Access Control Basics

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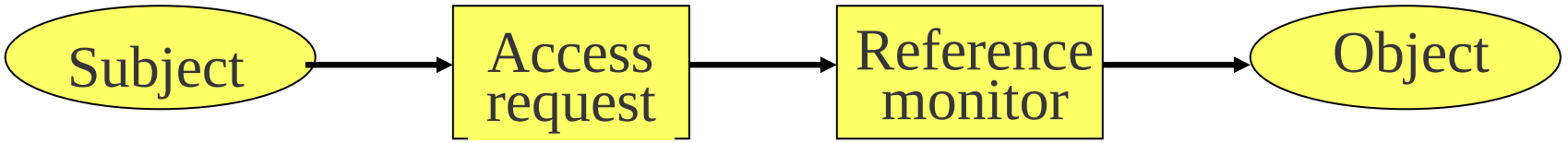
Access Control - basic concepts

- An access control system regulates the operations that can be executed on data and resources to be protected
- Its goal is to control operations executed by subjects in order to prevent actions that could damage data and resources
- Access control is typically provided as part of the operating system and of the database management system (DBMS)

Access Control - basic concepts



• The very nature of access control suggests that there is an *active* subject *requiring access* to a passive *object* to perform some specific *access operation.*

• A *reference monitor* grants or denies access

• This fundamental and simple notion of access control is due to Lampson

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B. Lampson. Protection. *ACM Operating System Reviews*, **8**, 1974.

Access Control Mechanism

- It is typically a software system implementing the access control function
- It is usually part of other systems
- The access control mechanism uses some access control policies to decide whether to grant or deny a subject access to a requested resource
- We will refer to an *access control system* as system comprising an access control mechanism and all information required to take access control decisions (for example, access permissions)

Object

- Anything that holds data, such as relations, directories, interprocess messages, network packets, I/O devices, or physical media
- We often refer to objects, controlled by the access control system, as *protection objects*
- Note that not all resources managed by a system need to be protected

Subject

- An abstraction of any active entity that performs computation in the system
- Subjects can be classified into:
  - *users* -- single individuals connecting to the system
  - *groups* -- sets of users
  - *roles* -- named collections of privileges / functional entities within the organization
  - *processes* -- executing programs on behalf of users
- Relations may exist among the various types of subject

Access Operations - Access Modes

- Operations that a subject can exercise on the protected objects in the system
- Each type of operation corresponds to an *access mode*
- The basic idea is that several different types of operation may be executed on a given type of object; the access control system must be able to control the specific type of operation
- The most simple example of access modes is:
  - read look at the contents of an object
  - write change the contents of an object
- In reality, there is a large variety of access modes
- The access modes supported by an access control mechanism depend on the resources to be protected (read, write, execute, select, insert, update, delete, …)
- Often an access control system uses modes with the same name for different types of object; the same mode can correspond to different operations when applied to different objects

