Kerberos – Private Key System

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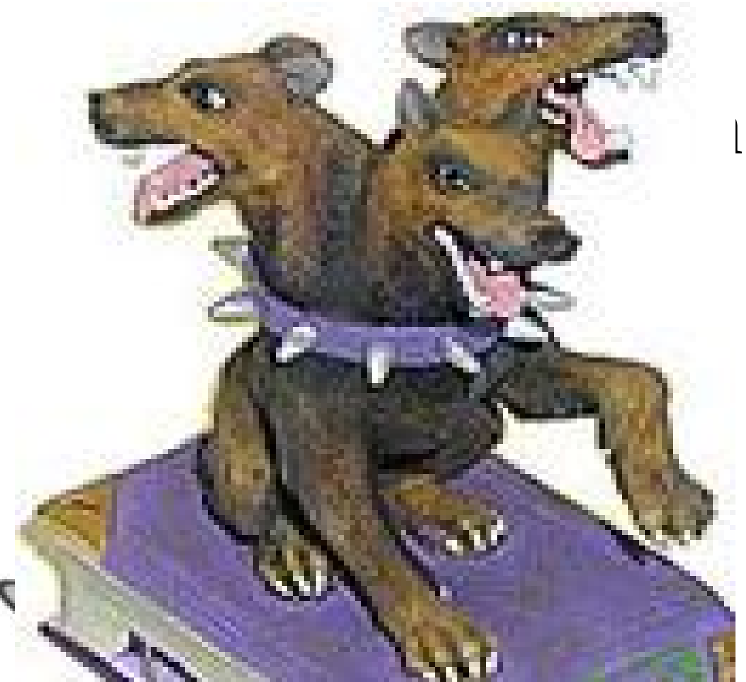
History

- Cerberus, the hound of Hades, (Kerberos in *Greek*)
- Developed at MIT in the mid 1980s
- Available as open source or supported commercial software
- Combination of topics covered previously in class

What do we want to do?

- Want to be able to access all resources from anywhere on the network.
- Don't want to be entering password to authenticate for each access to a network service.
  - Time consuming
  - Insecure

Ingredients



Review: Cryptology

- **Cryptology** is the study of mathematical techniques related to aspects of information security such as confidentiality, data integrity, authentication, and non-repudiation

Review: Cryptology (cont)

- Private Key Mechanism
  - A single secret key (Y) is used for both encryption and decryption by the parties
  - Symmetric Algorithm

Review: Authentication

- **Authentication** is a mechanism that verifies a claim of identity
- Various systems provide means to reliably authenticate
  - Difficult to reproduce artifact; *digital signatures*
  - Shared secret; *symmetric key systems*
  - Electronic signature; *private key infrastructure*
- Needham-Schroeder with Denning-Sacco modification

Review: Authorization

- **Authorization** is the process of giving individuals access to system objects based on their identity

