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Systems and Information Security SEGSI

Topic 1

Access Control

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Access Control

- Access control is the key to security
- Alternate definitions:
  - The ability to allow access only to authorized users, programs or system processes and resources
  - The granting or denial, in accordance with a security model, of access permissions to resources
  - Procedures performed by hardware, software or administrators to monitor access, validate and grant/deny access requests, based on pre-defined rules

Security Principles

- **Availability**
  - Systems are always usable and productive
- **Integrity**
  - Information is not corrupted or modified in unauthorized ways
- **Confidentiality**
  - Information is protected from unauthorized views or uses

Guarantee of security principles

- Through **identification**
  - Process of obtaining an identity
- Through **authentication**
  - Process by which an identity is validated or verified
- Through **authorization**
  - Process of assigning access modes according to identity
- Through **accounting**
  - Collection of access event information

Implementation

- Hardware
- Software
  - Applications
  - Standard protocols (Kerberos, IPSec)
- Physical access
- Logical implementation (written policies)

What to protect

- **Data**
  - Prevent unauthorized modification, copying, or viewing
- **Systems**
  - Use, unauthorized settings or service unavailability
- Almost all current operating systems still tend to assume that there is a very secure physical infrastructure (computing, peripherals, network, etc.)

Pro-active Control

- Background Checks
- Separation of tasks/responsibilities
- Distribution of knowledge
- Access/use policies and rules
- Classification of data
- Compulsory identification
- Handling procedures
- Modification of control procedures

Privacy Issues

- Access versus privacy control (GDPR)
  - Typically there is expectation of privacy by users
  - Policies can not only include privacy requirements
  - Monitoring activity in access to systems and services collides with privacy
  - In each service the banners should detail the expectations of privacy and the level of monitoring that will be carried out...

Physical access control

- Guards at the door
- Locks and traps
- Secure CCTV, IR sensors, alarms
- Identification devices
- Biometric Identification
- Perimeter Barriers
- Guard dogs
- Wide range facial recognition
- Etc.

Authentication

- Types of Authentication
  - Information only you know (**KNOW**)
    - Password, PIN, name of dog, some code, etc.
  - Object only you own (**HAVE**)
    - ATM Card, smart card, token, key, ID Card, national Card, passport, etc.
  - Characteristics of own (**BE**)
    - Fingerprint recognition, voice recognition, facial recognition, iris recognition, retinal recognition, body odor, DNA, etc.

Multi-factor Authentication

- 2 Factor Authentication
  - To increase security use 2 types of authentication:
    - ATM Card + PIN
    - Credit Card + signature
    - PIN + digital print
- 3 Factor Authentication
  - For even greater security:
    - Username + password + digital print
    - Username + passcode + token SecurID
    - Credit Card + signature + extra control

Passwords

- Problems with passwords
  - Potentially "unsafe"
    - Appeal to names of relatives, pets, phone numbers, birthdays, etc.
  - Decipherable
    - Computer programs may attempt to decode passwords on almost all operating systems
  - Inconvenient
    - They can be difficult and many to memorize
  - May be repudiated
    - When a transaction is only authenticated with a password, there is no real proof of identity of the individual who performed the transaction

Passwords

- Passwords attacks
  - Brute force (exhaustive)
    - Easy to make but take too long
  - Dictionary of words
    - Based on word repositories
  - Dictionary and heuristics
    - Example: John the Ripper, etc.
  - Fake login program
    - The authentication screen can be simulated
    - Why is used Ctrl+Alt+Del in MS-Windows?

