PennState

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?

Access Control

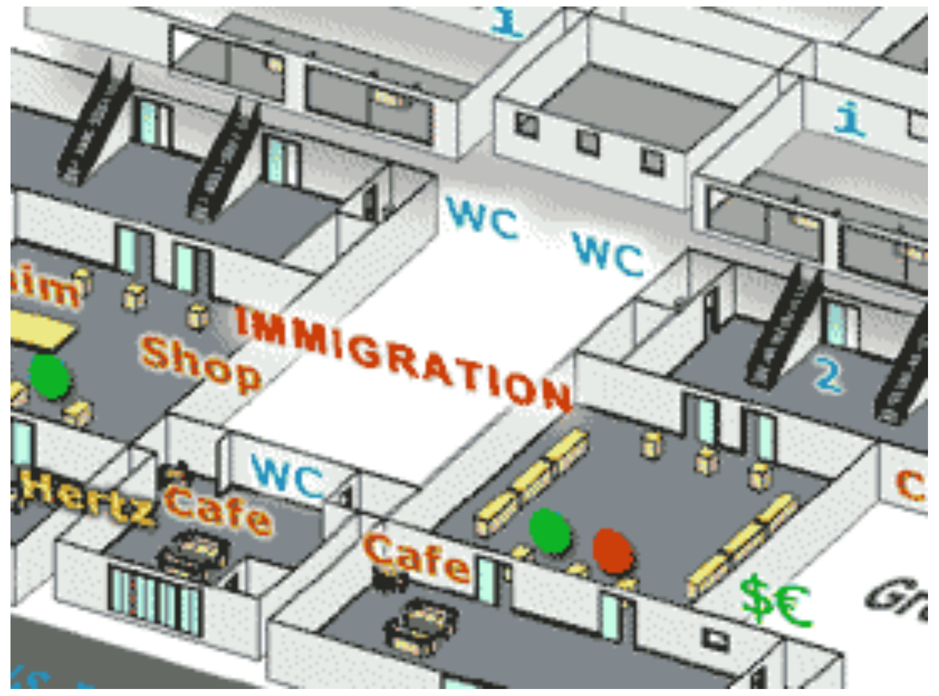
- Why do you need access control?
  - Protection
    - Prevent errors - oops, I overwrote your files
  - Security
    - Prevent unauthorized access under all conditions

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?)

Access Control Policy

- 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

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

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

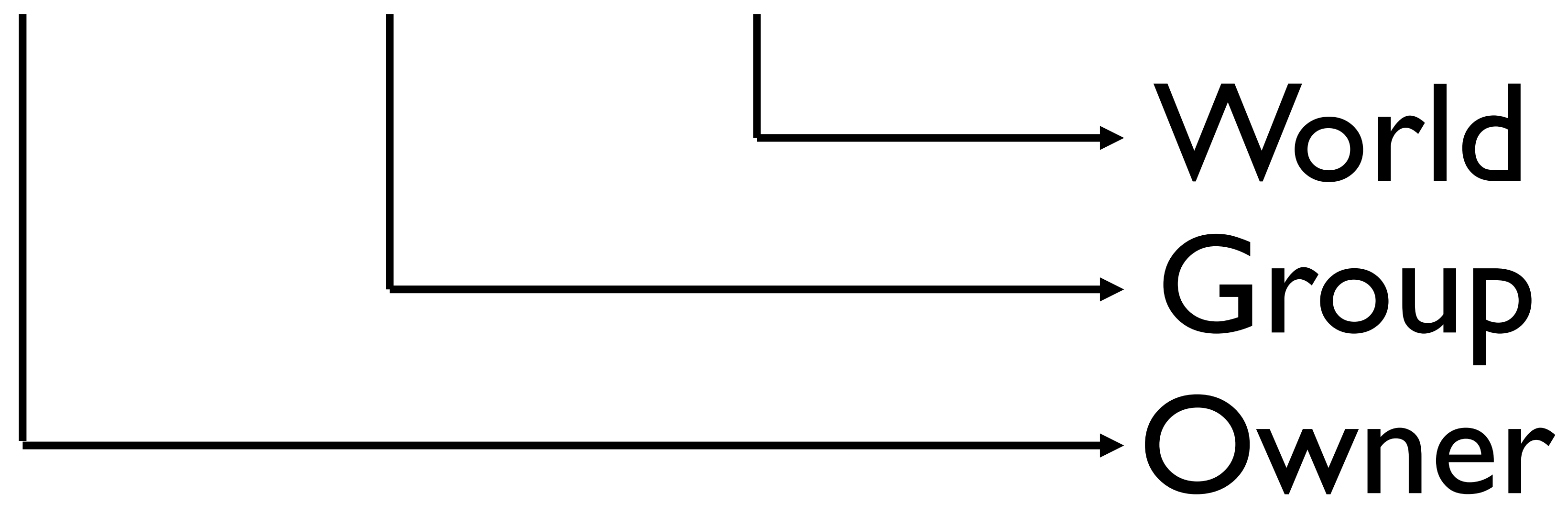
- UNIX and Windows Protection Systems
  - How do they identify subjects/objects to express access control policies?

