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CSE 543: Computer Security
Module: Access Control

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Access Control

- Method for restricting the operations that processes may perform on a computer system
  - aka Authorization

Access Control

- Why do you need access control?

A Brief History

- Early computing systems had no isolation
  - Shared memory space
  - Shared file space
- Some physical limitations made this OK
  - Batch processing
  - Load the tape/disk for the application
  - Network? What network?
- In the mid-60s people started to work on ‘multiuser’ or ‘time-sharing’ systems
  - What about a bug?
  - What about my data?

Multiprogrammed Systems

- Multics project
  - AT&T, MIT, Honeywell, etc.
  - General purpose, multi-user system
  - Comprehensive security
    - Hardware protection
    - Subject labeling
    - Permission management
- UNIX project
  - Spin-off of Multics project
    - When AT&T left
  - A stripped-down multiuser system

Access Control

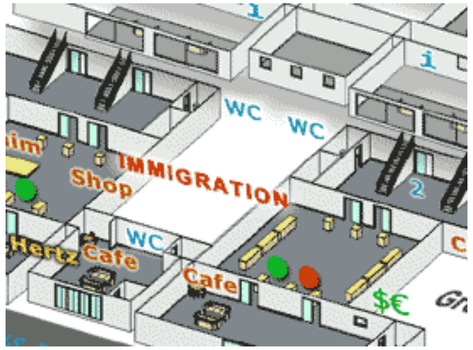
- Why do you need access control?
  - Protection
    - Prevent errors - oops, I overwrote your files
  - Security
    - Prevent unauthorized access under all conditions

Access Control

- What is needed for "security"?
  - Protect the process - limit others' access to your resources
  - Confine the process - limit your access to others' resources

Security Policies

- A security policy specifies the rules of security
  - Some statement of secure procedure or configuration that parameterizes the operation of a system
  - Example: Airport Policy
    - Take off your shoes
    - No bottles that could contain > 3 ozs
    - Empty bottles are OK?
    - You need to put your things through X-ray machine
    - Laptops by themselves, coat off
    - Go through the metal detector



- Goal: prevent on-airplane (metal) weapon, flammable liquid, dangerous objects … (successful?)

Control Access

- An identity permits access to resources
- In computer security this is called
  - *Access control*
  - *Authorization*
- In authorization, we talk about:
  - Subjects (for whom an action is performed)
  - Objects (upon what an action is performed)
  - Operations (the type of action performed)
- Authorization limits a *subject*'s access perform an *operation* on an *object*
  - The combination of object and operations allowed are called a *permission*

Access Control Policy

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- What is access control policy?
  - *Check whether a process is authorized to perform perform operations on an object*
- Authorize
  - Subject: Process
  - Object: Resource that is security-sensitive
  - Operations: Actions taken using that resource
- An object+operations is called a permission
  - Sets of permissions for subjects and objects in a system is called an access control policy