Biometrics

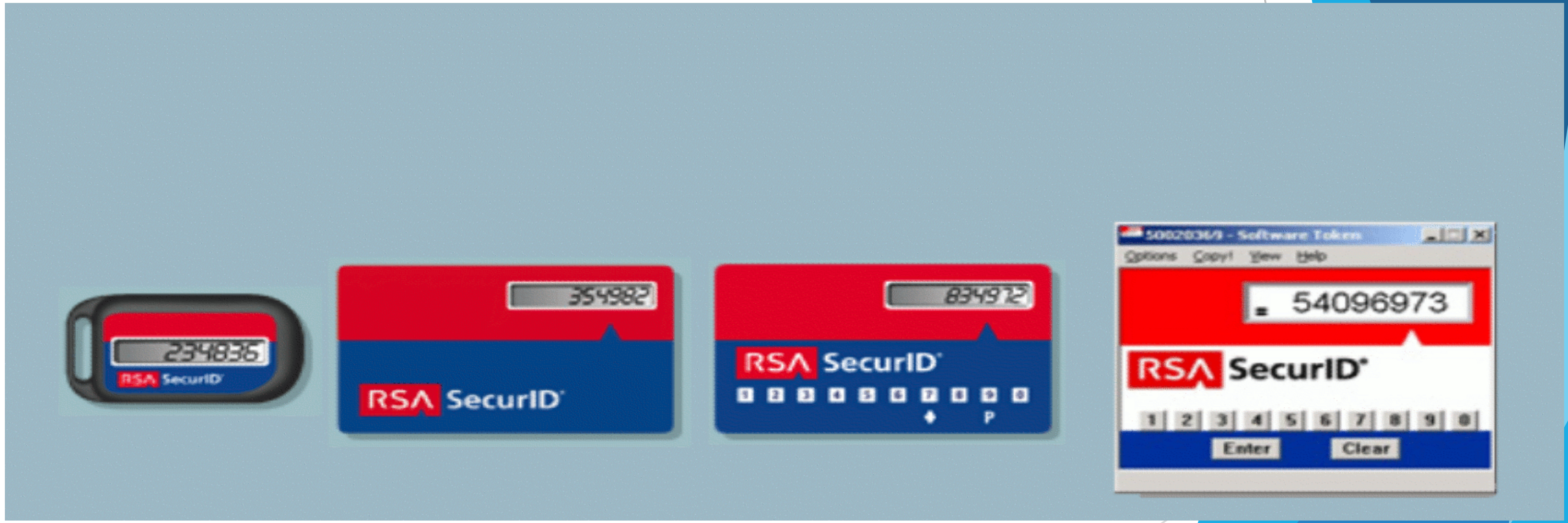
- Authentication by human characteristics
  - Measurable and distinctive personal characteristics are used to prove identity
    - Fingerprint (is unique except for twins)
    - The way the signature is made (dynamics)
    - Iris Patterns
    - Retinal patterns
    - The timbre/spectral composition of voice
    - Face characteristics
    - DNA
    - Relative blood composition
    - Etc.

Applications of Biometrics

- Control access to resources and networks
- Marking on time clocks
- Authorization of banking transactions
- In elections / passports / credit cards

Tokens

- Aim to facilitate one-time passwords
  - Physical card
  - SecurID
  - S/Key
  - Smart card



Access Control

- Common to all methods previously described, there is a shared secret that must be agreed between the system and the user
    - Usually, a password
- Like that, the sequence of operations is create_user – share_secret – access
- The database where the secret is stored varies according to the operating system and role played by it
    - Linux: /etc/passwd at the least
    - Windows: SAM on local systems, Active Directory (AD) on domain controllers

Access Control

- This might be a problem due to several reasons
  - If the system that stores the database is inaccessible, how can a user log?
  - When a user tries to log, how confident can he be that the system is the one that he expects to be?
  - How will be the organization aware of user’s log?
- Additionally, if a user logs into a network controlled by a server with several other server for different services, how confident can he be that each one of those servers is the expected one?

- Some centralized databases for user and eventually systems have been developed to mitigate these legitimate interests

LDAP

- ***Lightweight Directory Access Protocol*** (**LDAP**) is one of those
- It is a non-relational database that can host entity authentication
- Its data structure is very flexible and optimized for query operations
- Its structure is a tree, each branch being an **object** that has **attributes**
- The top of the structure is called **root**
- Attributes are indexed in order to optimize the search/query
- The client (human or system) accesses the global directory (which can contain multiple LDAP servers) through a client or ***Directory User Agent*** (**DUA**)
- This client in turn interacts with one or more servers or ***Directory System Agents*** (**DSA**) through the protocol LDAP

