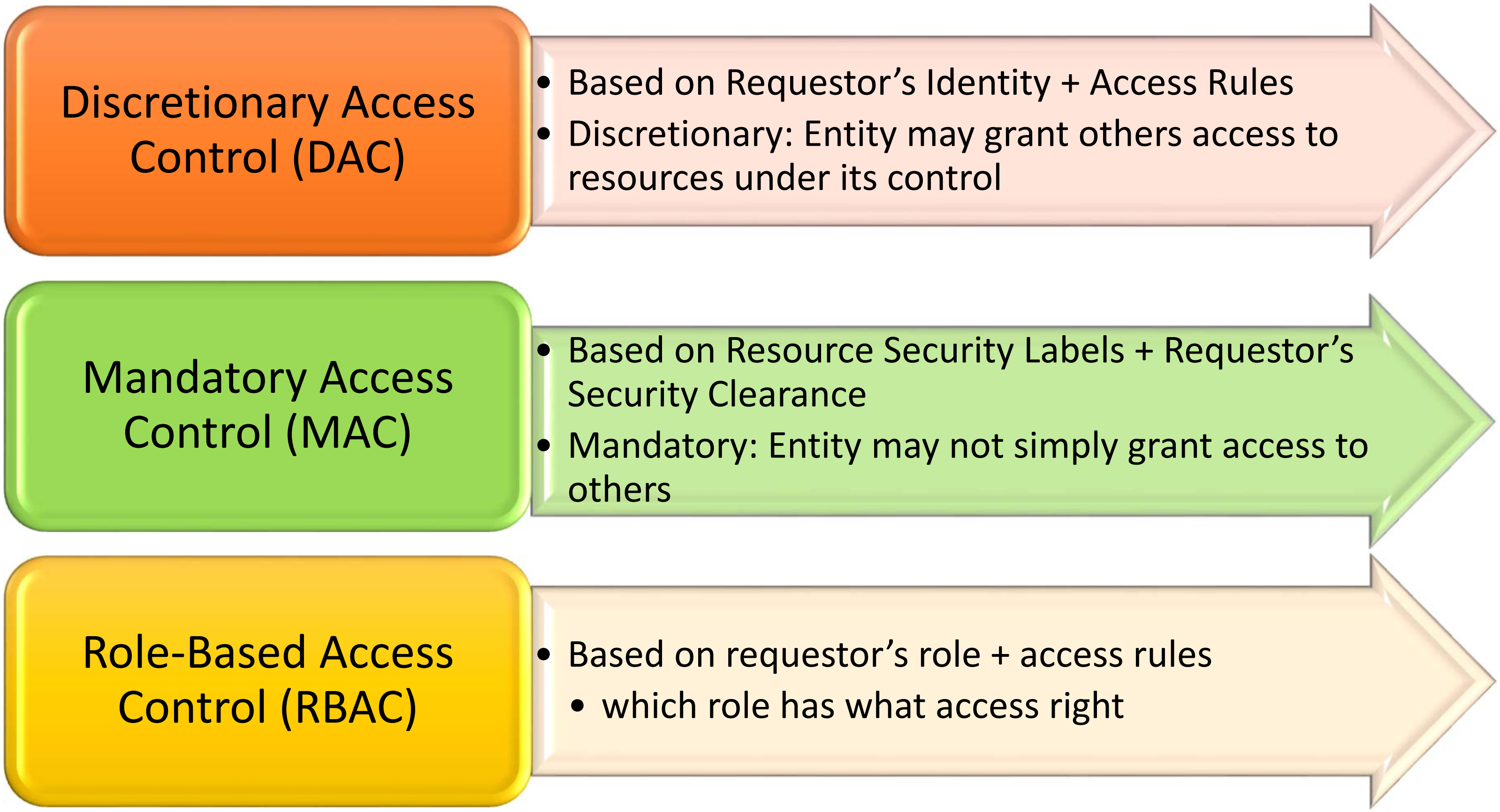
CS-457
Information Security

Module 6 Access Control

a) Access Control at the Operating System

Based on Supplied Reading Material

The 3 Types of Access Control Policies



Discretionary Access Control (DAC)

- Based on Requestor’s Identity + Access Rules
- Discretionary: Entity may grant others access to resources under its control

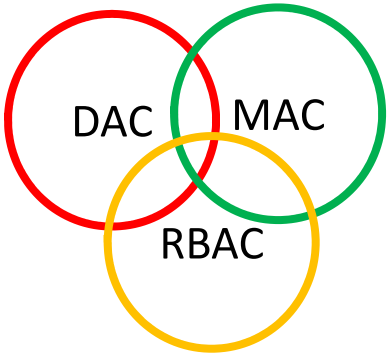
Mandatory Access Control (MAC)

- Based on Resource Security Labels + Requestor’s Security Clearance
- Mandatory: Entity may not simply grant access to others

Role-Based Access Control (RBAC)

- Based on requestor’s role + access rules
  - which role has what access right

May be implemented as stand alone, or as a mix



Access Control: Subjects vs Objects

Subjects
(Requesters)

