Computer Security: Principles and Practice

Fourth Edition

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Chapter 4

Access Control

Access Control Definitions 1/2

NISTIR 7298 defines access control as:

"the process of **granting** or **denying** specific requests to: (1) obtain and use **information** and related information processing **services**; and (2) enter specific **physical facilities**"

Access Control Definitions 2/2

RFC 4949 defines access control as:

"a process by which use of system resources is regulated according to a **security policy** and is permitted only by **authorized entities** (users, programs, processes, or other systems) according to that policy"

	Basic Security Requirements
1	Limit information system access to authorized users, processes acting on behalf of authorized users, or devices (including other information systems).
2	Limit information system access to the types of transactions and functions that authorized users are permitted to execute.
	Derived Security Requirements
3	Control the flow of CUI in accordance with approved authorizations.
4	Separate the duties of individuals to reduce the risk of malevolent activity without collusion.
5	Employ the principle of least privilege, including for specific security functions and privileged accounts.
6	Use non-privileged accounts or roles when accessing nonsecurity functions.
7	Prevent non-privileged users from executing privileged functions and audit the execution of such functions.
8	Limit unsuccessful logon attempts.
9	Provide privacy and security notices consistent with applicable CUI rules.
10	Use session lock with pattern-hiding displays to prevent access and viewing of data after period of inactivity.
11	Terminate (automatically) a user session after a defined condition.
12	Monitor and control remote access sessions.
13	Employ cryptographic mechanisms to protect the confidentiality of remote access sessions.
14	Route remote access via managed access control points.
15	Authorize remote execution of privileged commands and remote access to security-relevant information.
16	Authorize wireless access prior to allowing such connections.
17	Protect wireless access using authentication and encryption.
18	Control connection of mobile devices.
19	Encrypt CUI on mobile devices.
20	Verify and control/limit connections to and use of external information systems.
21	Limit use of organizational portable storage devices on external information systems.
22	Control CUI posted or processed on publicly accessible information systems.

CUI = controlled unclassified information

Table 4.1

Access Control **Security Requirements** (SP 800-171)

(Table is on page 107 in the textbook)

Access Control Principles

- In a broad sense, **all of computer security is concerned with access control**

- RFC 4949 defines computer security as:

"measures that implement and assure security services in a computer system, particularly those that assure access control service"

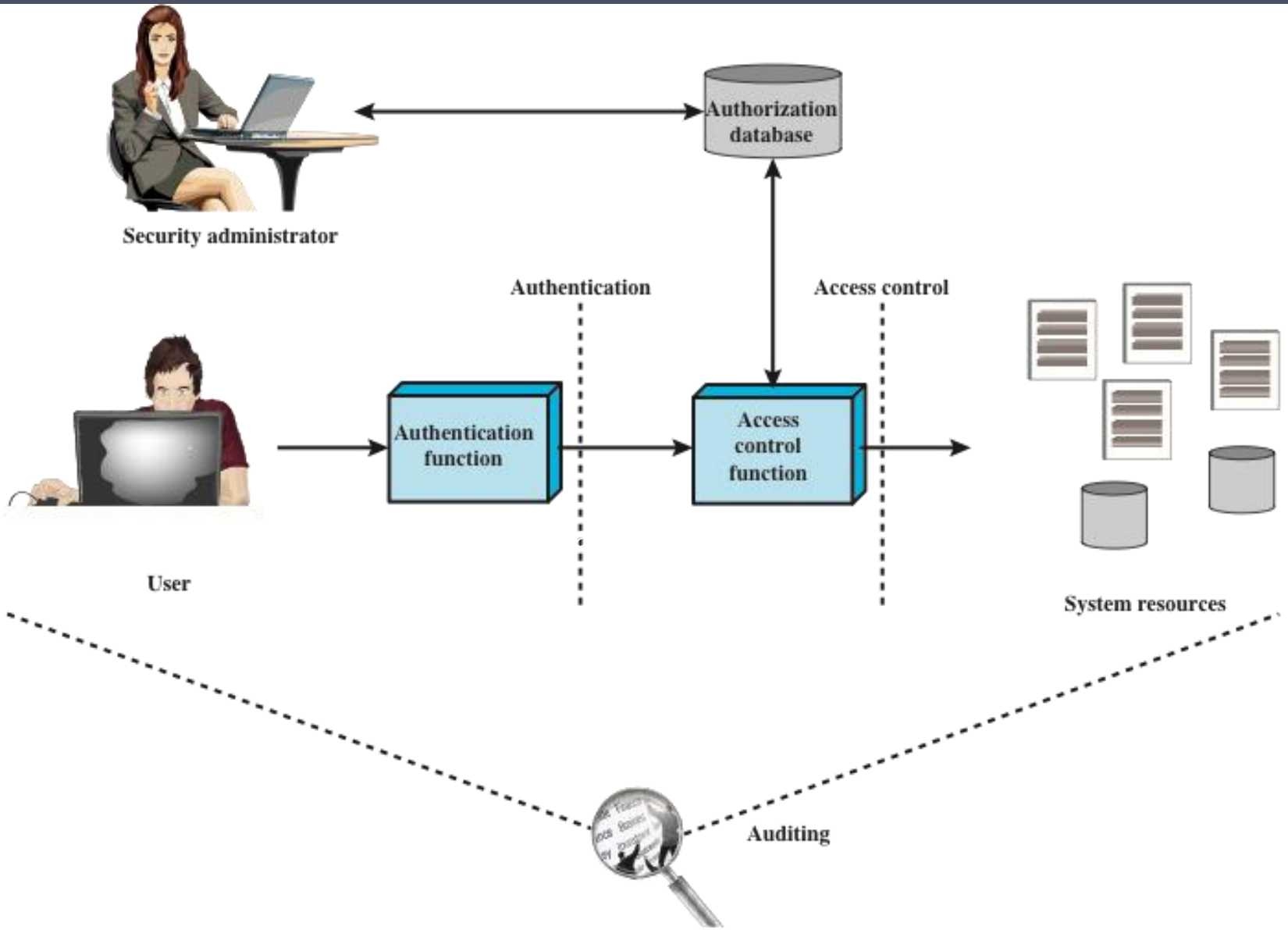


Figure 4.1 Relationship Among Access Control and Other Security Functions

Source: Based on [SAND94].

