Distributed Authentication in Kerberos Using Public Key Cryptography

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Outline

- Public Key Cryptography for Kerberos
- Alternative Approaches
- The PKDA Protocol
- Migration to PKDA
- Implementation and Progress

Why Public Key in Kerberos

- Reduce/eliminate sensitive information at KDC
- Distribute functions of TGS for scalability
  - on-line banking with millions of consumers in a single trust domain

PKDA

- Public-key based Kerberos for Distributed Authentication
- Public-key cryptography built upon certificate infrastructure
- Mutual authentication and key exchange
- Data integrity and privacy protection

PKDA

- Extension to Kerberos V5 Authentication Framework (RFC 1510)
- Builds upon X.509, PKCS standards
- Supports Rights Delegation
- Enhancement to User Privacy Protection over Kerberos V5

Alternative Approaches

- Secure Socket Layer (SSL 3.0)
- Public Key Cryptography for Initial Authentication in Kerberos (pk-init)
- PKDA

SSL 3.0

- Supports TCP but not UDP
- Client and server exchange certificates
- Both parties cache session key and session_id locally
- Reuse session key by resending session_id
- Choice of cryptographic algorithms
- Certificate revocation checking unspecified

pk-init

- Supports both TCP and UDP
- No client keys at KDC; server keys still stored
- TGS interaction required for every session ticket
- Session tickets reusable during lifetime

PKDA

- Supports both TCP and UDP
- Client and server exchange certificates
- Session ticket and key exchanged directly - no TGS involved
- Ticket reusable for subsequent interactions
- Certificate revocation checking unspecified

PKDA vs. SSL 3.0

- Protocol layer
- End-to-end message encryption
- Ticket reusability/session caching
- Rights delegation in PKDA

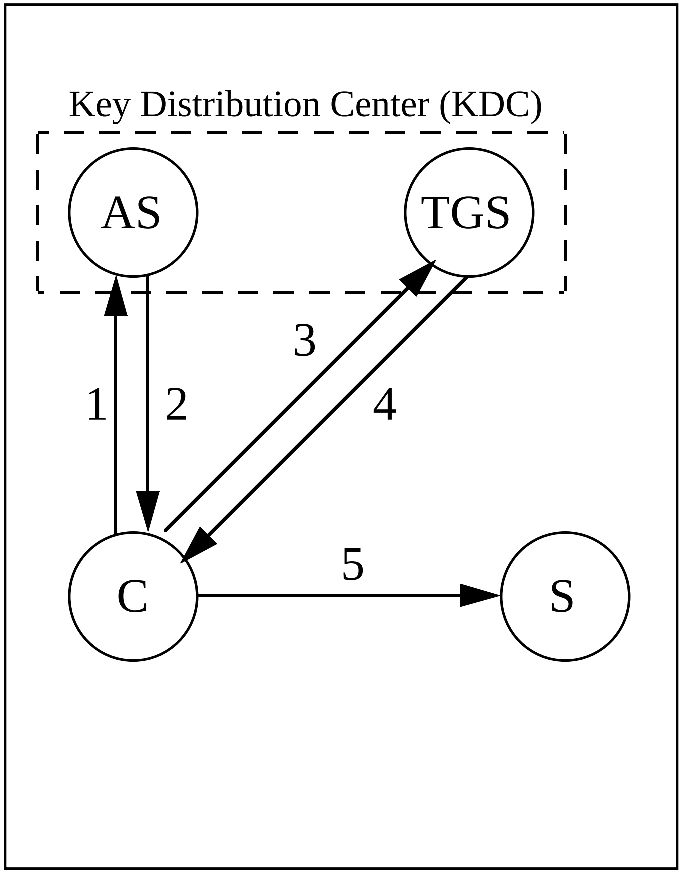
PKDA vs. pk-init

- PKDA is fully distributed; no centralized KDC/TGS
- PKDA enhances privacy of principals
- PKDA requires code modifications to clients and servers; pk-init requires code modifications for clients and KDC

Notation

C	Client
S	Server
K_r	random one-time symmetric key
$K_{c,s}$	symmetric key shared by C and S
$\{M\}K_{c,s}$	message encrypted using key $K_{c,s}$
$\{M\}P_s$	message encrypted using public key of S
$\{M\}P_c^{-1}$	message signed using private key of C
Ts#	time-stamps
T_{auth}	Initial Authentication Time
$T_{c,s}$	Ticket for session between S and C

