# Authentication & Kerberos

# Authentication Basics

- Clear Text Passwords
- Message Digests of Passwords
- Adding Randomness
- Password Encryption
- Authentication Token
- Certificate based authentication

# Kerberos

- trusted key server system from MIT
- provides centralised private-key third-party authentication in a distributed network
  - allows users to access the services distributed through network
  - without needing to trust all workstations
  - rather all trust a central authentication server
  - Function of centralized authentication server is to authenticate users to servers and servers to users
  - It relies exclusively on symmetric encryption, no use of public key encryption.
- two versions in use: 4 & 5

# Kerberos Requirements

- first published report identified its requirements as:
  - Security : A network eavesdropper should not be able to obtain the necessary information to impersonate a user.
  - Reliability : Kerberos should be highly reliable and should employ a distributed server architecture, with one system able to back up another
  - Transparency : Ideally, the user should not be aware that authentication is taking place, beyond the requirement to enter a password.
  - Scalability : Should support large number of clients and servers, this suggest a modular distributed architecture.
- implemented using an authentication protocol based on Needham-Schroeder

# How does kerberos works?

- Four parties involved in kerberos protocol:
  - **Alice:** Client workstation
  - **Authentication Server (AS):** Verifies users during login
  - **Ticket Granting Server (TGS) :** Issues **tickets** to certify the proof of identity
  - **Bob:** Server offering various services

# Kerberos 4 Overview

- a basic third-party authentication scheme
- have an Authentication Server (AS)
  - It knows the passwords of all users and stores these in a centralized database
  - It shares a unique secret key with each server
  - Keys distributed physically or in some other secure manner
  - users initially negotiate with AS to identify self
  - AS provides a non-corruptible authentication credential (ticket granting ticket TGT)

- Alice -> AS; IDa ||Pa||IDb
- AS -> Alice Ticket
- Alice -> Bob IDa ||Ticket

– Ticket = Ekb ([IDa] || ADa || IDb] )

- Alice - Client
- AS - Authentication server
- Bob - Server
- IDa - Identifier of user, Alice
- IDb - Identifier of server, Bob
- Pa - password of user, Alice
- ADa - network address of Alice
- Kb - secret encryption key shared by AS and Bob

- Problems
  - User would need a new ticket for every different service
  - A plaintext transmission of the password, an eavesdropper could capture the password and use any service accessible to the victim.
  - Ticket Granting server (TGS) can solve this problem

- users subsequently request access to other services from TGS on basis of users TGT
- Once per user logon session:

  Alice->AS  IDa || $ID_{tgs}$

  AS ->Alice  Eka [$Ticket_{tgs}$]

  Once per type of service:

  Alice -> TGS  IDa || IDb ||$Ticket_{tgs}$

  TGS -> Alice  $Ticket_B$

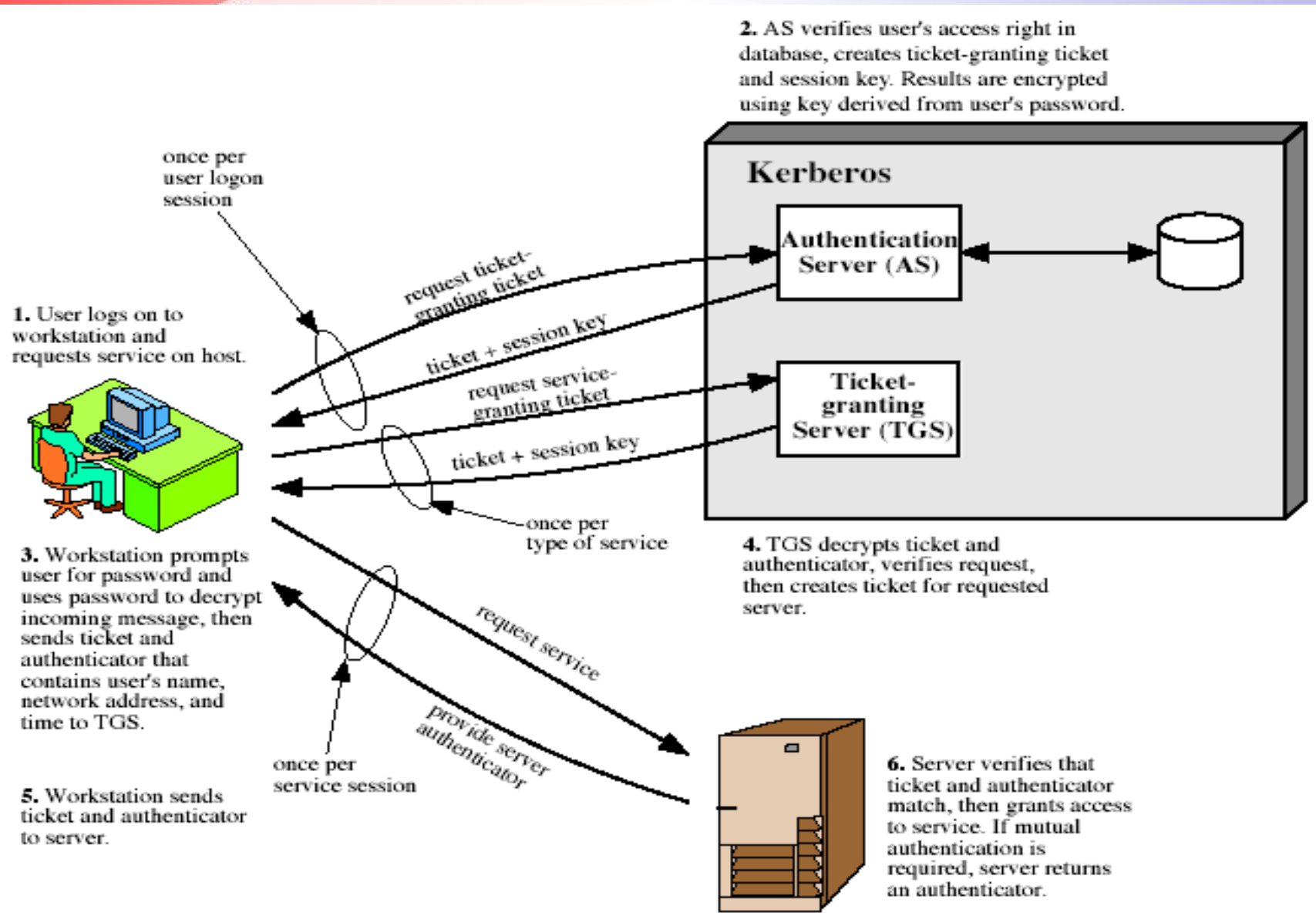
  Once per service session:

  Alice -> Bob  IDa || $Ticket_B$

$Ticket_{tgs} = E_{ktgs}[IDa \| ADa \| ID_{tgs} \| TS_1 \| Lifetime_1]$

$Ticket_B = E_{kb}[IDa \| ADa \| IDb \| TS_2 \| Lifetime_2]$

# Kerberos 4 Overview



# 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 **Kerberos realm**
  - typically a single administrative domain
- if have multiple realms, their Kerberos servers must share keys and trust

# Kerberos Version 5

- developed in mid 1990's
- provides improvements over v4

It addresses

  - environmental shortcomings
    - encryption algo, network protocol, byte order, ticket lifetime, authentication forwarding, interrealm auth
  - and technical deficiencies
    - double encryption, non-std mode of use, session keys, password attacks

