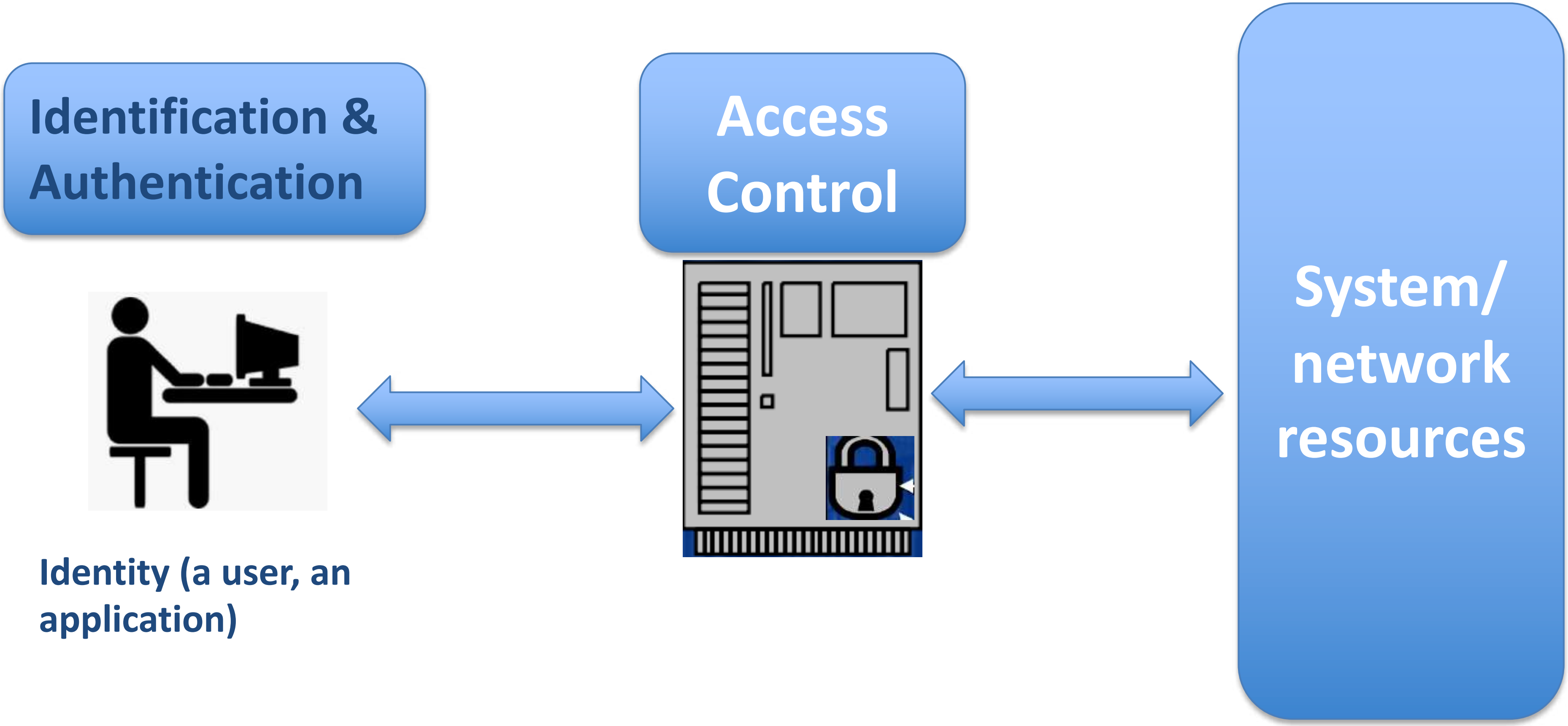
University of Glasgow

COMPSCI4062/COMPSCI5063 Cyber Security Fundamentals (CSF)

Identification and Authentication



Identification & Authentication

Access Control

System/ network resources

Identity (a user, an application)

Identity, Identification and Authentication

- **Definitions**
  - Identity
    - Representation of an entity inside a computer system
    - It often implies the use of a unique name for an entity
    - ❖A person’s identity can change or be falsified, e.g., last name
  - Identification
    - is the claim of a user or an application that is using/running in the system
    - This could be achieved by a user ID, process ID, a smart card or anything else that may uniquely identify a subject or a person.
    - ❖The ID, smart card could be stolen
  - Authentication
    - Verification/prove process of the identity of an entity

