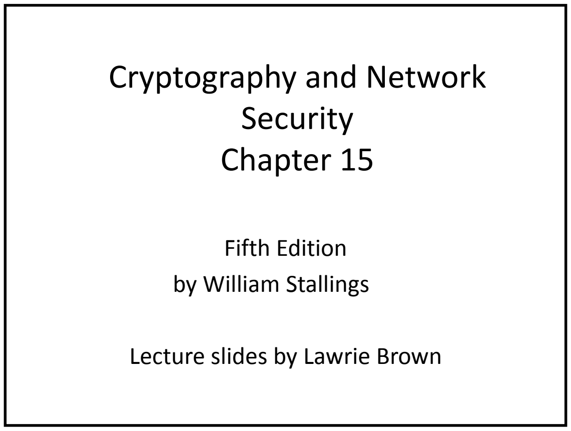
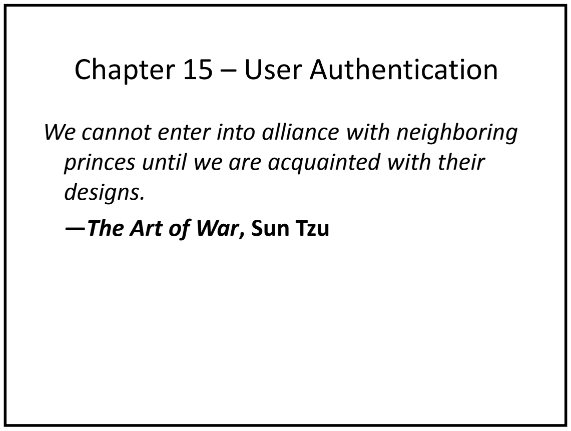


Cryptography and Network Security
Chapter 15

Fifth Edition
by William Stallings

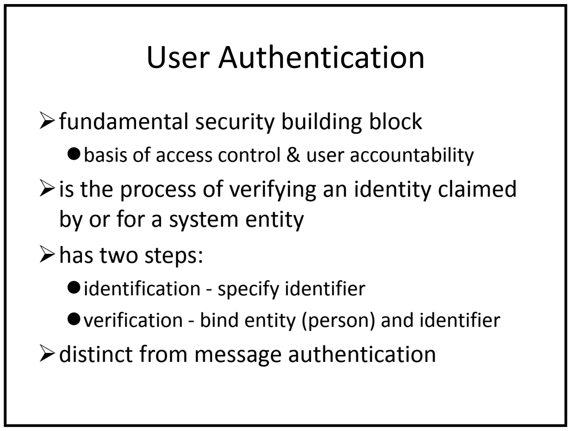
Lecture slides by Lawrie Brown



Chapter 15 – User Authentication

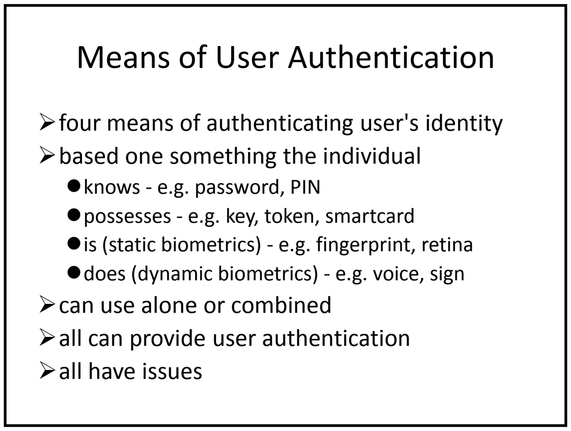
We cannot enter into alliance with neighboring princes until we are acquainted with their designs.

—***The Art of War*, Sun Tzu**



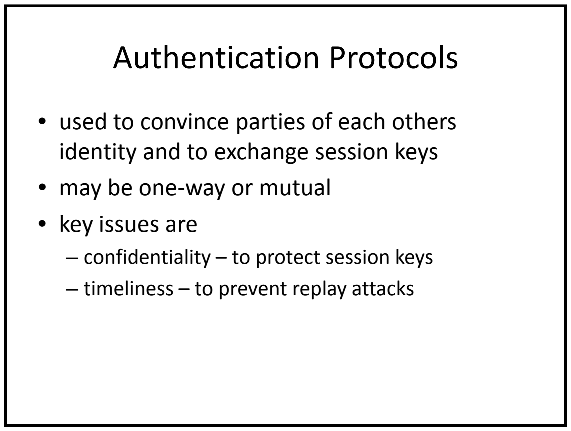
User Authentication

- ➢fundamental security building block
  - ●basis of access control & user accountability
- ➢is the process of verifying an identity claimed by or for a system entity
- ➢has two steps:
  - ●identification - specify identifier
  - ●verification - bind entity (person) and identifier
- ➢distinct from message authentication



