

# Identification, Authentication & Authorization

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# Identification, Authentication & Authorization

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- Identification: This is an action in which the user (untrusted party) declares his identity. Identification is the ability to identify uniquely a user of a system or an application that is running in the system

Authentication: This is an action(s) to prove that the user is who he claims to be. Authentication is the act of proving the identity of a computer system user

- Authorization: This action(s) is required to determine which actions a specific user can perform. Authorization is the function of specifying access rights/privileges to resources

# Identification

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- Here the system has to trust an untrusted party and hence may appear irrelevant.
- However for authentication, proper identification is mandatory
- Once identification is established, the system has to validate that one individual
- E.g. Automatic identification of personnel by scanning the badge at the entry gate instead of manual identification by security personnel to prevent delay and long queues at the entrance

# Authentication

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- This is the most attacked process and is the weakest link in the security chain
- Authentication can be performed in three different ways
  - Something you know - This is a way to identify a user using something like a PIN, a password, or a passphrase
  - Something you have - This is a way to identify a user using something like a smart card or a badge
  - Something you are - This is a way to identify a user using biometrical characteristics of the user

# MFA

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- The three authentication mechanisms have inherent weaknesses and hence cannot be used alone
- Each option has different type of weakness and they can be combined to create a secure system
- Hence Multi Factor Authentication is used to provide two or more verification factors to gain access to a resource
- MFA reduces likelihood of a successful cyber attack
- Multifactor authentication combines two or more independent credentials: what the user knows, such as a password; what the user has, such as a security token; and what the user is, by using biometric verification methods

# Authorization

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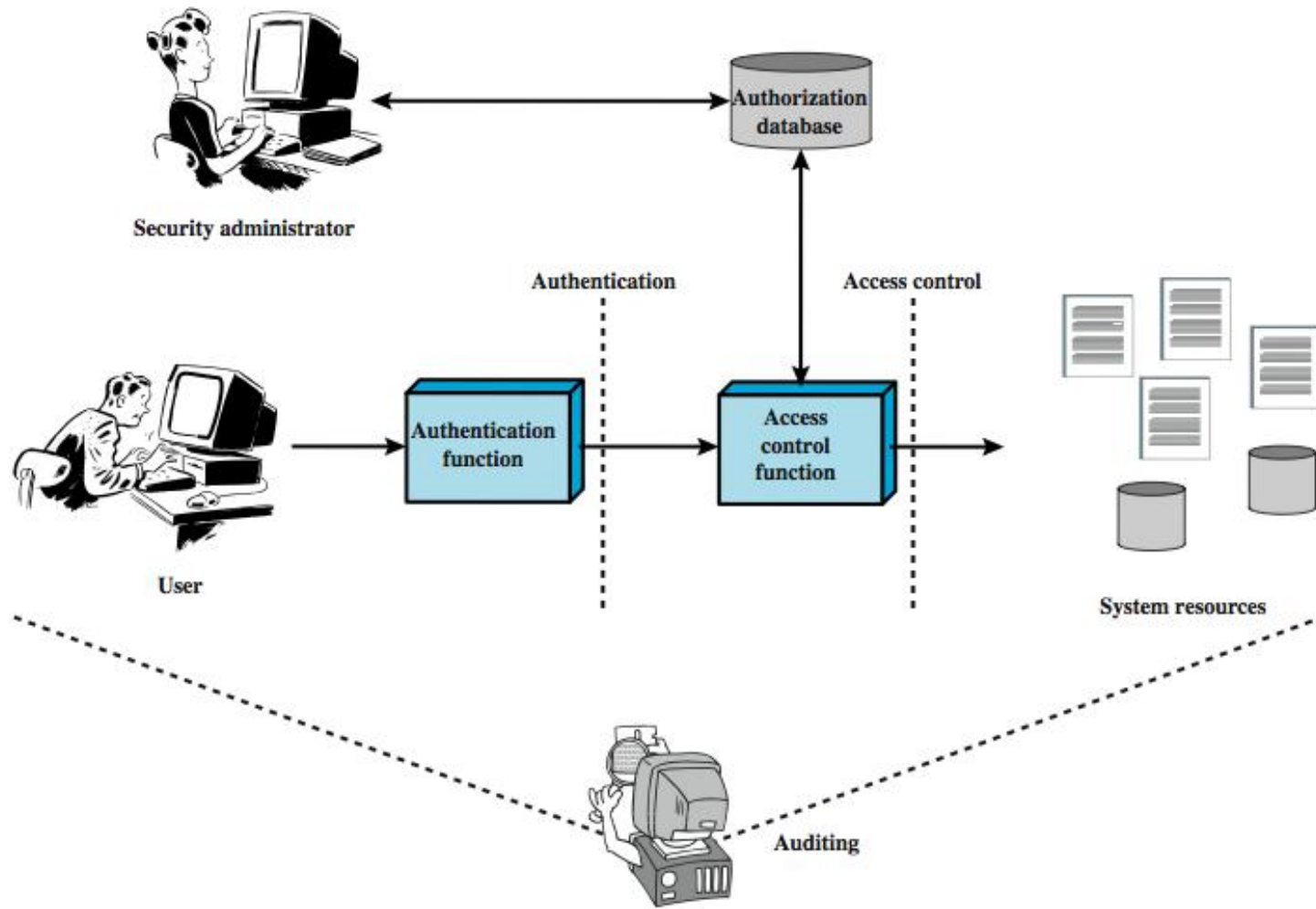
- The goal of authorization is to be sure that the given user has clearance to do what he is asking to do
- There are multiple ways to grant privileges to a user, based on the access control model the system uses
- The primary goal of controls is to ensure the confidentiality and integrity of data by disallowing unauthorized access by authorized or unauthorized subjects
- The main access control models are
  - Mandatory Access Control (MAC)
  - Discretionary Access Control (DAC)
  - Role-based Access Control (RBAC)
  - Lattice-based Access Control (LBAC)

# Access Control

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- ◆ “The prevention of unauthorized use of a resource, including the prevention of use of a resource in an unauthorized manner”
- ◆ Central element of computer security
- ◆ Assume have users and groups
  - ◆ authenticate to system
  - ◆ assigned access rights to certain resources on system

# Access Control Principles





# Access control policies

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- ◆ **Discretionary** access control (DAC): based on the identity of the requestor and access rules
- ◆ **Mandatory** access control (MAC): based on comparing security labels with security clearances (mandatory: one with access to a resource cannot pass to others)
- ◆ **Role-based** access control (RBAC): based on user roles
- ◆ **Attribute-based** access control: based on the attributes of the user, the resources and the current environment