Identity

- Purposes
  - For access control
  - For accountability
    - Logging & Auditing
- Identities in a security system
  - A data file (an object in general)
    - File name: for the human being
    - File descriptor: for a process
    - File allocation table entry: for the kernel (MS-DOS and Windows 9x OS)
- A user
  - Any name comprised of an arbitrary number of alphanumeric characters
    - May be constrained in some ways, e.g., name + organization

Groups and Roles

- An identity may refer to an entity that is comprised of **a group of entities**
  - A convenient way of performing access control and other security functions to a set of entities at the same time
  - Models of groups
    - Static: alias to a set of entities
    - Dynamic: construct for grouping a set of entities
- An identity may refer to **a role**
    - To tie entities together
    - To represent rights or security functions to which entities are assigned or entitled

Identity and Certificate

- Certificate issued by a certificate authority (CA)
- CA acts as a trusted 3rd party
  - Class 1
    - Authentication of an e-mail address, web application,
  - Class 2
    - Verification of real name and address through an online database - online purchasing
  - Class 3
    - Background check by an investigative service- a higher level of assurance
  - Example: Certificate Authority Security Council (CASC) funded in 2013- dedicated to addressing industry issues and educating the public on internet security.

Trust of Identity

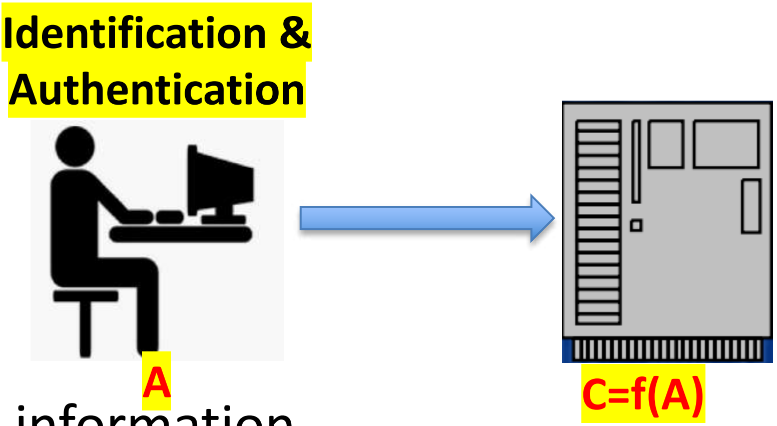
- Trust of a certificate
  - Depending on the trustworthiness of the certificate authority (CA)
  - Depending on the level of trust indicated by the CA
    - High: a passport
    - Low: an unsworn statement
  - It’s all relative
- The point
  - Identity has the trust issue
  - Certificate also has the trust issue

Authentication

- Purpose
  - To verify that a stated identity really belongs to the right entity
- Methods
  - What the entity knows – knowledge-based authentication
    - Password, PIN, DoB, mother’s maiden name, etc
  - What the entity has – token-based authentication
    - Badge, ID card, key, etc.
  - What the entity is – Biometric authentication
    - Fingerprints, personal characteristics, gait and motion biometrics, etc.
  - Where the entity is
    - Specific terminal, special access device, etc

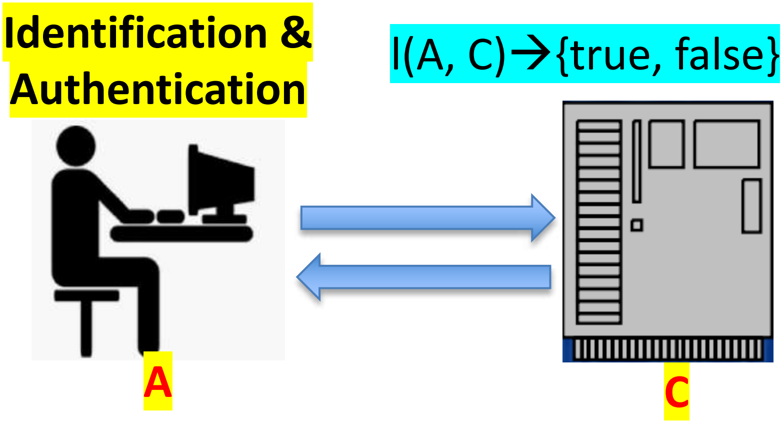
Authentication Components

- For creating and storing authentication information
  - Authentication information: A
    - For an entity to prove its identity
  - Complementary information: C
    - For a system to store authentication information along with the corresponding identity
    - For a system to verify authentication information
  - Complementary functions: F
    - For a system to generate the complementary information from the authentication information
    - For f belongs to F, f: A→ C