- Process (on behalf of some user)
- Device

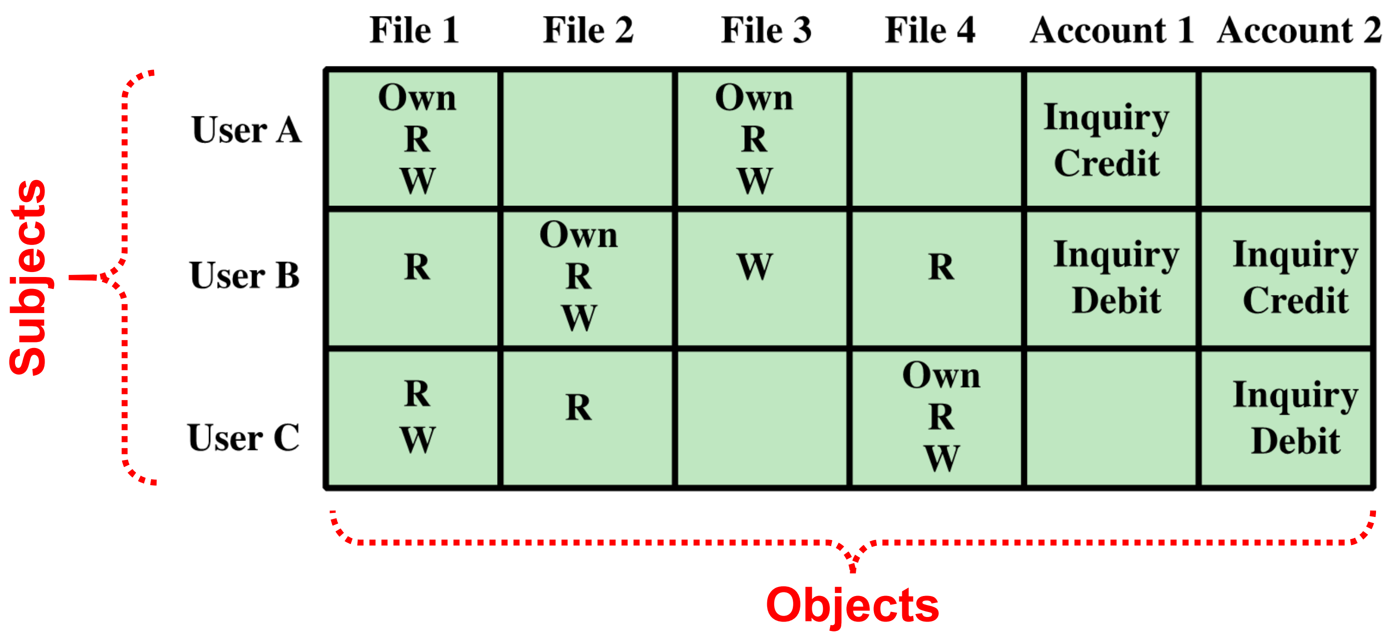
Objects
(Resources being accessed)

- Data
- Memory
- CPU time
- Other Subjects treated as objects

The Concept of an Access Control Matrix

- Each entry specifies the set of access "*rights*" a subject has on some object, e.g. a file

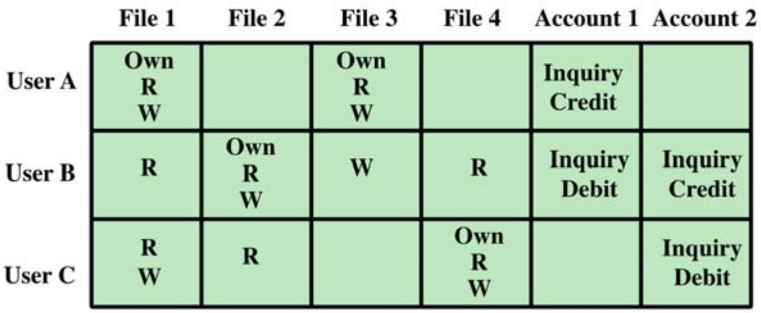
$$A[i,j] = \{\, right_1, right_2\,, \cdots, right_n \,\}$$