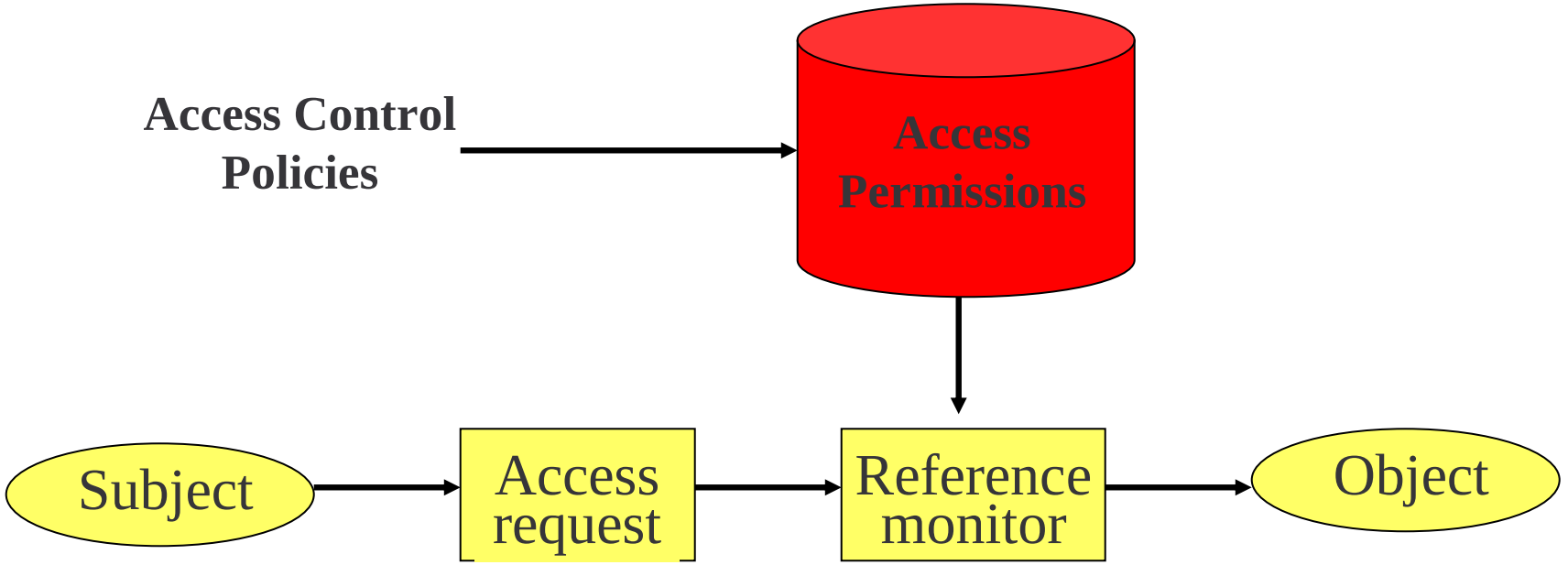
Access Operations - Access Modes
An example

- Unix operating system
  - Access modes defined for files
    - read: reading from a file
    - write: writing to a file
    - execute: executing a (program) file
  - Access models defined for directories
    - read: list a directory contents
    - write: create or rename a file in a directory
    - execute: search a directory

Access Operations
Access Permissions and Attributes

- How does the reference monitor decides whether to give access or not?
- Main approaches:
  - It uses *access permissions*
    - Typical of discretionary access control (DAC) models
  - It uses information (often referred to as *attributes*) concerning subjects and objects
    - Typical of multilevel access control (MAC) models
- More innovative approaches have been developed where access permissions can be also expressed in terms of object and subject attributes and even context parameters

Access Operations
Access Permissions



Access Permissions

- Access permissions, also called *authorizations*, are expressed in terms of subjects, objects, and access modes
- From a conceptual point of view an access permission is a tuple <*s, o, a*> where
  - *s* is a subject
  - *o* is an object
  - *a* is an access mode

  It states that subject *s* has the permission to execute operation *a* on object *o*

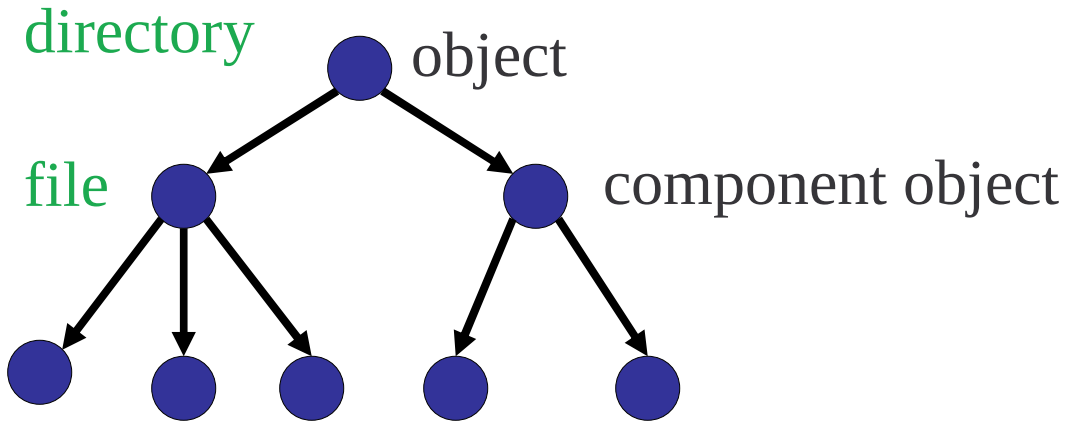
  We also say that *s* has access right *a* on object *o*
- Example: the access permission <Bob, Read, F1> states that Bob has the permission to read file F1