# Access Control Requirements

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- ◆ Reliable input: a mechanism to authenticate
- ◆ Fine and coarse specifications: regulate access at varying levels (e.g., an attribute or entire DB)
- ◆ Least privilege: min authorization to do its work
- ◆ Separation of duty: divide steps among different individuals
- ◆ Open and closed policies: accesses specifically authorized or all accesses except those prohibited
- ◆ Policy combinations and conflict resolution
- ◆ Administrative policies: who can add, delete, modify rules

# Access Control Elements

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- ◆ Subject: entity that can access objects
  - ◆ a process representing user/application
  - ◆ often have 3 classes: **owner, group, world**
- ◆ Object: access controlled resource
  - ◆ e.g. files, directories, records, programs etc
  - ◆ number/type depend on environment
- ◆ Access right: way in which subject accesses an object
  - ◆ e.g. read, write, execute, delete, create, search

# Discretionary Access Control

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- ◆ Often provided using an access matrix
  - ◆ lists subjects in one dimension (rows)
  - ◆ lists objects in the other dimension (columns)
  - ◆ each entry specifies access rights of the specified subject to that object
- ◆ Access matrix is often sparse
- ◆ Can decompose by either row or column

# Access Control Structures

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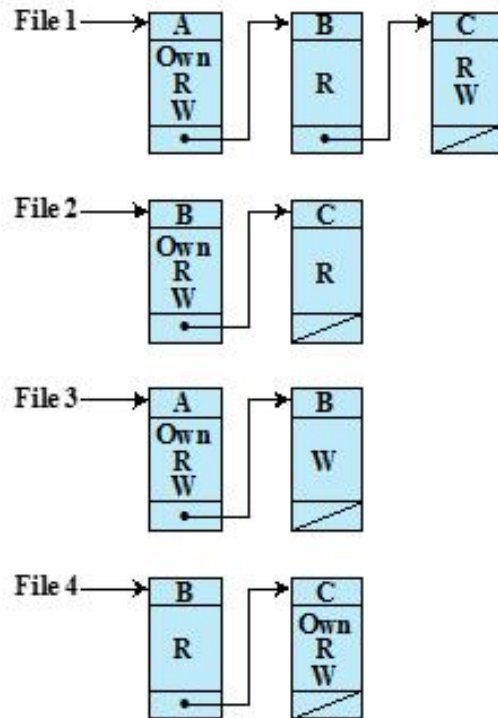
- ◆ Access control lists (decomposed by column)
- ◆ Capability tickets (decomposed by row)

# An access matrix

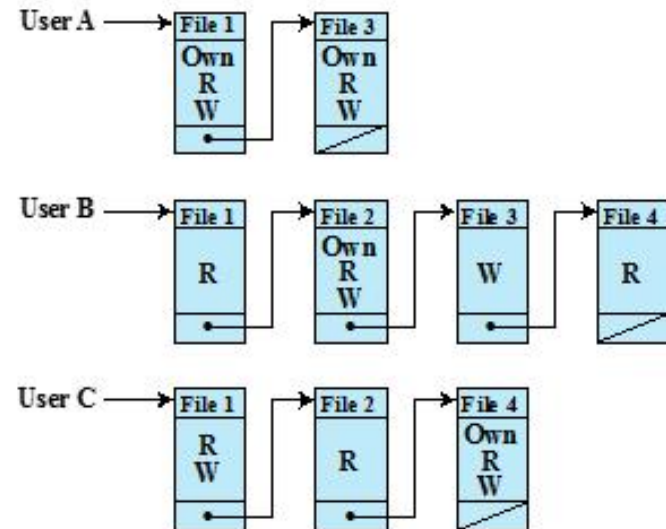
		OBJECTS			
		File 1	File 2	File 3	File 4
SUBJECTS	User A	Own Read Write		Own Read Write	
	User B	Read	Own Read Write	Write	Read
	User C	Read Write	Read		Own Read Write

(a) Access matrix

# Access matrix data structures



(b) Access control lists for files of part (a)



(c) Capability lists for files of part (a)

# Alternate authorization table

Subject	Access Mode	Object
A	Own	File 1
A	Read	File 1
A	Write	File 1
A	Own	File 3
A	Read	File 3
A	Write	File 3
B	Read	File 1
B	Own	File 2
B	Read	File 2
B	Write	File 2
B	Write	File 3
B	Read	File 4
C	Read	File 1
C	Write	File 1
C	Read	File 2
C	Own	File 4
C	Read	File 4
C	Write	File 4