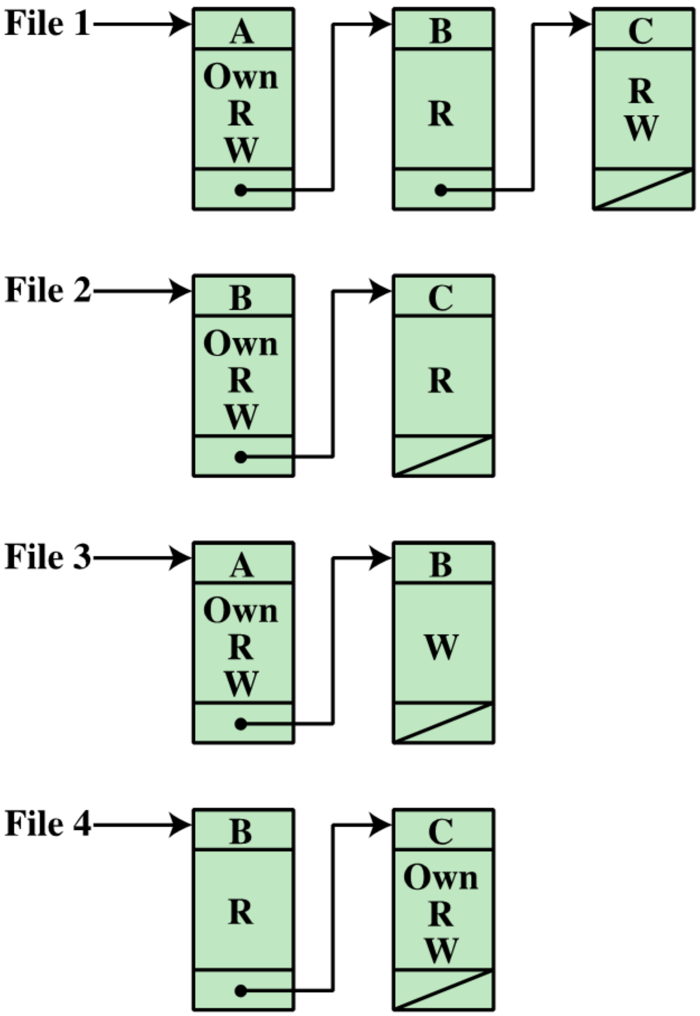
	File 1	File 2	File 3	File 4	Account 1	Account 2
User A	Own R W		Own R W		Inquiry Credit	
User B	R	Own R W	W	R	Inquiry Debit	Inquiry Credit
User C	R W	R		Own R W		Inquiry Debit

- For a large number of subjects and objects, the matrix will be sparse, i.e. most entries will be empty.
- Instead of storing it as a matrix, use:
  - Access Control Lists
  - Capability Lists

The Access Control List: *Object-Focused*



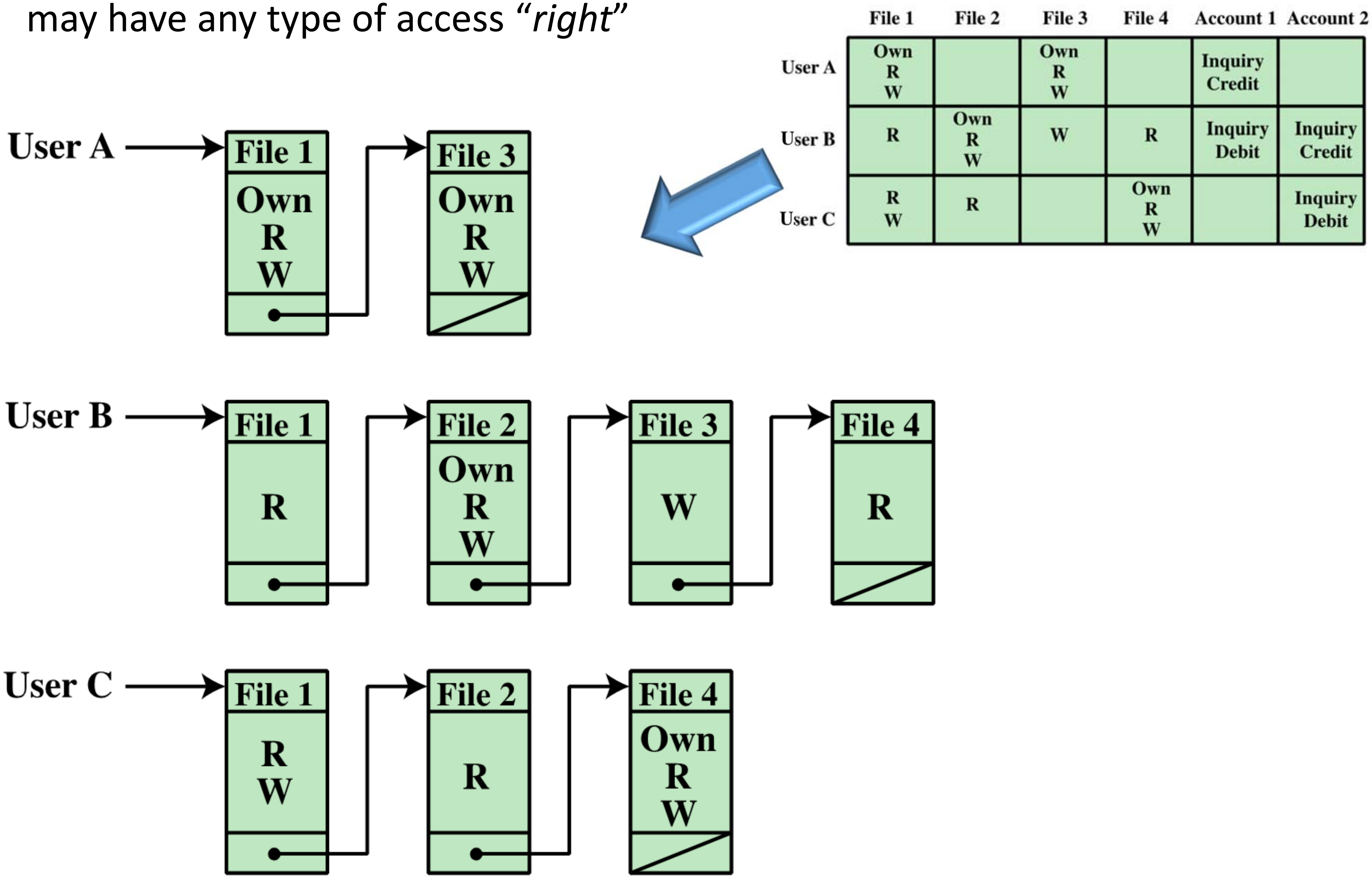
	File 1	File 2	File 3	File 4	Account 1	Account 2
User A	Own R W		Own R W		Inquiry Credit	
User B	R	Own R W	W	R	Inquiry Debit	Inquiry Credit
User C	R W	R		Own R W		Inquiry Debit