Access Control Policy

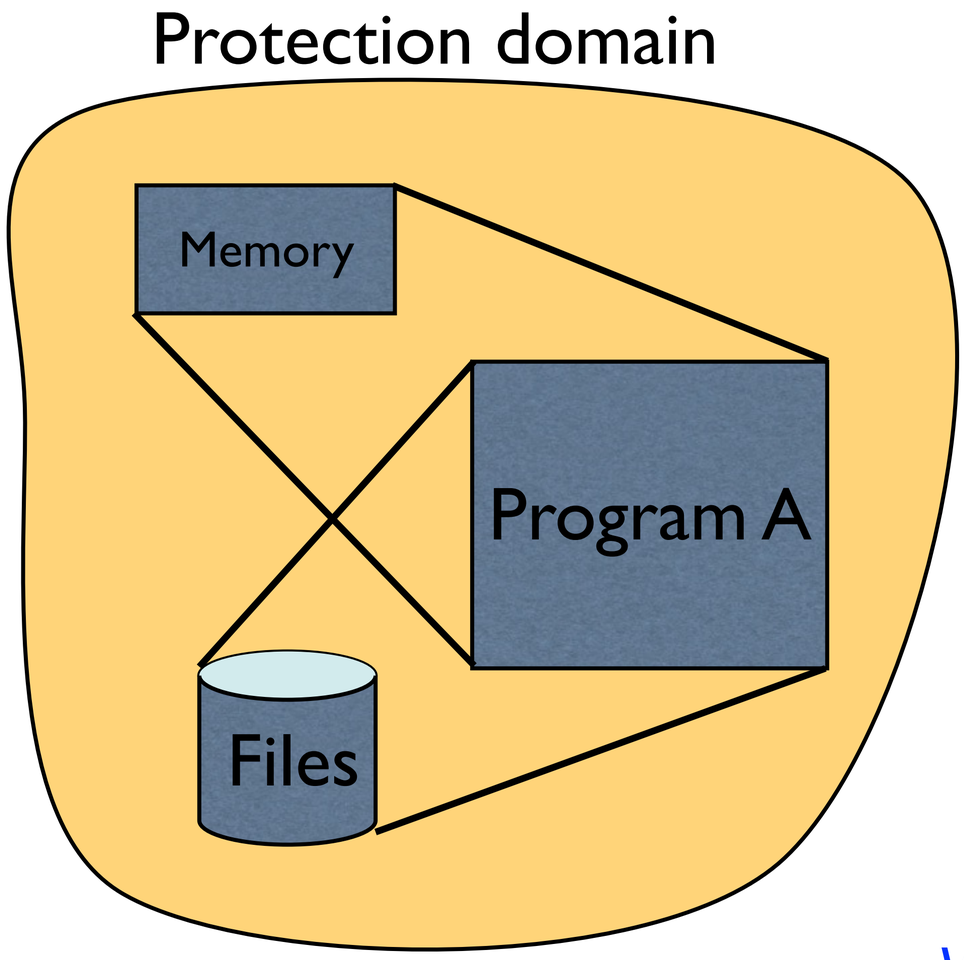
- Access control policy determines what *operations* a particular *subject* can perform for a set of *objects*
- It answers the questions
  - E.g., do you have the permission to read /etc/passwd
  - Does Alice have the permission to view the CSE website?
  - Do students have the permission to share project data?
  - Does Dr. Hussain have the permission to change your grades?

- An Access Control Policy answers these questions

Access Control Concepts

- Subjects are the active entities that do things
  - E.g., you, Alice, students, Prof. Jaeger
- Objects are passive things that things are done to
  - E.g., /etc/passwd, CSE website, project data, grades
- Operations are actions that are taken
  - E.g., read, view, share, change

Protection Domains



- The *protection domain* is a term for describing the totality of permissions available to an individual process
- Protection domain includes
  - Process memory
  - File system permissions - many things are files in UNIX
  - network resources
  - Etc.

What should the protection domain of each process be?

Policy is defined with respect to the protection domain it governs.

Access Policy Model

- A *protection system* answers authorization queries using a protection state (S), which can be modified by protection state methods (M)
  - Authorization query: Can subject perform requested operation on object? Y/N
- A *protection state* (S) relates subjects, objects, and operations to authorization query results
  - E.g., in mode bits, ACLs, … — the policy
- A *protection state methods* (M) can change the protection state (i.e., policy)
  - Add/remove rights for subjects to perform operations on objects — change the policy

Specifying Policy

- Problem - identify subjects, objects, and operations
  - And authorized permissions for subjects
  - And rules for switching between subjects
- Finer policy is better for security and functionality, but is harder to write and manage

Protection Domains

- Balance function and security
- Functionality
  - Operations to get the job done
- Security
  - Prevent operations that may lead to compromise
- Challenge: Figuring out and specifying authorized operations for each process

The Access Matrix

- An access matrix is one way to represent a protection state.
  - Conceptual

- Columns are objects, subjects are rows.
  - To determine if S_i has right to access object O_j, find the appropriate entry.
  - Often entries list the set of operations permitted for that subject-object pair

- The access matrix represents O(|S|*|O|) rules

	O_1	O_2	O_3
S_1	Y	Y	N
S_2	N	Y	N
S_3	N	Y	Y

The Access Matrix

- Suppose the private key file for J is object O_1
  - Only J can read
- Suppose the public key file for J is object O_2
  - All can read, only J can modify
- Suppose all can read and write from object O_3
- What's the access matrix?

	O_1	O_2	O_3
J	?	?	?
S_2	?	?	?
S_3	?	?	?

