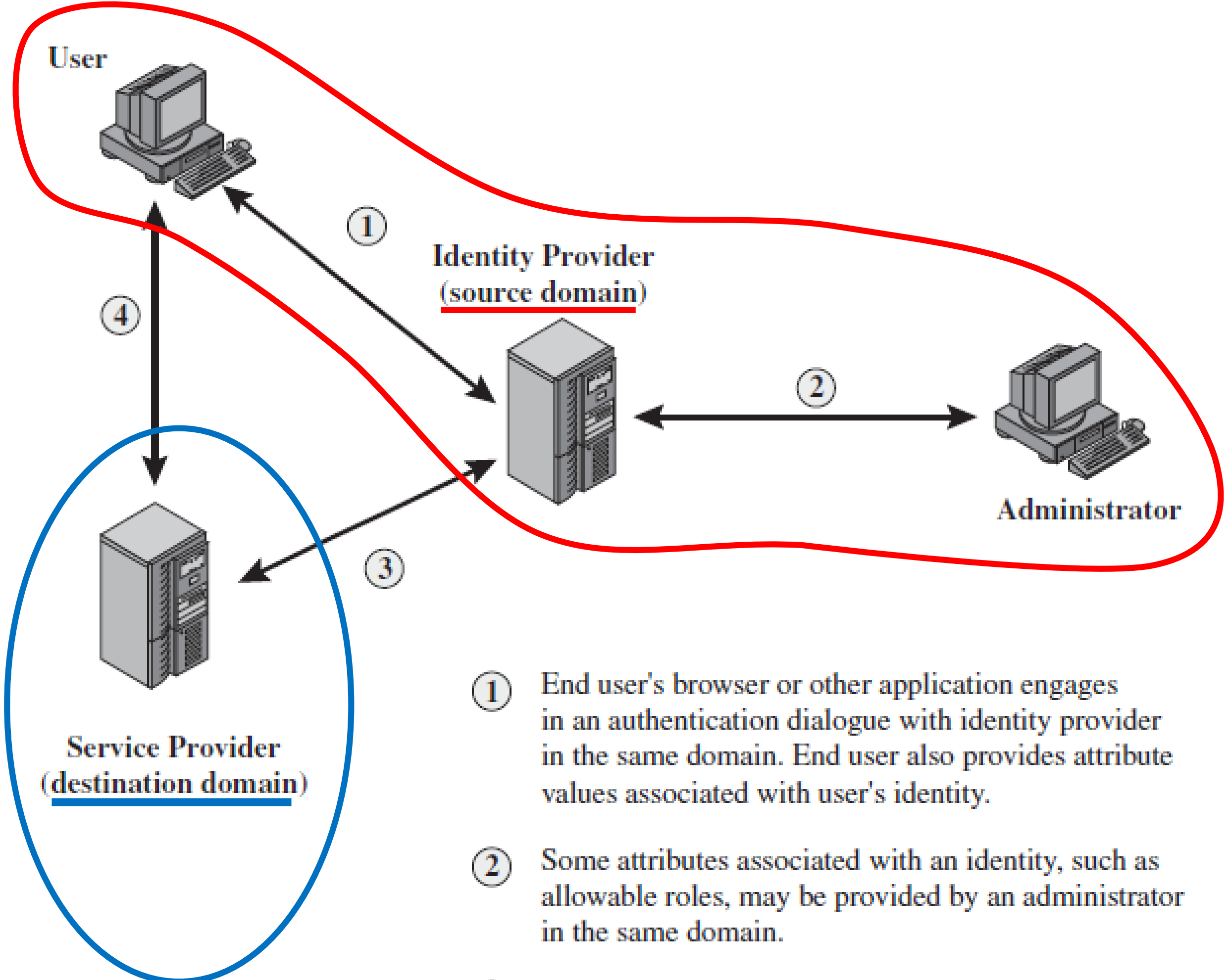
Federated Identity Management

- **use of common identity management scheme**
  - across multiple enterprises & numerous applications
  - supporting many thousands, even millions of users
- **principal elements are:**
  - authentication, authorization, accounting, provisioning, workflow automation, delegated administration, password synchronization, self-service password reset, federation
- **Kerberos contains many of these elements**