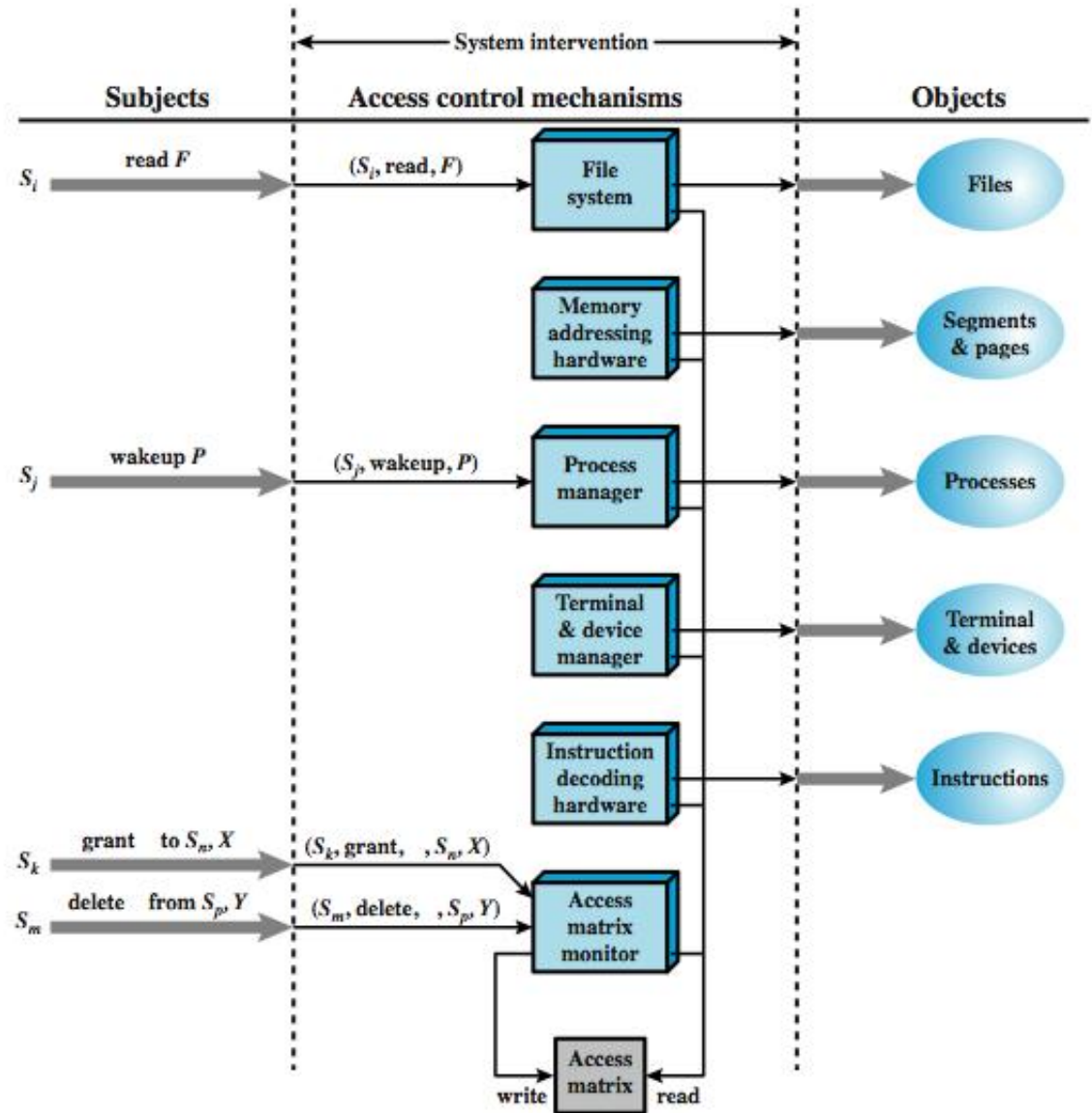
# An Access Control Model

- ❖ Extend the universe of objects to include processes, devices, memory locations, subjects

		OBJECTS								
		subjects			files		processes		disk drives	
		S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	F <sub>1</sub>	F <sub>1</sub>	P <sub>1</sub>	P <sub>2</sub>	D <sub>1</sub>	D <sub>2</sub>
SUBJECTS	S <sub>1</sub>	control	owner	owner control	read *	read owner	wakeup	wakeup	seek	owner
	S <sub>2</sub>		control		write *	execute			owner	seek *
	S <sub>3</sub>			control		write	stop			