Traditional Kerberos



1. **AS_REQ**: C, TGS, Ts1
2. **AS_REP**: $\{K_{c,tgs}$,TGS,Ts1$\}K_c$, $T_{c,tgs}$
3. **TGS_REQ**: C, S, Ts2, $T_{c,tgs}$, $\{auth\}K_{c,tgs}$
4. **TGS_REP**: C, $\{K_{c,s}$,S,Ts2$\}K_{c,tgs}$, $T_{c,s}$
5. **AP_REQ**: $T_{c,s}$, $\{C,Ts3\}K_{c,s}$

where

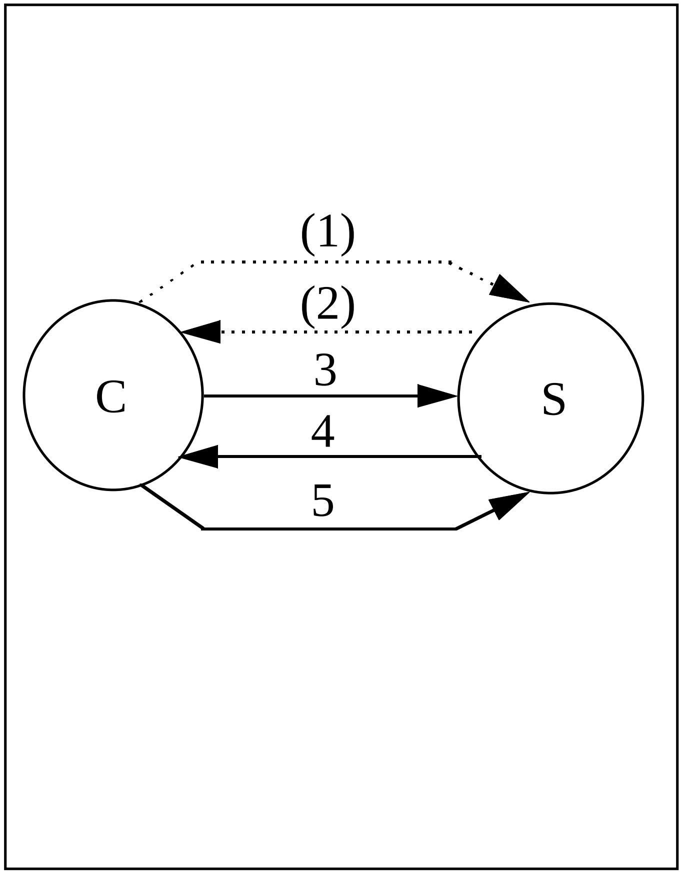
$T_{c,tgs} = TGS,\{K_{c,tgs},C,T_{auth}\}K_{tgs}$

is the ticket granting ticket (TGT);

$T_{c,s} = S,\{K_{c,s},C,T_{auth}\}K_{s,tgs}$

is the service ticket.

PKDA Protocol

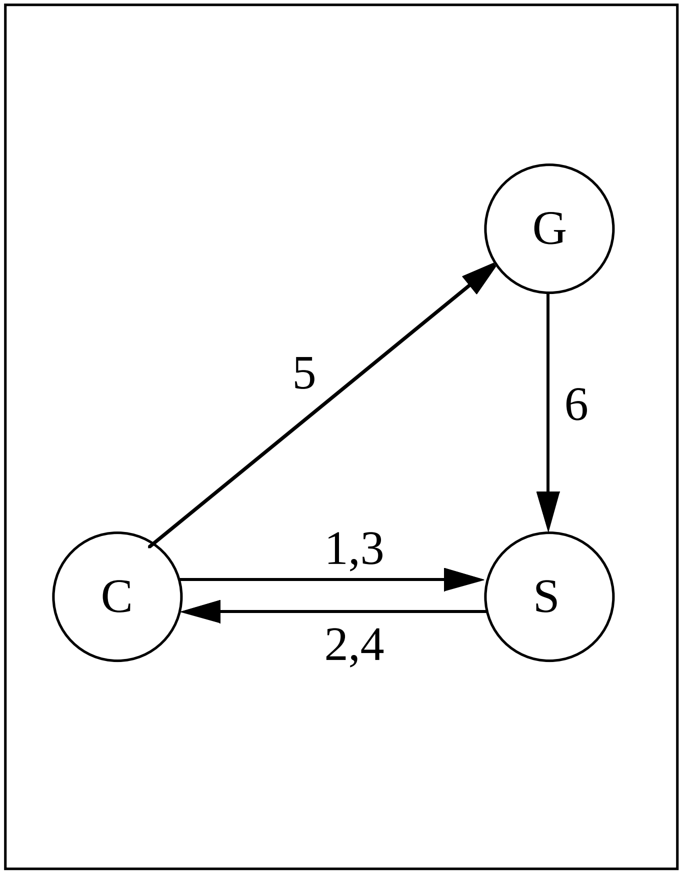


1. **SCERT_REQ**: S
2. **SCERT_REP**: s-cert
3. **PKTGS_REQ**:
   S, $\{C, c\text{-cert}, \{S, P_s, K_r, T_{auth}\}P_c^{-1}\}P_s$
4. **PKTGS_REP**: $\{C, S, K_{c,s}, T_{auth}\}K_r$, $T_{c,s}$
5. **AP_REQ**: $T_{c,s}$, $\{C, Ts1\}K_{c,s}$

where ticket

$$T_{c,s} = S, \{K_{c,s}, C, T_{auth}\}K_s$$

Rights Delegation



1. **SCERT_REQ**: S
2. **SCERT_REP**: s-cert
3. **PKTGS_REQ**:

   S, $\{C, c\text{-cert}, \{S, P_s, K_r, T_{auth}\}P_c^{-1}\}P_s$

   with 'PROXIABLE' flag set
4. **PKTGS_REP**: $\{C, S, K_{c,s}, T_{auth}\}K_r$, $T_{c,s}$
5. **KRB_CRED**: $\{T_{c,s}, \{C, Ts1\}K_{c,s}, K_{proxy}\}K_{c,g}$
6. **AP_REQ**: $T_{c,s}$, $\{C, Ts1\}K_{c,s}$

where ticket is <u>proxiable</u>:

$$T_{c,s} = S, \{K_{c,s}, C, T_{auth}\}K_s$$

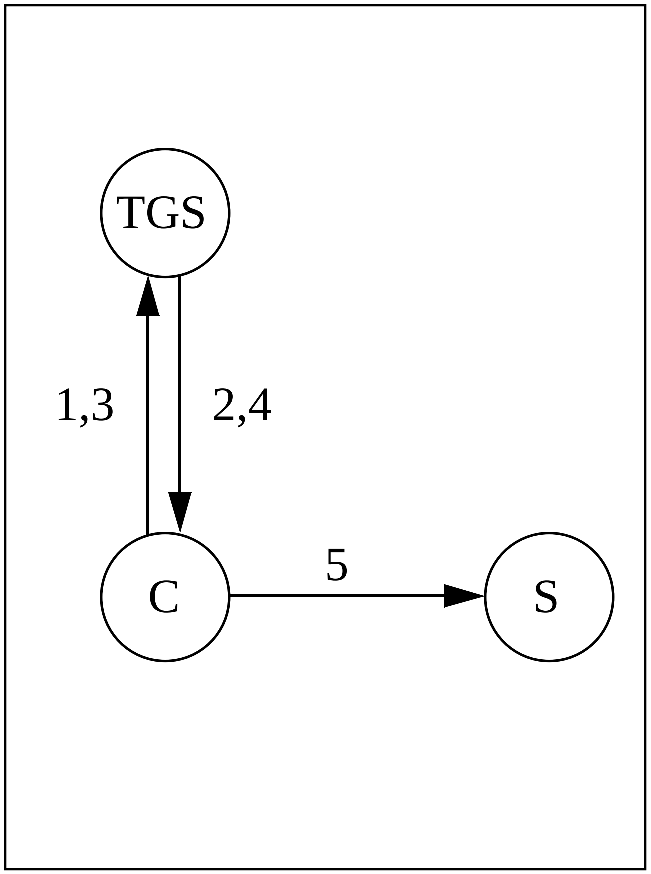
and $K_{c,g}$ is previously established symmetric key between C and G.

Accomodating Conventional Application Servers

If Server does not understand PKDA:

- Obtain conventional TGT from PKDA-enabled TGS
- Use TGT to request a service ticket for server S
- Capture all benefits of pk-init without need for server code change

Obtaining Session Tickets from a PDKA-Enabled TGS



0. **SCERT_REQ**: TGS

0. **SCERT_REP**: tgs-cert

1. **PKTGS_REQ**:

   TGS, {C,ccert,{TGS, P_{tgs}, T_{auth},K_r}P_c^{-1}}P_{tgs}

2. **PKTGS_REP**: {C,TGS,$K_{c,tgs}$,T_{auth}}K_r, $T_{c,tgs}$

3. **TGS_REQ**: C, S, Ts1, $T_{c,tgs}$, {auth}$K_{c,tgs}$

4. **TGS_REP**: C, {K_{cs},S,Ts1}$K_{c,tgs}$, $T_{c,s}$

5. **AP_REQ**: $T_{c,s}$, {C,Ts2}$K_{c,s}$

where

$T_{c,tgs}$ = TGS,{$K_{c,tgs}$,C,T_{auth}}K_{tgs}

is the ticket granting ticket;

$T_{c,s}$ = S,{$K_{c,s}$,C,T_{auth}}$K_{s,tgs}$

is the service ticket.

Implementation of PKDA

- Protocol Verification
- Working Implementation for CMU's NetBill electronic payment system
  - Use DCE RPCs: enhancements to IDL compiler automatically adds PKDA RPCs to interfaces
- Protocol Specification in Internet Draft
  - ftp://ietf.org/internet-drafts/draft-sirbu-kerb-ext-00.txt