Access Control Policies

- Discretionary access control (**DAC**)
  - Controls access based on the **identity** of the requestor and on **access rules** (authorizations) stating what requestors are (or are not) allowed to do
- Mandatory access control (**MAC**)
  - Controls access based on comparing **security labels** with **security clearances**
- Role-based access control (**RBAC**)
  - Controls access based on the **roles** that users have within the system and on **rules** stating what accesses are allowed to users in given roles
- Attribute-based access control (**ABAC**)
  - Controls access based on **attributes** of the user, the **resource** to be accessed, and **current environmental conditions**

Subjects, Objects, and Access Rights

Subject

An entity capable of accessing objects

Three classes
- Owner
- Group
- World

Object

A resource to which access is controlled

Entity used to contain and/or receive information

Access right

Describes the way in which a subject may access an object

Could include:
- Read
- Write
- Execute
- Delete
- Create
- Search

Discretionary Access Control (DAC)

- Scheme in which an entity may be granted access rights that permit the entity, by its own volation, to **enable another entity** to access some resource
- Often provided using an **access matrix**
  - One dimension consists of **identified subjects** that may attempt data access to the resources
  - The other dimension lists the **objects** that may be accessed
- Each entry in the matrix indicates the **access rights** of a particular subject for a particular object

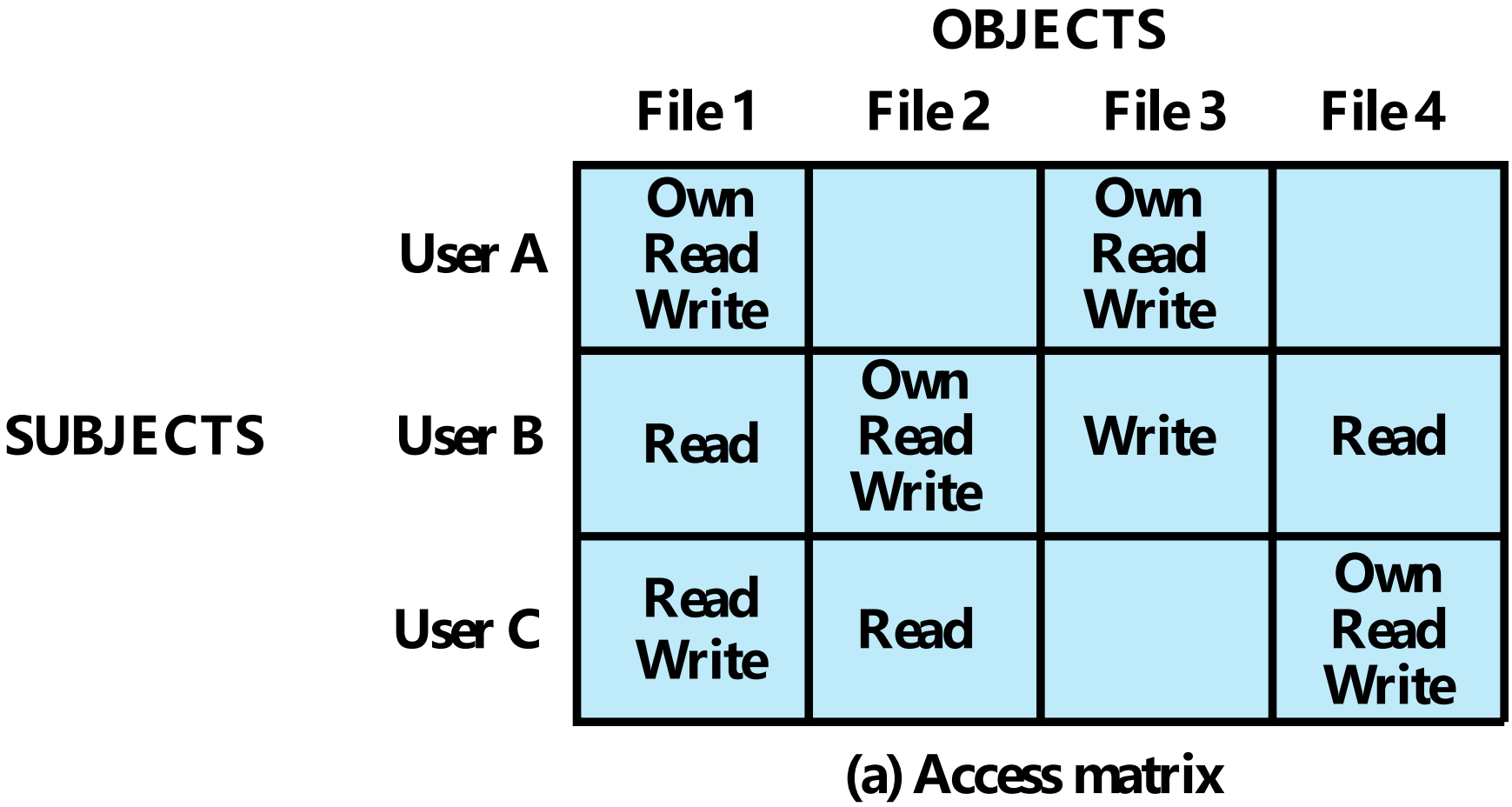
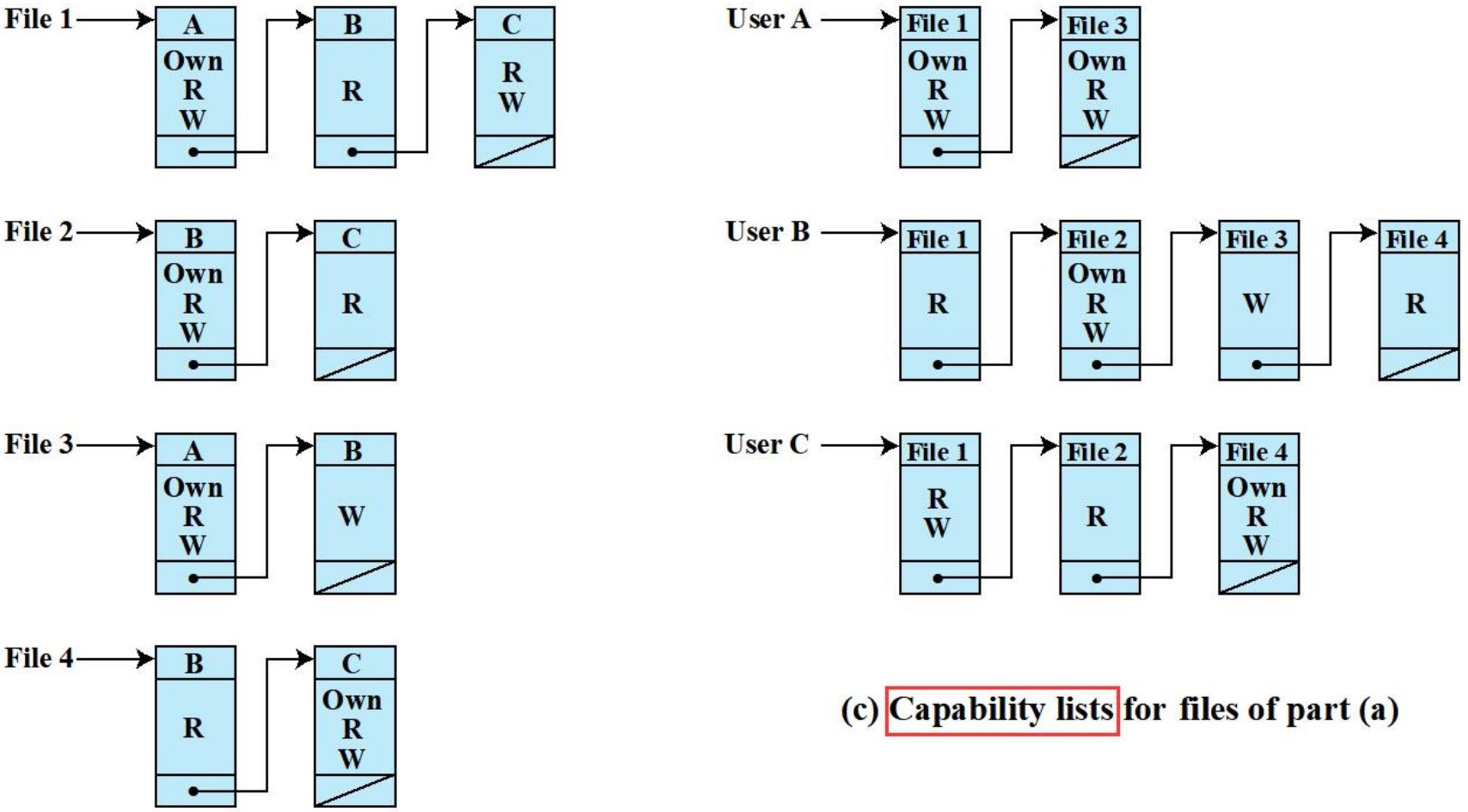


