Network Security

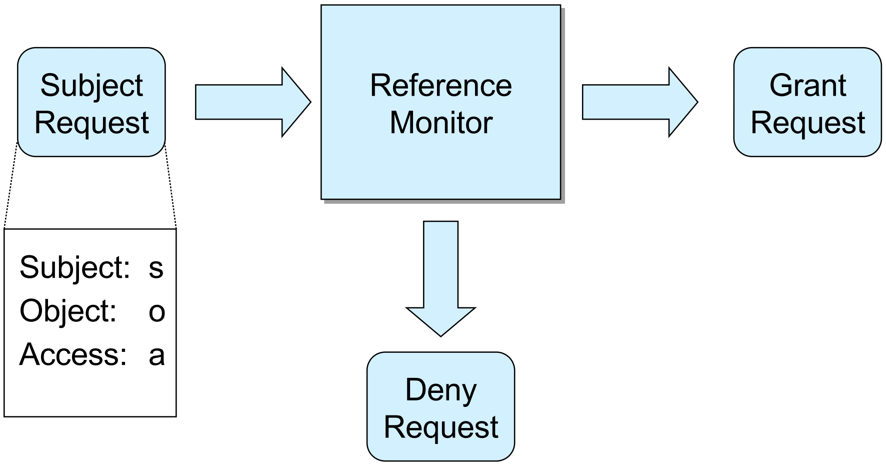
Chapter 9
Access Control

What is Access Control?

- Definition:

  Access control comprises those mechanisms that enforce mediation on subject requests for access to objects as defined in some specified security policy.

- An important conceptual model in this context is the *reference monitor*:



Security Policy (with respect to access control)

- In order to make access control decisions, the reference monitor needs to know the *security policy* of the system
- Definition:

  The *security policy* of a system defines the conditions under which subject accesses to objects are mediated by the system reference monitor functionality
- Remarks:
  - The above definition is usually given in the context of computer and operating systems security
  - The reference monitor is just a conceptual entity, it does not necessarily need to have a physical or logical counterpart in a given system
  - The term *security policy* is often also used in a wider sense to describe a specification of all security aspects of a system including threats, risks, security objectives, countermeasures, etc.

Classical Computer Subjects, Objects & Types of Access

- Definition:

  A *subject* is an active entity that can initiate a request for resources and utilize these resources to complete some task
- Definition:

  An *object* is a passive repository that is used to store information
- The above two definitions come from classical computer science:
  - Subjects are processes, and files, directories, etc. are objects
- However, it is not always obvious to identify subjects and objects in the context of communications:
  - Imagine an entity sending a message to another entity: is the receiving entity to be viewed as an object?
- Furthermore, we need to have some understanding of what is an *access* and what types of access do exist:
  - Classical computer science examples for access types: read, write, execute
  - Object oriented view: any method of an object defines one type of access

Security Labels (1)

- Definition:

  A *security level* is defined as a hierarchical attribute with entities of a system in order to denote their degree of sensitivity

  - Examples:
    - Military: unclassified < confidential < secret < top secret
    - Commercial: public < sensitive < proprietary < restricted

- Definition:

  A *security category* is defined as a nonhierarchical grouping of entities to help denote their degree of sensitivity

  - Example (commercial): department A, department B, administration, etc.

- Definition:

  A *security label* is defined as an attribute that is associated with system entities to denote their hierarchical sensitivity level and security categories

  - In terms of mathematical sets: Labels = Levels × Powerset(Categories)

Security Labels (2)

- Security labels that denote the security sensitivity of:
  - Subjects are called *clearances*
  - Objects are called *classifications*
- An important concept to the specification of security polices are *binary relations* on the set of labels:
  - A binary relation on a set *S* is a subset of the cross-product *S* × *S*
  - Example:
    - *Dominates: Labels × Labels*

      $$\begin{aligned} Dominates = \{(b1,b2) \mid\ & b1, b2 \in Labels \wedge \\ & level(b1) \geq level(b2) \wedge \\ & categories(b2) \subseteq categories(b1)\} \end{aligned}$$