ACLs and Capabilities

- An access matrix is one way to represent a protection state.
  - Conceptual

- Columns are objects
  - Access control lists define the subjects that can access each object - and the operations
- Subjects are rows
  - Capabilities define the objects that can be accessed by each subject - and the operations

- This is how access policies are stored

	O_1	O_2	O_3
S_1	Y	Y	Y
S_2	N	Y	Y
S_3	N	Y	Y

Access Control Problem

- Identify subjects, objects, and operations in each system
  - Minimize effort of parties that specify policies
  - Minimize likelihood of failures
    - Protection — failures due to benign errors
    - Security — failures due to malicious activities
    - Function — failures because programs don't run
- Design an Access Control Model
  - Subjects - Per process or group a set of processes?
  - Objects - Per object or group a set of objects or permissions (object/ops)?
  - Rules - How to compose multiple requirements?

Access Control Problem

- You run three programs
  - One from the system - passwd
  - One application - editor
  - One from the Internet - email attachment
- What access control policies should be assigned to each program? For protection? For security?
- How to make specifying access control policies easy?

Homework!

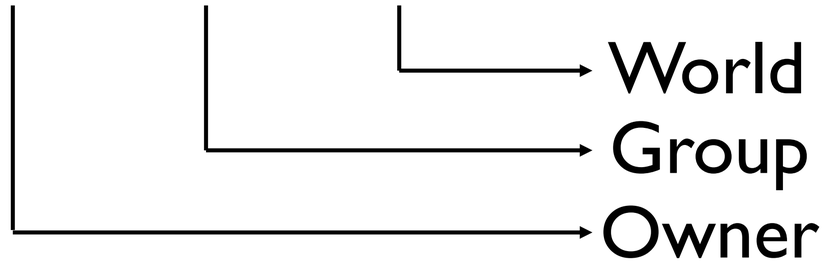
Commodity OS Security

- UNIX and Windows Protection Systems
  - How do they identify subjects/objects to express access control policies?

The UNIX FS access policy

- Really, this is a bit string ACL encoding an access matrix
- E.g.,

rwx rwx rwx



- And a policy is encoded as "r", "w", "x" if enabled, and "-" if not, e.g,

rwxrw---x

- Says owner can read, write and execute, group can read and write, and world can execute only.

Caveats: UNIX Mode Bits

- Access is often not really this easy: you need to have certain rights to parent directories to access a file (execute, for example). The reasons for this are quite esoteric.

rwx rw- --x

- The preceding policy may appear to be contradictory
  - A member of the group does not have execute rights, but members of the world do, so …
  - A user appears to be both allowed and prohibited from executing access
  - Not really: these policies are *monotonic* … the absence of a right does not mean they should not get access at all. If any of your identities have that right in any class (world, group, owner), you are authorized.

UNIX UIDs

- Processes and files are associated with user IDs (UIDs)
- File UID indicates its owner (who gets owner perms)
  - Group UID also (who gets group perms)
- Process UID indicates the owner of the process
  - Normal user
  - System (root)
  - Now, some special UIDs for some programs
  - Also, a process may run under multiple Group UIDs

- How do we switch UIDs (e.g., run a privileged program)?

UID Transition: Setuid

- A special bit in the mode bits
- Execute file
  - Resulting process has the effective (and fs) UID/GID of file owner
- Enables a user to *escalate privilege*
  - For executing a trusted service
- Downside: User defines execution environment
  - e.g., Environment variables, input arguments, open descriptors, etc.
- Service must protect itself or user can gain unauthorized access
  - UNIX services often run as root UID -- many via setuid!