Access Permissions

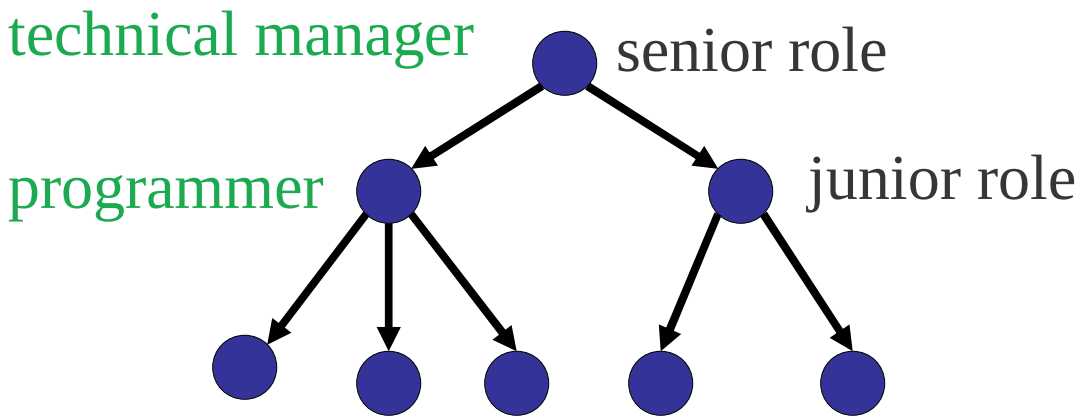
- Subjects, objects, and access modes can be organized into hierarchies
- The semantics of the hierarchy depends on the domain
- The use of hierarchies has two important advantages:
  - It reduces the number of permissions that need to be entered into the access control system, thus reducing administration costs
  - Combined with negative authorizations (to be discussed later on), it supports the specification of exceptions