Authentication Components

- For performing authentication
  - Authentication functions: L
    - For the system to verify an identity
    - For l ∈L, l: A ×C→{true, false}
- For managing authentication information
  - For an entity to create or to alter the authentication and the corresponding complementary information



Identification & Authentication

I(A, C)→{true, false}

A

C

Passwords

- Purpose
  - To use information that an entity knows to verify that a stated identity really belongs to the entity
- Authentication method
  - What an entity knows
- Password protection
  - Passwords are not allowed to be transmitted without proper protection
  - For $f \in F$, $f: A \rightarrow C$ uses a one-way hash function

Password Attacks-Dictionary Attack

- Dictionary attack
  - Most passwords are not random sequences of characters and numbers, but instead are combinations of “normal” words, proper names, acronyms, etc.
    - E.g., “Betty23” or “ChocolateFrog”
  - In a dictionary attack a list of possible passwords is used in order to break into an account
    - The list might contain common words, names, acronyms, common passwords, etc.
    - This vastly reduces the search space

Password Attacks-
Brute-Force Attacks

- Brute-Force Attacks (exhaustive attack) involves trying every possible combination of characters until the correct password is found
- The time required to crack a password depends upon the length of the password
  - e.g., if a password is between 1 and 8 characters long, and is comprised of upper or lower case letter (52), numbers (10), or special characters (32 in an English keyboard). Then there are $\sum_{i=1}^{8} 94^i = 6.1\times 10^{15}$ possible passwords
  - If the password is exactly 8 characters long, then there are 94^8 possible passwords. ($\sum_{i=1}^{7} 94^i$ less possible passwords)
  - Making a password standards public can be a security risk

Counter-Measures to Password Guessing

- Goal
  - To maximize the amount of time consumed before the password is correctly guessed
- Calculation
  - P: probability of correctly guessing a password in a specified period of time, e.g., 0.5
    - In number of time units
  - G: number of password guesses that can be carried out in one time unit
  - T: number of time units for the calculation
  - N: total number of possible passwords
  - **Anderson's Formula**: $P \geq TG/N$ or $N \geq TG/P$

An Example of Password Guessing

- The objective
  - To determine the minimum length of password in a system
- Parameters
  - A=96 characters
  - G=10^4per second
  - P=0.5
  - T=365 days =365 ×24 ×60 ×60 seconds=31.536 ×10^6
- Assumptions
  - The length of time required to try out each password is constant
  - All passwords are equally like to be selected
- The result
  - N≥TG/P=6.31× 10^{11}
  - N=$\sum_{i=1}^{S} 96^i \geq 6.31\times 10^{11}$ → S≥ 6

Password Selection

- Theorem
  - When the selection of a password from a set of possible passwords is equally probable, the expected time that is needed for guessing a password is the longest
- Strong passwords
  - At least one digit
  - At least one letter (upper and lower)
  - At least one special character, e.g., punctuation, control character

Methods against Password Guessing

- Exponential back-off
  - Wait for t^{n-1}seconds before the next log-in when the n^{th}authentication attempt fails
    - t is a system parameter
- Disconnection
  - Disconnect after a specified number of failed attempts
- Disabling
  - Disable after a specified number of failed attempts
- Jailing (Honey pot)
  - Fool the attacker, then record all the activities that the attacker conducts