    - If $(b1, b2) \in Dominates$, we also write *b1 dominates b2*

Security Policy Specification

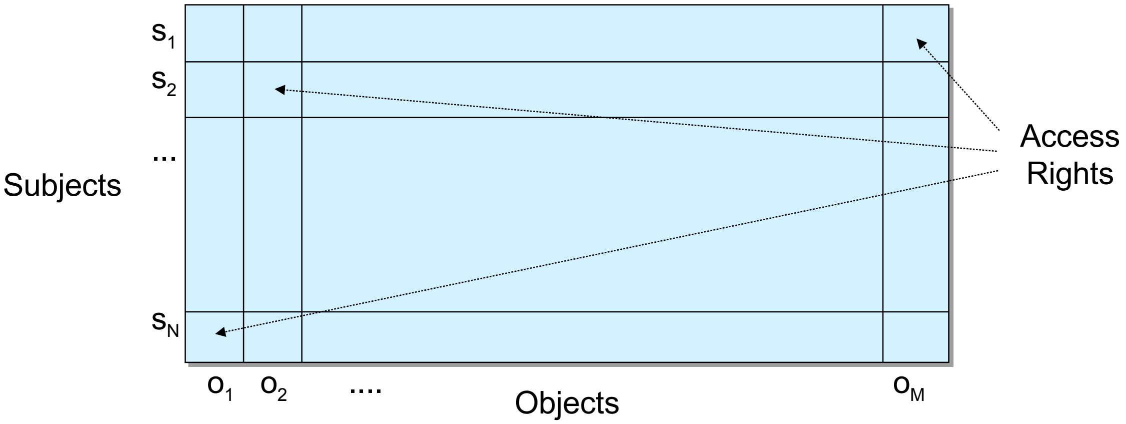
- Formal expressions for security policy rules:
  - Consider the following mappings:
    - allow: Subjects × Accesses × Objects → boolean
    - own: Subjects × Objects → boolean
    - admin: Subjects → boolean
    - dominates: Labels × Labels → boolean
  - The above mappings can be used to specify well-known security policies:
    - ownership: ∀ s ∈ Subjects, o ∈ Objects, a ∈ Accesses: allow(s, o, a) ⇔ own(s, o)
    - own_admin: ∀ s ∈ Subjects, o ∈ Objects, a ∈ Accesses: allow(s, o, a) ⇔ own(s, o) ∨ admin(s)
    - dom: ∀ s ∈ Subjects, o ∈ Objects, a ∈ Accesses: allow(s, o, a) ⇔ dominates(label(s), label(o))
- The dom-policy requires a system to store and process security labels for each entity, but allows for more complex access control schemes than the ownership and own_admin policies

Types of Access Control Mechanisms

- An *access control mechanism* is an actual realization of the reference monitor concept
- There are two main types of access control mechanisms:
  - *Discretionary access control* comprises those procedures and mechanisms that enforce the specified mediation at the discretion of individual users
    - Example: the Unix operating system allows users to give or withdraw the read/write/execute access rights for files they own
  - *Mandatory access control* comprises those procedures and mechanisms that enforce the specified mediation at the discretion of a centralized system administration facility
- Both types may be combined, with the mandatory access control decisions most of the times overriding discretionary ones
  - Example:
    - Use of discretionary access control on personal computers combined with mandatory access control for communications (→ firewalls)

Access Matrices

- A useful concept in the description of access control mechanisms is the *access matrix:*
  - In an access matrix for two sets of subjects and objects every row corresponds to one subject and every column to one object
  - Each cell of the matrix defines the access rights of the corresponding subject to the corresponding object



Common Access Control Schemes

- *Access Control Lists (ACL):*
  - ACLs are the basis for an access control scheme, where for each object a list of valid subjects is stored which might have access to this object (possibly together with the type of access that is allowed)
  - ACLs are usually used with discretionary access control, as there are too many ACLs for being maintained by a central administration facility
- *Capabilities:*
  - Capabilities are somehow the opposite concept to ACLs as with capabilities each subject owns a list of access rights to objects
  - The advantage (and danger) of capabilities is, that a subject can give some of it’s capabilities to other subjects
- *Label-based access control:*
  - If security labels are stored and processed with the entities of a system, they can be used to perform label-based access control
  - This scheme is usually used as a mandatory access control mechanism

→ Data integrity of access control data structures is critical!