Kerberos

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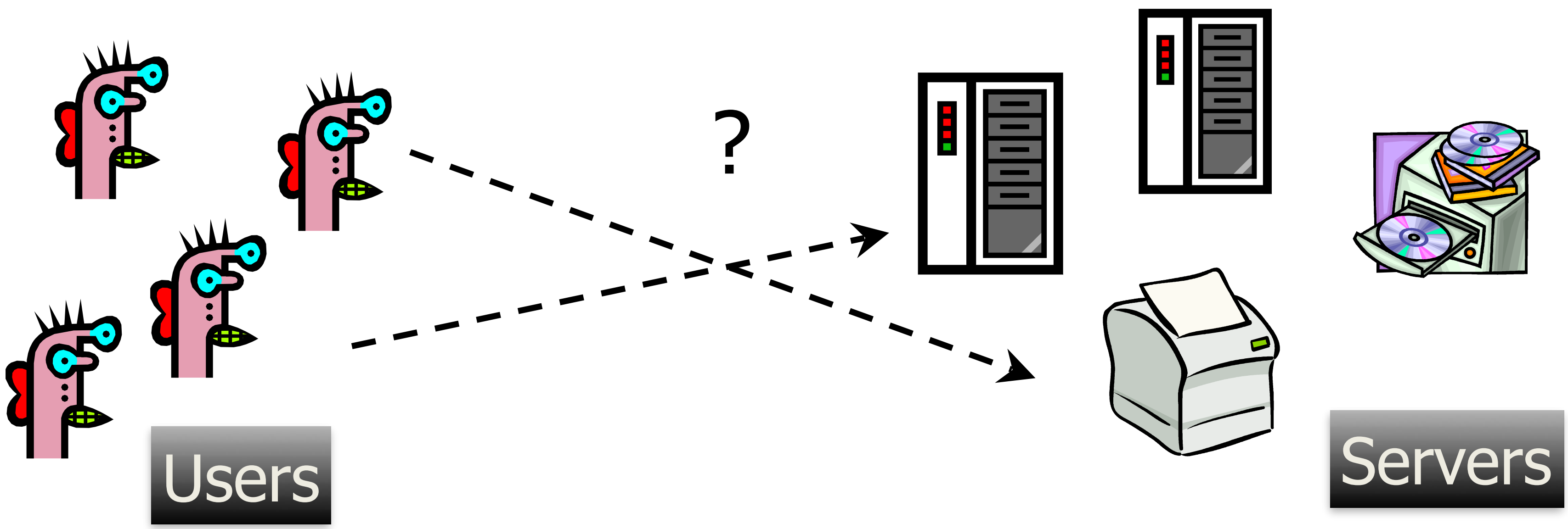
Many-to-Many Authentication



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

Naïve solution: every server knows every user's password

- Insecure: break into one server ⇒ compromise all users
- Inefficient: to change password, user must contact every server