Biometrics

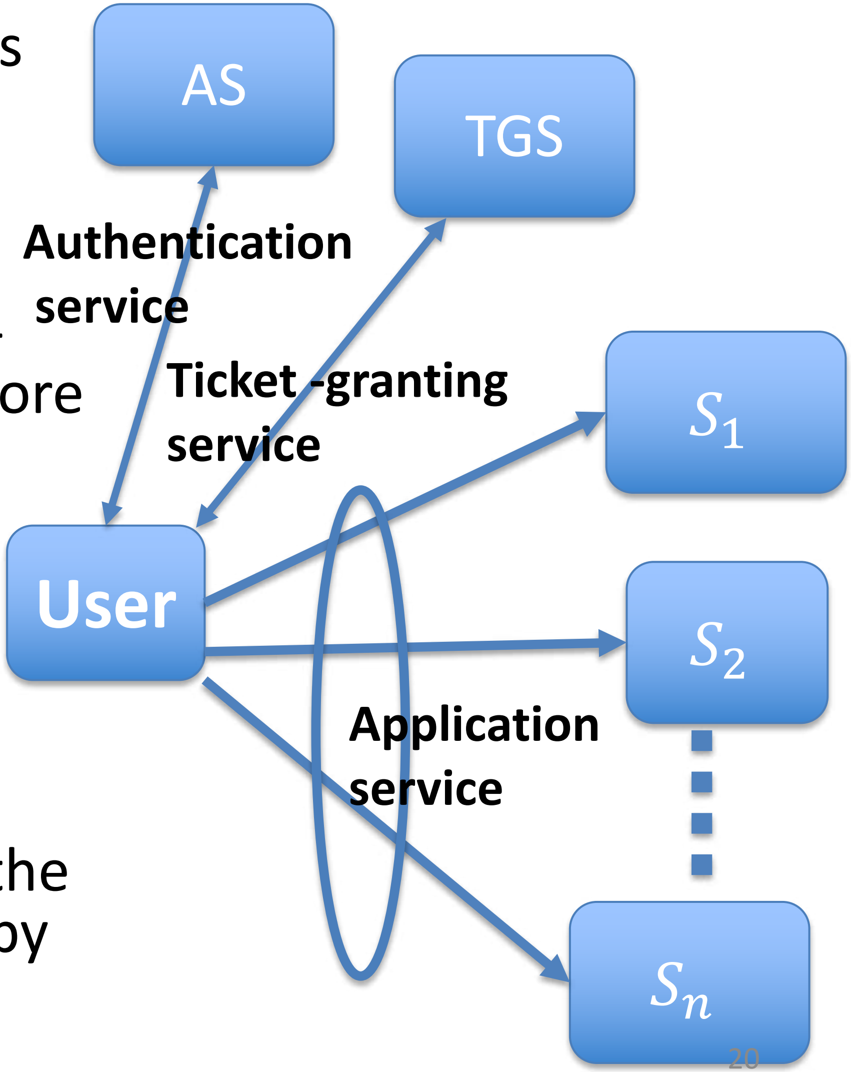
- Purpose
  - The use of automated measurement of biological or behavioural features to characterize and hence, identify an entity
- Methods (requires special sensors)
  - Fingerprints
  - Voices recognition
  - Eyes
  - Faces
  - Keystrokes (pressure, interval, duration, position, etc)
  - Gaits and motion biometrics

Strong authentication

- Authentication mechanisms utilize one or more of the flowing to establish a user’s identity:
  - What the entity knows – knowledge-based authentication
    - Password, PIN, DoB, mother’s maiden name, etc
  - What the entity has – token-based authentication
    - Badge, ID card, key, etc.
  - What the entity is – Biometric authentication
    - Fingerprints, personal characteristics, gait and motion biometrics, etc.
  - Where the entity is
    - Specific terminal, special access device, etc
- Combing two or more of these authentication mechanisms strengthens the authentication process

Kerberos Authentication

- Foundation
  - Needham-Schroeder protocol plus Denning and Sacco modification
- Kerberos application scenario
  - A system consist of a central authentication server AS, a ticket-granting server TGS and one or more application servers $S_1, \ldots, S_n$
  - AS authenticates a user to the Kerberos system
  - TGS issues tickets to the user to authenticate to the application servers
  - $S_1, S_2, \ldots, S_n$ can be accessed by the user by presenting tickets issued by TS