LDAP

- The LDAP protocol uses TCP as a transport mechanism and is based on ***Abstract Syntax Notation One*** **(ASN.1)**
- All LDAP messages are encapsulated in a format called LDAPMessage, a string in string format that contains a sequence number, an identifier, the intended operation, and a message
- If a message in which the sequence number is not recognized, the connection is terminated by returning a disconnection indication with an error code (ProtocolError) to the client
- In all other cases where it is not possible for the client or server to analyze the message, the connection is immediately terminated and may or may not return a message to the other end

LDAP

- The definition of the attributes of objects in LDAP must comply with the definition of the *schema* (defined in RFC 4512) and is therefore not free
- The *schema* contains the possible classes each containing the attributes that are valid and what kind of use is allowed in each one
- Some attributes are required, others are optional
- The definition of classes implements the concept of <u>inheritance</u>, so that when a class is a subclass of another, it incorporates the attributes of the hierarchically superior, and more attributes can be defined in the subclass

LDAP

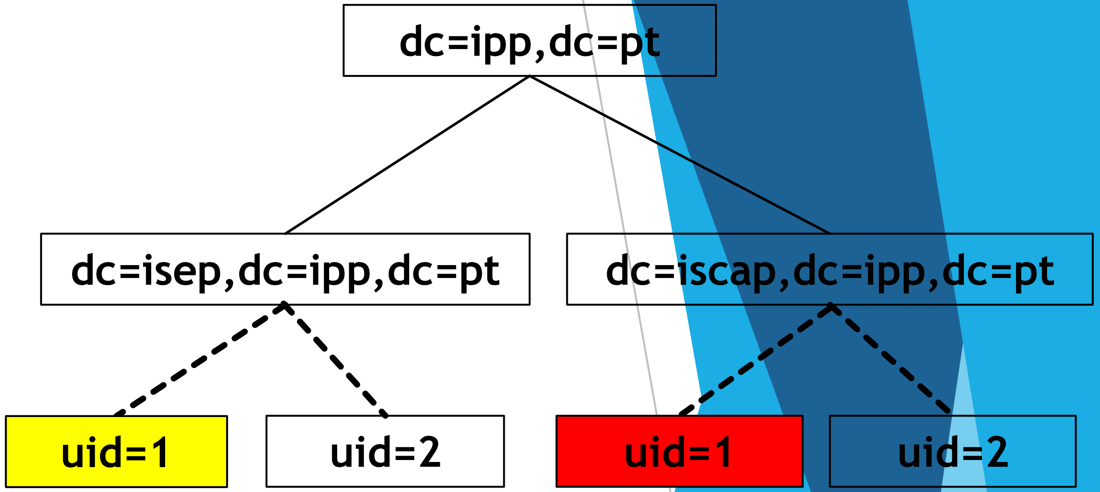
- There are structural and auxiliary classes (however optional)
- Each object belongs to a single structural class, but can additionally belong to several auxiliary classes
- Among the mandatory attributes is the ***Domain Component*** (**DC**) which can belong to the ***dcObject*** class (which is an auxiliary) usually combined with the structural class ***Organization***
  - Alternatively you can use the structural class ***Domain***
- Naming based on the DNS domain name has become common, with each of its parts being a **dc**, separated by commas
- DNS: **isep.ipp.pt**
- root: **dc=isep,dc=ipp,dc=pt**

LDAP

- The name that identifies a single, unique object in the LDAP tree is a ***Distinguished Name*** (**DN**)
- If the DN corresponds to *root*, it is called ***base DN*** or ***root DN***
- A DN must be unique in LDAP unambiguously identifying the object
- Attribute names however can be repeated throughout the structure, provided they are on different branches of the tree
- ***Relative Distinguished Names*** (**RDN**) are then distinguished, which, being unique and exclusive in the branch in which they are found, can be repeated in another branch.
- In the image, objects with RDN 1 have the DN

  (with yellow background) **uid=1,dc=isep,dc=ipp,dc=pt**

  (with red background) **uid=1,dc=iscap,dc=ipp,dc=pt**
- Under dc=isep, dc=ipp, dc=pt there can only be one uid=1, being one RDN, yet there may be others uid <> 1, as under dc=iscap, dc=ipp, dc=pt