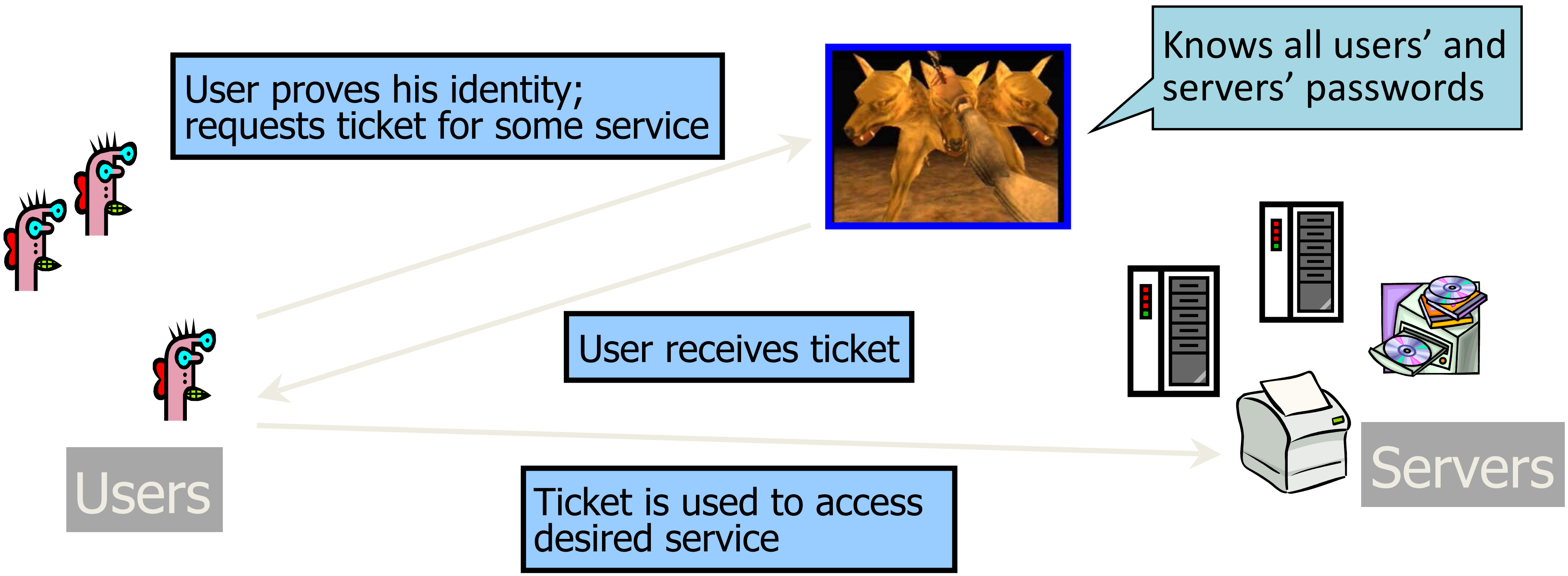
Requirements

- Security
  - … against attacks by passive eavesdroppers and actively malicious users
- User-friendliness
  - Transparent authentication process
  - Easy for legitimate user to change passwords
- Scalability
  - Large number of users and servers

Threats (an incomplete list)

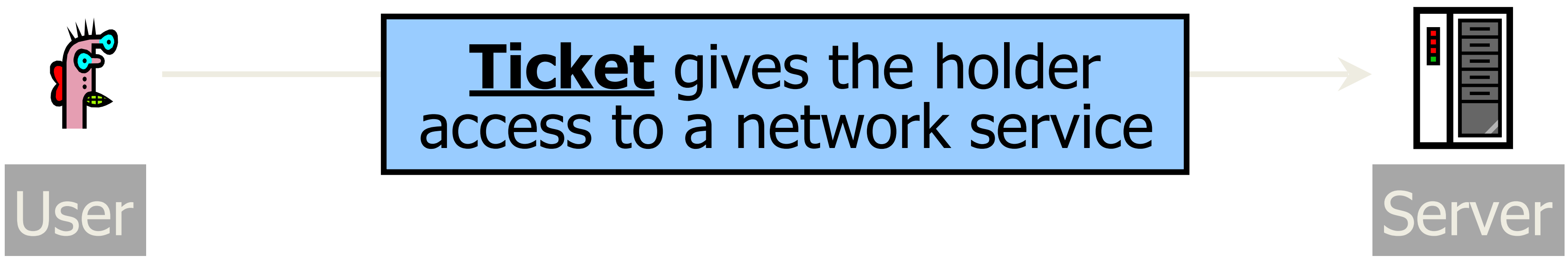
- User impersonation
  - Malicious user with access to a workstation pretends to be another user from the same workstation
- Network address impersonation
  - Malicious user changes network address of his workstation to impersonate another workstation
- Eavesdropping, tampering, replay
  - Malicious user eavesdrops, tampers, or replays other users' conversations to gain unauthorized access