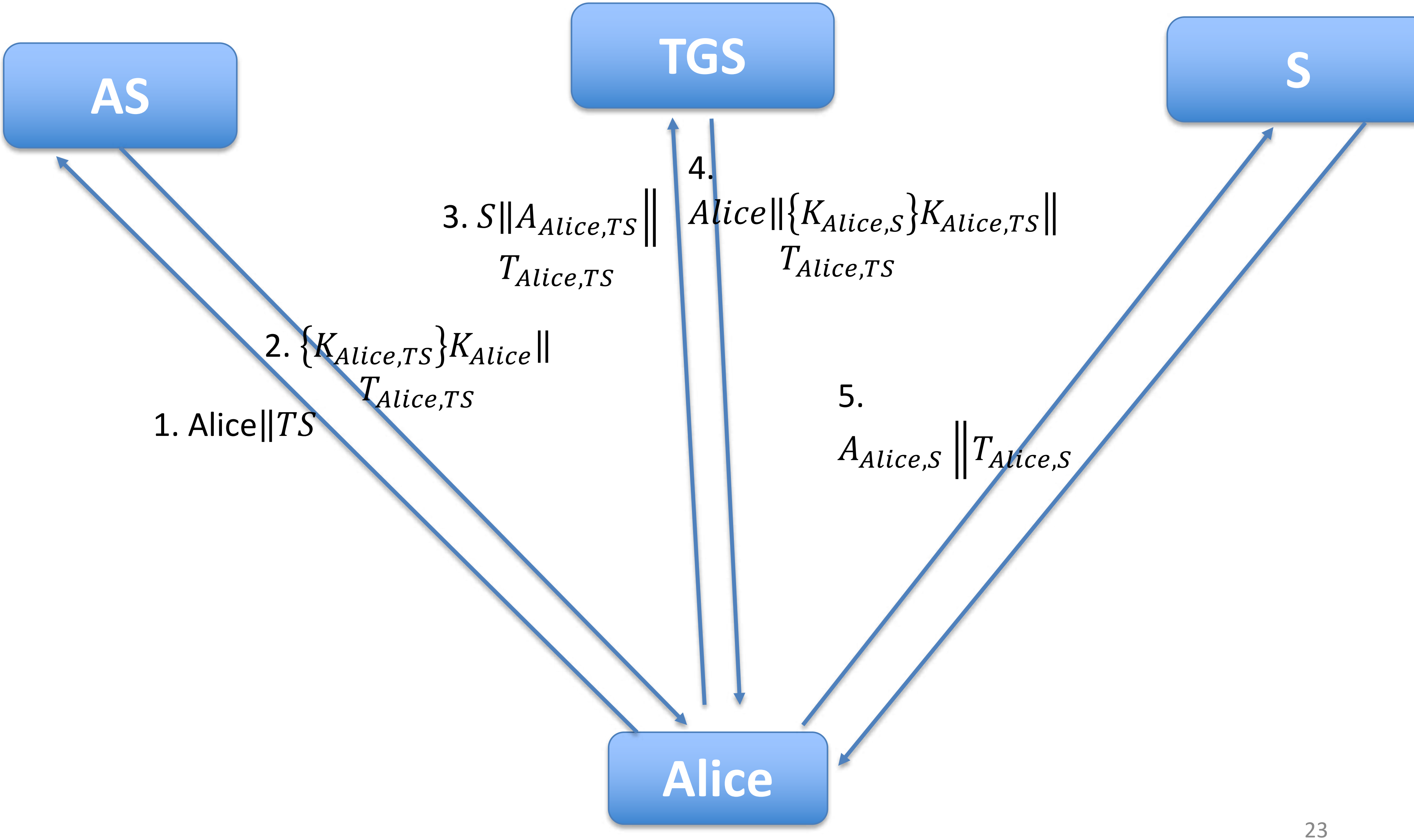
Components of the Kerberos Protocol

- Secret key based cryptography
- The authentication server AS shares a secret key with each and every user and with the ticket-Granting server TGS
  - Question: how to achieve the above?
- The ticket-Granting Server TGS shares a secret key with each and every of the applications severs $S_1, \ldots, S_n$

Components of the Kerberos Protocol

- Ticket
  - $T_{Alice,Server} = \{Alice \| Alice's\ address \| valid\ time \| K_{Alice,Server}\} K_{server}$
    - ❖ $K_{Alice,Server}$ is the session key generated by the server that created the ticket to be shared between “Alice” and “Server” so as to access “Server”
    - ❖ K_{server} is the secret key that “Server” shares with the server that created the ticket
  - To be presented by Alice to Server for access
- Authenticator
  - $A_{Alice,Server} = \{Alice \| t \| K_t\}\ K_{Alice,Server}$
    - ❖ $K_{Alice,Server}$ is the session key that is shared between “Alice” and “Server” so as to access “Server”
    - ❖ t is the timestamp when the authenticator is created
    - ❖ K_t is an alternative session key
  - To prove to Server that Alice has the session key

