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Cryptography: Key Distribution

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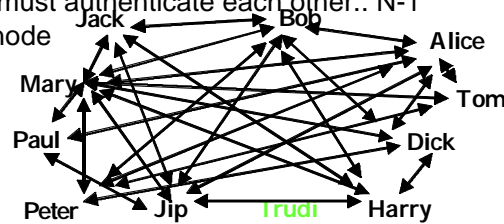
Key Distribution

- 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

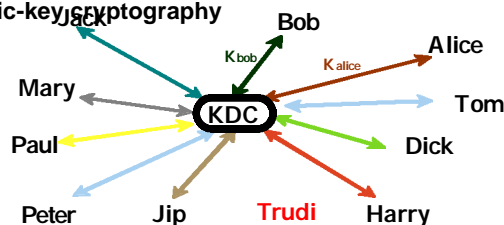
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Trusted intermediaries

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

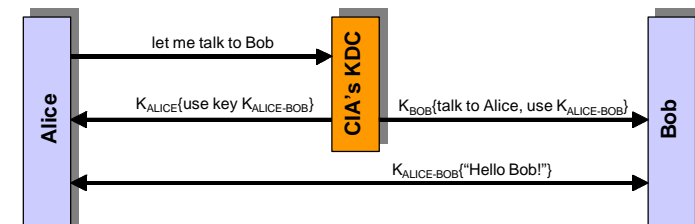
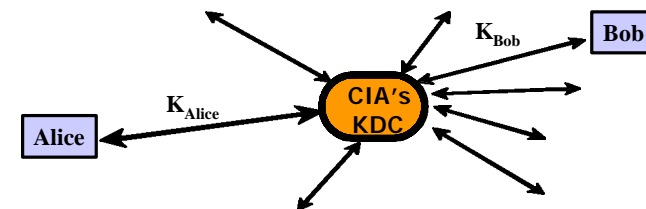


- Possible solution: Key Distribution Center - KDC
 - similar to CAs for public-key cryptography



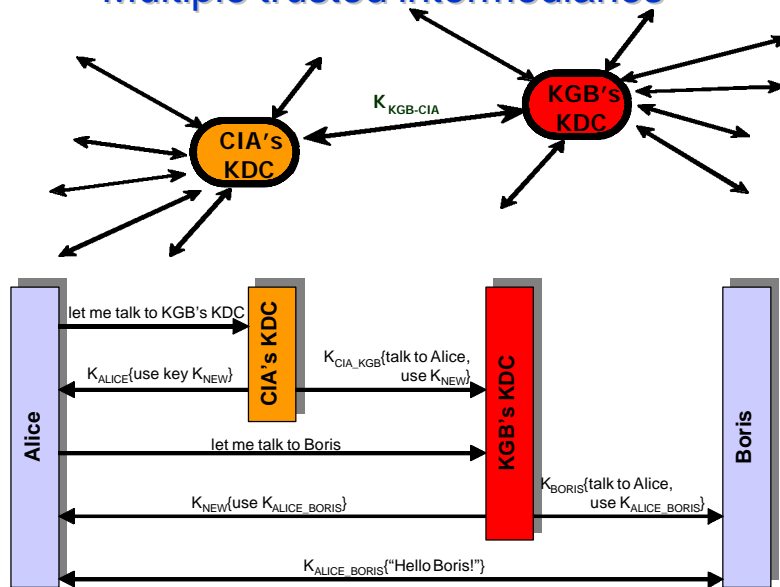
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Trusted intermediaries



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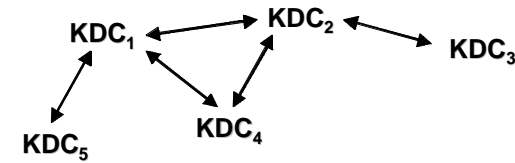
Multiple trusted intermediaries