Identity Management



Identity Federation

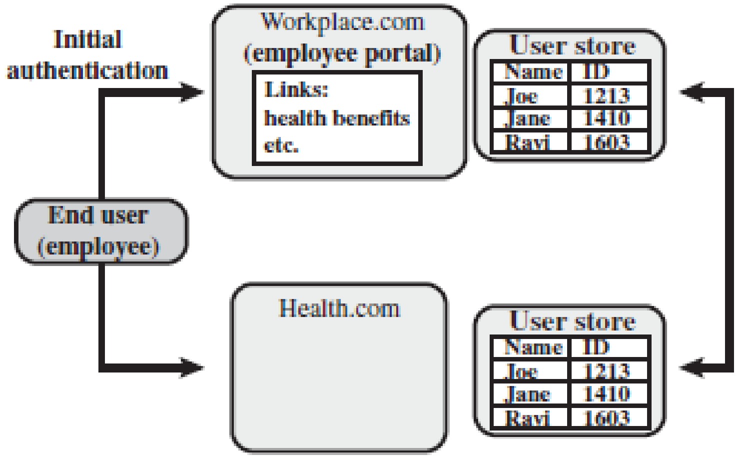


1. End user's browser or other application engages in an authentication dialogue with identity provider in the same domain. End user also provides attribute values associated with user's identity.
2. Some attributes associated with an identity, such as allowable roles, may be provided by an administrator in the same domain.
3. A service provider in a remote domain, which the user wishes to access, obtains identity information, authentication information, and associated attributes from the identity provider in the source domain.
4. Service provider opens session with remote user and enforces access control restrictions based on user's identity and attributes.

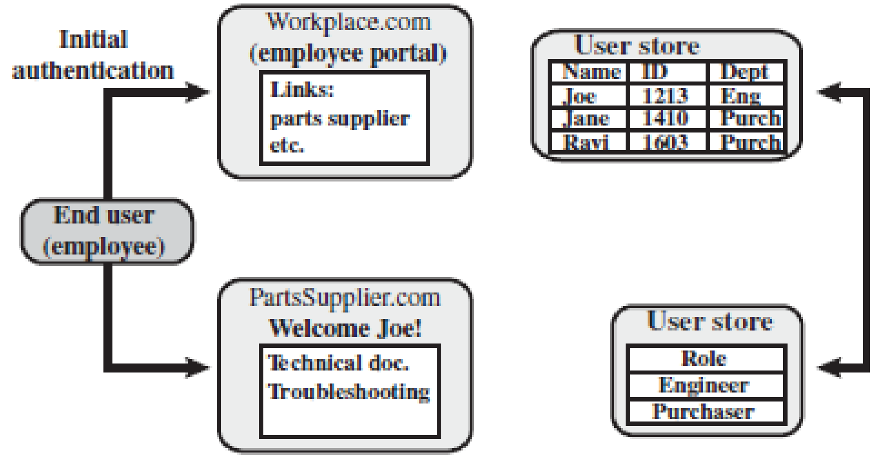
Standards Used in Federated environment

- **Security Assertion Markup Language (SAML)**
  - XML-based language for exchange of security information between online business partners
- **part of OASIS (Organization for the Advancement of Structured Information Standards) standards for federated identity management**
  - e.g. WS-Federation for browser-based federation
- **need a few mature industry standards**

Federated Identity Example



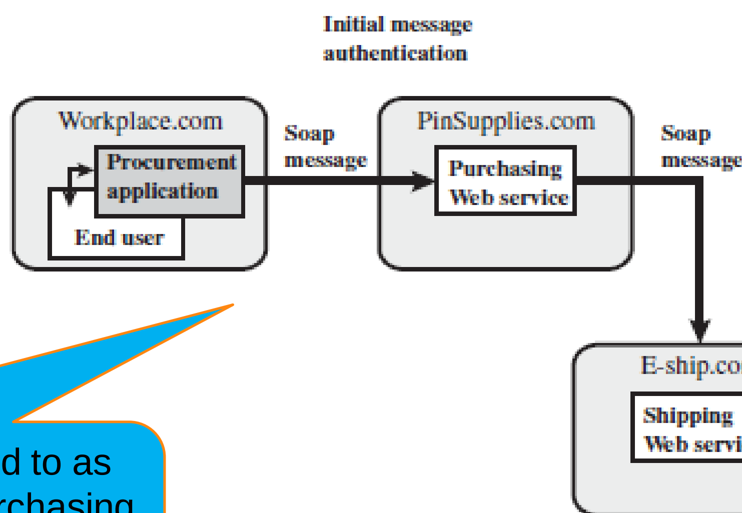
(a) Federation based on account linking



(b) Federation based on roles

Figure4.10a Workplace.com contracts with Health.com to provide employee health benefits

Figure 4.10b PartsSupplier.com is a regular supplier of parts to Workplace.com. A role-based access control (RBAC) scheme is used



(b) Chained Web services

The scenario in Figure 4.10c can be referred to as document-based. Workplace.com has a purchasing agreement with PinSupplies.com which has a business relationship with E-Ship.com.

Further Reading

- **Study Guide 4**
- **Chapter 4 of the textbook: Network Security Essentials- Application & Standards" by William Stallings 5th Edition, Prentice Hall, 2013**
- **Additional resources for this week**

- **Acknowledgement: part of the materials presented in the slides was developed with the help of Instructor's Manual and other resources made available by the author of the textbook.**