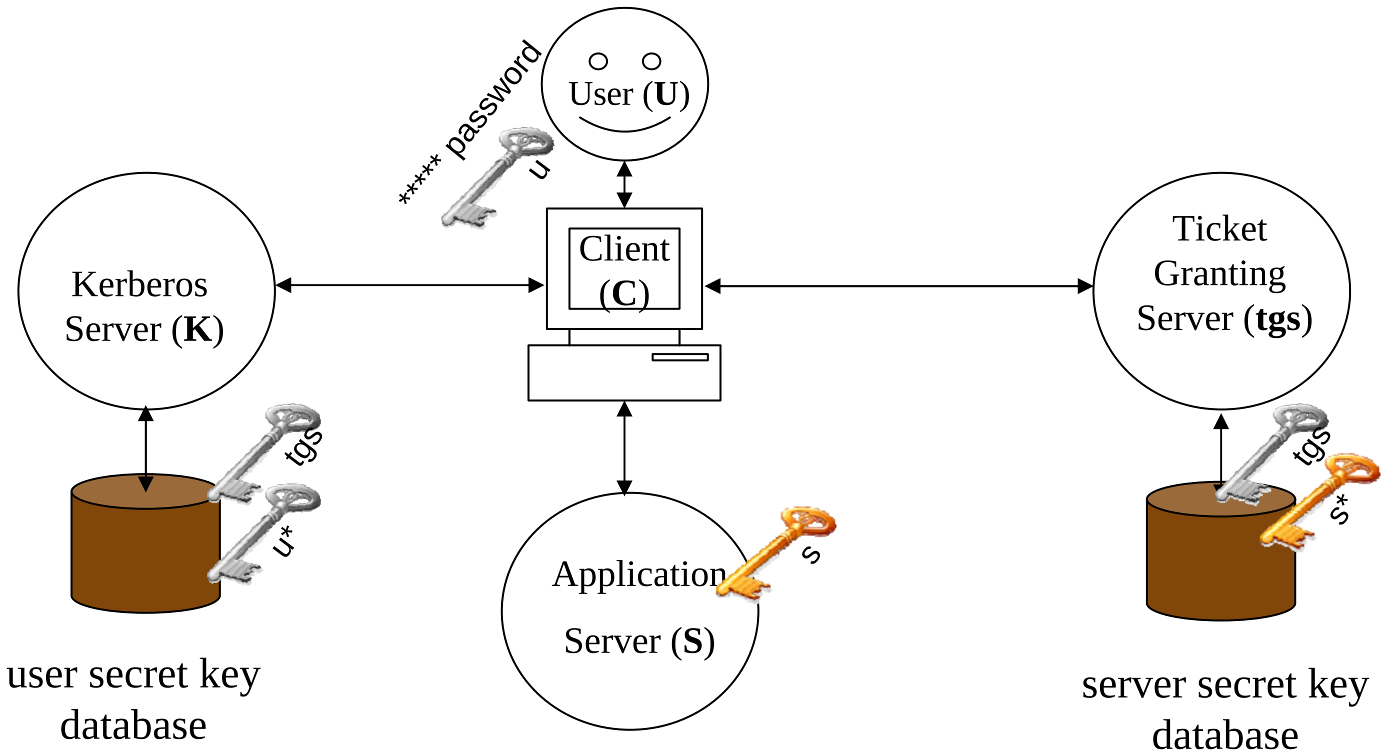
Putting it all together

- User's passwords are never sent across the network
- Secret keys are only passed across the network in encrypted form
- Client and server systems mutually authenticate
- It limits the duration of their users' authentication
- Authentications are reusable and durable

Kerberos Terminology

- **Realm**: Kerberos “site”
- **Process**: client
- **Principle**: basic entity: user, service, host
  - Associated with a key
- **Instance**: optional additional identifier to make associated principles unique within a realm
- **Verifier:** application server
- **Authenticator**: encrypted data structure that confirms identity
- **Ticket**: a block of data sent to a service containing a user id, server id, and timestamp and time-to-live, encrypted with secret key

Kerberos Structure



Requirements:

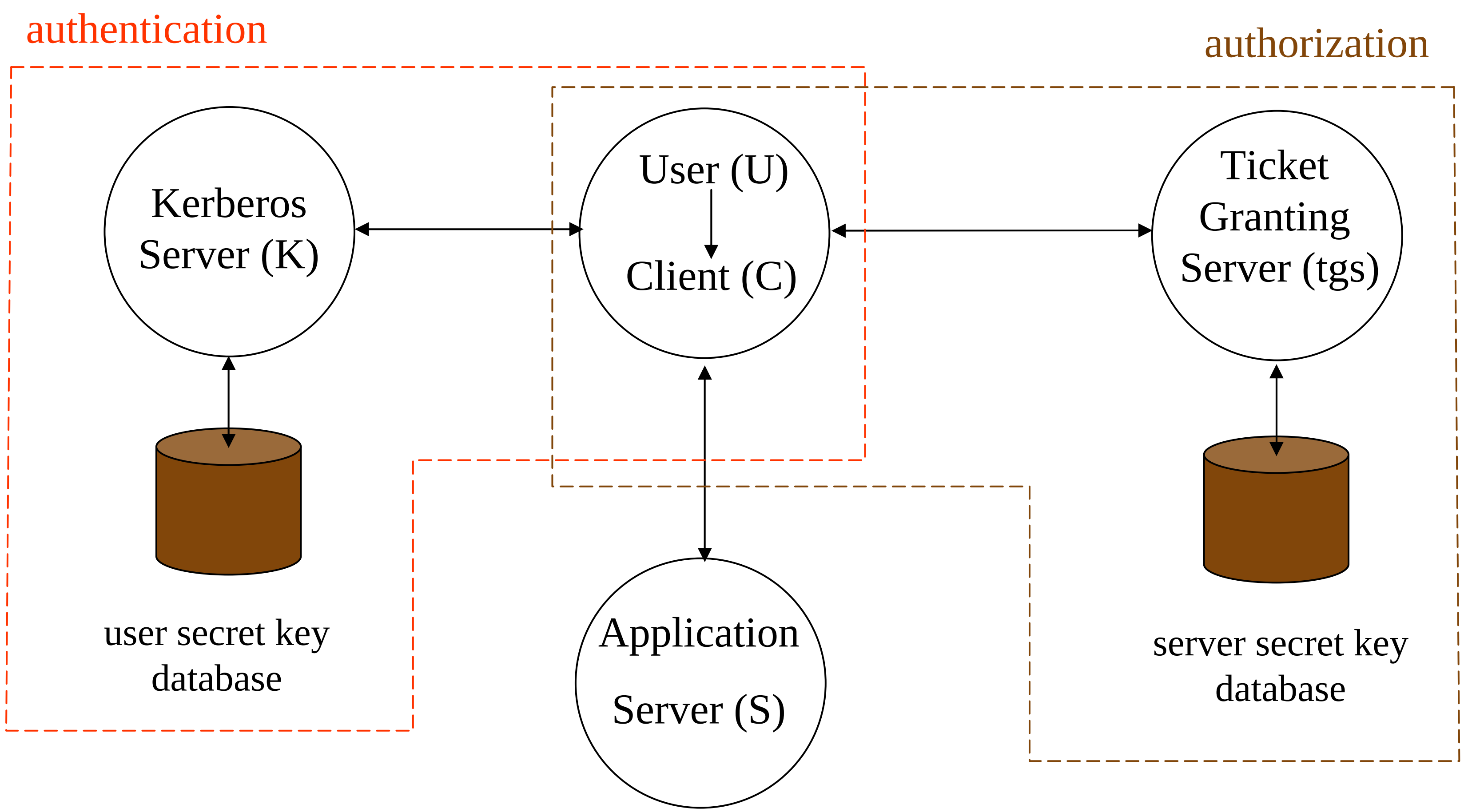
•each user has a private password known only to the user