- For each object (e.g. a file), create a list of all subjects who have any type of access "*right*" on this object (file)

The Capability List: *Subject-Focused*

- For each subject (e.g. a user), create a list of all objects (e.g. files) on which it may have any type of access "*right*"



	File 1	File 2	File 3	File 4	Account 1	Account 2
User A	Own R W		Own R W		Inquiry Credit	
User B	R	Own R W	W	R	Inquiry Debit	Inquiry Credit
User C	R W	R		Own R W		Inquiry Debit

DAC: The *Extended* Access Control Matrix

- Subjects are also treated as objects:
  - There is a column for each subject just like any other object

OBJECTS

SUBJECTS	subjects			files		processes		disk drives	
	S_1	S_2	S_3	F_1	F_2	P_1	P_2	D_1	D_2
S_1	control	owner	owner control	read*	read owner	wakeup	wakeup	seek	owner
S_2		control		write*	execute			owner	seek *
S_3			control		write	stop			

To authorize subject S_i attempting an access operation α (e.g. *read*) on X, it must first be true that:

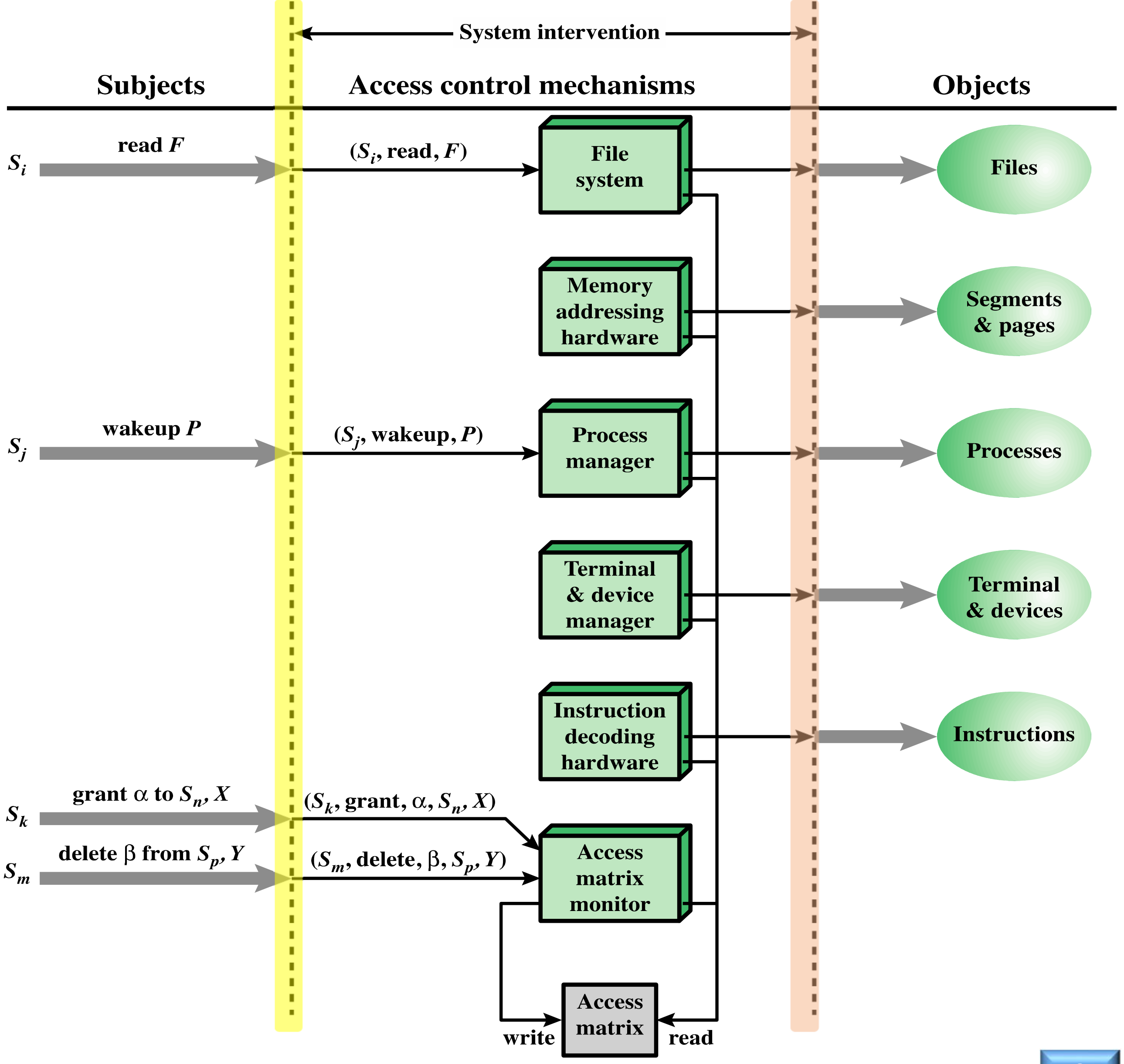
$$\boxed{\alpha \in A[\, S_i \,, X \,]}$$