Solution: Trusted Third Party



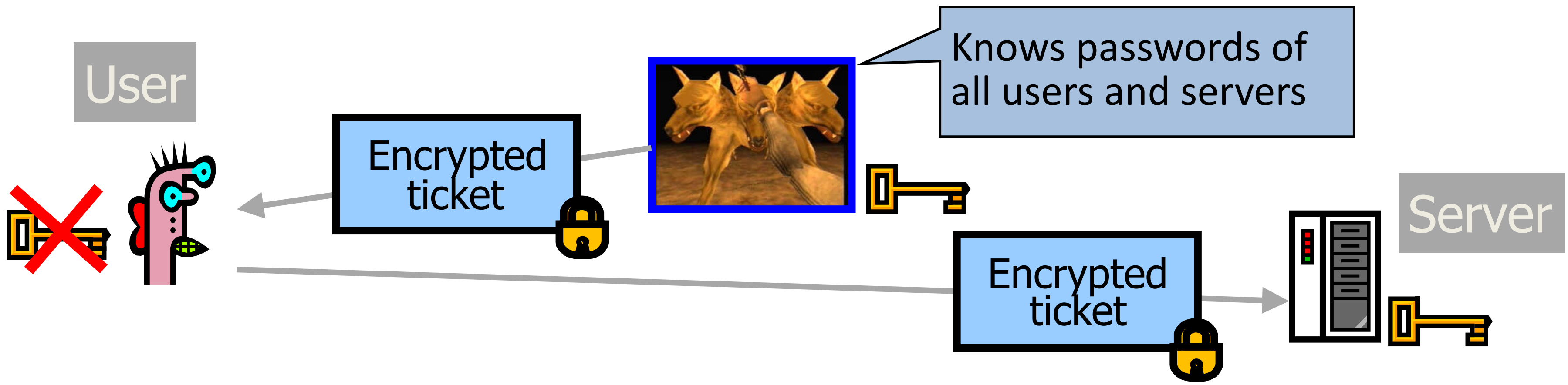
- Trusted authentication service on the network
  - Knows all passwords, can grant access to any server
  - Convenient (but also the single point of failure!)
  - Requires high level of physical security

What Should a Ticket Look Like?



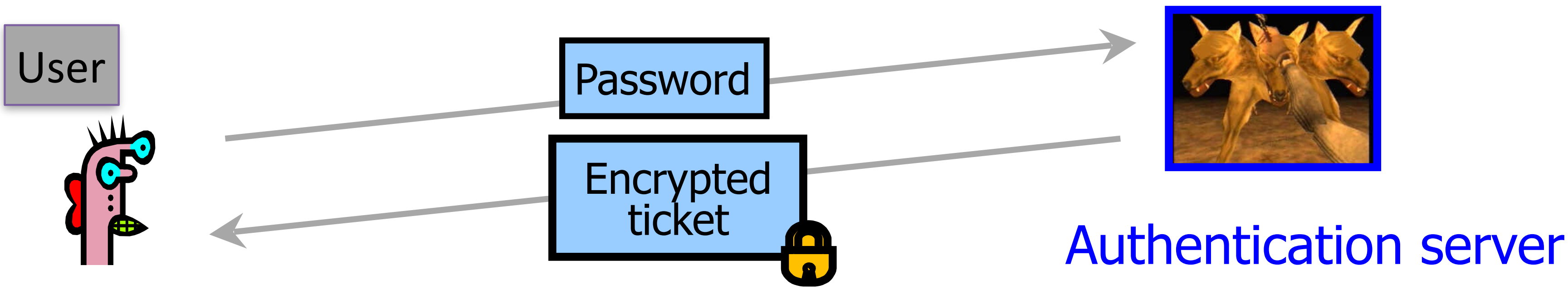
- User should not be able to access server without first proving his identity to authentication service
- Ticket proves that user has authenticated
  - Authentication service encrypts some information with a key known to the server (but not the user!)
    - The only thing the user can do is pass the ticket to the server
    - Hash functions would've worked well, but this is 1980s design
  - Server decrypts the ticket and verifies information

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 (session key, etc.)