•a user's secret key can be computed by a one-way function from the user's password

•the Kerberos server knows the secret key of each user and the tgs

•each server has a secret key know by itself and tgs

Key Distribution Center (KDC)



Ticket

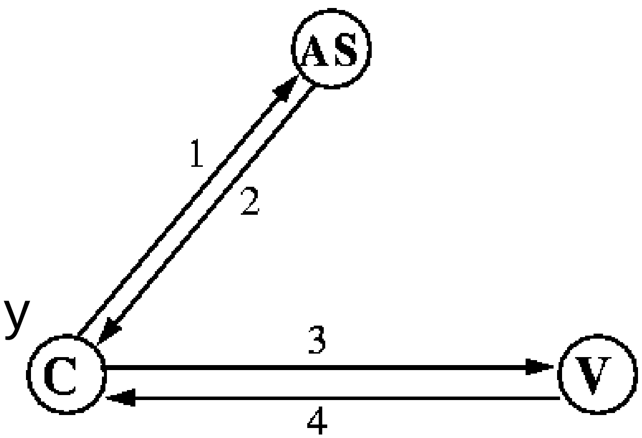
- Encrypted certificate issued by KDC
  - name of the principle (C)
  - name of server (S)
  - random session key (**$K_{C,S}$**)
  - expiration time (lifetime)
  - timestamp

Ticket Structure:

$E_{K(s)}$ {C, S, $K_{C,S}$, timestamp, lifetime}

Kerberos Protocol Simplified

- Client to Authentication Server
  - Authentication request
- Authentication to Server
  - Reply with ticket and session key