Figure 4.2 Example of Access Control Structures



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

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

Figure 4.2 Example of Access Control Structures

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

Table 4.2

Authorization Table

for Files in Figure 4.2

(Table is on page 113 in the textbook)

		OBJECTS								
		subjects			files		processes		disk drives	
		S_1	S_2	S_3	F_1	F_2	P_1	P_2	D_1	D_2
SUBJECTS	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			

* - copy flag set

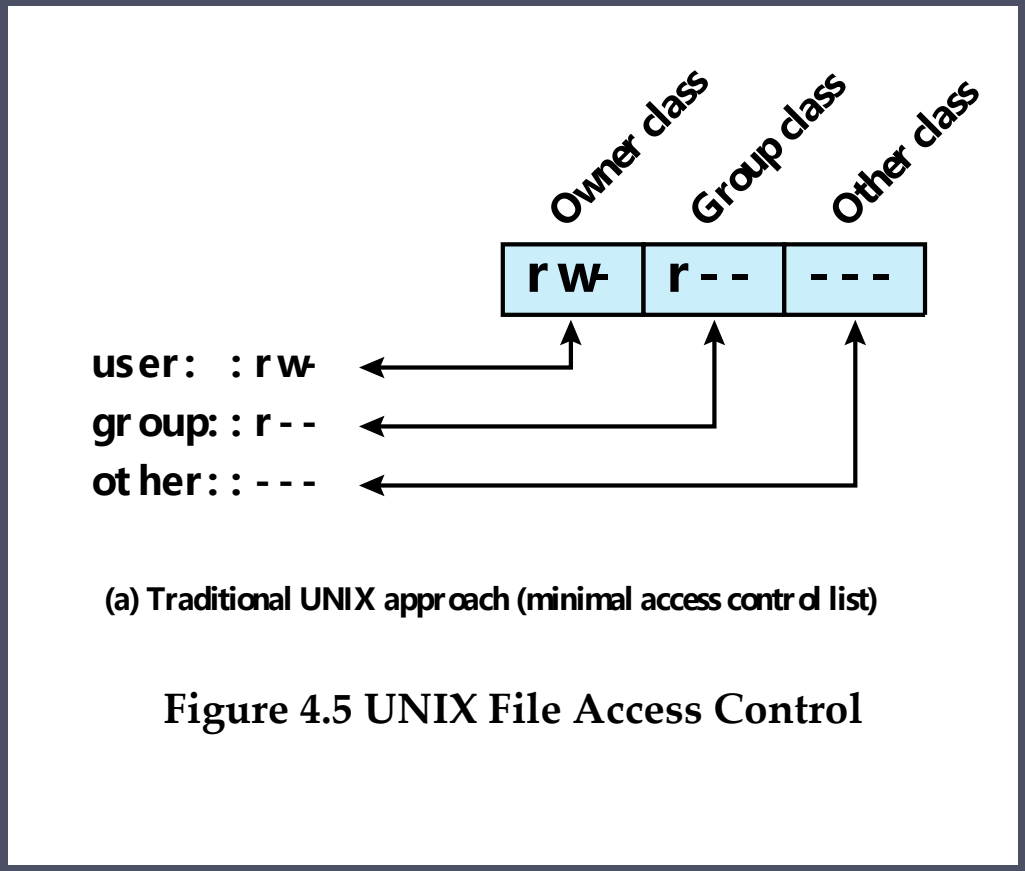
Figure 4.3 Extended Access Control Matrix