*right** means copy flag is set, so the subject can transfer that access right to other subjects

DAC: Organization of the Access Control Function in the OS

For each type of objects, an interface module (highlighted in yellow) receives and reformats the request, then forwards it to the appropriate controller of that type of objects

Permission Granted



DAC: commands (as issued by S_0) and rules

(You may print this as Cheat Sheet)

Rule	Command (by S_o)	Authorization	Operation
R1	**transfer** $\begin{Bmatrix}\alpha^* \\ \alpha\end{Bmatrix}$ **to** S, X	'α*' in $A[S_o, X]$	insert $\begin{Bmatrix}\alpha * \\ \alpha\end{Bmatrix}$ in $A[S, X]$
R2	**grant** $\begin{Bmatrix}\alpha * \\ \alpha\end{Bmatrix}$ **to** S, X	'owner' in $A[S_o, X]$	insert $\begin{Bmatrix}\alpha * \\ \alpha\end{Bmatrix}$ in $A[S, X]$
R3	**delete** α **from** S, X	'control' in $A[S_o, S]$ or 'owner' in $A[S_o, X]$	delete α from $A[S, X]$
R4	$w \leftarrow$ **read** S, X Tell me what S can do with X	'control' in $A[S_o, S]$ or 'owner' in $A[S_o, X]$	copy $A[S, X]$ into w
R5	**create object** X	None	add column for X to A; store 'owner' in $A[S_o, X]$
R6	**destroy object** X	'owner' in $A[S_o, X]$	delete column for X from A
R7	**create subject** S	none	add row for S to A; execute **create object** S; store 'control' in $A[S, S]$
R8	**destroy subject** S	'owner' in $A[S_o, S]$	delete row for S from A; execute **destroy object** S