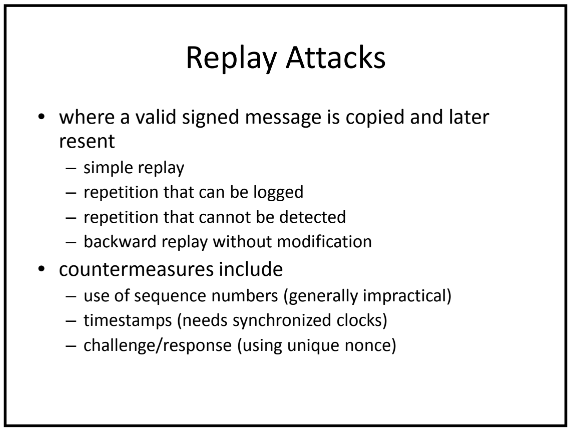
Means of User Authentication

- ➢four means of authenticating user's identity
- ➢based one something the individual
  - ●knows - e.g. password, PIN
  - ●possesses - e.g. key, token, smartcard
  - ●is (static biometrics) - e.g. fingerprint, retina
  - ●does (dynamic biometrics) - e.g. voice, sign
- ➢can use alone or combined
- ➢all can provide user authentication
- ➢all have issues



Authentication Protocols

- used to convince parties of each others identity and to exchange session keys
- may be one-way or mutual
- key issues are
  - – confidentiality – to protect session keys
  - – timeliness – to prevent replay attacks



Replay Attacks

- where a valid signed message is copied and later resent
  - – simple replay
  - – repetition that can be logged
  - – repetition that cannot be detected
  - – backward replay without modification
- countermeasures include
  - – use of sequence numbers (generally impractical)
  - – timestamps (needs synchronized clocks)
  - – challenge/response (using unique nonce)

One-Way Authentication

- required when sender & receiver are not in communications at same time (eg. email)
- have header in clear so can be delivered by email system
- may want contents of body protected & sender authenticated

Using Symmetric Encryption

- as discussed previously can use a two-level hierarchy of keys
- usually with a trusted Key Distribution Center (KDC)
  - each party shares own master key with KDC
  - KDC generates session keys used for connections between parties
  - master keys used to distribute these to them

Needham-Schroeder Protocol

- original third-party key distribution protocol
- for session between A B mediated by KDC
- protocol overview is:

  1. A->KDC: ID_A || ID_B || N_1

  2. KDC -> A: $E(K_a,[K_s||ID_B||N_1|| E(K_b,[K_s||ID_A]))])$

  3. A -> B: $E(K_b, [K_s||ID_A])$

  4. B -> A: $E(K_s, [N_2])$

  5. A -> B: $E(K_s, [f(N_2)])$

Needham-Schroeder Protocol

- used to securely distribute a new session key for communications between A & B
- but is vulnerable to a replay attack if an old session key has been compromised
  - then message 3 can be resent convincing B that is communicating with A
- modifications to address this require:
  - timestamps in steps 2 & 3 (Denning 81)
  - using an extra nonce (Neuman 93)

One-Way Authentication

- use refinement of KDC to secure email
  - since B no online, drop steps 4 & 5
- protocol becomes:

  1. A->KDC: ID_A || ID_B || N_1

  2. KDC -> A: $E(K_a, [K_s||ID_B||N_1 || E(K_b,[K_s||ID_A]))])$

  3. A -> B: $E(K_b, [K_s||ID_A])$ || $E(K_s, M)$
- provides encryption & some authentication
- does not protect from replay attack

Kerberos

➢ trusted key server system from MIT

➢ provides centralised private-key third-party authentication in a distributed network
  - ● allows users access to services distributed through network
  - ● without needing to trust all workstations
  - ● rather all trust a central authentication server

➢ two versions in use: 4 & 5

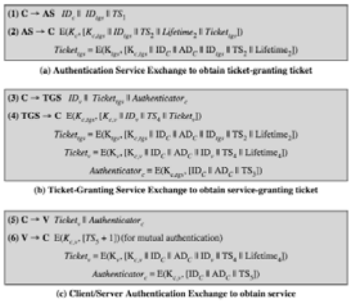
Kerberos Requirements

- its first report identified requirements as:
  - secure
  - reliable
  - transparent
  - scalable
- implemented using an authentication protocol based on Needham-Schroeder