Protection Domains

- **Set of objects** together with **access rights** to those objects
- More flexibility when associating **capabilities** with protection domains
- In terms of the access matrix, **a row defines a protection domain**
- User can **spawn** processes with a subset of the access rights of the user
- **Association** between a process and a domain can be static or dynamic
- **In user mode** certain areas of memory are protected from use and certain instructions may not be executed
- **In kernel mode** privileged instructions may be executed and protected areas of memory may be accessed

UNIX
File Access Control

- Unique user identification number (**user ID**)
- Member of a primary group identified by a **group ID**
- Belongs to a specific group
- **9 protection bits**
  - Specify **read**, **write**, and **execute** permission for the **owner** of the file, members of the **group** and all **other** users
- The owner ID, group ID, and protection bits are part of the file's inode
- **Left 3 protection bits**
  - SetUID, SetGID, Sticky



(a) Traditional UNIX approach (minimal access control list)

Figure 4.5 UNIX File Access Control

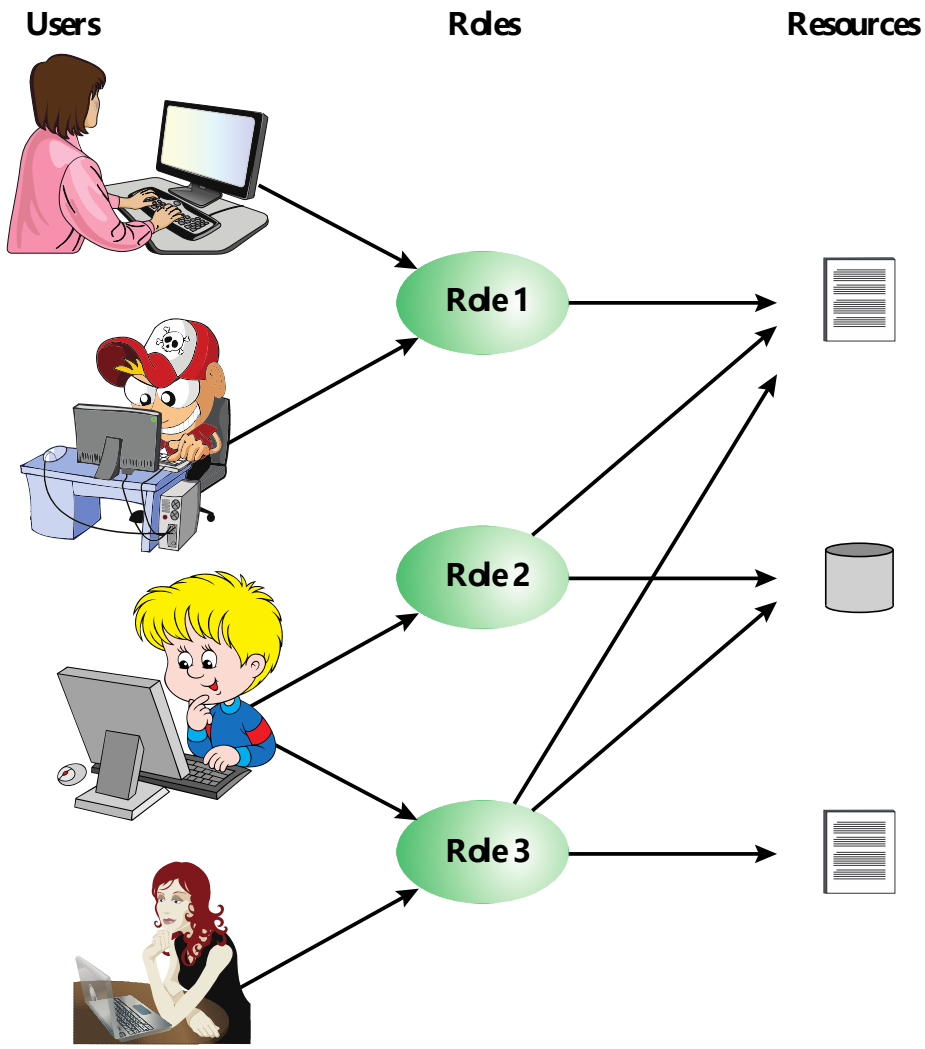
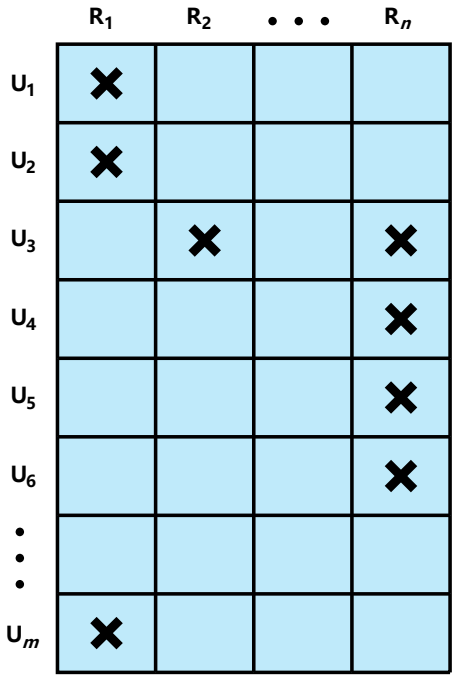