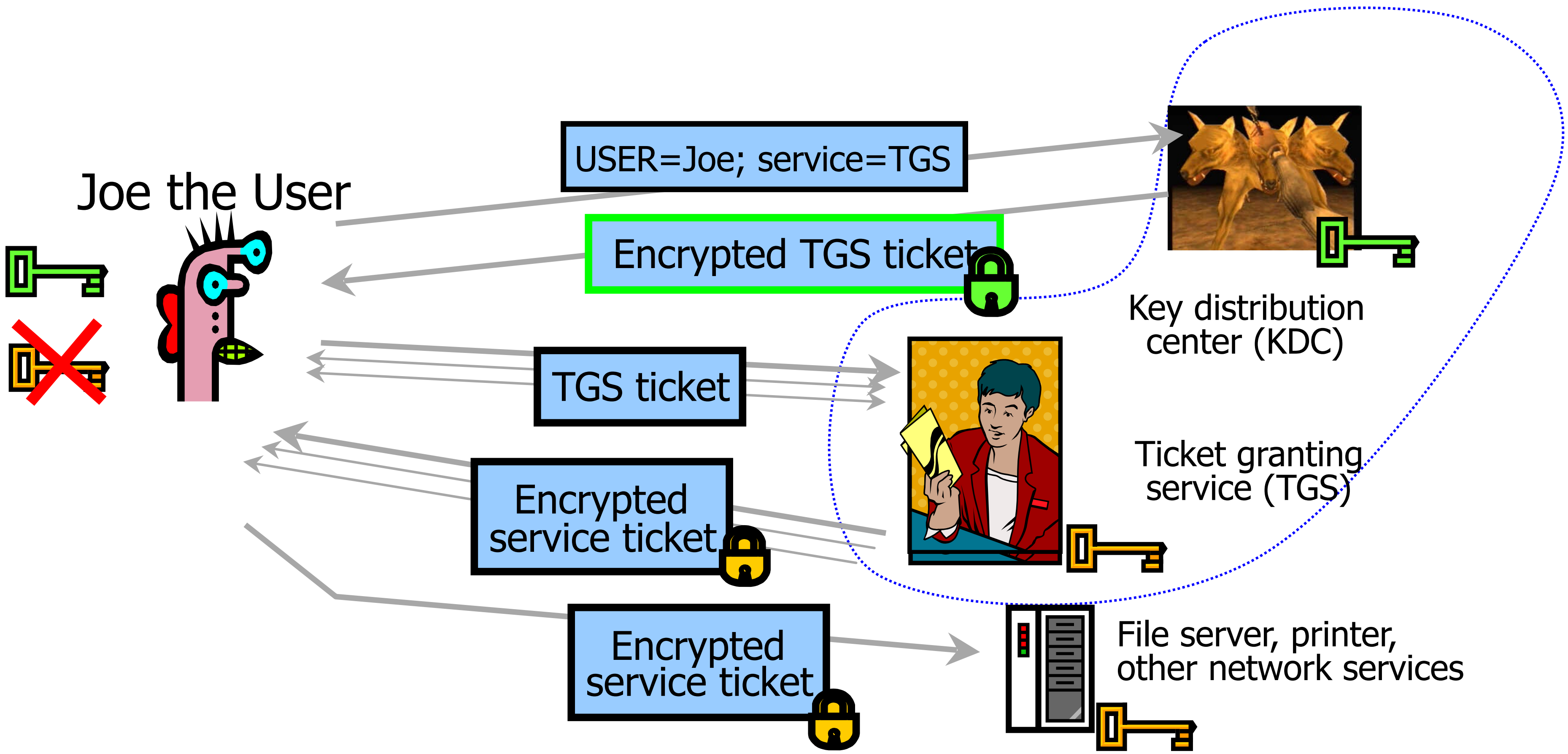
Naïve Authentication



- 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.

Two-Step Authentication

- Prove identity once to obtain a special TGS ticket
- Use TGS to get tickets for any network service