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 v4 Dialogue



(1) **C → AS** $ID_c \| ID_{tgs} \| TS_1$

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

$Ticket_{tgs} = E(K_{tgs}, [K_{c,tgs} \| ID_C \| AD_C \| ID_{tgs} \| TS_2 \| Lifetime_2])$

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

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

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

$Ticket_{tgs} = E(K_{tgs}, [K_{c,tgs} \| ID_C \| AD_C \| ID_{tgs} \| TS_2 \| Lifetime_2])$

$Ticket_v = E(K_v, [K_{c,v} \| ID_C \| AD_C \| ID_v \| TS_4 \| Lifetime_4])$

$Authenticator_c = E(K_{c,tgs}, [ID_C \| AD_C \| TS_3])$

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

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

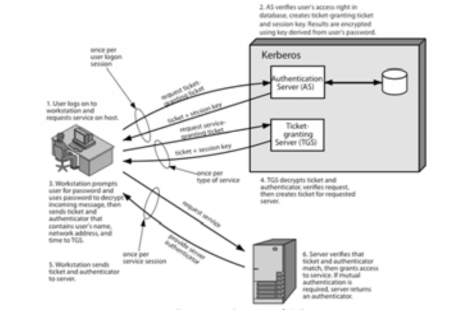
(6) **V → C** $E(K_{c,v}, [TS_5 + 1])$ (for mutual authentication)

$Ticket_v = E(K_v, [K_{c,v} \| ID_C \| AD_C \| ID_v \| TS_4 \| Lifetime_4])$

$Authenticator_c = E(K_{c,v}, [ID_C \| AD_C \| TS_5])$

(c) Client/Server Authentication Exchange to obtain service

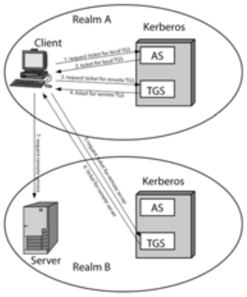
Kerberos 4 Overview


2. AS verifies user's access right in database, creates ticket-granting ticket and session key. Results are encrypted using key derived from user's password.
Kerberos
Authentication Server (AS)
Ticket-granting Server (TGS)
once per user logon session
1. User logs on to workstation and requests service on host.
request ticket-granting ticket
ticket + session key
request service-granting ticket
ticket + session key
once per type of service
4. TGS decrypts ticket and authenticator, verifies request, then creates ticket for requested server.
3. Workstation prompts user for password and uses password to decrypt incoming message, then sends ticket and authenticator that contains user's name, network address, and time to TGS.
request service
provide server authenticator
once per service session
5. Workstation sends ticket and authenticator to server.
6. Server verifies that ticket and authenticator match, then grants access to service. If mutual authentication is required, server returns an authenticator.

Kerberos Realms

- a Kerberos environment consists of:
  - a Kerberos server
  - a number of clients, all registered with server
  - application servers, sharing keys with server
- this is termed a realm
  - typically a single administrative domain
- if have multiple realms, their Kerberos servers must share keys and trust

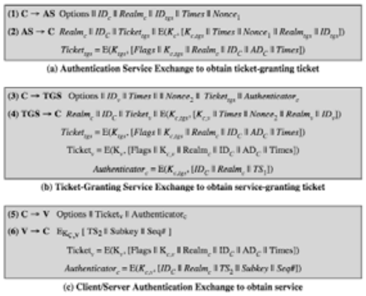
Kerberos Realms


Realm A
Kerberos
Client
1. request ticket for local TGS
2. ticket for local TGS
3. request ticket for remote TGS
4. ticket for remote TGS
AS
TGS
7. request remote service
5. request ticket for remote server
6. ticket for remote server
Kerberos
AS
TGS
Server
Realm B

Kerberos Version 5

- developed in mid 1990’s
- specified as Internet standard RFC 1510
- provides improvements over v4
  - addresses environmental shortcomings
    - encryption alg, network protocol, byte order, ticket lifetime, authentication forwarding, interrealm auth
  - and technical deficiencies
    - double encryption, non-std mode of use, session keys, password attacks

Kerberos v5 Dialogue



(1) C → AS Options $\|$ ID_c $\|$ $Realm_c$ $\|$ ID_{tgs} $\|$ $Times$ $\|$ $Nonce_1$

(2) AS → C $Realm_c$ $\|$ ID_C $\|$ $Ticket_{tgs}$ $\|$ $E(K_c, [K_{c,tgs} \| Times \| Nonce_1 \| Realm_{tgs} \| ID_{tgs}])$