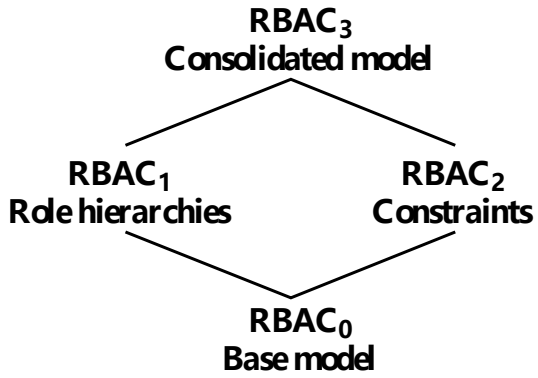
Figure 4.6 Users, Roles, and Resources



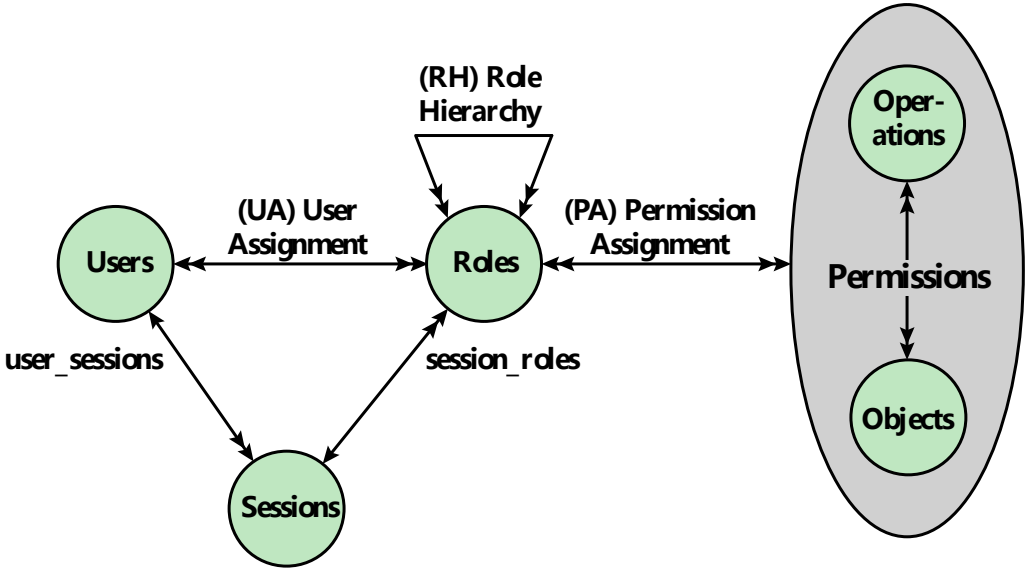
OBJECTS

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			

Figure 4.7 Access Control Matrix Representation of RBAC



(a) Relationship among RBAC models



(b) RBAC models

Figure 4.8 A Family of Role-Based Access Control Models.

Table 4.4
Scope RBAC Models

Models	Hierarchies	Constraints
$RBAC_0$	No	No
$RBAC_1$	Yes	No
$RBAC_2$	No	Yes
$RBAC_3$	Yes	Yes

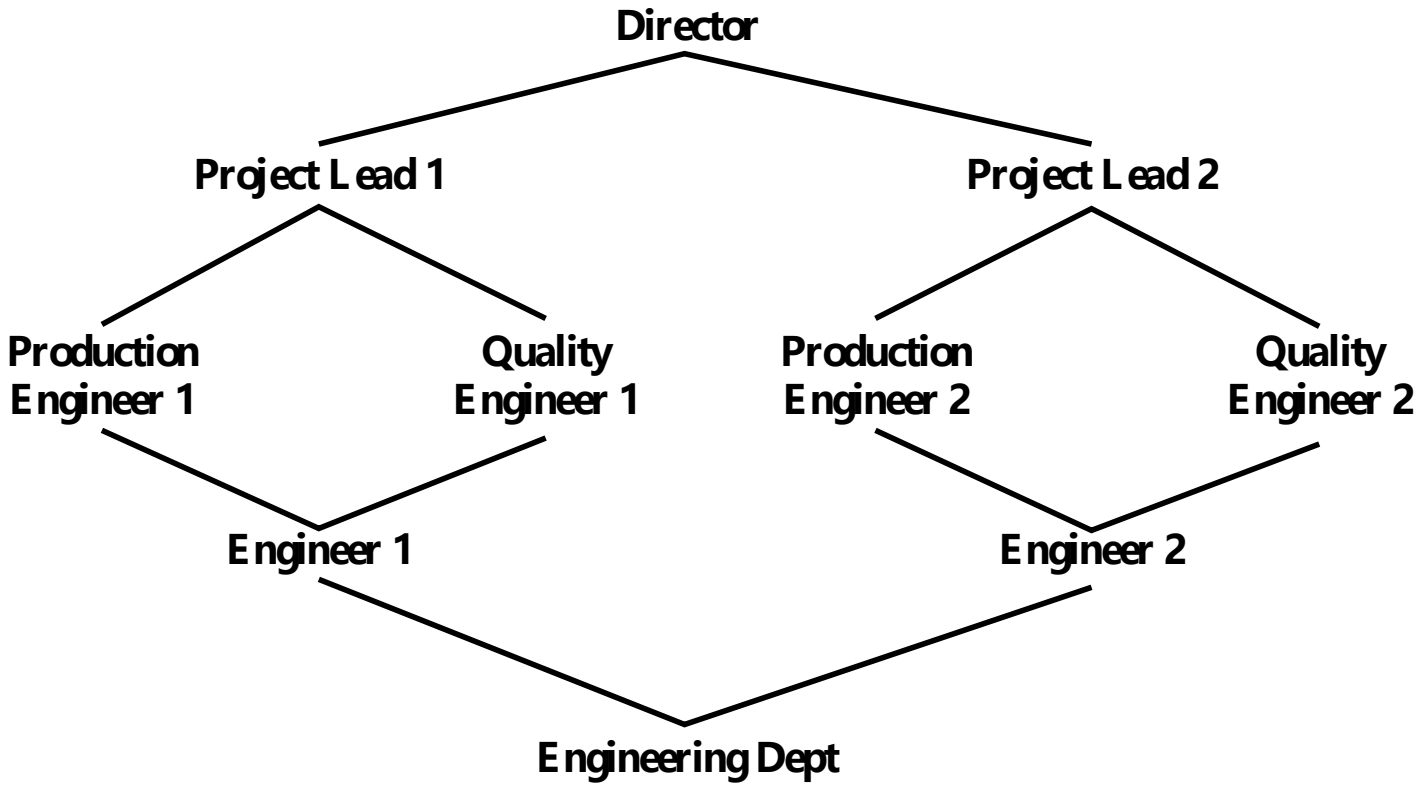


Figure 4.9 Example of Role Hierarchy

Constraints - RBAC

- Provide a means of **adapting RBAC to the specifics** of administrative and security policies of an organization
- A defined **relationship** among roles or a **condition** related to roles
- Types:

Mutually exclusive roles	Cardinality	Prerequisite roles
• **A user** can only be **assigned to one role** in the set (either during a session or statically) • Any **permission** (access right) can be **granted to only one role** in the set	• Setting a **maximum number** with respect to roles	• **Dictates** that a user can only be assigned to a particular role if it is already assigned to some other specified role

Attribute-Based Access Control (ABAC)

Can define authorizations that express conditions on **properties** of both the resource and the subject

Strength is its **flexibility** and **expressive** power

Main obstacle to its adoption in real systems has been concern about the **performance impact** of evaluating predicates on both resource and user properties for each access

Web services have been pioneering technologies through the introduction of the **eXtensible Access Control Markup Language** (XACML)

There is considerable interest in applying the model to **cloud services**

ABAC Model: Attributes

Subject attributes

- 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

Object attributes

- An object (or resource) is a **passive** information system-related **entity** containing or receiving information
- Objects have **attributes** that can be leverages to make access control decisions

Environment attributes

- Describe the operational, technical, and even situational **environment** or **context** in which the information access occurs
- These attributes have so far been largely **ignored** in most access control policies

ABAC


Distinguishable because it controls access to objects by evaluating rules against the attributes of entities, operations, and the environment relevant to a request
Relies upon the evaluation of attributes of the subject, attributes of the object, and a formal relationship or access control rule defining the allowable operations for subject-object attribute combinations in a given environment
Systems are capable of enforcing DAC, RBAC, and MAC concepts
Allows an unlimited number of attributes to be combined to satisfy any access control rule

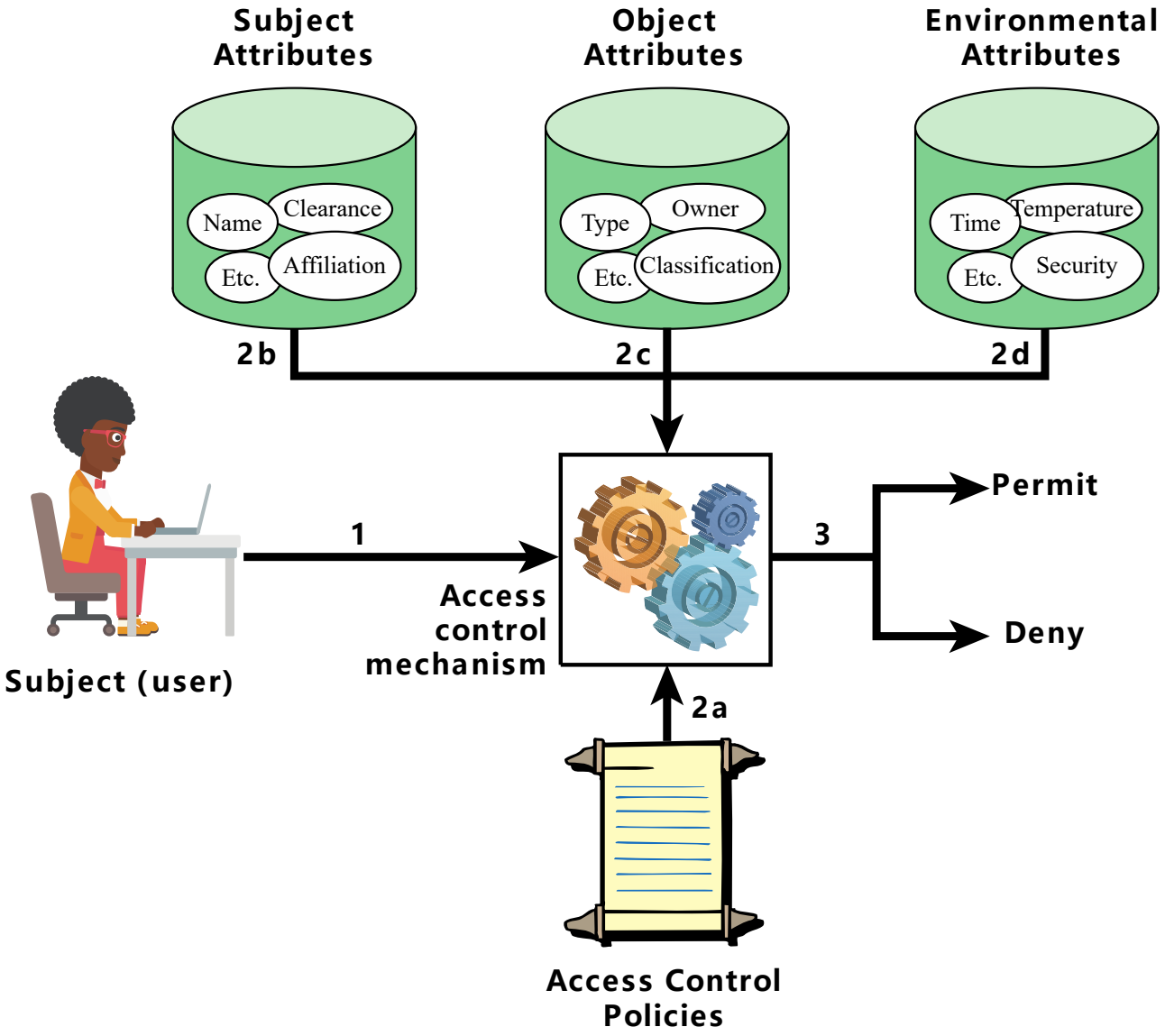


Figure 4.10 ABAC Scenario

ABAC Policies

A policy is **a set of rules and relationships** that govern allowable behavior within an organization, based on the privileges of subjects and how resources or objects are to be protected under which environment conditions

Typically written from **the perspective of the object** that needs protecting **and the privileges** available to subjects

Privileges represent the **authorized behavior** of a subject and are defined by an authority and embodied in a policy

Other terms commonly used instead of privileges are: **rights**, **authorizations**, and **entitlements**

Identity, Credential, and Access Management (ICAM)

