Many-to-Many Authentication

How do users prove their identities when requesting services from machines on the network?

Naïve solution: every server knows every user’s password
- Insecure: compromise of one server is enough to compromise all users
- Inefficient: to change his password, user must contact every server

Requirements
- Security
- Against attacks by passive eavesdroppers and actively malicious users
- Reliability
- Transparency
- Users shouldn’t be aware of authentication taking place
- Entering password is OK, if done rarely
- Scalability
- Large number of users and servers

Recall the threats
- User impersonation
- Malicious user with access to a workstation pretends to be another user from the same workstation
- Network address impersonation
- Malicious user changes network address of his workstation to impersonate another workstation
- Eavesdropping, tampering and replay
- Malicious user eavesdrops on, tampers with or replays other users’ conversations to gain unauthorized access
Solution: Trusted Third Party

- Trusted authentication service on the network
- Knows all passwords, can grant access to any server
- Convenient, but also the single point of failure
- Requires high level of physical security

What is a ticket for?

- Ticket gives holder access to a network service

What Should a Ticket Include?

- User name
- Server name
- Address of user’s workstation
  - Otherwise, a user on another workstation can steal the ticket and use it to gain access to the server
- Ticket lifetime
- A few other things (e.g., session key)

How Is Authentication Done?

- Insecure: passwords are sent in plaintext
  - Eavesdropper can steal the password and later impersonate the user to the authentication server
- Inconvenient: need to send the password each time to obtain the ticket for any network service
  - Separate authentication for email, printing, etc.
Solution: Two-Step Authentication

Prove identity **once** to obtain special **TGS ticket**.
Instead of password, use key derived from password
Use **TGS** to get tickets for many network services

Still Not Good Enough

- **Ticket hijacking**
  - Malicious user may steal the service ticket of another user on the same workstation and use it
    - IP address verification does not help
  - Servers must be able to verify that the user who is presenting the ticket is the same user to whom the ticket was issued
- **No server authentication**
  - Attacker may misconfigure the network so that he receives messages addressed to a legitimate server
    - Capture private information from users and/or deny service
  - Servers must prove their identity to users

Summary of Kerberos

- Kc is long-term key of client C
  - Derived from user’s password
  - Known to client and key distribution center KDC
- KTGS is long-term key of ticket granting service TGS
  - Known to KDC and TGS
- Ky is long-term key of network service V
  - Known to V and TGS; separate key for each service
- Kc,TGS is short-term key between C and TGS
  - Created by KDC, known to C and TGS
- Kc,V is short-term key between C and V
  - Created by TGS, known to C and V

Symmetric Keys in Kerberos
Obtaining Service

- For each service request, client uses the short-term key for that service and the ticket he received from TGS

Obtaining A Service Ticket

- Client uses TGS ticket to obtain a service ticket and a short-term key for each network service
  - One encrypted, unforgeable ticket per service (printer, email, etc.)

Kerberos in Large Networks

- One KDC isn’t enough for large networks (why?)
- Network is divided into realms
  - KDCs in different realms have different key databases
- To access a service in another realm, users must...
  - Get ticket for home-realm TGS from home-realm KDC
  - Get ticket for remote-realm TGS from home-realm TGS
    - As if remote-realm TGS were just another network service
  - Get ticket for remote service from that realm’s TGS
  - Use remote-realm ticket to access service
  - N(N-1)/2 key exchanges for full N-realm interoperation
Important Ideas in Kerberos

- Use of short-term session keys
- Minimize distribution and use of long-term secrets; use them only to derive short-term session keys
- Separate short-term key for each user-server pair
  - But multiple user-server sessions reuse the same key!
- Proofs of identity are based on authenticators
  - Client encrypts his identity, address and current time using a short-term session key
  - Also prevents replays (if clocks are globally synchronized)
  - Server learns this key separately (via encrypted ticket that client can’t decrypt) and verifies user’s identity

Problematic Issues

- Password dictionary attacks on client master keys
- Replay of authenticators
  - 5-minute lifetimes long enough for replay
  - Timestamps assume global, secure synchronized clocks
  - Challenge-response would be better
- Encryption is used for authentication
  - Same user-server key used for all sessions
- Homebrewed PCBC mode of encryption
  - Tries to combine integrity checking with encryption
- Extraneous double encryption of tickets
- No ticket delegation
  - Printer can’t fetch email from server on your behalf

Kerberos Version 5

- Better user-server authentication
  - Separate subkey for each user-server session instead of re-using the session key contained in the ticket
  - Authentication via subkeys, not timestamp increments
- Authentication forwarding
  - Servers can access other servers on user’s behalf
- Realm hierarchies for inter-realm authentication
- Richer ticket functionality
- Explicit integrity checking + standard CBC mode
- Multiple encryption schemes, not just DES

Practical Uses of Kerberos

- Email, FTP, SSH, network file systems and many other applications have been kerberized
  - Use of Kerberos is transparent for the end user
  - Transparency is important for usability!
- Local authentication
  - login and su in OpenBSD
- Authentication for network protocols
  - rlogin, rsh, telnet
- Secure windowing systems
  - xdm, kx