Cryptography: Key Distribution

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Corso di Sicurezza nelle reti di telecomunicazioni, a.a. 2008/2009

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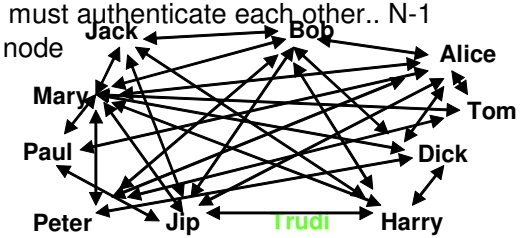
Key Distribution

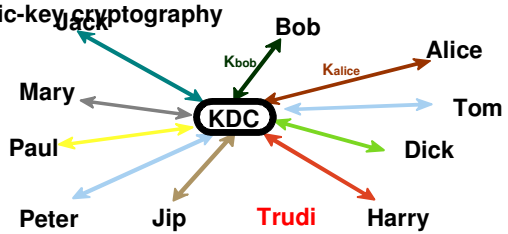
- Symmetric schemes require both parties to share a common secret key
- Issue is how to securely distribute this key
  - **often secure system failure due to a break in the key distribution scheme**
- Given parties A and B have various **key distribution** alternatives:
  - **A can select key and physically deliver to B**
  - **third party can select & deliver key to A & B**
  - **if A & B have communicated previously can use previous key to encrypt a new key**
  - **if A & B have secure communications with a third party C, C can relay key between A & B**

Trusted intermediaries

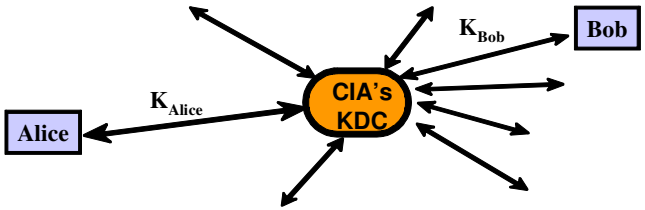
- With N nodes, each node must authenticate each other.. N-1 keys maintained by each node

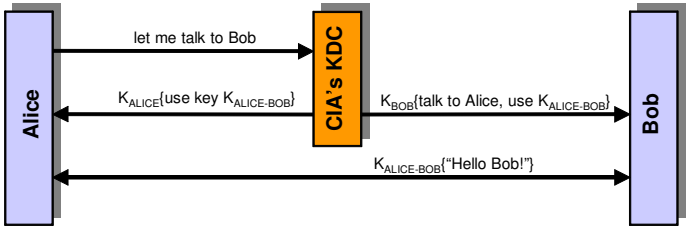


- Possible solution: Key Distribution Center - KDC
  - **similar to CAs for public-key cryptography**