- specified as Internet standard RFC 1510

# Comparison V4 *Vs* V5

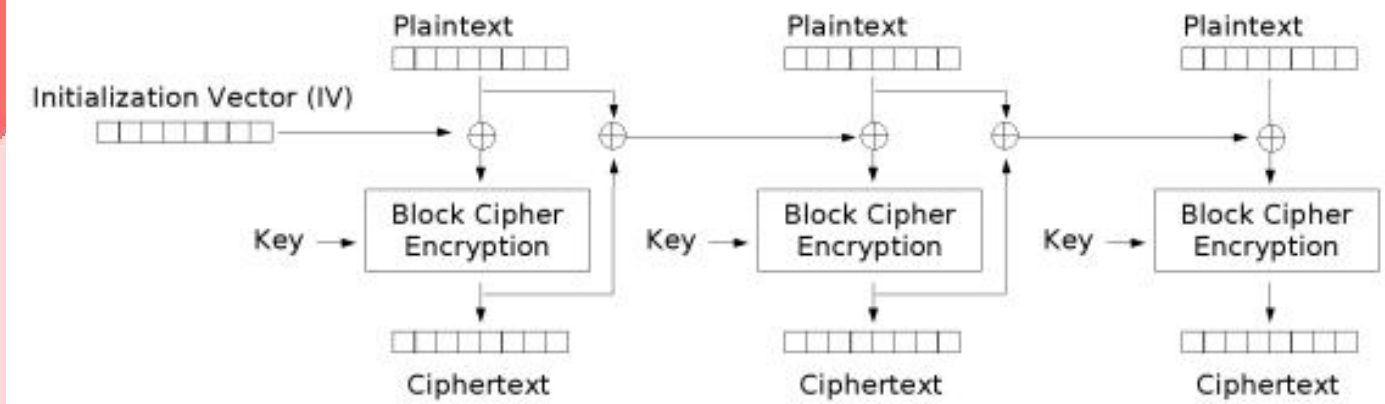
| Points | Version 4 | Version 5 |
|---|---|---|
| Encryption system dependence | requires the use of DES | Cypertext is tagged with an encryption type identifier so any encryption techniques can be used. |
| Internet protocol dependence | Requires the use of IP addresses. Other addresses such as ISO network address are not accommodated. | Network addresses are tagged with type and length, so network address can be used. |
| Message byte ordering | Sender employs a byte ordering of its own choosing and tags the message to indicate LSB in lowest address or MSB in lowest address. | Message structures are defined using Abstract Syntax Notation One and basic Encoding Rules (BER), which provide an unambiguous byte ordering |

# Comparison V4 Vs V5 cont…

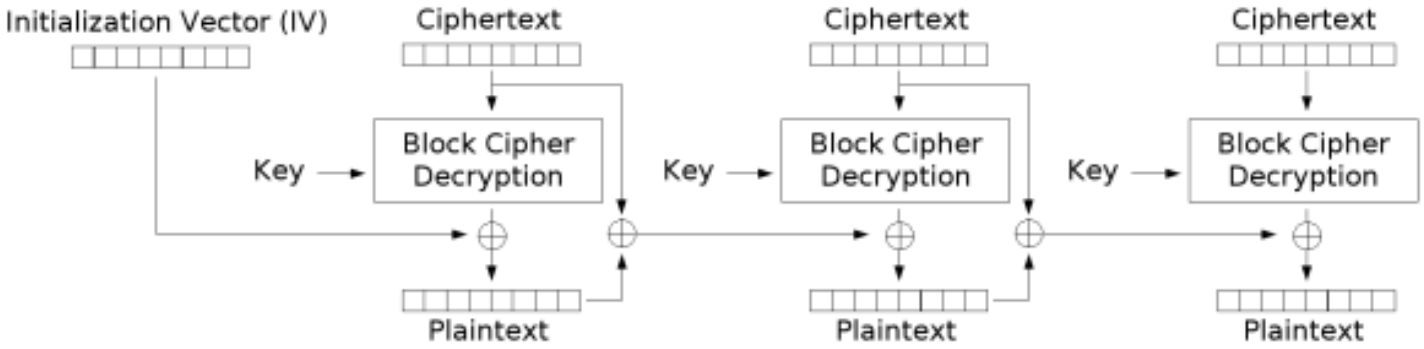
| | Version 4 | Version 5 |
|---|---|---|
| Ticket Lifetime | Encoded in an 8-bit quantity in units of five minutes thus max. lifetime is 1280 minutes | Tickets include an explicit start time and end time |
| Authentication forwarding | Not allow | Allow |
| Interrealm authentication | Interoperability among N realms requires $N^2$ Kerberos to Kerberos relationships | Requires fewer relationships |