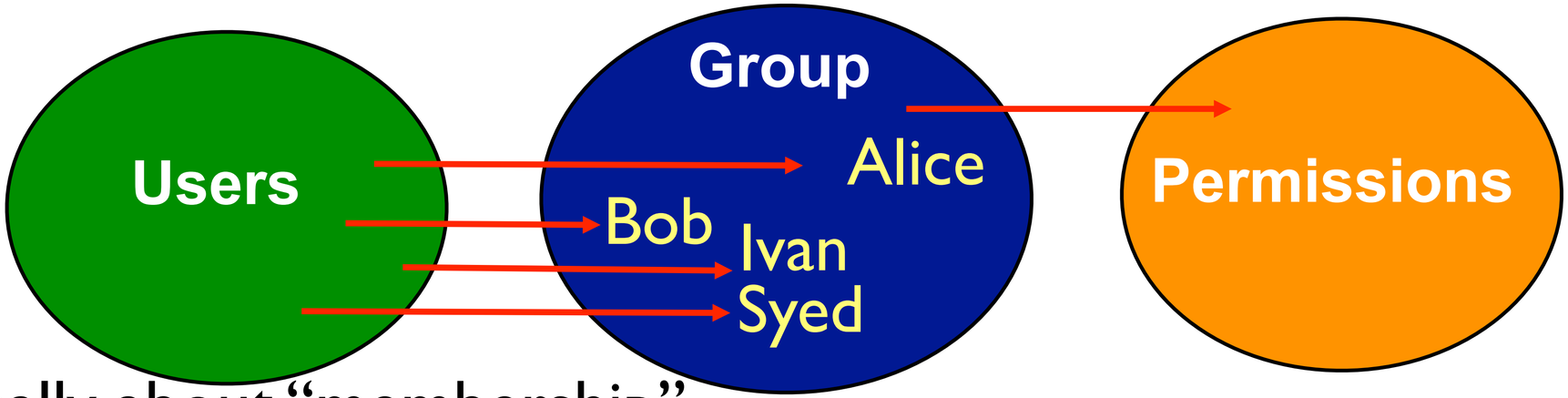
Job Functions

- In an enterprise, we don't really do anything as ourselves, we do things as some job function
  - E.g., student, professor, doctor

- One could manage this as groups, right?
  - We are assigned to groups all the time, and given similar rights as them, i.e., mailing lists

Groups

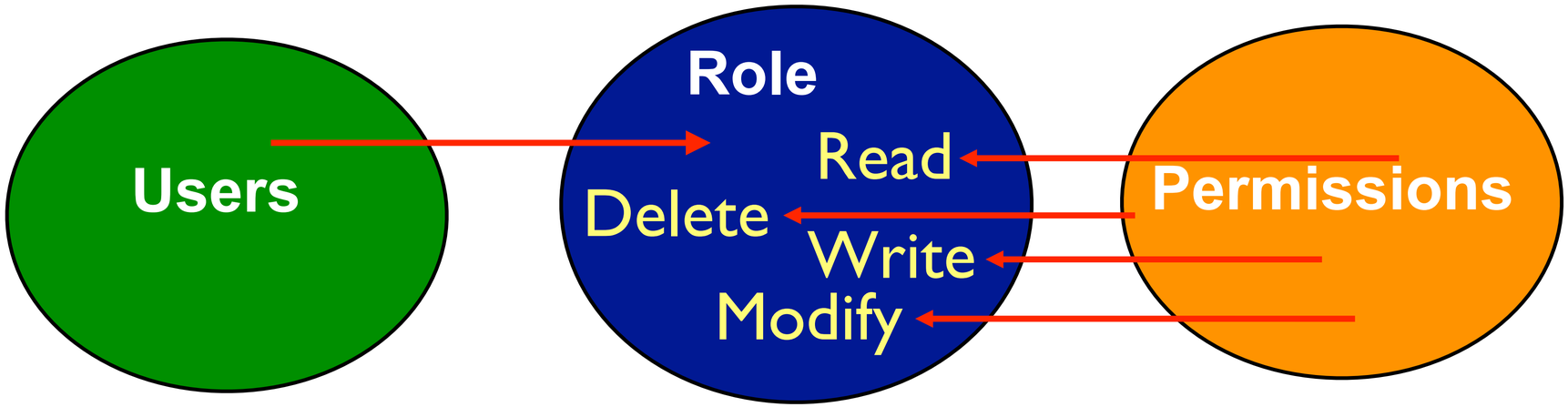
- Groups are collections of identities who are assigned rights as a collective
- Important in that it allows permissions to be assigned in aggregates of users …



- This is really about "membership"
  - Group-Permission assignments are transient

Roles

- A role is a collection of privileges/permissions associated with some function or affiliation
- NIST studied the way permissions are assigned and used in the real world, and this is it …



- Important: the permission-role membership is static, the user-role membership is transient

Role Based Access Control

- Most formulations are of the type
  - U: users -- these are the subjects in the system
  - R: roles -- these are the different roles users may assume
  - P: permissions --- these are the rights which can be assumed
- There is a many-to-many relation between:
  - Users and roles
  - Roles and permissions
- Relations define the role-based access control policy

Take Away

- Goal: Define protection states to restrict the operations that each process may perform
  - For protection from bugs and security from adversaries
  - Operating systems do that by
    - Associating processes with IDs (subjects)
    - Authorizing objects and operations (permissions)
- Approach: Protection system
  - Protection state: Relates subjects to authorized permissions
  - Methods for modifying the protection state
- UNIX and Windows implement protection systems
  - Have different notions of subjects and permissions
  - Trade-off complexity and expressive power
- Compared with role-based access control models