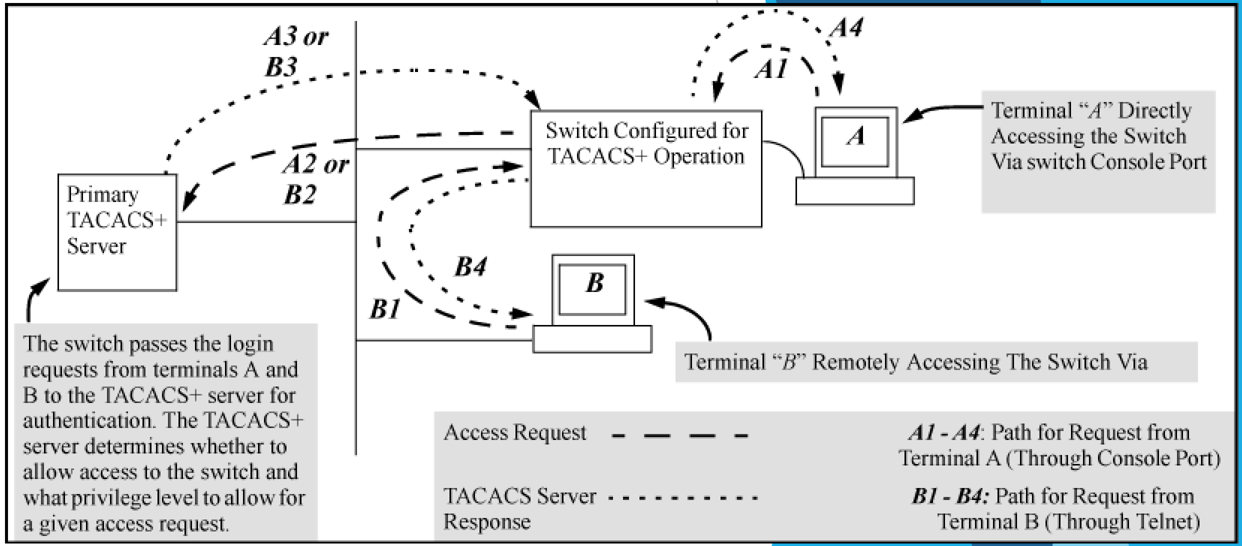


AAA

- To allow everyone to be aware (and able to demonstrate) the granted and / or denied access, an **AAA** (***Authentication*, *Authorization*, *Accounting***) system is a requisite
- Protocols have been developed to ensure support for AAA
- Among these, the ***Remote Authentication Dial In User Service*** (**RADIUS**) (RFC 2865)
- RADIUS is both a service and a protocol that use UDP to avoid constraints associated with TCP
- In RADIUS, accounting requests are registered only for the beginning and end of the session
- It uses 8 bits to set Attribute – Value pairs (AV)
  - AVPs contain authentication, accounting, authorization, routing, security and configuration information for the request and response

AAA

- Another protocol that supports AAA is the ***Terminal Access Controller Access-Control System Plus*** (**TACACS+**)
  - Evolution of TACACS and XTACACS but incompatible with them
- Unlike RADIUS it uses TCP
- One significant difference is that TACACS+ isolates the checks (authentication and authorization) and repeats the authorization whenever the execution of a new command is required



A3 or B3
A4
A1
A2 or B2
Primary TACACS+ Server
Switch Configured for TACACS+ Operation
A
Terminal "A" Directly Accessing the Switch Via switch Console Port
B4
B
B1
Terminal "B" Remotely Accessing The Switch Via
Access Request
TACACS Server Response
A1 - A4: Path for Request from Terminal A (Through Console Port)
B1 - B4: Path for Request from Terminal B (Through Telnet)

The switch passes the login requests from terminals A and B to the TACACS+ server for authentication. The TACACS+ server determines whether to allow access to the switch and what privilege level to allow for a given access request.