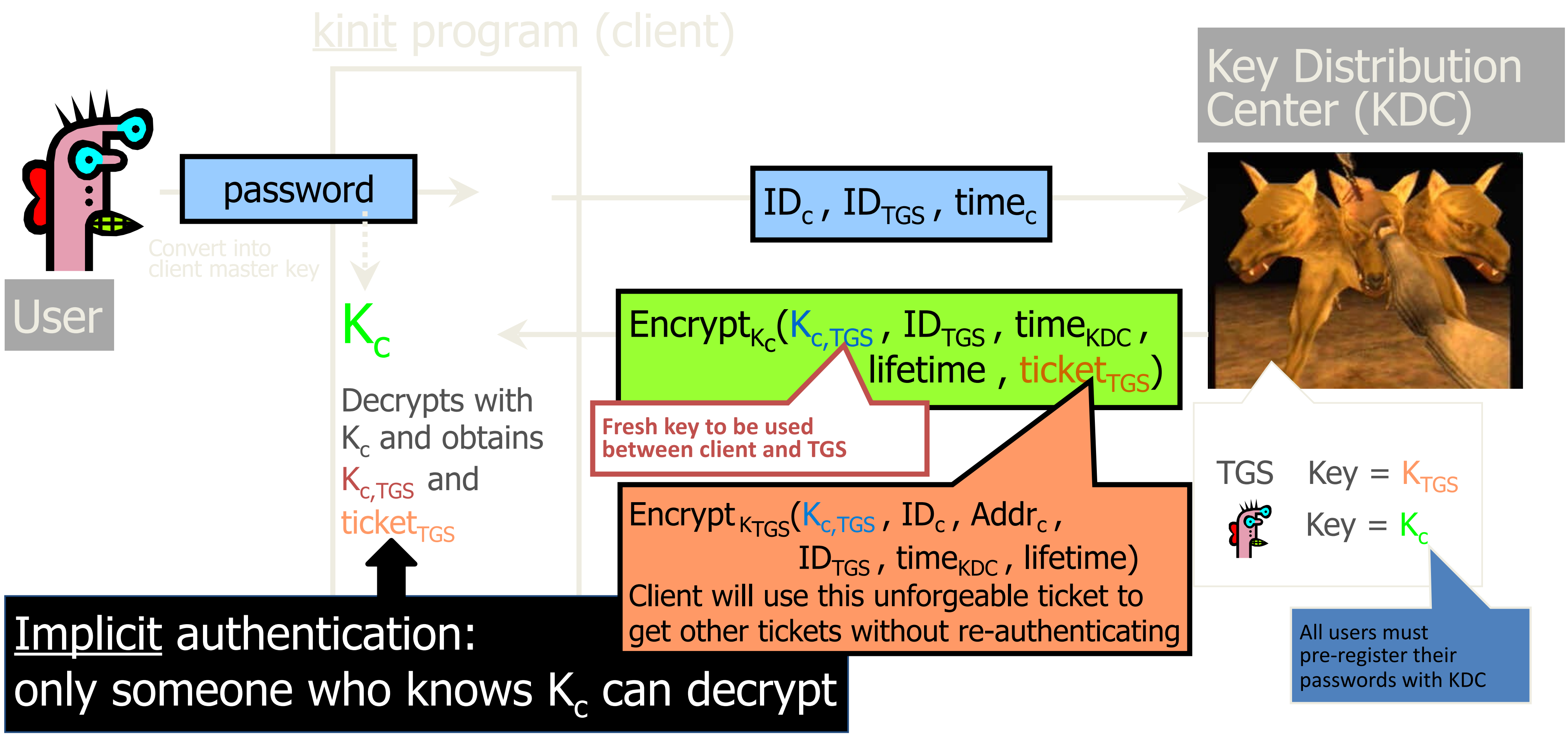
Threats

- Ticket hijacking
  - Malicious user may steal the service ticket of another user on the same workstation and try to use it
    - Network address verification does not help
  - Servers must 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