- A **comprehensive approach** to managing and implementing **digital identities, credentials, and access control**
- Developed by the U.S. government
- Designed to:
  - **Create trusted digital identity representations** of individuals and nonperson entities (NPEs)
  - **Bind those identities to credentials** that may serve as a proxy for the individual of NPE in access transactions
    - A credential is an object or data structure that authoritatively binds an identity to a **token** possessed and controlled by a subscriber
  - **Use the credentials to provide authorized access** to an agency's resources

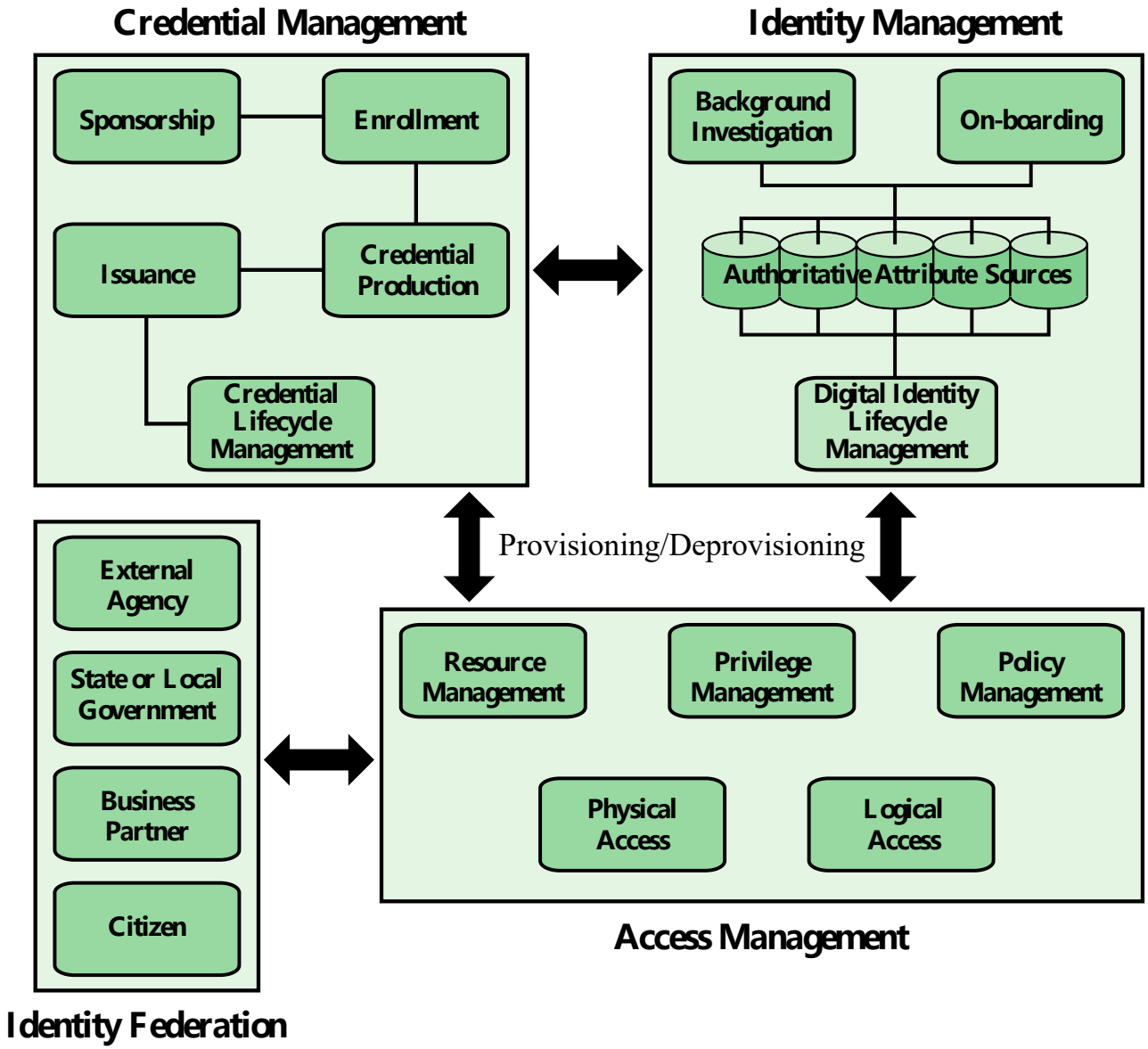