$Ticket_{tgs} = E(K_{tgs}, [Flags \| K_{c,tgs} \| Realm_c \| ID_C \| AD_C \| Times])$

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

(3) C → TGS Options $\|$ ID_v $\|$ $Times$ $\|$ $\|$ $Nonce_2$ $\|$ $Ticket_{tgs}$ $\|$ $Authenticator_c$

(4) TGS → C $Realm_c$ $\|$ ID_C $\|$ $Ticket_v$ $\|$ $E(K_{c,tgs}, [K_{c,v} \| Times \| Nonce_2 \| Realm_v \| ID_v])$

$Ticket_{tgs} = E(K_{tgs}, [Flags \| K_{c,tgs} \| Realm_c \| ID_C \| AD_C \| Times])$

$\mathrm{Ticket}_v = \mathrm{E}(\mathrm{K}_v, [\mathrm{Flags} \| \mathrm{K}_{c,v} \| \mathrm{Realm}_c \| \mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{Times}])$

$Authenticator_c = E(K_{c,tgs}, [ID_C \| Realm_c \| TS_1])$

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

(5) C → V Options $\|$ Ticket_v $\|$ $\mathrm{Authenticator}_c$

(6) V → C $\mathrm{E}_{K_{C,V}}[\mathrm{TS}_2 \| \mathrm{Subkey} \| \mathrm{Seq\#}]$

$\mathrm{Ticket}_v = \mathrm{E}(\mathrm{K}_v, [\mathrm{Flags} \| \mathrm{K}_{c,v} \| \mathrm{Realm}_c \| \mathrm{ID}_C \| \mathrm{AD}_C \| \mathrm{Times}])$

$Authenticator_c = E(K_{c,v}, [ID_C \| Realm_c \| TS_2 \| Subkey \| Seq\#])$

(c) Client/Server Authentication Exchange to obtain service

Remote User Authentication

- in Ch 14 saw use of public-key encryption for session key distribution
  - assumes both parties have other’s public keys
  - may not be practical
- have Denning protocol using timestamps
  - uses central authentication server (AS) to provide public-key certificates
  - requires synchronized clocks
- have Woo and Lam protocol using nonces
- care needed to ensure no protocol flaws

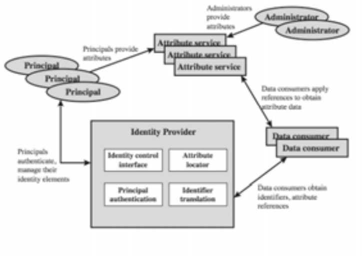
One-Way Authentication

- ➢ have public-key approaches for email
  - ● encryption of message for confidentiality, authentication, or both
  - ● must now public keys
  - ● using costly public-key alg on long message
- ➢ for confidentiality encrypt message with one-time secret key, public-key encrypted
- ➢ for authentication use a digital signature
  - ● may need to protect by encrypting signature
- ➢ use digital certificate to supply public key

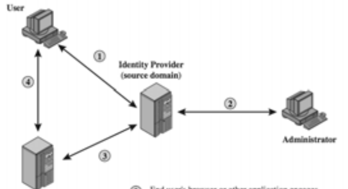
Federated Identity Management

- ➢ 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


Administrators provide attributes
Administrator
Administrator
Principals provide attributes
Attribute service
Attribute service
Attribute service
Principal
Principal
Principal
Data consumers apply references to obtain attribute data
Identity Provider
Identity control interface
Attribute locator
Principal authentication
Identifier translation
Data consumer
Data consumer
Principals authenticate, manage their identity elements
Data consumers obtain identifiers, attribute references

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 identiy.

② Some attributes associated with an identity, such as allowable roles, may be provided by an administrator in the same domain.

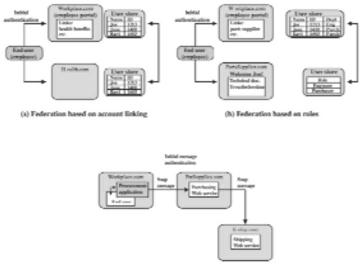
③ A service provider in a remote domain, which the user wishes to access, obtains identity information, authentication information, and associated attributes from the identity provider in the source domain.

④ Service provider opens session with remote user and enforces access control restrictions based on user's identity and attributes.

Standards Used

- 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 Examples



(a) Federation based on account linking

(b) Federation based on roles

(b) Chained Web Services

Summary

- have considered:
  - remote user authentication issues
  - authentication using symmetric encryption
  - the Kerberos trusted key server system
  - authentication using asymmetric encryption
  - federated identity management