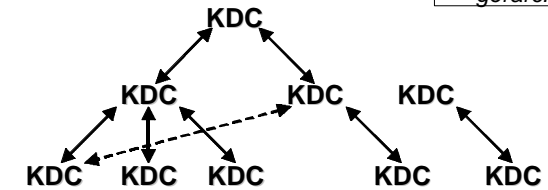
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Multiple trusted intermediaries

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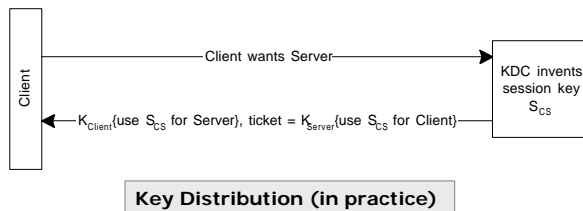
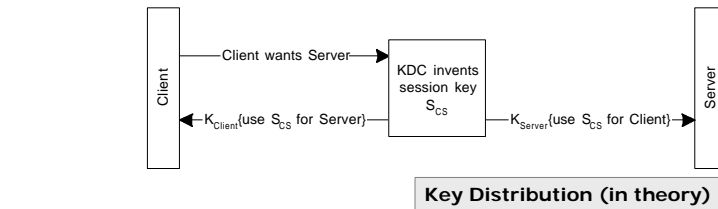


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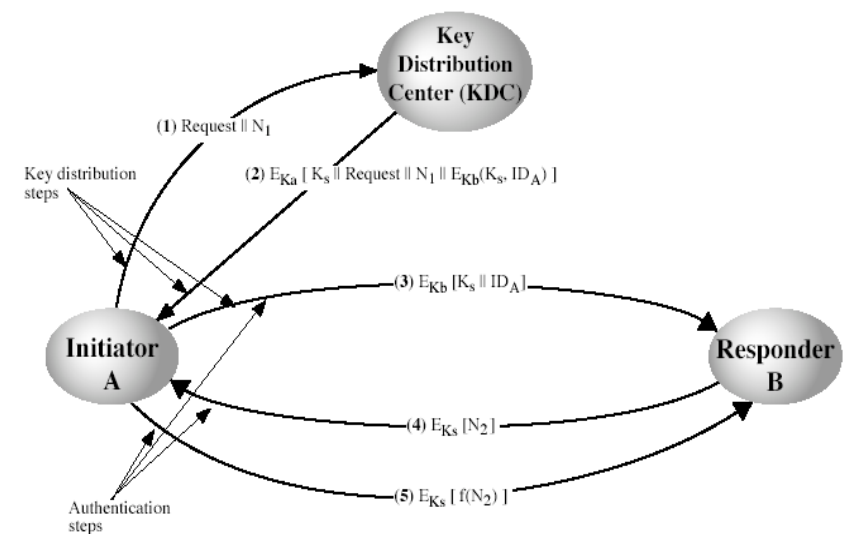
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Key Distribution in practice



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Key Distribution



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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 : $E_{K_A}[K_s \text{req} N_1 \text{ticket}]$ | = $E_{K_A}[K_s ID_B N_1 E_{K_B}[K_s ID_A]]$ |
| 3. A → B : ticket | = $E_{K_B}[K_s ID_A]$ |
| 4. B → A : challenge | = $E_{K_s}[N_2]$ |
| 5. A → B : response | = $E_{K_s}[f(N_2)]$ |

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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)
- N_1 e N_2 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. $f(x)=x+1$

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Kerberos



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 Windows2000 and linux (PAM)

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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**

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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