UNIX®

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)?

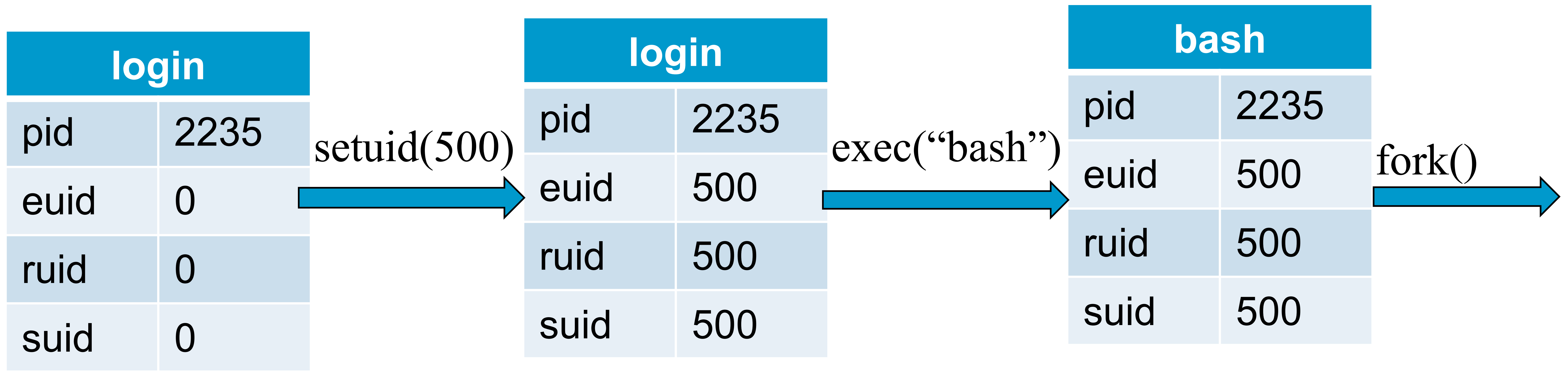
UID Transition: Setuid

- 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!

Changing Effective User ID

- A process that executes a set-uid program can drop its privilege; it can
  - drop privilege permanently
    - removes the privileged user id from all three user IDs
- drop privilege temporarily
  - removes the privileged user ID from its effective uid but stores it in its saved uid, later the process may restore privilege by restoring privileged user ID in its effective uid