The Kerberos Protocol



AS

TGS

S

3. $S\|A_{Alice,TS}\|T_{Alice,TS}$

4. $Alice\|\{K_{Alice,S}\}K_{Alice,TS}\|T_{Alice,TS}$

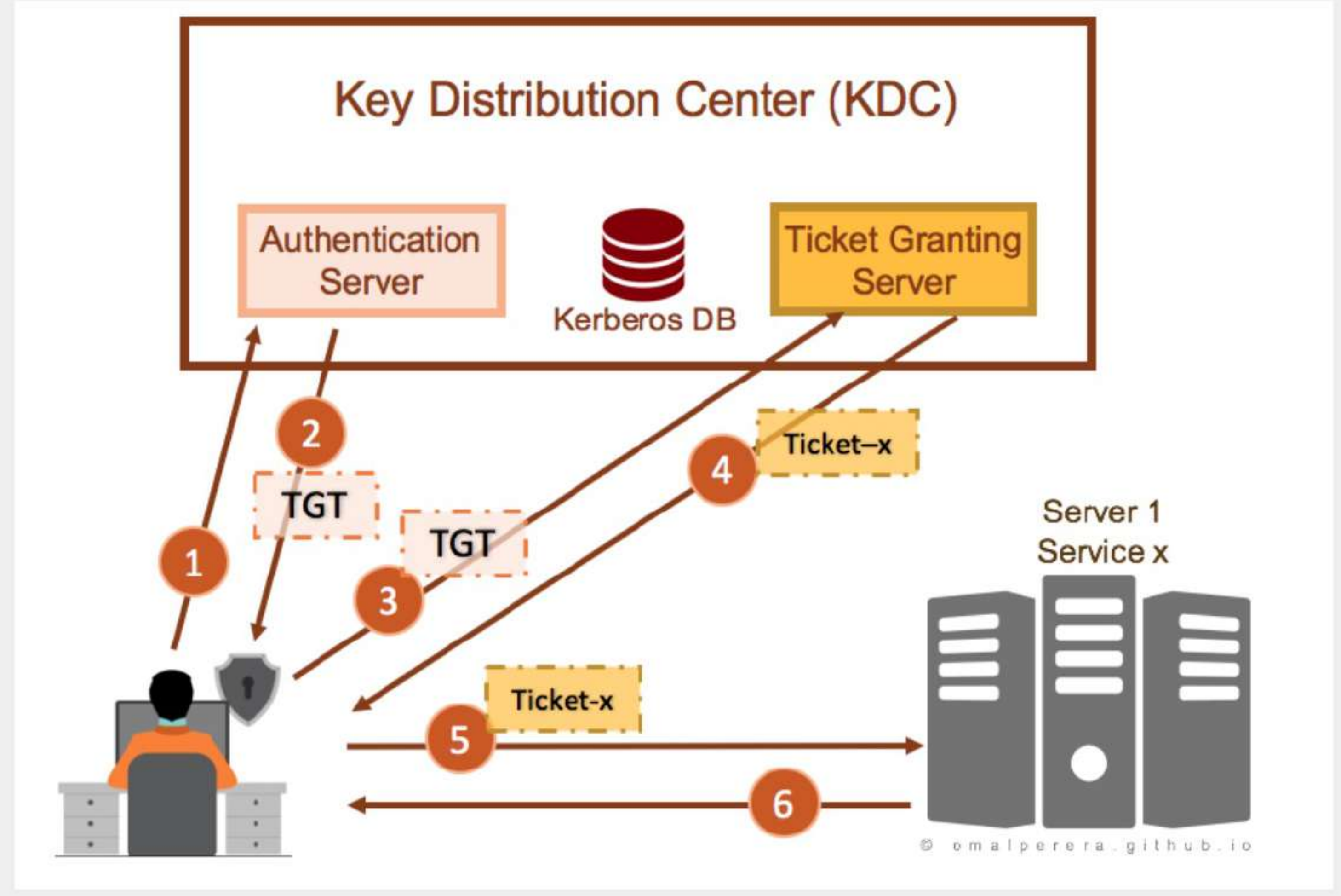
2. $\{K_{Alice,TS}\}K_{Alice}\|T_{Alice,TS}$

1. Alice$\|TS$

5. $A_{Alice,S}\|T_{Alice,S}$

Alice

The Kerberos Protocol



- Kerberos protocol messages are protected against eavesdropping and replay attacks.

*This figure is from website

Significance of Kerberos

- **Single sign-on**
  - User only needs to log in once with the Authentication Server (AS)
    - ❖Result: a ticket-issuing ticket is issued to the user to access the Ticket-Granting Server (TGS)
  - TGS issues tickets to the user to access the application servers
    - ❖Result: logging-in to the application servers is transparent to the user
- Widely used in financial systems and large-scale e-commerce applications

Summary

- Identity
- Identification
- Authentication
- Passwords and password attacks
  - Challenge and response
  - Biometrics
  - The Kerberos protocol
- **Reference book**: Introduction to Computer Security by Matt Bishop, 2004

Lab report

- Lab work and report instruction

- Moodle group (COMPSCI5063)
- Moodle group (COMPSCI4062)

- Lab 1 example