# V4 -Technical deficiencies

- Double encryption
  - Once with the secret key of the target server
  - Again with a secret key known to the client
- PCBC encryption
  - making use of non standard mode of DES known as propagating block chaining (PCBC)
  - Vulnerable to an attack involving the interchange of ciphertext blocks




Propagating Cipher Block Chaining (PCBC) mode encryption




Propagating Cipher Block Chaining (PCBC) mode decryption

- Session keys
  - Same ticket may be used repeatedly to gain service from the server, there is the risk that an opponent will replay messages from an old session to the client or the server
  - In V5, it is possible to negotiate a subsession key

Password attack

- Both versions are vulnerable to a password attack.

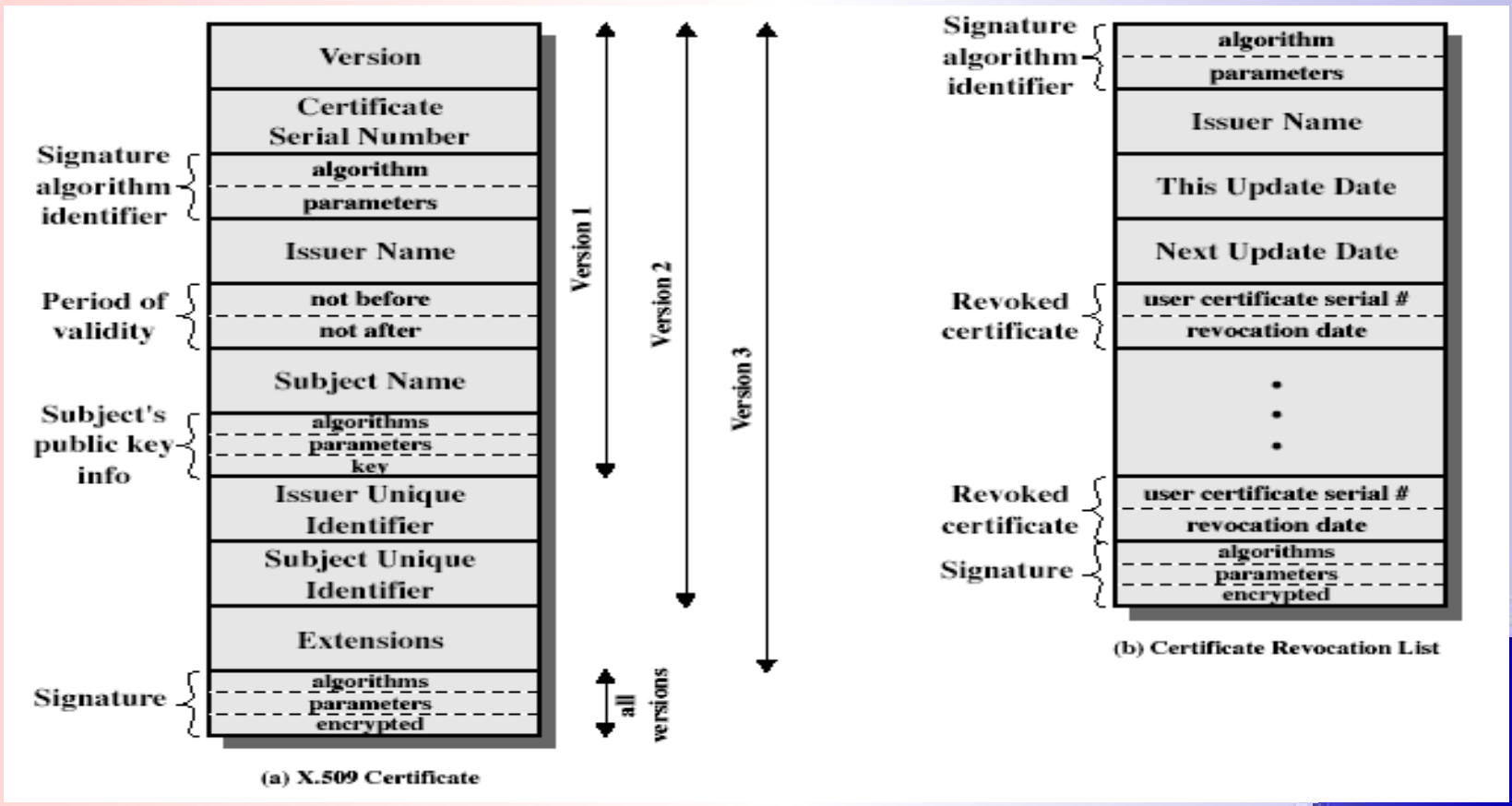
# X.509 Authentication Service

- CCITT : International Telegraph and Telephone Consultative Committee
- part of CCITT X.500 directory service standards
  - distributed servers maintaining some info database
- defines framework for authentication services
  - directory may store public-key certificates
  - with public key of user
  - signed by certification authority
- also defines authentication protocols
- uses public-key crypto & digital signatures
  - algorithms not standardised, but RSA recommended

# X.509 Certificates

- issued by a Certification Authority (CA), containing:
  - version (1, 2, or 3)
  - serial number (unique within CA) identifying certificate
  - signature algorithm identifier
  - issuer X.500 name (CA)
  - period of validity (from - to dates)
  - subject X.500 name (name of owner)
  - subject public-key info (algorithm, parameters, key)
  - issuer unique identifier (v2+)
  - subject unique identifier (v2+)
  - extension fields (v3)
  - signature (of hash of all fields in certificate)
- notation CA<<A>> denotes certificate for A signed by CA