Symmetric Keys in Kerberos

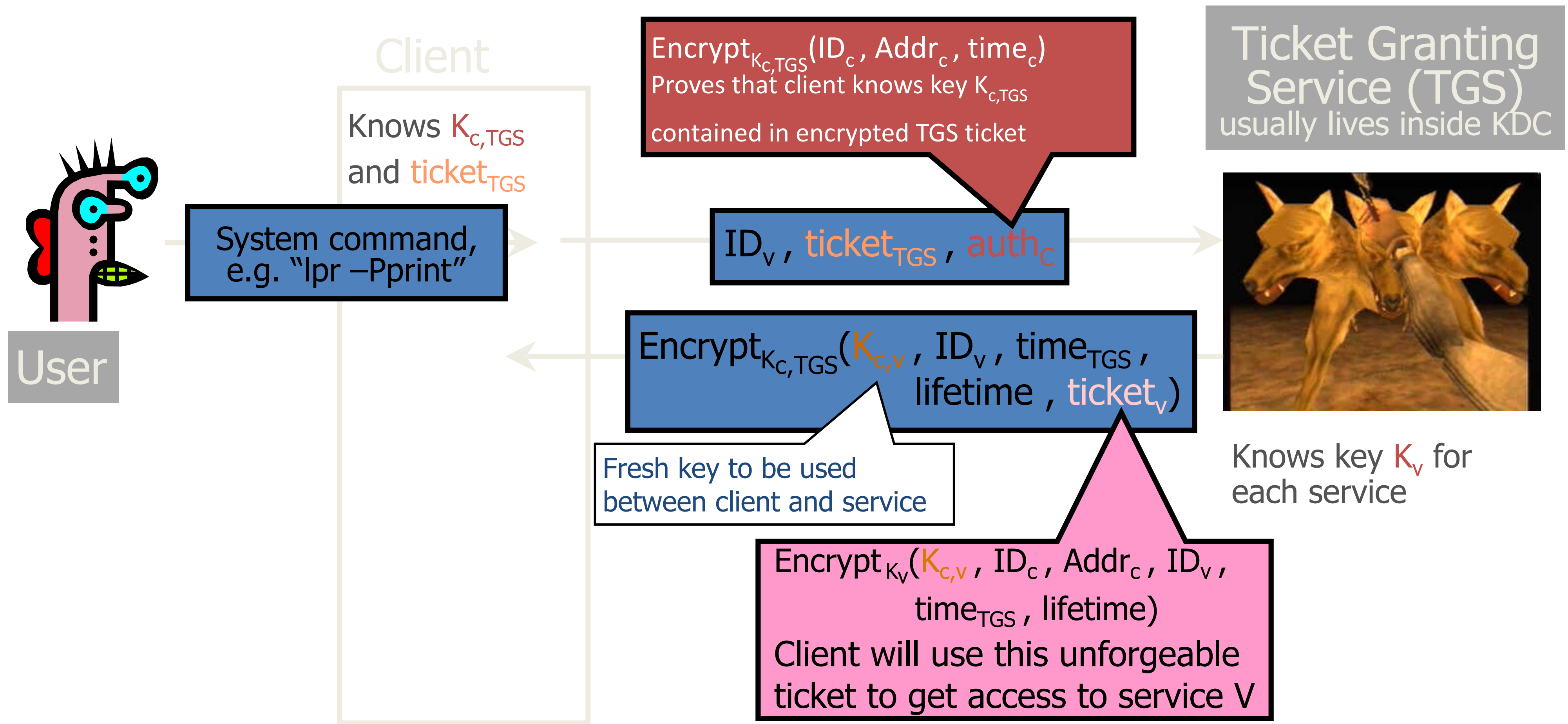
- K_c is <u>long-term</u> key of client C
  - Derived from the user's password
  - Known to the client and the key distribution center (KDC)
- K_{TGS} is <u>long-term</u> key of TGS
  - Known to KDC and the ticket granting service (TGS)
- K_v is <u>long-term</u> key of network service V
  - Known to V and TGS; each service V has its own long-term key
- $K_{c,TGS}$ is <u>short-term</u> session key betw. C and TGS
  - Created by KDC, known to C and TGS
- $K_{c,v}$ is <u>short-term</u> session key between C and V
  - Created by TGS, known to C and V