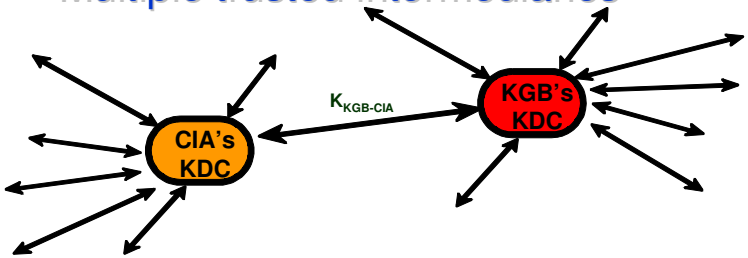


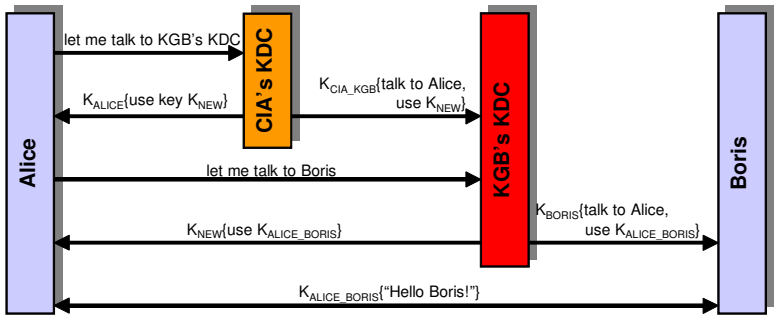
Trusted intermediaries





Multiple trusted intermediaries





Multiple trusted intermediaries

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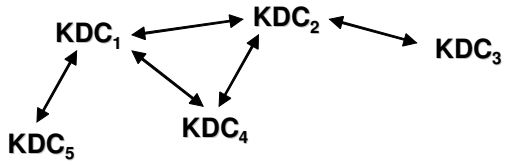

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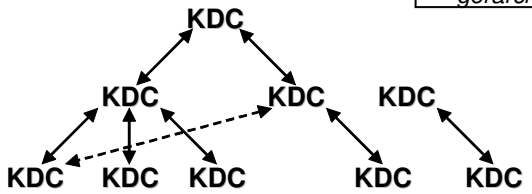
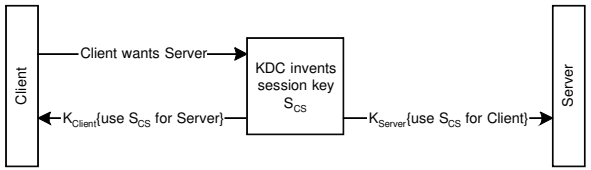
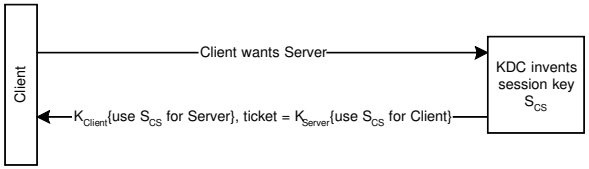


Key Distribution in practice

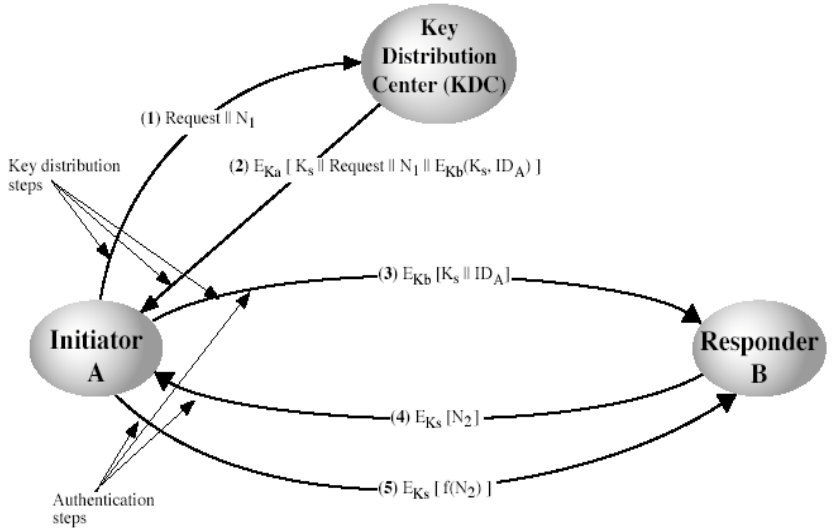


Key Distribution (in theory)



Key Distribution (in practice)

Key Distribution



Key Distribution

- Needham-Schroeder Protocol
  - **original third-party key distribution protocol**
  - **for session between A B mediated by KDC**

- Protocol overview:

1. **A → KDC :** **req** || N_1 = ID_A || ID_B || N_1
2. **KDC → A :** E_{Ka}[Ks || req || N_1 || ticket] = E_{Ka}[Ks || ID_B || N_1 || E_{Kb}[Ks||ID_A]]
3. **A → B : ticket** = E_{Kb}[Ks||ID_A]
4. **B → A : challenge** = E_{Ks}[N_2]
5. **A → B : response** = E_{Ks}[f(N_2)]