Source: techhub.hpe.com

AAA

- Later, an evolution based on RADIUS, although not compatible with it, emerged: **Diameter** (RFC 6733 in current version)
- As most important aspects,
  - Supports ***Extensible Authentication Protocol*** (**EAP**)
  - Supports ***Stream Control Transmission Protocol (*****SCTP**)
  - Allows failover mechanisms
  - It is based on TCP
  - Uses 32 bits to define Attribute-Value pairs (Attribute-Value Pair AVP) and is therefore more scalable
  - Supports wired networks, Wi-Fi, 3G, IP Multimedia Systems (IMS), and LTE/4G

Access Control

- There is still a problem, the confidence that a user might or can have when accessing a system that it is the correct one
- This has been solved with **Kerberos**, which is the most common system
- Kerberos was developed by MIT for internal use and later made available for external use
- The latest version is V5, described in RFC 4120
- It offers a ***Single Sign-On*** (**SSO**) solution to users and provides protection for authentication credentials
- It is designed to ensure strong authentication for client/server applications through the use of secret key cryptography
- Through extensions described in RFC 4556, initial authentication can use the ***Public Key Infrastructure*** (**PKI**)

Kerberos

- Each of the entities to which Kerberos can distribute keys is called a ***principal***
- Kerberos divides infrastructure into ***realms***
- Each realm must contain the key distribution service called ***Key Distribution Center*** (KDC)
- All users and resources (*principals*) are registered on the KDC, which maintains a database of everyone's keys
- The authentication server performs the functions of the KDC, two distinct and parallel services
  - *Authentication Service* (AS)
  - *Ticket Granting Service* (TGS)

Kerberos

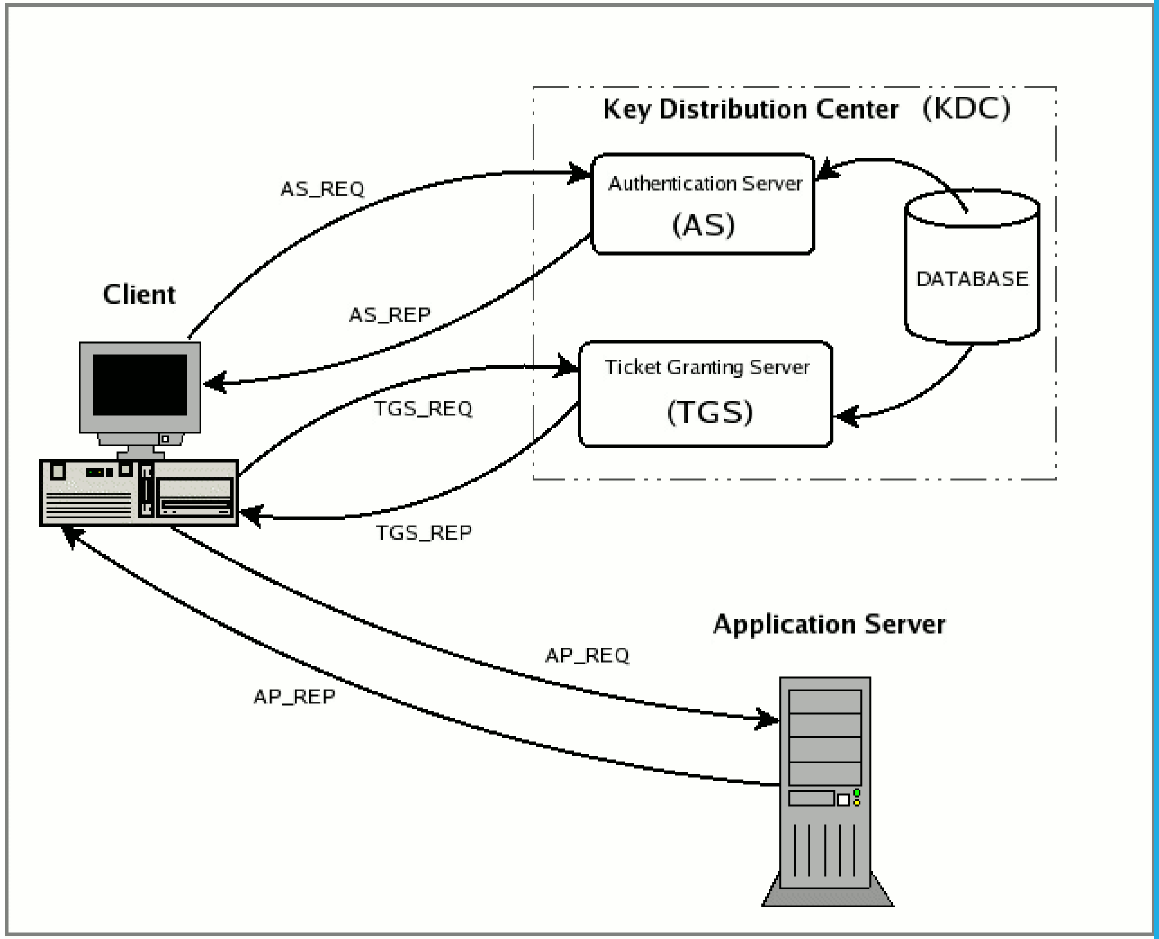
- **Authentication Server (AS)**
  - Have a key shared with the principals
  - Accept or reject the access attempt
  - Provide principals with a ticket allowing them to prove their identity to TGS
- **Ticket Granting Service (TGS)**
  - Provides ***Ticket-Granting tickets*** (**TGT**), session keys for temporary communication, to principals
  - Temporary, as TGT has a lifetime
  - If there is no time synchronization on the principals, access will be denied
  - TGT proves that the principal has authenticated with the KDC and is authorized to request access to resources