What happens during logging in



login	
pid	2235
euid	0
ruid	0
suid	0

login	
pid	2235
euid	500
ruid	500
suid	500

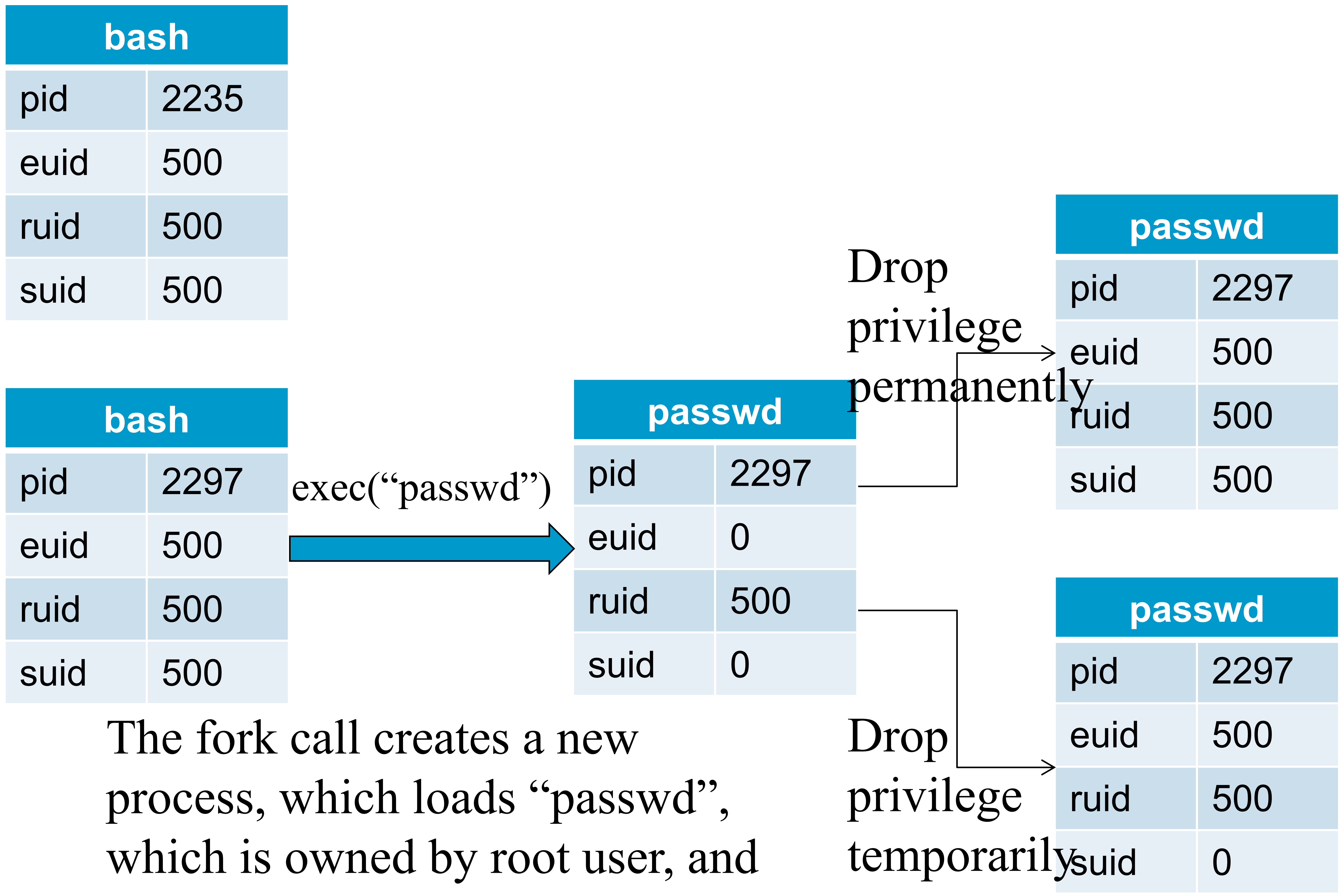
bash	
pid	2235
euid	500
ruid	500
suid	500

After the login process verifies that the entered password is correct, it issues a setuid system call.

The login process then loads the shell, giving the user a login shell.

The user types in the passwd command to change his password.

What happens during logging in



bash	
pid	2235
euid	500
ruid	500
suid	500

bash	
pid	2297
euid	500
ruid	500
suid	500

exec("passwd")

passwd	
pid	2297
euid	0
ruid	500
suid	0

Drop privilege permanently

passwd	
pid	2297
euid	500
ruid	500
suid	500

Drop privilege temporarily

passwd	
pid	2297
euid	500
ruid	500
suid	0

The fork call creates a new process, which loads "passwd", which is owned by root user, and has setuid bit set.