DAC Homework Exercise

Starting from this access control matrix of one row and one column

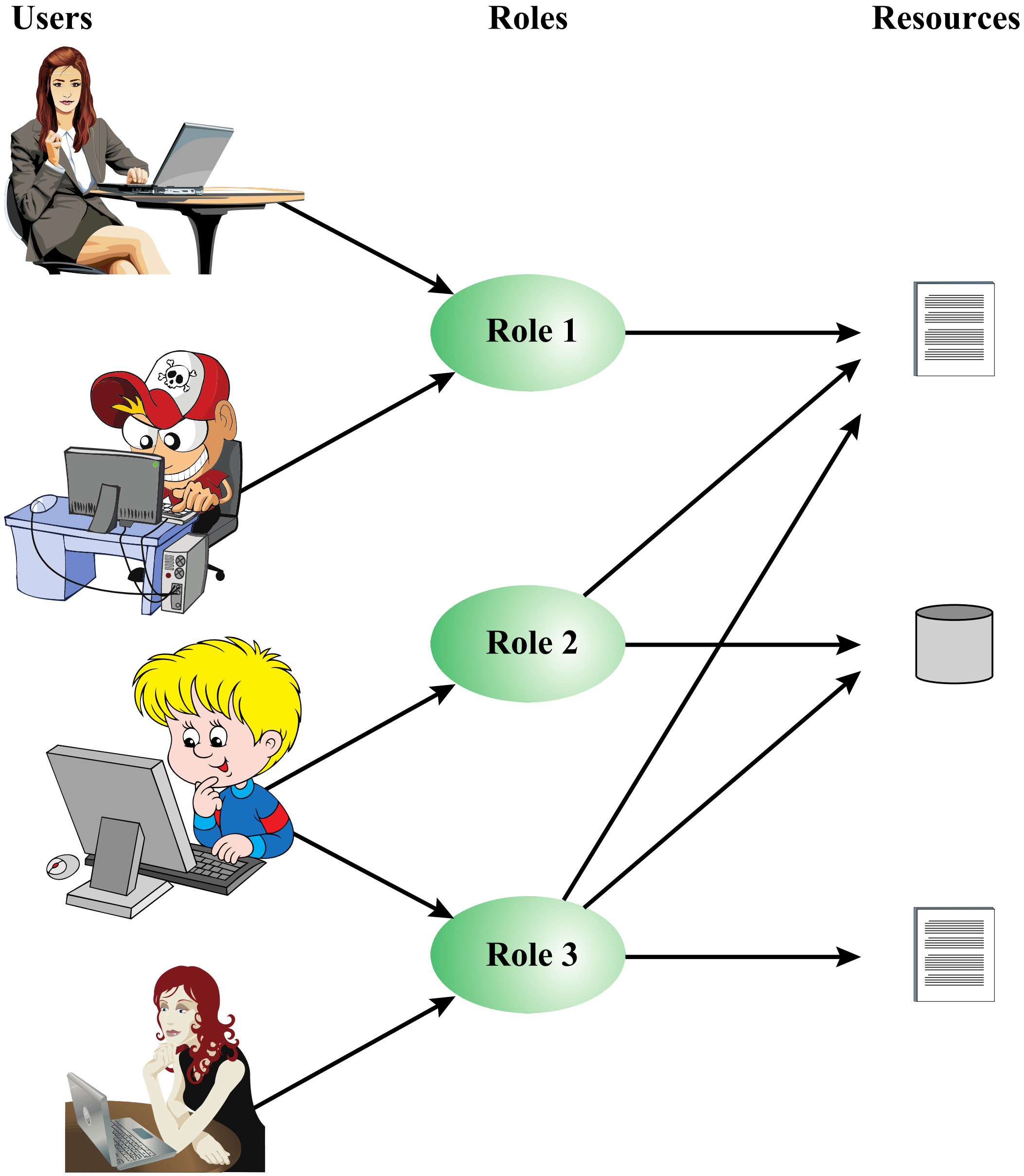
	root
root	Own, Control

Show whether the following sequence of commands will be authorized (explain why/why not). If authorized, show the effect on the access control matrix.

1. (root , create subject , Nancy)
2. (root , create object , F1)
3. (root , read , F1)
4. (root , grant read , to root , F1)
5. (root , read , F1)
6. (root , grant read , to Nancy , F1)
7. (root , create subject , Basma)
8. (Nancy , transfer read , to Basma , F1)
9. (root , grant write* , to Basma , F1)
10. (Basma , transfer write , to Nancy , F1)
11. (root , write , F1)
12. (root , delete read , from Basma , F1)
13. (root , grant control , to Nancy , Basma)
14. (Basma , read , F1)
15. (Nancy , delete write , from Basma , F1)
16. (Nancy , destroy subject , Basma)

Role-Based Access Control: RBAC

- ‘**Role**’ is a job function within some context (e.g. ‘manager’ in an organization)
- Access rights are assigned to roles (*many-to-many*)
- Users are given one or more roles (*many-to-many*)
  - Statically, i.e. permanently
  - Dynamically, i.e. when needed, then role is revoked