\* - copy flag set

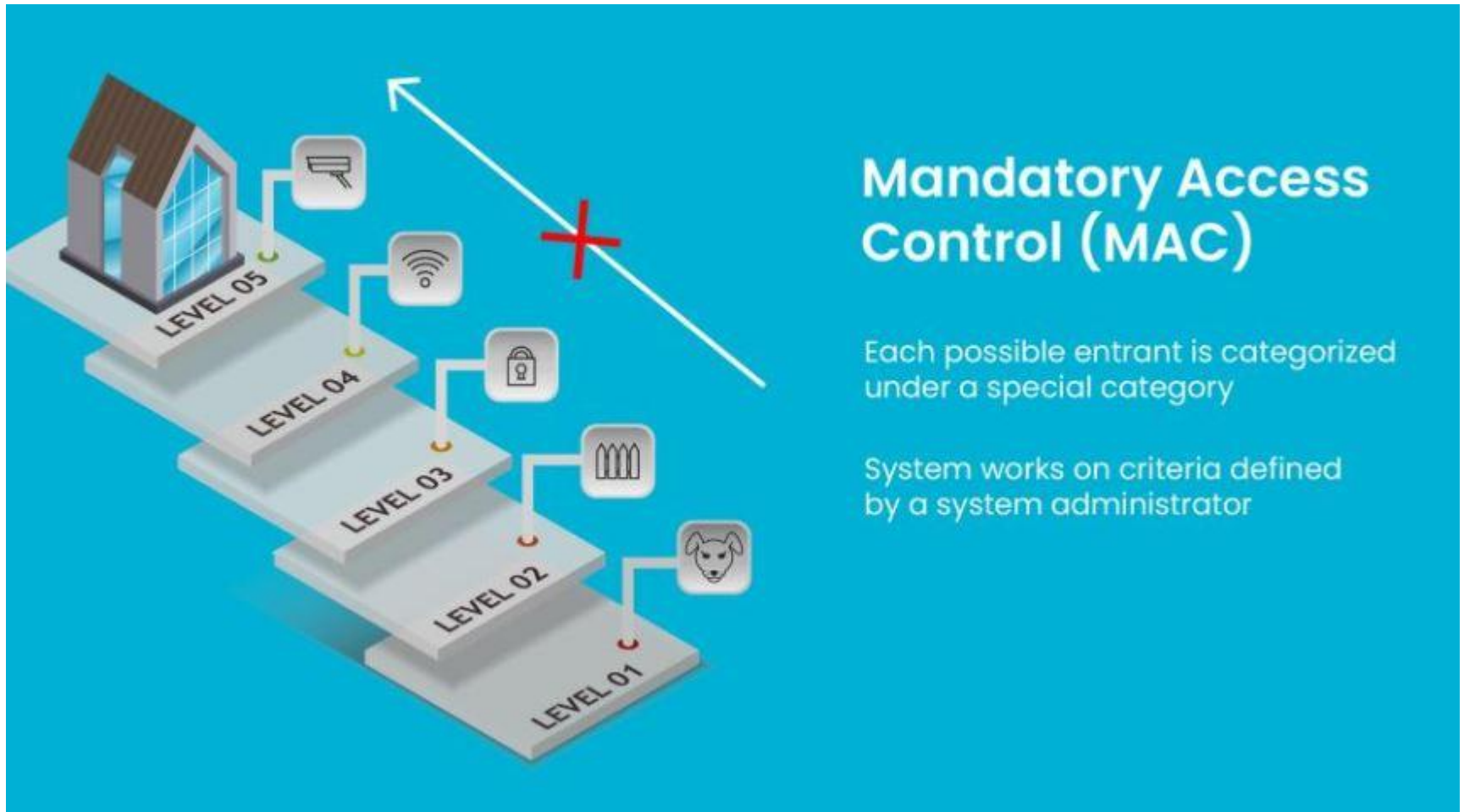
# Access Control Function



# Access control system commands

Rule	Command (by $S_o$ )	Authorization	Operation
R1	transfer $\begin{Bmatrix} \alpha^* \\ \alpha \end{Bmatrix}$ to $S, X$	' $\alpha^*$ ' in $A[S_o, X]$	store $\begin{Bmatrix} \alpha^* \\ \alpha \end{Bmatrix}$ in $A[S, X]$
R2	grant $\begin{Bmatrix} \alpha^* \\ \alpha \end{Bmatrix}$ to $S, X$	'owner' in $A[S_o, X]$	store $\begin{Bmatrix} \alpha^* \\ \alpha \end{Bmatrix}$ in $A[S, X]$
R3	delete $\alpha$ from $S, X$	'control' in $A[S_o, S]$ or 'owner' in $A[S_o, X]$	delete $\alpha$ from $A[S, X]$
R4	$w \leftarrow$ read $S, X$	'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 <b>create object</b> $S$ ; store 'control' in $A[S, S]$
R8	destroy subject $S$	'owner' in $A[S_o, S]$	delete row for $S$ from $A$ ; execute <b>destroy object</b> $S$

# MAC –Mandatory Access Control



## Advantages: Mandatory Access Control (MAC)



High-level data protection



Centralized Information



Privacy

## Disadvantages: Mandatory Access Control (MAC)



Careful Setting-Up Process



Regular Update Required:



Lack of Flexibility



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# Bell-LaPadula Model, Step 1

- Security levels arranged in linear ordering
  - Top Secret: highest
  - Secret
  - Confidential
  - Unclassified: lowest
- Levels consist of *security clearance*  $L(s)$ 
  - Objects have *security classification*  $L(o)$

# Example

<i>security level</i>	<i>subject</i>	<i>object</i>
Top Secret	Tamara	Personnel Files
Secret	Samuel	E-Mail Files
Confidential	Claire	Activity Logs
Unclassified	Ulaley	Telephone Lists

- Tamara can read all files
- Claire cannot read Personnel or E-Mail Files
- Ulaley can only read Telephone Lists



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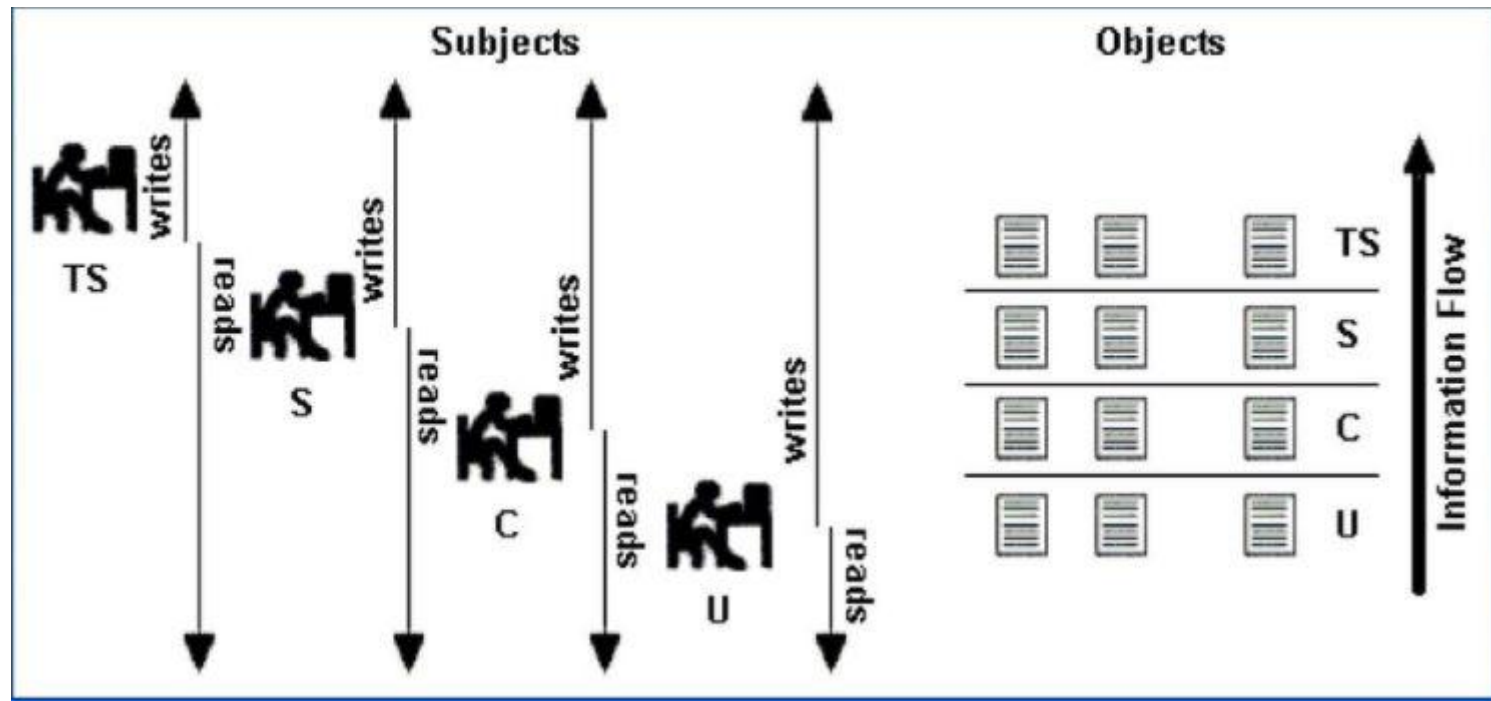
# Reading Information

- Information flows *up*, not *down*
  - “Reads up” disallowed, “reads down” allowed
- Simple Security Condition (Step 1)
  - Subject  $s$  can read object  $o$  iff,  $L(o) \leq L(s)$  and  $s$  has permission to read  $o$ 
    - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - Sometimes called “no reads up” rule