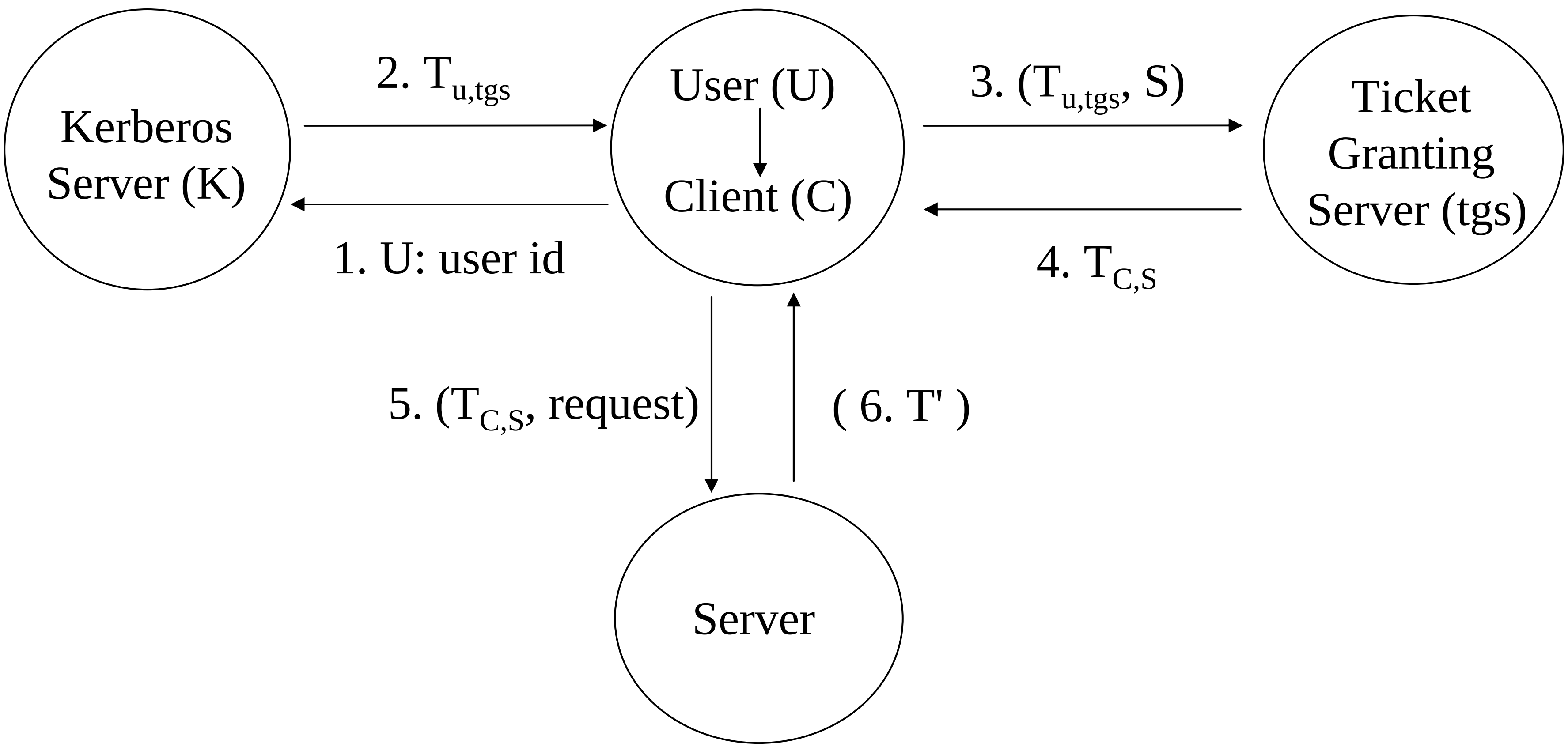


1. as_req: $c, v, time_{exp}, n$
2. as_rep: $\{K_{c,v}, v, time_{exp}, n, \ldots\}K_c, \{T_{c,v}\}K_v$
3. ap_req: $\{ts, ck, K_{subsession}, \ldots\}K_{c,v}\ \{T_{c,v}\}K_v$
4. ap_rep: $\{ts\}K_{c,v}$ (optional)

$T_{c,v} = K_{c,v}, c, time_{exp} \ldots$

- Client to Verifier
  - User authenticates to verifier
  - Communicates with session key
- Verifier to Client
  - Optional, mutual authentication

Protocol Overview



Kerberos: Phase 1

1. The user logs on to the client and the client asks for credentials for the user from Kerberos

U --> C : U (user id)
C --> K: (U, tgs)

2. Kerberos constructs a ticket for U and tgs and a credential for the user and returns them to the client

$T_{u,tgs} = E_{K(tgs)}$ { U, tgs, $K_{u,tgs}$, ts, lt}
K --> C: $E_{K(u)}$ {$T_{u,tgs}$, $K_{u,tgs}$, ts, lt}

The client obtains the user's password, P, and computes:

K'(u) = f(P)

The user is authenticated to the client if and only if K'(u) decrypts the credential.