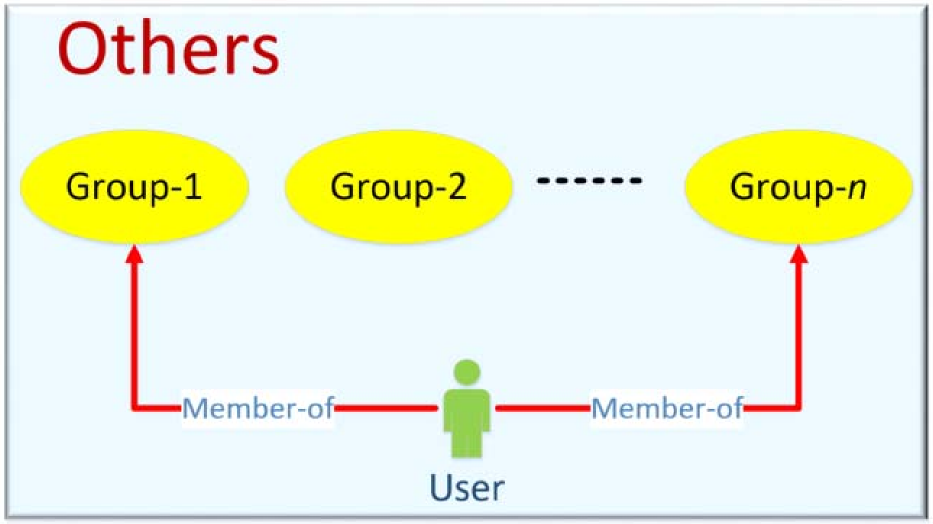
RBAC Example

OBJECTS

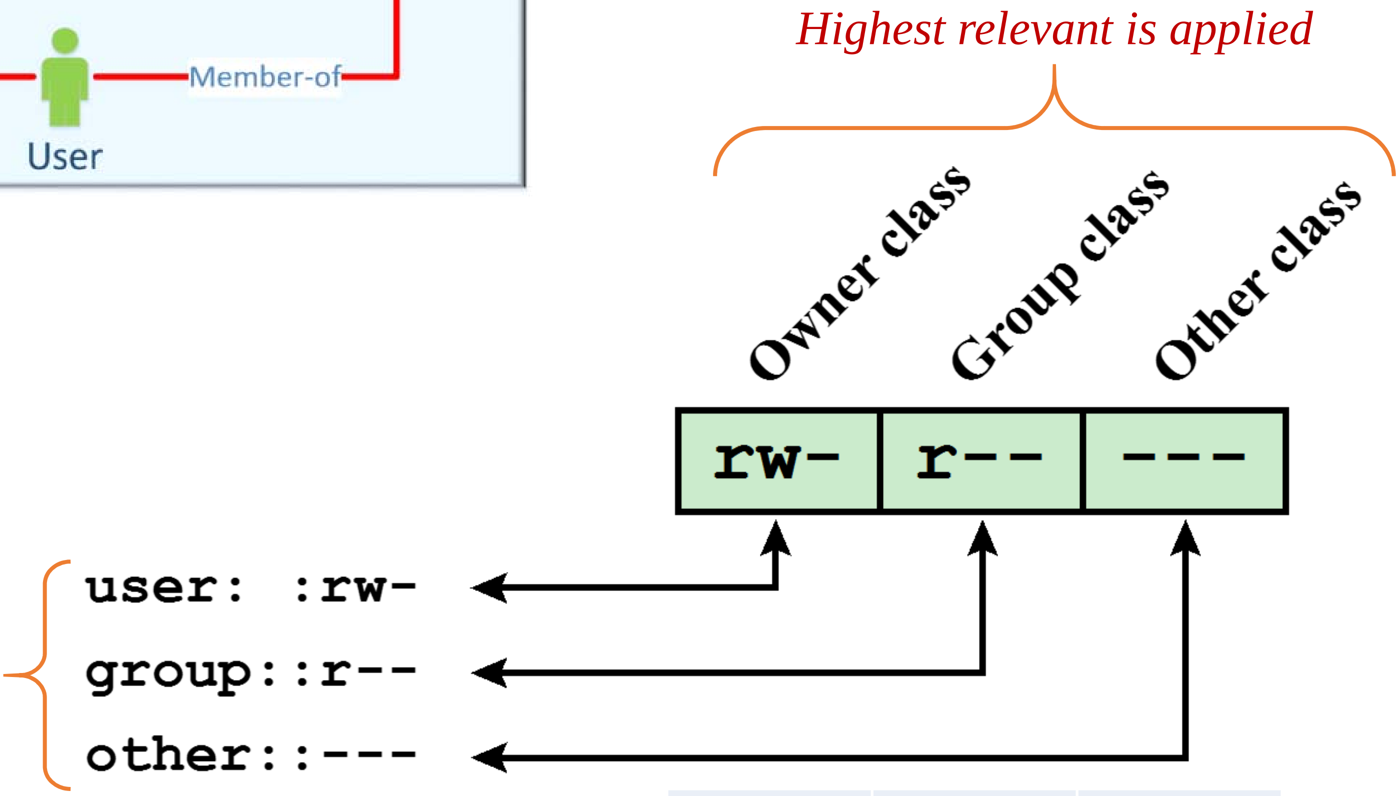
ROLES	R_1	R_2	R_n	F_1	F_1	P_1	P_2	D_1	D_2
R_1	control	owner	owner control	read*	read owner	wakeup	wakeup	seek	owner
R_2		control		write*	execute			owner	seek *
• • •									
R_n			control		write	stop			

	R_1	R_2	• • •	R_n
U_1	✖			
U_2	✖			
U_3		✖		✖
U_4				✖
U_5				✖
U_6				✖
• • •				
U_m	✖			

Traditional UNIX File Access Control



chown: changes owner
chgrp: changes group


Highest relevant is applied

9 (of the 12) protection bits each file has

```
user: :rw-
group::r--
other::---
```

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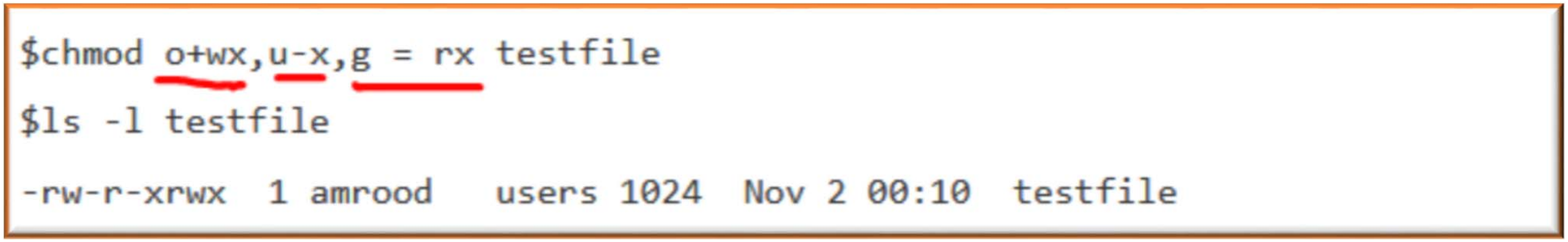
File vs. Directory Access Modes