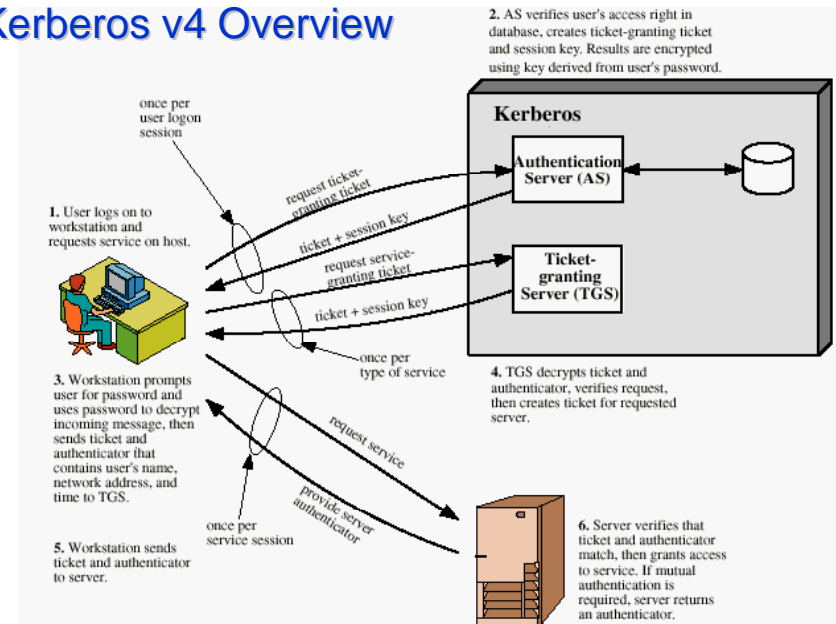
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AS and TGS

- 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

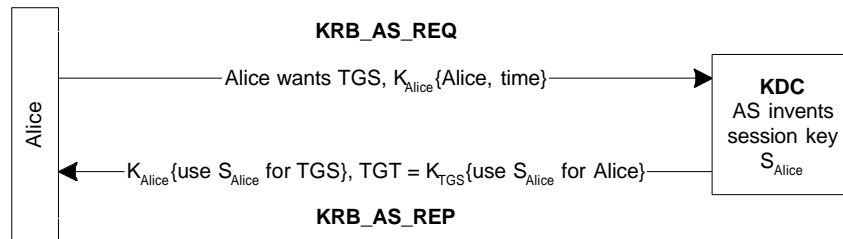
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Kerberos v4 Overview



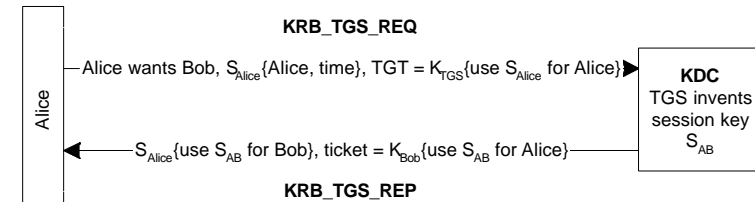
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Authentication Service



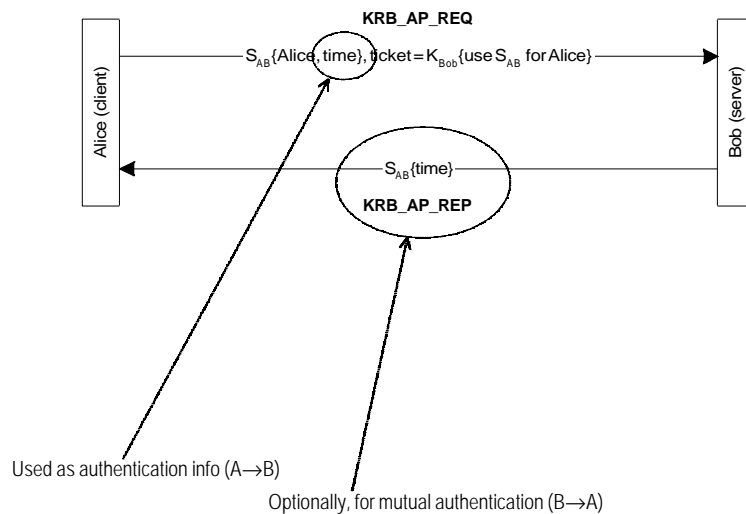
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Ticket-Granting Service



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Client/Server exchange



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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

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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