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# Writing Information

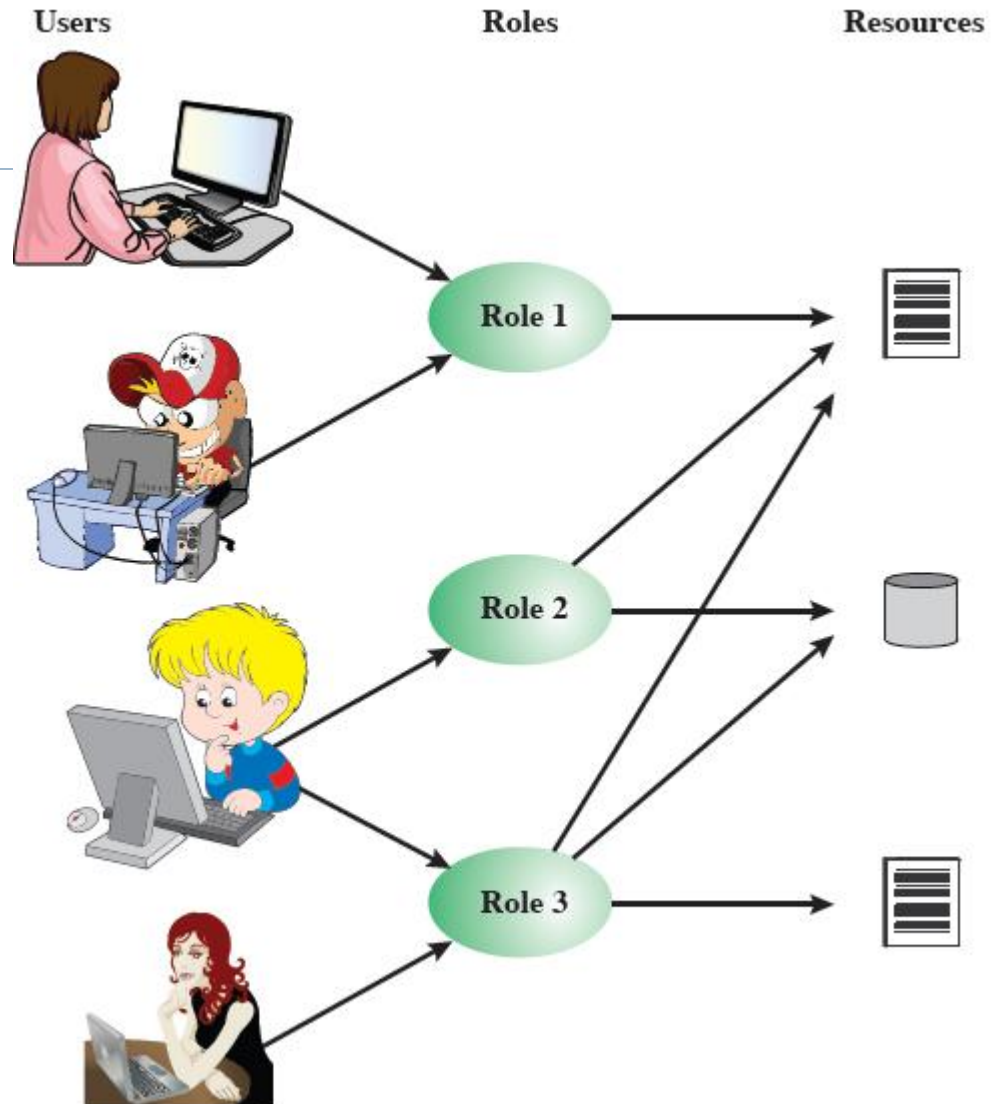
- Information flows up, not down
  - “Writes up” allowed, “writes down” disallowed
- \*-Property (Step 1)
  - Subject  $s$  can write object  $o$  iff  $L(s) \leq L(o)$  and  $s$  has permission to write  $o$ 
    - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - Sometimes called “no writes down” rule



# Role-Based Access Control

*Access based on 'role', not identity*

*Many-to-many relationship between users and roles*



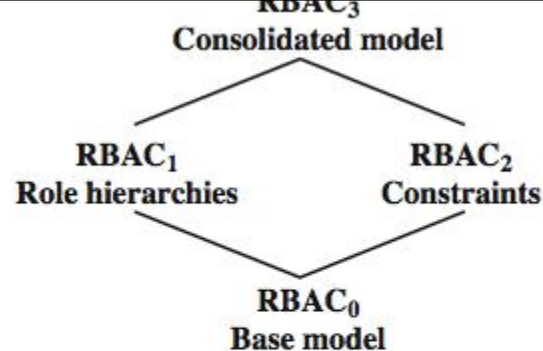
# Role-Based Access Control

Role-users and  
roles-object  
access matrix

	R <sub>1</sub>	R <sub>2</sub>	...	R <sub>n</sub>
U <sub>1</sub>	×			
U <sub>2</sub>	×			
U <sub>3</sub>		×		×
U <sub>4</sub>				×
U <sub>5</sub>				×
U <sub>6</sub>				×
...				
U <sub>m</sub>	×			

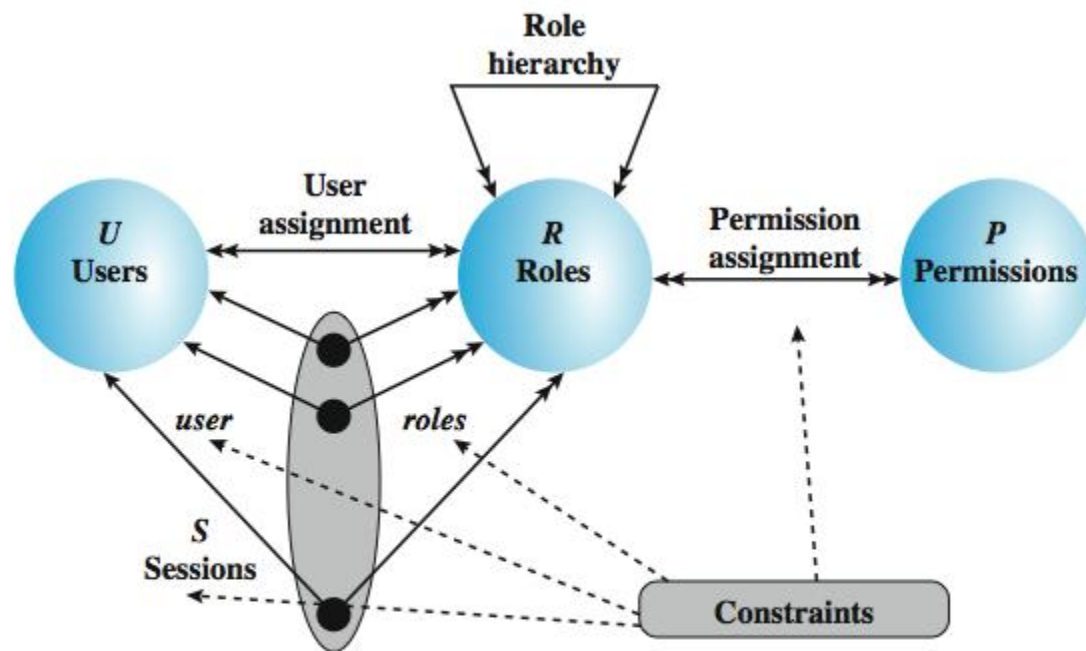
		OBJECTS								
		R <sub>1</sub>	R <sub>2</sub>	R <sub>n</sub>	F <sub>1</sub>	F <sub>1</sub>	P <sub>1</sub>	P <sub>2</sub>	D <sub>1</sub>	D <sub>2</sub>
ROLES	R <sub>1</sub>	control	owner	owner control	read *	read owner	wakeup	wakeup	seek	owner
	R <sub>2</sub>		control		write *	execute			owner	seek *
	•									
	•									
	R <sub>n</sub>			control		write	stop			