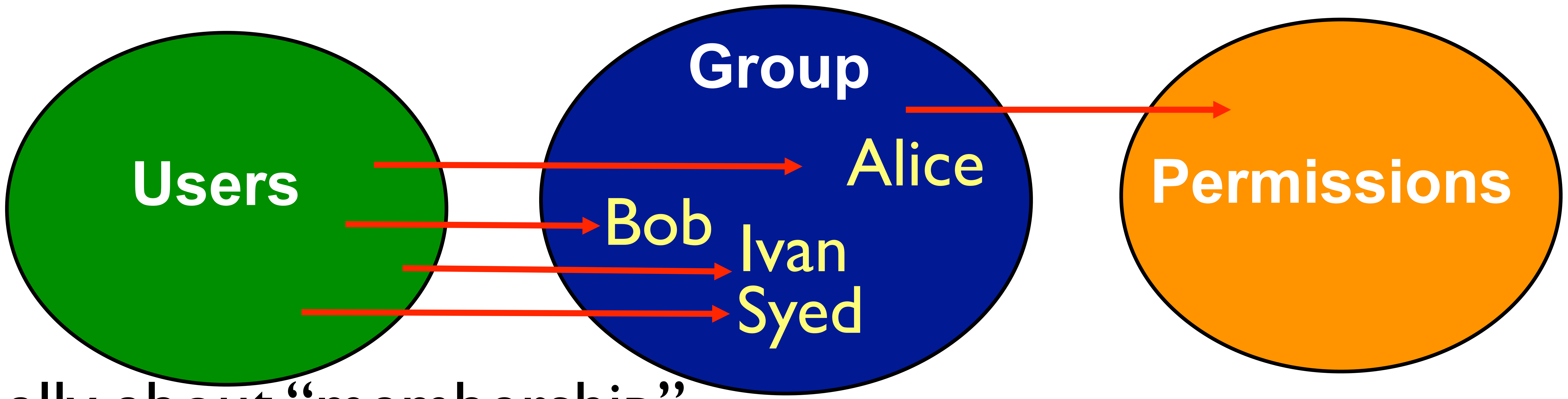
Job Functions

- 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

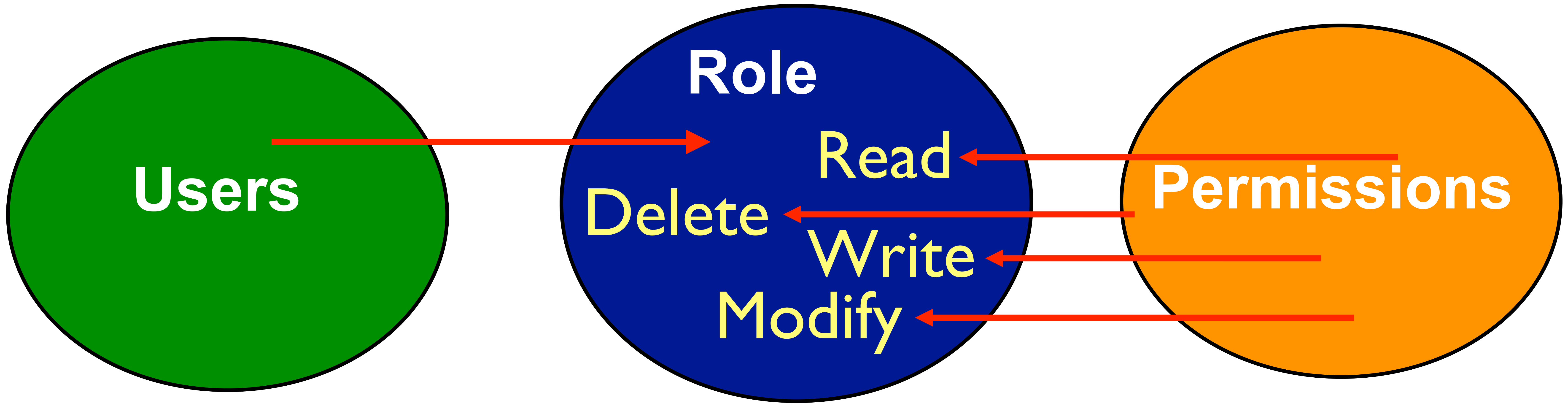
- Groups are collections of identities who are assigned rights as a collective
- Important in that it allows permissions to be assigned in aggregates of users …



- 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