# X.509 Certificates



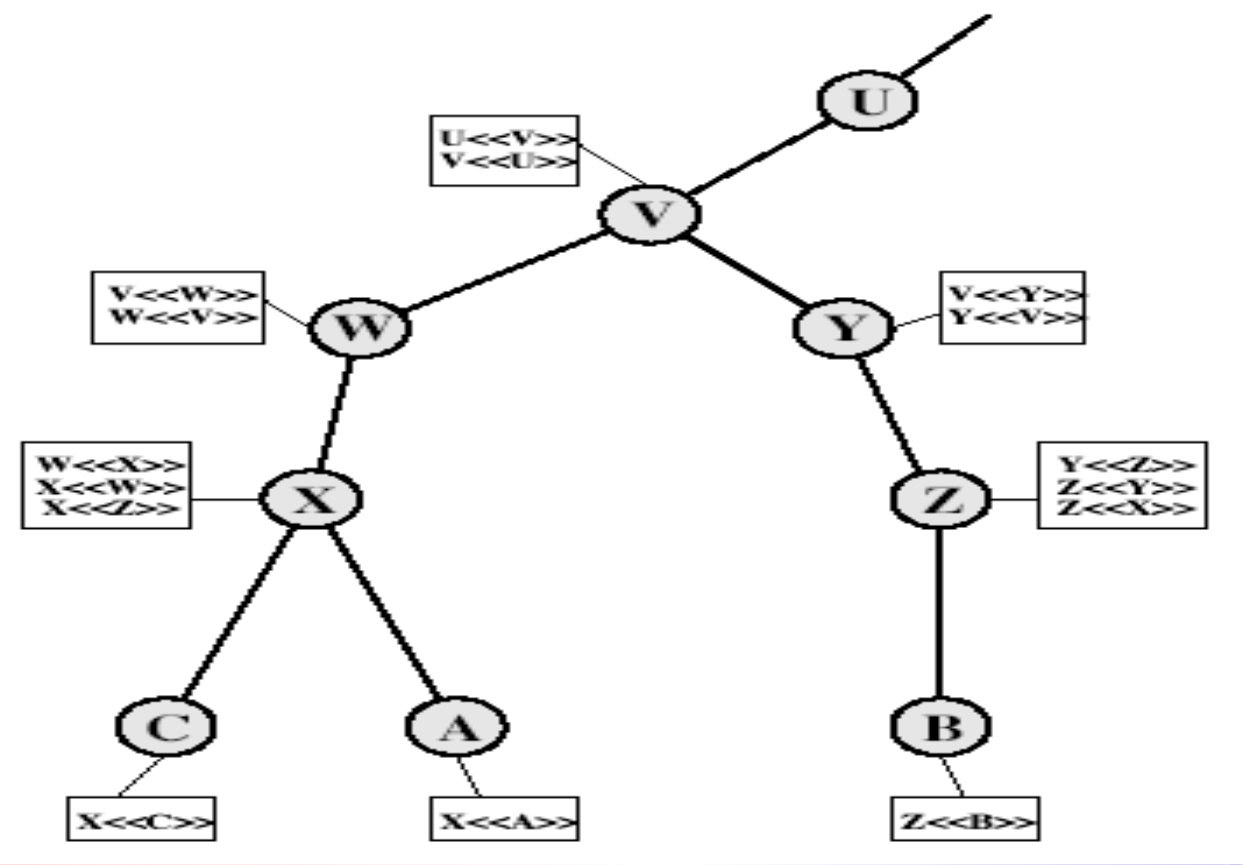
# Obtaining a Certificate

- any user with access to CA can get any certificate from it
- only the CA can modify a certificate
- because cannot be forged, certificates can be placed in a public directory

# 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

# CA Hierarchy Use



# Certificate Revocation

- certificates have a period of validity
- may need to revoke before expiry, eg:
  1. user's private key is compromised
  2. user is no longer certified by this CA
  3. CA's certificate is compromised
- CA's maintain list of revoked certificates
  - the Certificate Revocation List (CRL)
- users should check certs with CA's CRL

# Authentication Procedures

- X.509 includes three alternative authentication procedures:
  - One-Way Authentication
  - Two-Way Authentication
  - Three-Way Authentication
  - all use public-key signatures

# One-Way Authentication

- 1 message ( A->B) used to establish
  - 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

# Two-Way Authentication

- 2 messages (A->B, B->A) which also establishes 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

# Three-Way Authentication

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

# X.509 Version 3

- has been recognised that additional information is needed in a certificate
  - email/URL, policy details, usage constraints