“Single Logon” Authentication



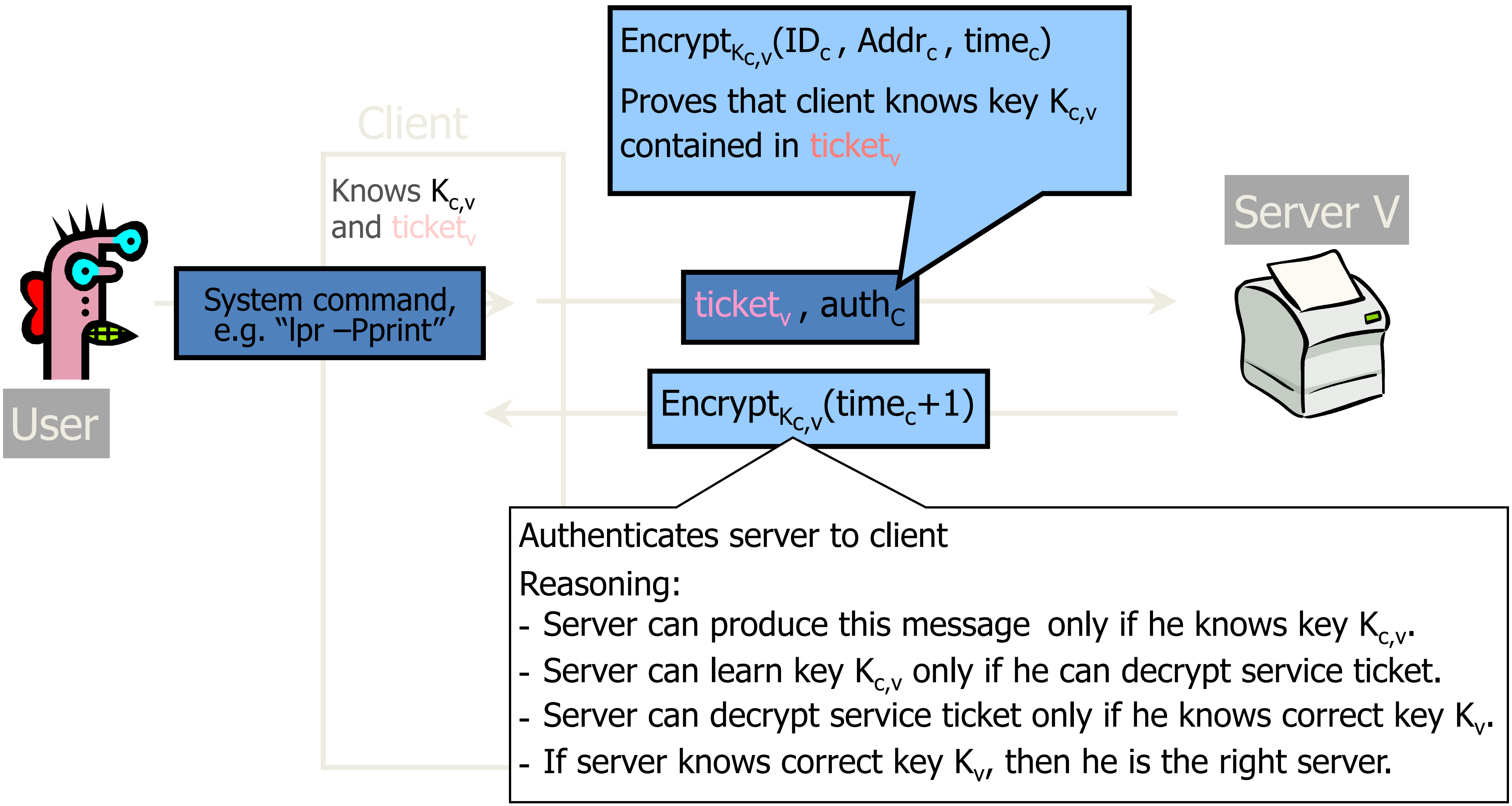
- Client only needs to obtain TGS ticket **once** (say, every morning)
- Ticket is encrypted; client cannot forge it or tamper with it

Obtaining a Service Ticket



- Client uses TGS ticket to obtain a service ticket and a <u>short-term session key</u> for each network service (printer, email, etc.)