Key Distribution

- Lo scopo è quello di creare una nuova chiave di sessione K_S tra A e B
- K_A e K_B sono chiavi condivise rispettivamente tra A e KDC, e tra B e KDC (master keys)
- N1 e N2 sono due valori di *nonce* utilizzati per evitare attacchi di tipo "*replay*" (replay attack)
- I passi da 1 a 3 servono per scambiare la chiave di sessione K_S
- I passi 4 e 5 (insieme al 3) svolgono il ruolo di autenticazione

- f(x) è una qualsiasi funzione di x, e.g. f(x)=x+1

Kerberos

- Designed at MIT based on late-70 's work by Needham and Schroeder
- 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**
  - **relies on key distribution center (KDC) to perform mediated authentication**
  - **relies on conventional encryption**
- KDC shares a key with each client and server
- Currently in use version 4 and 5 (Kerberos V4 and Kerberos V5)
- Version 4 makes use of DES
- Implemented in MS Windowns2000 and linux (PAM)

Kerberos

- When a client wants to connect to a server
  - **KDC sends to client**
    - Session key encrypted with clients key
    - Session key + client ID encrypted with servers key (the ticket)
  - **User forwards the latter (the ticket) to the server**
  - **User decrypts session key, server decrypts ticket to recover client ID and session key**
    - Only the client can recover the client-encrypted session key
    - Only the server can recover the server-encrypted session key
- To avoid long-term password storage within the client workstation, the KDC generates a short-term client key
  - **KDC sends the short-term client key encrypted with the user's password to the client**
  - **Future client↔KDC communications use the short-term client key**

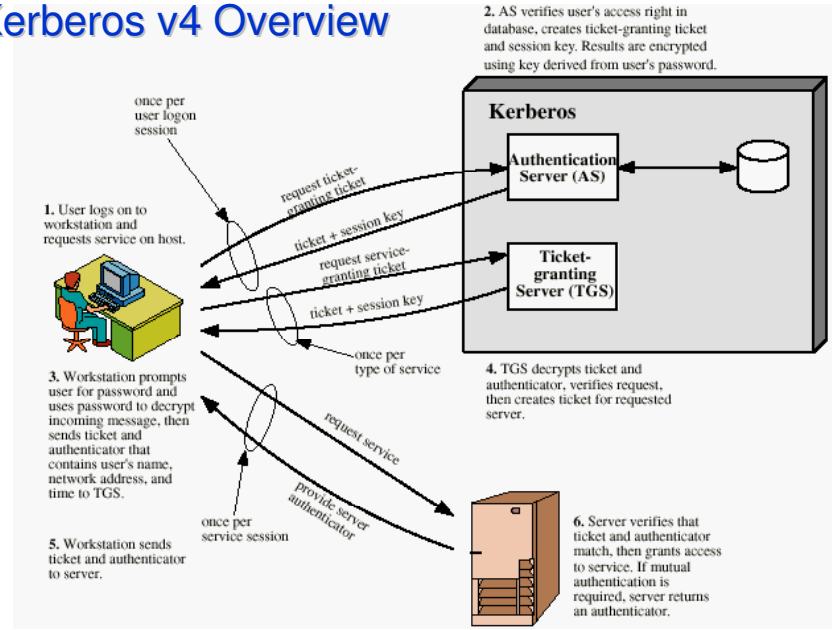
Kerberos (cont.)