# Role-Based Access Control



(a) Relationship among RBAC models

Double arrow: 'many' relationship  
Single arrow: 'one' relationship

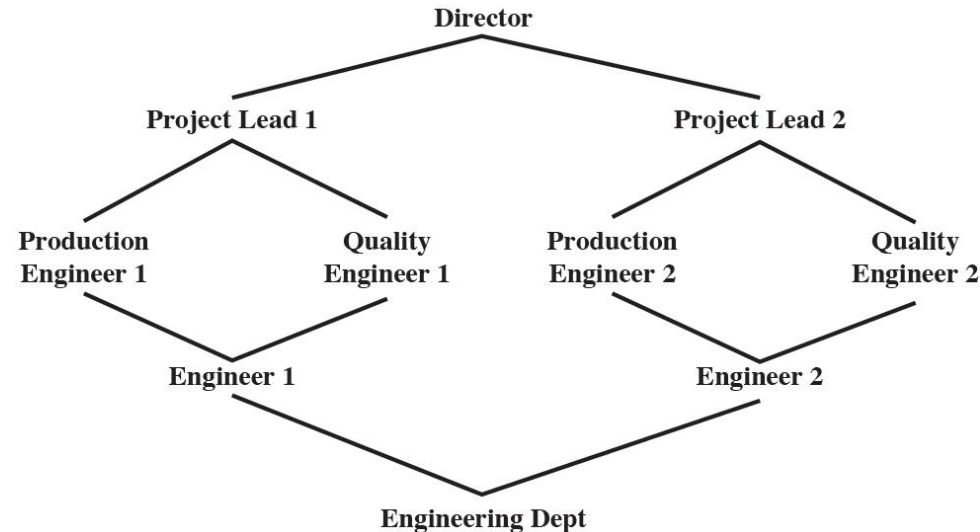


(b) RBAC models



# Example of role hierarchy

- ❖ Director has most privileges
- ❖ Each role inherits all privileges from lower roles
- ❖ A role can inherit from multiple roles
- ❖ Additional privileges can be assigned to a role



# Constraints

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◆ A condition (restriction) on a role or between roles

◆ **Mutually exclusive**

◆ role sets such that a user can be assigned to only one of the role in the set

◆ Any permission can be granted to only one role in the set

◆ **Cardinality**: set a maximum number (of users) wrt a role (e.g., a department chair role)

◆ **Prerequisite role**: a user can be assigned a role only if that user already has been assigned to some other role



# Case study: RBAC system for a bank

Role	Function	Official Position
A	financial analyst	Clerk
B	financial analyst	Group Manager
C	financial analyst	Head of Division
D	financial analyst	Junior
E	financial analyst	Senior
F	financial analyst	Specialist
G	financial analyst	Assistant
...	...	...
X	share technician	Clerk
Y	support e-commerce	Junior
Z	office banking	Head of Division

# Case study: RBAC system for a bank

- ◆ b has more access than A (strict ordering)
- ◆ Inheritance makes tables simpler