Obtaining Service

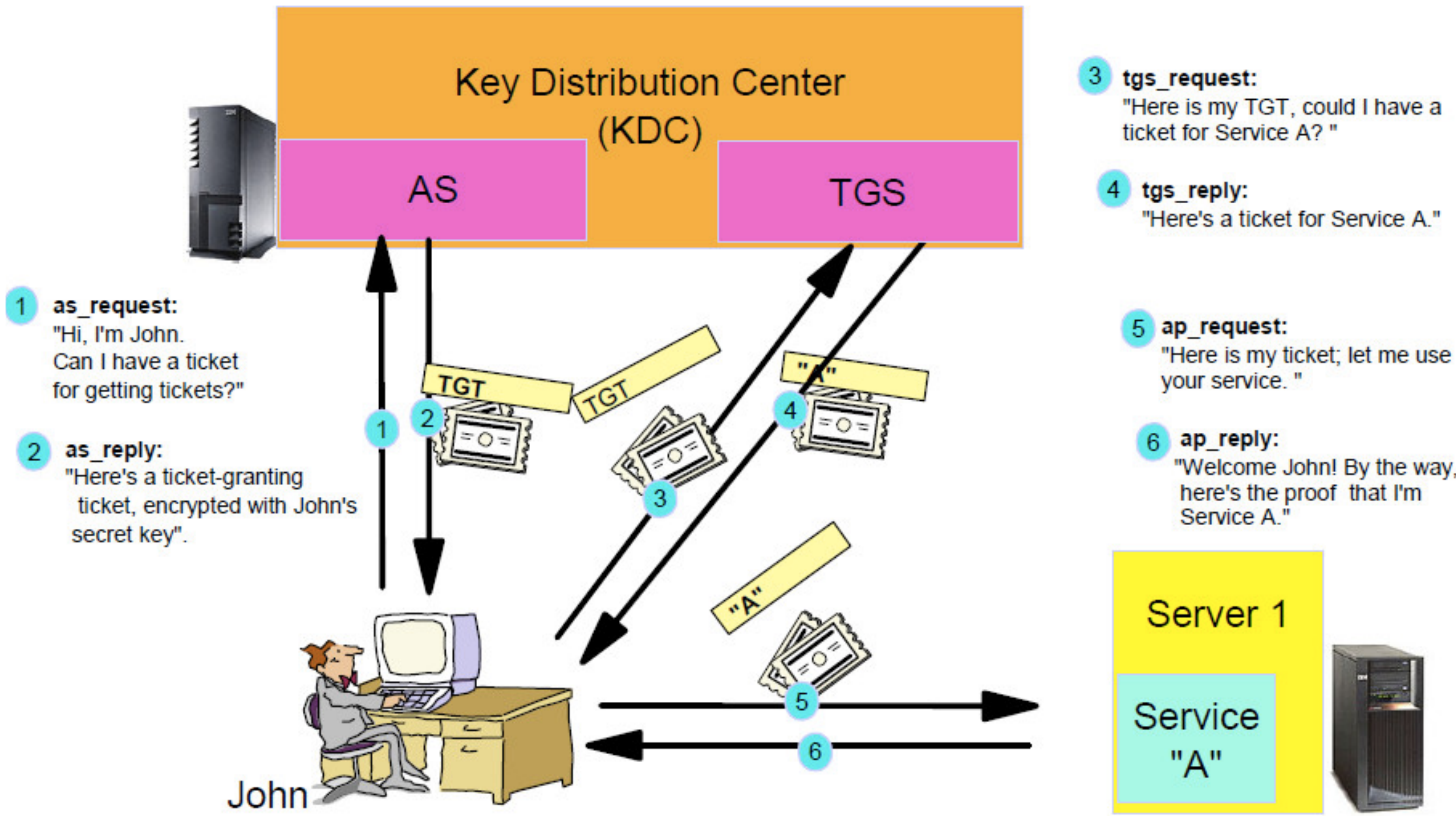


- For each service request, client uses the short-term key for that service and the ticket he received from TGS

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

Summary of Kerberos



Important Ideas in Kerberos

- Short-term session keys
  - Long-term secrets used only to derive short-term keys
  - Separate session key for each user-server pair
    - Re-used by multiple sessions between same user and server
- Proofs of identity based on authenticators
  - Client encrypts his identity, addr, time with session key; knowledge of key proves client has authenticated to KDC
    - Also prevents replays (if clocks are globally synchronized)
  - Server learns this key separately (via encrypted ticket that client can't decrypt), verifies client's authenticator
- Symmetric cryptography only

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 (delegation)
  - Servers can access other servers on user's behalf, e.g., can tell printer to fetch email
- Realm hierarchies for inter-realm authentication
- Explicit integrity checking + standard CBC mode
- Multiple encryption schemes, not just DES

Practical Uses of Kerberos

- Microsoft Windows
- Email, FTP, network file systems, 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
- Secure windowing systems

Charge

- Kaufman Chapters 13 and 14
- "Designing an Authentication System: A Dialogue in Four Scenes"
  - A high-level survey of network threats and design principles behind Kerberos