Kerberos

- Tickets are encrypted messages that prove authorization to access a resource
- A user asks for a ticket to access a resource, and if both (user and resource) are authenticated and the user has permission to use the resource, Kerberos (more exactly TGS) provides it
- In addition to lifetime, Kerberos tickets have specific usage parameters
- When a ticket expires the customer must request its renewal or a new ticket to continue using the feature
- Since all principals are authenticated, it ensures the identity and authorization of each other to the entire structure

Kerberos

- When a principal connects to the realm it sends an authentication request to the KDC
- If valid, a Ticket-Granting Ticket (TGT) is returned
- When the principal accesses after authenticating a resource on the network, the TGT he received is used to request another ticket to access the resource
- This new request is sent to the KDC which validates it



Source: kerberos.org

Kerberos

- Kerberos can manage trust relationships between different realms
- With this trust relationship, it is possible for a principal of a realm to access resources from a different realm without needing to have credentials in the AS of that other realm
- This process consists of defining each TGS as a principal in the other realm
- Regardless of the realm they are in, each principal can get a ticket to access resources from the other realm
- A realm is considered to be able to communicate with another realm if they both share an inter-realm key
  - This key will be used to encrypt remote realm resource access request tickets

Kerberos

- Kerberos also supports hierarchy between realms
  - An example is Microsoft's Active Directory domains in the same tree
- If there is a hierarchy, the trust relationship is transitive, that is, if *realm A* trusts *realm B* and *realm B* trusts *realm C*, then *realm A* trusts *realm C*

Kerberos

- As a drawback of Kerberos, note that KDC is a SPOF
- The keys are based on user passwords, so a "weak" password enhances their capture and subsequent access to the key
- Kerberos does not provide fault tolerance mechanisms, so it is reasonable to configure more than one KDC in the same realm, however:
  - The synchronization of databases must be done using external systems (automatic or manual)
  - Applications should be prepared on a trial-error basis, ie if the main KDC does not respond, try the alternate KDC and so on until success or failure after traversing all KDCs
    - This functionality is however available in Microsoft's Active Directory
- If the main KDC is down, Kerberos administration cannot be done until it is restored

Access Control Models

- Discretionary Access Control (DAC)
- Mandatory Access Control (MAC)
- Role Based Access Control (RBAC)
- Attribute Based Access Control (ABAC)
- Access Lists (ACLs)
- Capabilities
- Formal Models
  - Biba
  - Take/Grant
  - Clark/Wilson
  - Bell/LaPadula
    - Uses Set Theory to define the concept of secure state, access modes and roles in granting accesses

MAC versus DAC

- Discretionary Access Control (DAC)
  - The user of the objects decides how and with whom to share them
  - The system assumes a secondary role and essentially validates all interactions
- Imperative or Mandatory Access Control (MAC)
  - The system decides how objects are shared and validates the interactions
  - The user has a secondary role

RBAC versus ABAC

- Role Based Access Control (RBAC)
  - Access to objects is given accordingly to the role performed by the user, not the user by itself
  - The system decides how objects are shared and validates the interactions
- Attribute Based Access Control (ABAC)
  - The system decides how objects are shared according to definitions (like location, timeline, function) and validates the interactions