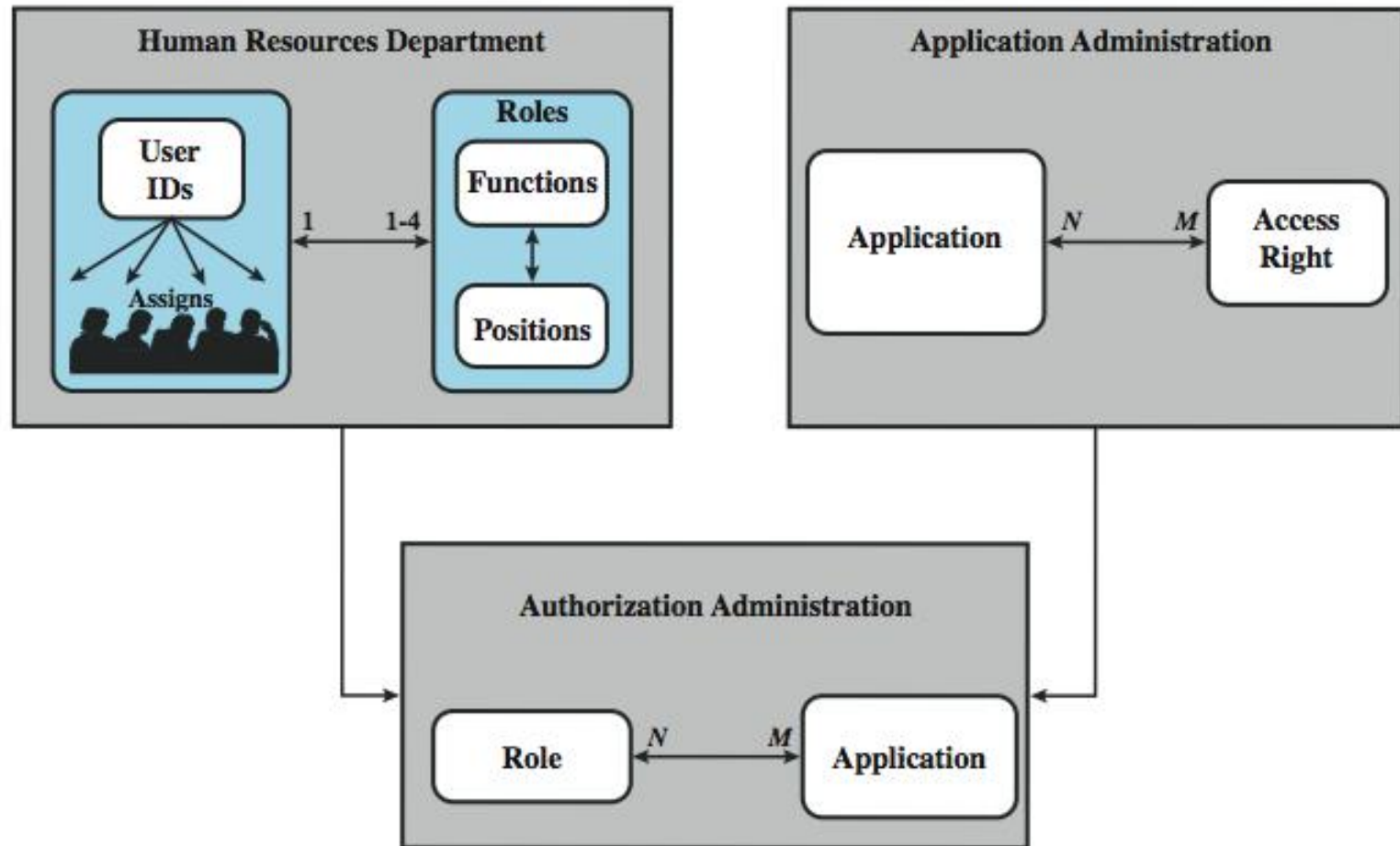
(b) Permission Assignments

Role	Application	Access Right
A	money market instruments	1, 2, 3, 4
	derivatives trading	1, 2, 3, 7, 10, 12
	interest instruments	1, 4, 8, 12, 14, 16
B	money market instruments	1, 2, 3, 4, 7
	derivatives trading	1, 2, 3, 7, 10, 12, 14
	interest instruments	1, 4, 8, 12, 14, 16
	private consumer instruments	1, 2, 4, 7
...	...	...

(c) PA with Inheritance

Role	Application	Access Right
A	money market instruments	1, 2, 3, 4
	derivatives trading	1, 2, 3, 7, 10, 12
	interest instruments	1, 4, 8, 12, 14, 16
B	money market instruments	7
	derivatives trading	14
	private consumer instruments	1, 2, 4, 7
...	...	...

# Case study: RBAC system for a bank



# Attribute-based access control

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- ◆ Fairly recent
- ◆ Define authorizations that express conditions on properties of both the resource and the subject
  - ◆ Each resource has an attribute (e.g., the subject that created it)
  - ◆ A single rule states ownership privileges for the creators
- ◆ Strength: its flexibility and expressive power
- ◆ Considerable interest in applying the model to cloud services

# Types of attributes

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- ◆ Subject attributes
- ◆ Object attributes
- ◆ Environment attributes

# Subject attributes

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- ◆? A subject is an active entity that causes information to flow among objects or changes the system state
- ◆? Attributes define the identity and characteristics of the subject
  - ◆? Name
  - ◆? Organization
  - ◆? Job title

# Object attribute

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- ◆? An object (or resource) is a passive information system-related entity containing or receiving information
- ◆? Objects have attributes that can be leveraged to make access control decisions
  - ◆? Title
  - ◆? Author
  - ◆? Date

# Environment attributes

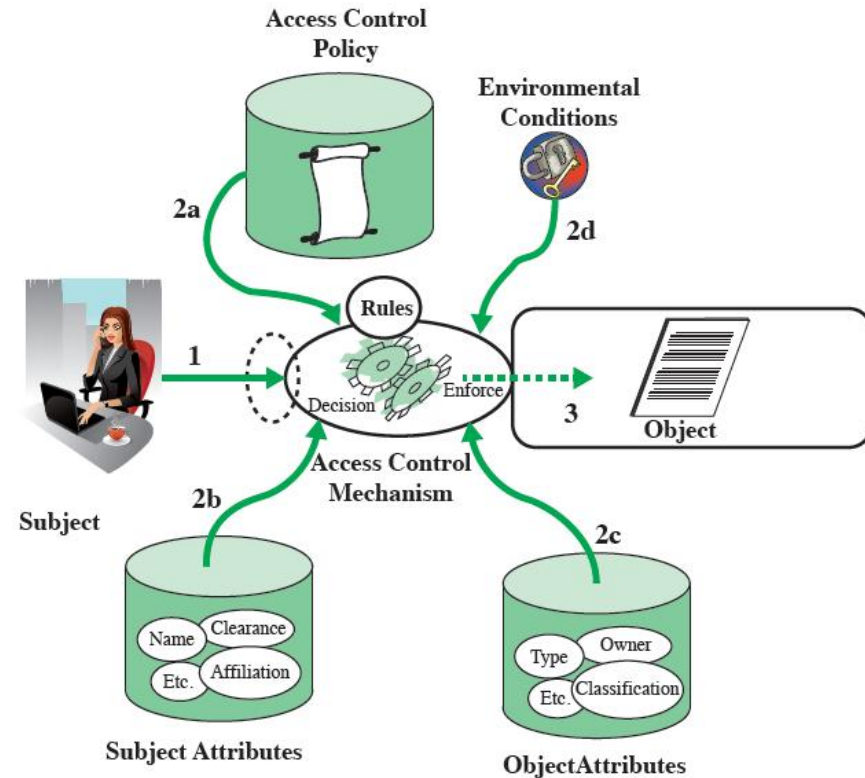
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- ◆ Describe the operational, technical, and even situational environment or context in which the information access occurs
  - ◆ Current date
  - ◆ Current virus/hacker activities
  - ◆ Network security level
  - ◆ *Not associated with a resource or subject*
- ◆ These attributes have so far been largely ignored in most access control policies

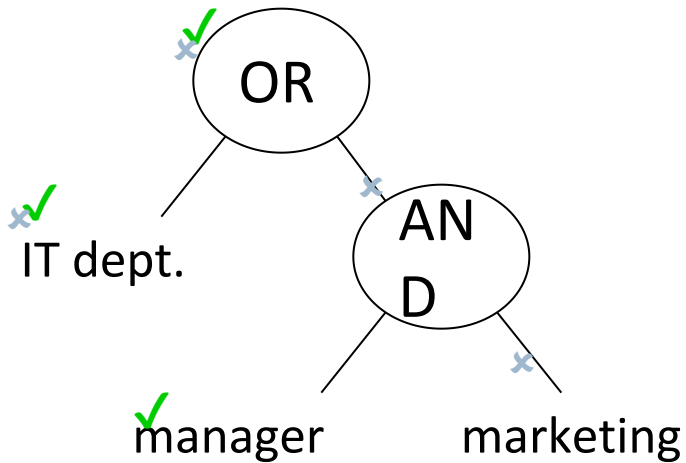


# Sample ABAC scenario

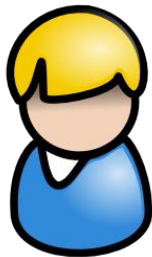
1. A subject requests access to an object
2. AC is governed by a set of rules (2a): assesses the attr of subject (2b), object (2c) and env (2d)
3. AC grants subject access to object if authorized



# ABAC



SK<sub>Sarah</sub>:  
“manager”  
“IT dept.”