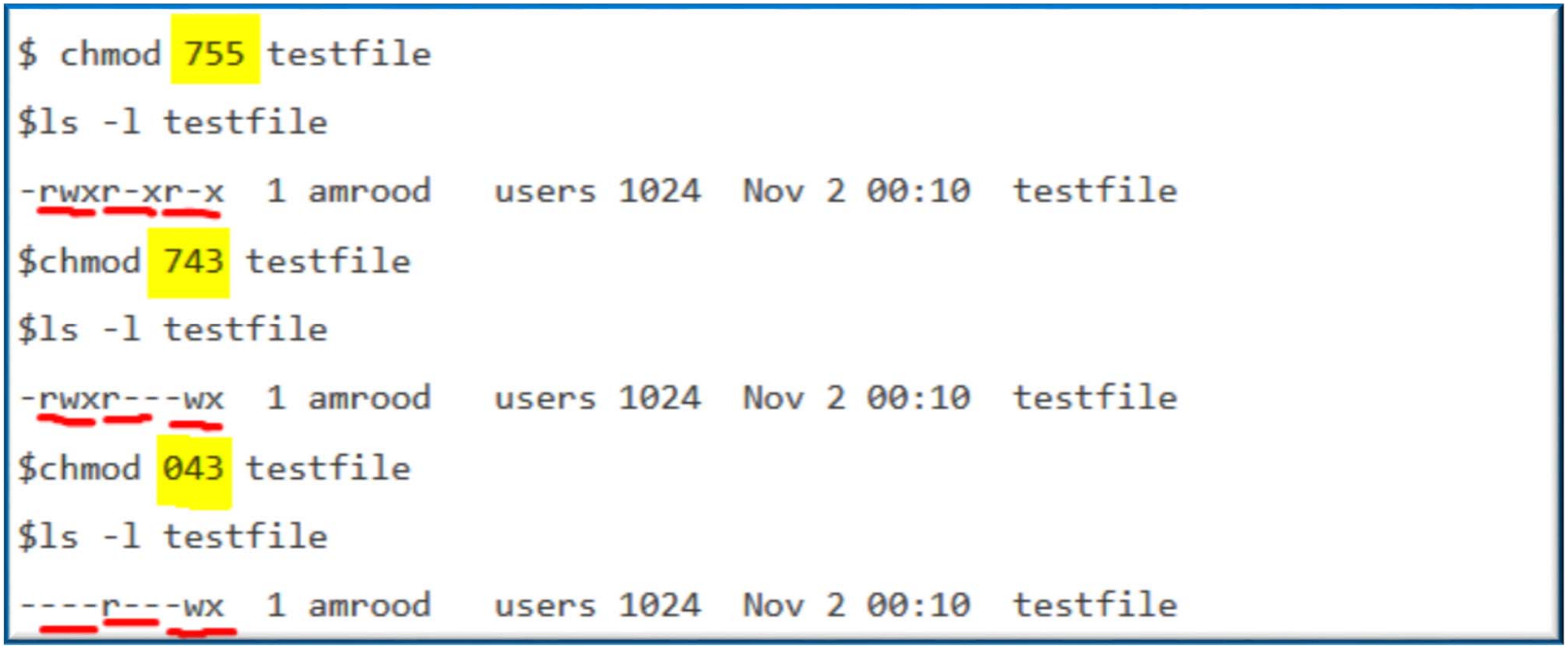
File Access Modes	Directory Access Modes
• **Read** Grants the capability to read, i.e., view the contents of the file. • **Write** Grants the capability to modify, or remove the content of the file. • **Execute** User with execute permissions can run a file as a program.	• **Read** Access to a directory means that the user can read the contents. The user can look at the filenames inside the directory. • **Write** Access means that the user can add or delete files from the directory. • **Execute** A user must have **execute** access to the a directory in order to execute a program inside that directory.

`chmod`: changes protection bits

Using the chmod command



```
$chmod o+wx,u-x,g = rx testfile
$ls -l testfile
-rw-r-xrwx  1 amrood   users 1024  Nov 2 00:10  testfile
```



```
$ chmod 755 testfile
$ls -l testfile
-rwxr-xr-x  1 amrood   users 1024  Nov 2 00:10  testfile
$chmod 743 testfile
$ls -l testfile
-rwxr---wx  1 amrood   users 1024  Nov 2 00:10  testfile
$chmod 043 testfile
$ls -l testfile
----r---wx  1 amrood   users 1024  Nov 2 00:10  testfile
```

Traditional UNIX File Access Control: other protection bits

SetUID bit

- *executable files*:
  - temporarily apply rights of file's creators to current executing user, if needed.
- *directory*:
  - ignored

SetGIU bit

- *executable files*:
  - temporarily apply rights of file's group to current executing user, if needed.
- *directory*:
  - newly-created files will inherit group of this director

Sticky bit

- *files*
  - outdated use
- *directory* (shared)
  - for each inside file, only the owner can rename, delete, or move this file

Traditional UNIX File Access Control: *Super User*

- Unrestricted access to ALL files, system-wide.
- Carefully develop programs owned by "superuser", especially if they have the SetUID bit on

Traditional Protection Bits (a.k.a. *minimal access control lists*) are adequate for small number of users and groups.
For larger systems, UNIX uses *extended Access Control Lists*
If interested, search for the many videos on YouTube on Unix ACLs