- rather than explicitly naming new fields defined a general extension method
- extensions consist of:
  - extension identifier
  - criticality indicator
  - extension value

# Certificate Extensions

- key and policy information
  - convey info about subject & issuer keys, plus indicators of certificate policy
- certificate subject and issuer attributes
  - support alternative names, in alternative formats for certificate subject and/or issuer
- certificate path constraints
  - allow constraints on use of certificates by other CA's

# Certificate filename extensions

Common filename extensions for

X.509 certificates are:

- .pem - (Privacy Enhanced Mail)
- .cer, .crt, .der
- .p7b, .p7c - PKCS#7 SignedData structure without data, just certificate(s) or CRL(s)
- .p12 - PKCS#12, may contain certificate(s) (public) and private keys (password protected)
- .pfx - e.g., with PFX files generated in IIS

# Indian Licensed CAs

- Safescrypt
- IDRBT(Institute for Development & Research in Banking Technology)
- National Informatics Center
- TCS
- MTNL
- GNFC(Gujarat Narmada Valley Fertilizers Company Ltd.)
- e Mudra CA

# Well Known CAs




# Well Known Global CAs

- Comodo
- DigiCert
- Entrust
- GeoTrust
- GlobalSign
- GoDaddy
- Network Solutions
- StartCom
- SwissSign
- Symantec
- Thawte
- Trustwave

# Summary

- have considered:
  - Kerberos trusted key server system
  - X.509 authentication and certificates