Kerberos: Phase 2

3. The client constructs an "*authenticator*" for user U and requests from TGS a ticket for server, S:

$A_U = E_{K(u,tgs)} \{C, ts\}$

C --> TGS : $(S, T_{u,tgs}, A_U)$

4. The ticket granting server authenticates the request as coming from C and constructs a ticket with which C may use S:

$T_{c,s} = E_{K(s)} \{C, S, K_{c,s}, ts, lt\}$

TGS --> C: $E_{K(u,tgs)} \{T_{c,s}, K_{c,s}, ts, lt\}$

Kerberos: Phase 3

5. The client builds an "*authenticator*" and send it together with the ticket for the server to S:

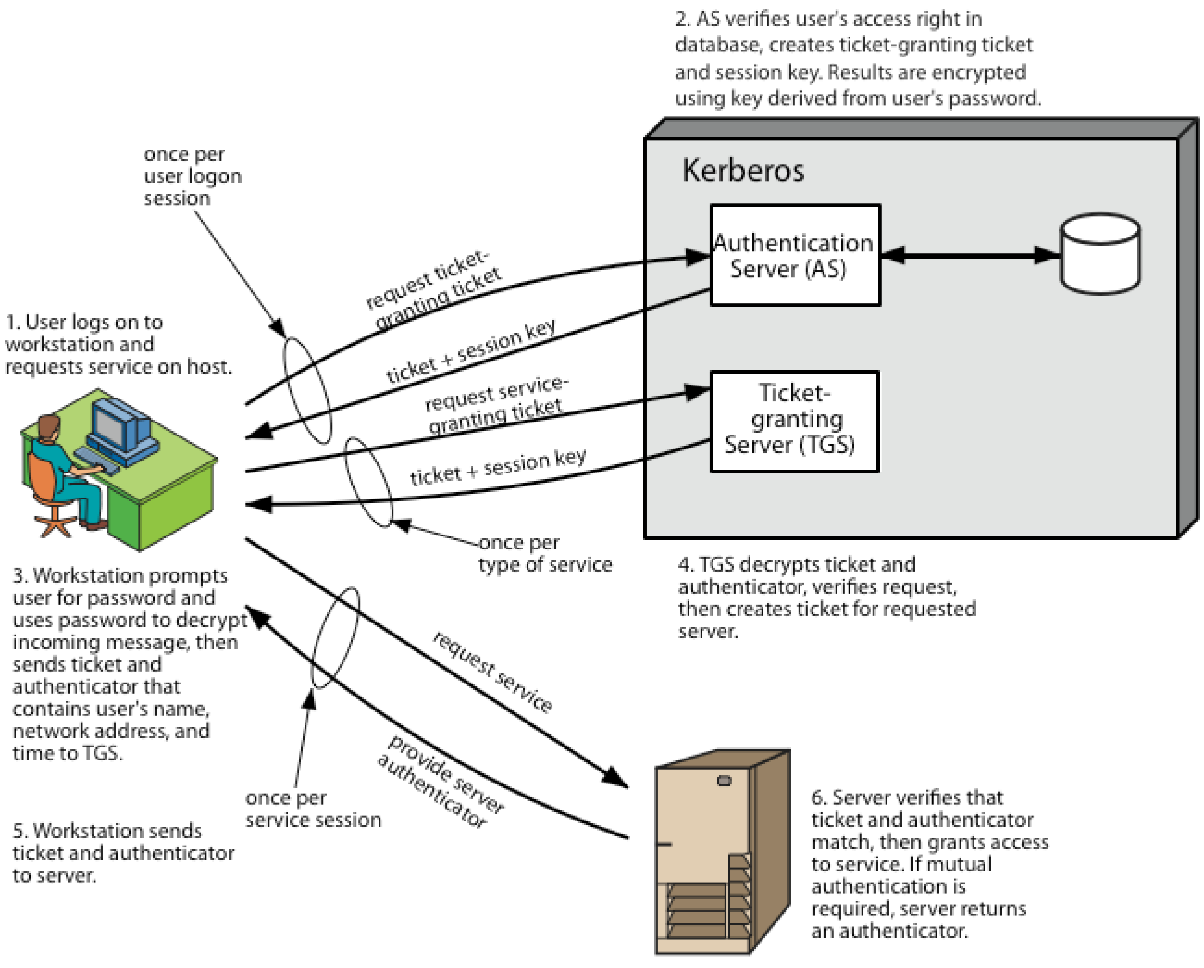
$A_c = E_{K(c,s)}$ { C, ts }

C --> S : ($T_{c,s}$, A_c)

6. The server (optionally) authenticates itself to the client by replying:

S --> C: $E_{K(c,s)}$ {ts + 1 }

Final Product



Limitations

- Every network service must be individually modified for use with Kerberos
- Doesn't work well in time sharing environment
- Requires a secure Kerberos Server
- Requires a continuously available Kerberos Server
- Stores all passwords encrypted with a single key
- Assumes workstations are secure
- May result in cascading loss of trust
- Scalability

Further Reading

- **RFC 1510**
- **Kerberos web site** *http://web.mit.edu/kerberos/www*
- O'Reilly Kerberos The Definitive Guide by Jason Garman
- *Video on Kerberos* from Oslo University College

Questions

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