DAC

- Relevant aspects
  - It is the owner of the object who controls the access permissions
  - The restriction of access is guaranteed by the user's profile of the object
  - It is used to separate and protect users from unauthorized data
  - It is used by Unix systems, Windows, Linux, Solaris, FreeBSD and others

MAC

- Relevant aspects
  - Sensitivity levels are used (labels)
  - Each object is assigned a level of sensitivity and will only be accessible by users with access up to that level
  - Only system administrators can change the level of objects
  - It is considered safer than DAC
  - Used in systems where security is critical

RBAC

- Relevant aspects
  - It is a static model based on user roles or profiles within the organization
  - Each defined profile has its own permissions to access specific objects (resources, data)
  - Allows organizations to eliminate the implementation of individual access controls
  - Controls are easy to establish and assign
  - Flexibility and simplicity
  - Complex in setup and administration on large organizations
  - Neglects the principle of least privilege

ABAC

- Relevant aspects
  - Dynamic model that leverages data and attributes unique to the user
  - Allows the creation of more complex and flexible authorization rules that take into account various attributes in addition to the profile, such as roles, location, time and date, among others
  - Allows more complex and flexible authorization rules to be defined, consistent security policies to be enforced, and risk-based security policies (e.g., conditional access) to be enforced
  - Requires little maintenance and is scalable
  - Initial configuration is complex
  - Management in large systems can become complicated when it comes to inheriting permissions, the need to grant more specific privileges makes it difficult to handle/create access profiles

Formal Methods

- Problems of formal methods
  - They are based on static infrastructures
  - They define very brief policies
  - Do not work in extremely dynamic and reconfigurable enterprise environments
  - None of the models mentioned deals with
    - Viruses/active content
    - Trojan horses and others
    - Firewalls
  - Documentation is scarce to assist in the implementation phase of systems

Access Control Lists (ACL)

- Relevant aspects
  - It is a mechanism used by the access control system to determine who can access which programs, by what methods and at what times
  - There are implementations of access control lists in all modern operating systems
  - Some types of access
    - Read/Write/Execute
    - Create/Modify/Delete/Rename

Capabilities

- Similar to ACL but read in reverse
- Each line contains the user and the accesses he has to the resources

ACL →

Object	r	w	x

Capabilities →

User	Resource 1	Recourse 2	Resource N
Bob	r	rw	x

ACL versus Capabilities

- ACL
  - Simple to implement
  - Data oriented
  - Less suited to environments where users are constantly changing
- Capabilities
  - Runtime security checking is more efficient
  - Delegation of rights without much difficulty
  - Change of a file status can suddenly become more tricky as it can be difficult to find out which users have access

UNIX Permissions

- Standard UNIX Systems
  - Permissions are ***Read Write eXecute***
  - User profiles are ***User Group Other***
  - Permissions applied to normal files
    - How They Work?
  - Permissions applied to directories
    - How They Work?
- Linux systems with file systems Ext2/3/4 and others
  - Additional permissions to those of rwx
    - a c d i j s t u A C D S T

Windows Permissions

- Windows systems
  - Permissions are ***Read eXecute Write Delete***
  - The permissions categories are many...
    - No access / List / Read
    - Add / Add & Read
    - Change / Full Control
  - For each object there is a list of entities that can manipulate this object
    - More versatile and simple to configure than the standard UNIX access control model

Access Control

- The gathering of all these properties (and some more irrelevant here) is the domain of ***Network Access Control*** (**NAC**)
- In fact, NAC is a concept of controlling access to an infrastructure by implementing security policies
- Its goals are to
  - Mitigate and/or prevent zero-day attacks
  - Apply a security policy across the infrastructure
  - Use identities to perform access control
- These objectives can be achieved through various mechanisms (security policies with definition of security control, filtering, prevention, among others)
- NAC will act as an automatic detection and response system that can react in real time to prevent threats before they do damage

NAC

- NAC can be implemented using two criteria separately or a mixture of both
- **Pre-admission**
  - Requires a system to meet all security requirements (such as installed updates, updated antivirus) before it can communicate with the network
- **Post-admission**
  - Allow or deny access based on user activity, which in turn is based on a previously defined authorization matrix
- The pre-admission criteria refers mainly to systems and services
- The post-admission criteria refers mainly to users