- The KDC sends also a ticket-granting ticket (TGT) to the client
  - **TGT contains the client short-term key and other user's information (user's name, expiration time, etc.) encrypted with the KDC master key**
- The TGT is used in the successive client↔KDC communications to inform the KDC about the short-term client key
- The KDC separates the authentication server and ticket-granting server
- The KDC is composed by two entities
  - **an Authentication Server (KDC/AS)**
    - users initially negotiate with AS to identify self
    - AS issues the ticket granting ticket TGT to talk to the KDC/TGS
  - **a Ticket Granting server (KDC/TGS)**
    - users subsequently request access to other services from TGS on basis of users TGT

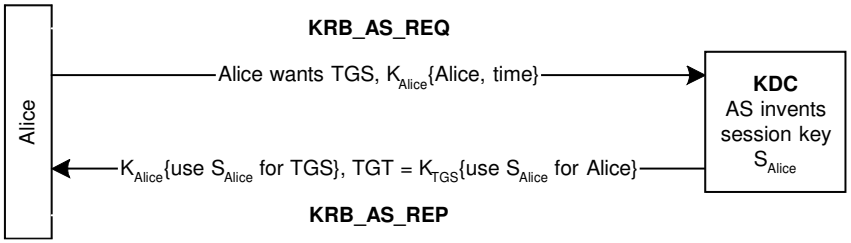
AS and TGS

- Due servizi:
  - Authentication Service (AS)
    - KDC/AS emana i "Ticket Granting Ticket" (TGT) validi per ottenere il "ticket-granting service" nel reame
    - prima di ottenere ticket per i servizi, si deve ottenere un TGT dall'AS
  - Ticket-Granting Service (TGS)
    - KDC/TGS emana ticket validi per accedere ad altri servizi nel reame o in TGS di reami di fiducia
    - per l'accesso ad un servizio, si deve contattare il TGS, presentare un TGT, e richiedere un ticket

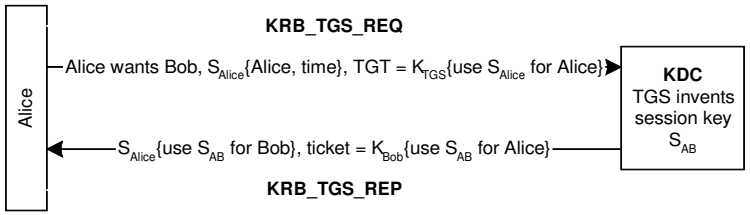
Kerberos v4 Overview



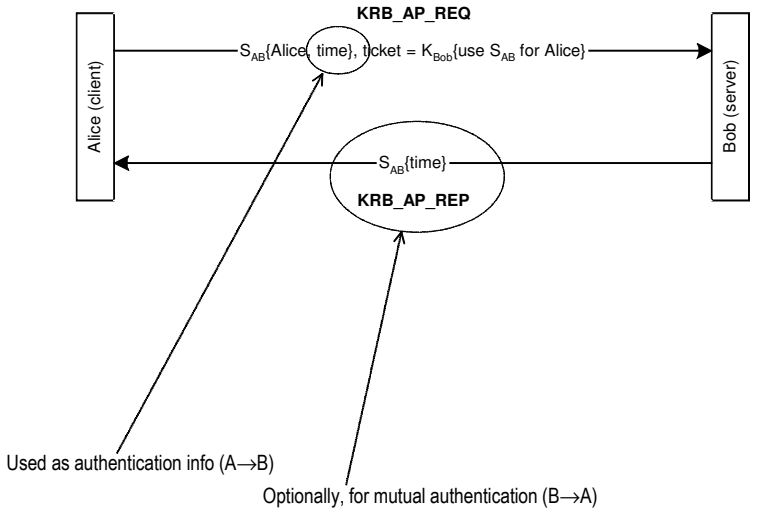
Authentication Service



Ticket-Granting Service



Client/Server exchange



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 V5

- Developed in mid 1990's
- 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
- Improvements:
  - **Extended ticket lifetimes (V4 max = 21 hours)**
  - **Allowed delegation of rights**
  - **Allowed hierarchical realms**
  - **Added algorithms other than DES**
  - **V4 used ad hoc encoding, V5 used ASN.1**
- Specified as Internet standard RFC 1510