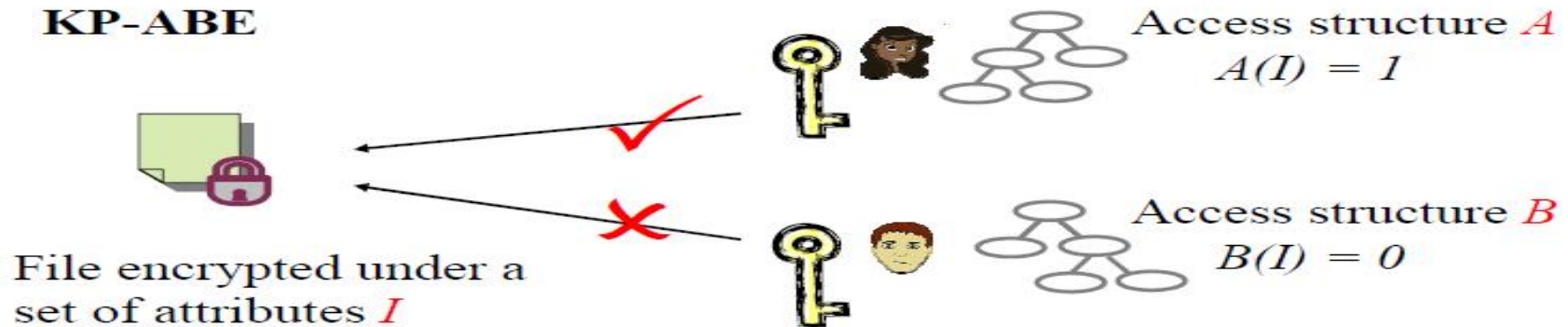


SK<sub>Kevin</sub>:  
“manager”  
“sales”

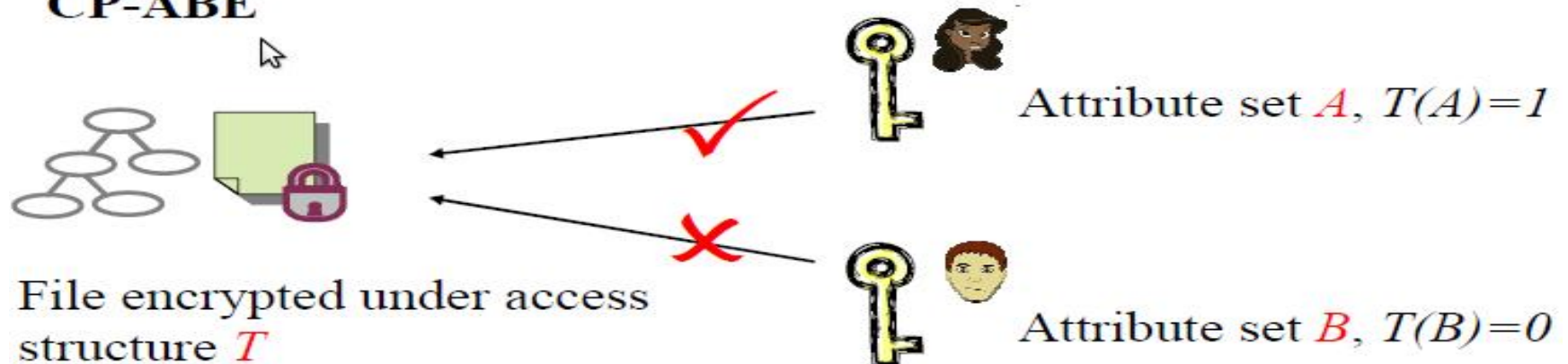


# Attribute Based Encryption : Two Types

## KP-ABE

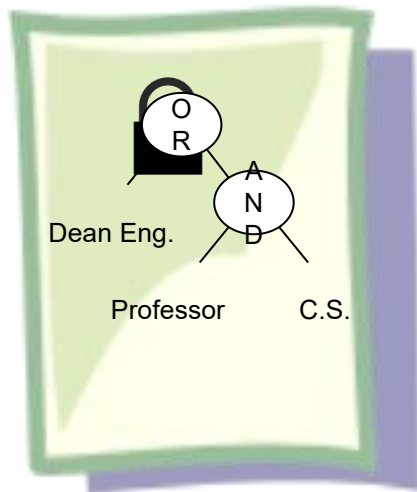


## CP-ABE

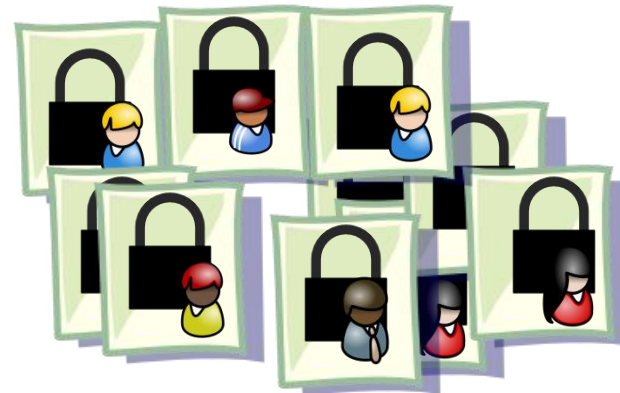


# Why CP-ABE?

Efficiency:



**vs.**



# Summary

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- ◆ introduced access control principles
  - ◆ subjects, objects, access rights
- ◆ discretionary access controls
  - ◆ access matrix, access control lists (ACLs), capability tickets
  - ◆ UNIX traditional and ACL mechanisms
- ◆ role-based access control
- ◆ case study