Object Hierarchy

PART-OF

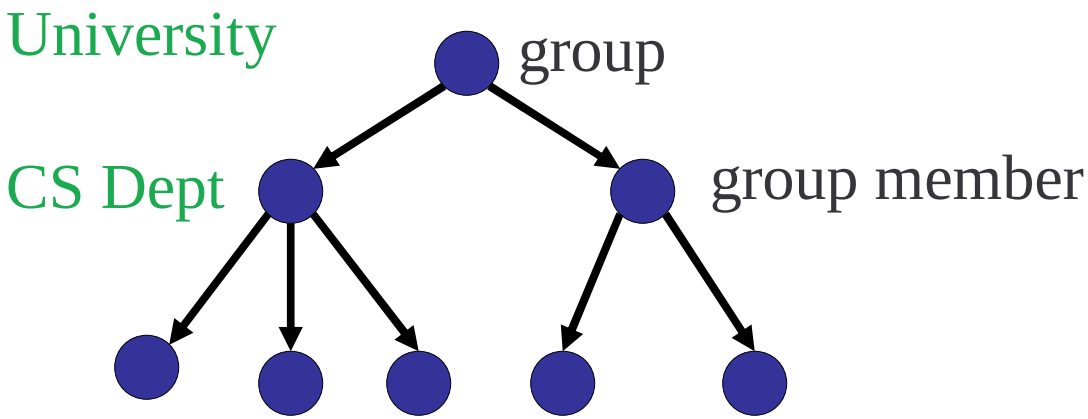


Role Hierarchy



Group Hierarchy

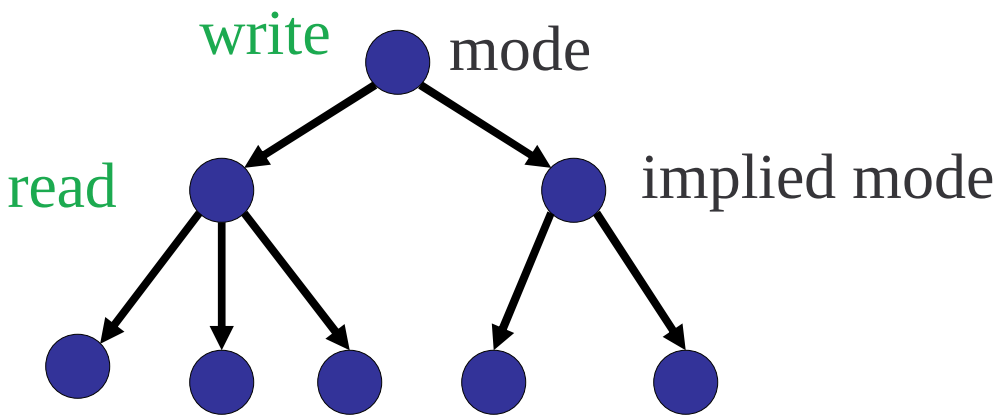
GROUP MEMBERSHIP



Suppose that the group CS department has 200 members and the University group 5000 members; suppose we have the policy that the department calendar can be read to all members of the University and written only by the members of CS; these policies can be encoded into two access permissions of the form:
<University, calendar, Read> <CS Dept, calendar, Write>

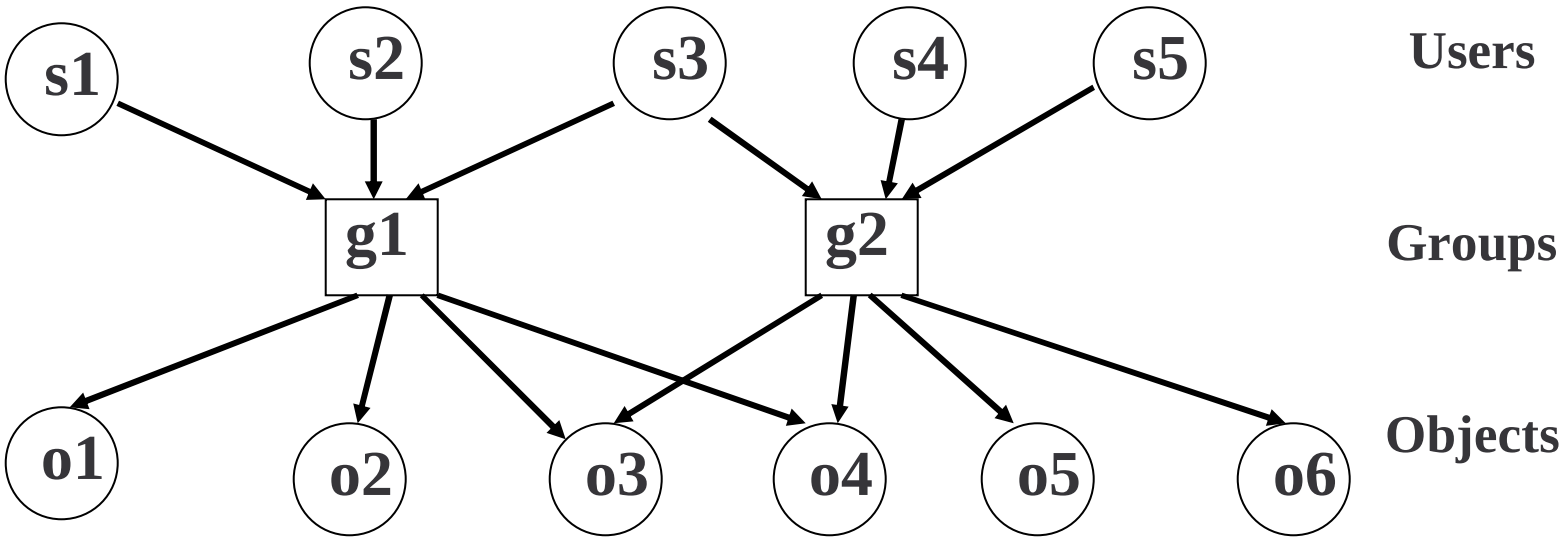
Access Mode Hierarchy

SUBSUMPTION



Groups and Negative Permissions

- Groups can be seen as an intermediate level between users and objects
- An example of an ideal world where all access permissions are mediated by groups



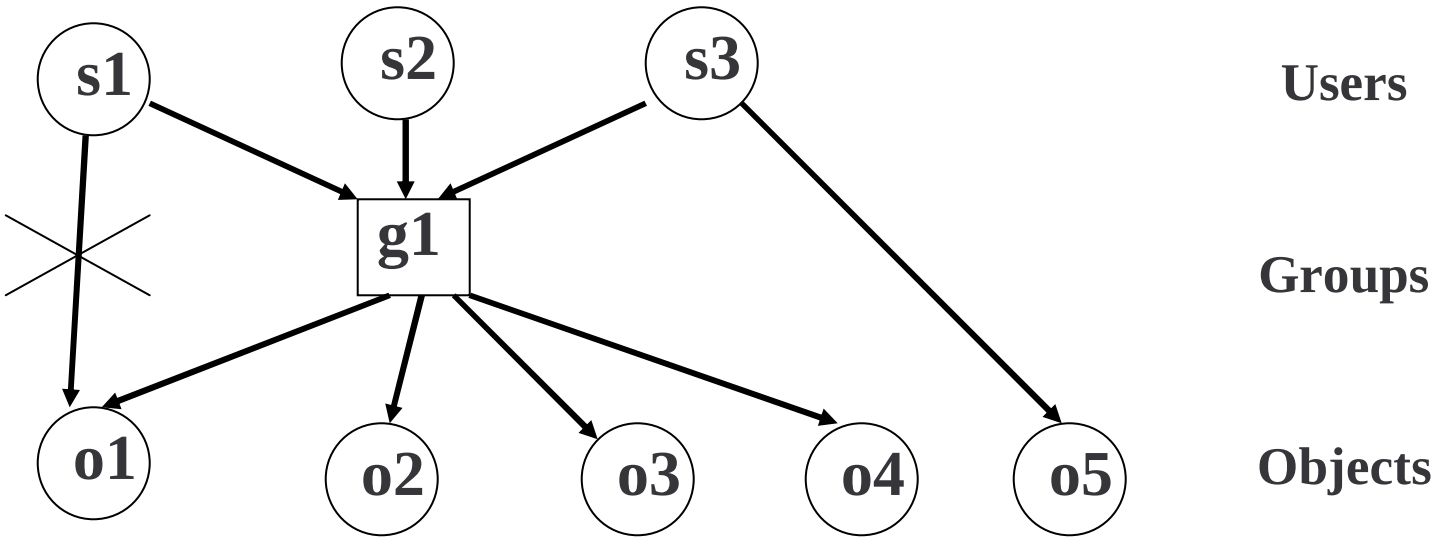
Groups and Negative Permissions

- Often access control policies have special cases where is proves convenient to give some user a permission for an object directly or *deny* a user a permission that it would normally derive from its membership in some group
- A *negative* permission specifies an operation that a subject is not allowed to perform
- Representing negative permissions requires extending our simple tuple model with an additional component:

  <*s, o, a, sign*> where *sign* Î{+, -}

Groups and Negative Permissions

An example in which not all access permissions are mediated through groups



Ownership and Administration

- A key question when dealing with access control is who specifies which subjects can access which objects for which operations
- In the case of permissions, this means specifying which are the subjects that can enter permissions

Ownership and Administration
Two basic options

- *Discretionary* approach
  - the owner of a resource decrees who is allowed to have access
  - But then: who is the owner of a resource?

- *Mandatory* approach
  - a system-wide policy decrees who is allowed to have access

Access Control Structures

The most well known access control structures for DAC models are based on the notion of *Access Control Matrix.* Let:

- *S* be a set of subjects
- *O* be a set of objects
- *A* be a set of access modes

An access control matrix *M* on *S, O,* and *A* is defined as

$$M = (M_{so})_{s \in S,\, o \in O} \text{ with } M_{so} \subset A$$

The entry M_{so} specifies the set of access operations subject *s* can perform on object *o.*

Access Control Structures
Example

	bill.doc	edit.exe	fun.dir
Alice	-	{execute}	{execute, read}
Bill	{read, write}	-	{execute, read, write}

Access Control Structures
Access Control Lists and Capabilities

- Directly implementing access control matrices is quite inefficient, because in most cases these matrices are sparse
- Therefore two main implementations have been developed
  - Access control lists
    - Used in DBMS and Operating Systems
  - Capabilities

Basic Operations in Access Control

- *Grant* permissions
  - Inserting values in the matrix's entries
- *Revoke* permissions
  - Remove values from the matrix's entries
- *Check* permissions
  - Verifying whether the entry related to a subject *s* and an object *o* contains a given access mode