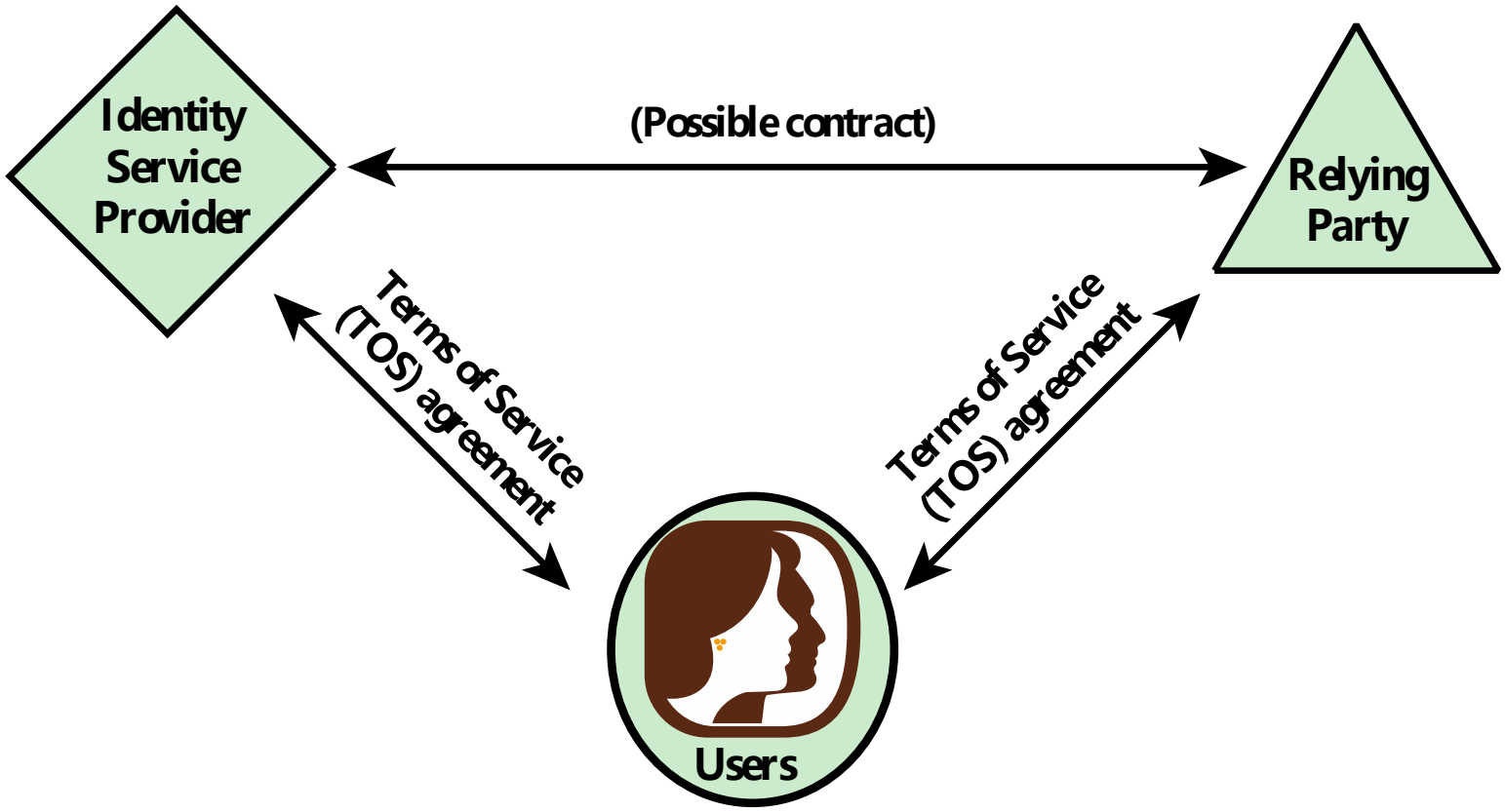
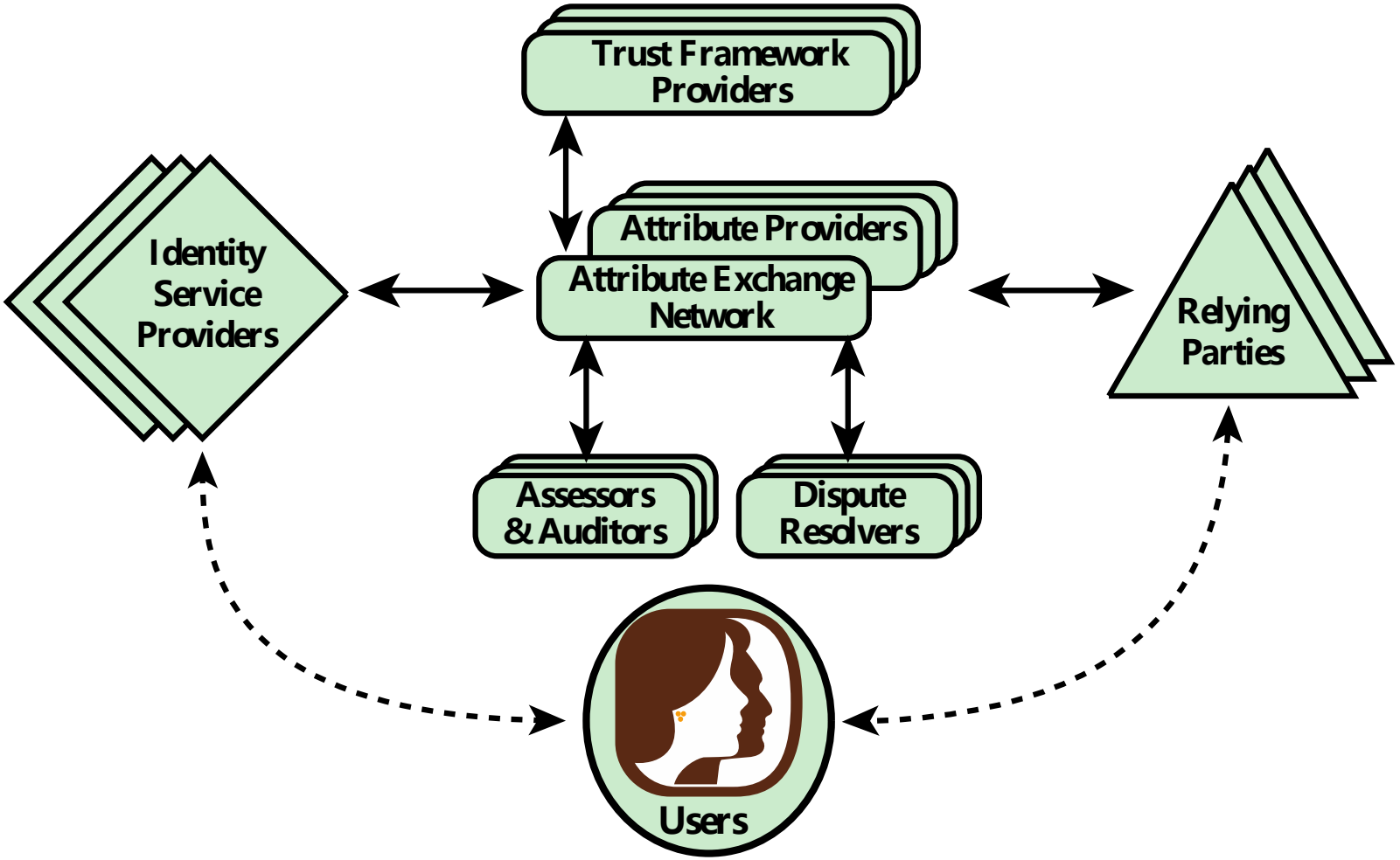


Figure 4.12 Identity, Credential, and Access Management (ICAM)



(a) Traditional triangle of parties involved in an exchange of identity information

Figure 4.13 Identity Information Exchange Approaches



(B) Identity attribute exchange elements

Figure 4.13 Identity Information Exchange Approaches

Table 4.5
Functions and Roles for Banking Example

(a) Functions and Official Positions

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

Table 4.5
Functions and Roles for Banking Example

(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
• • •	• • •	• • •

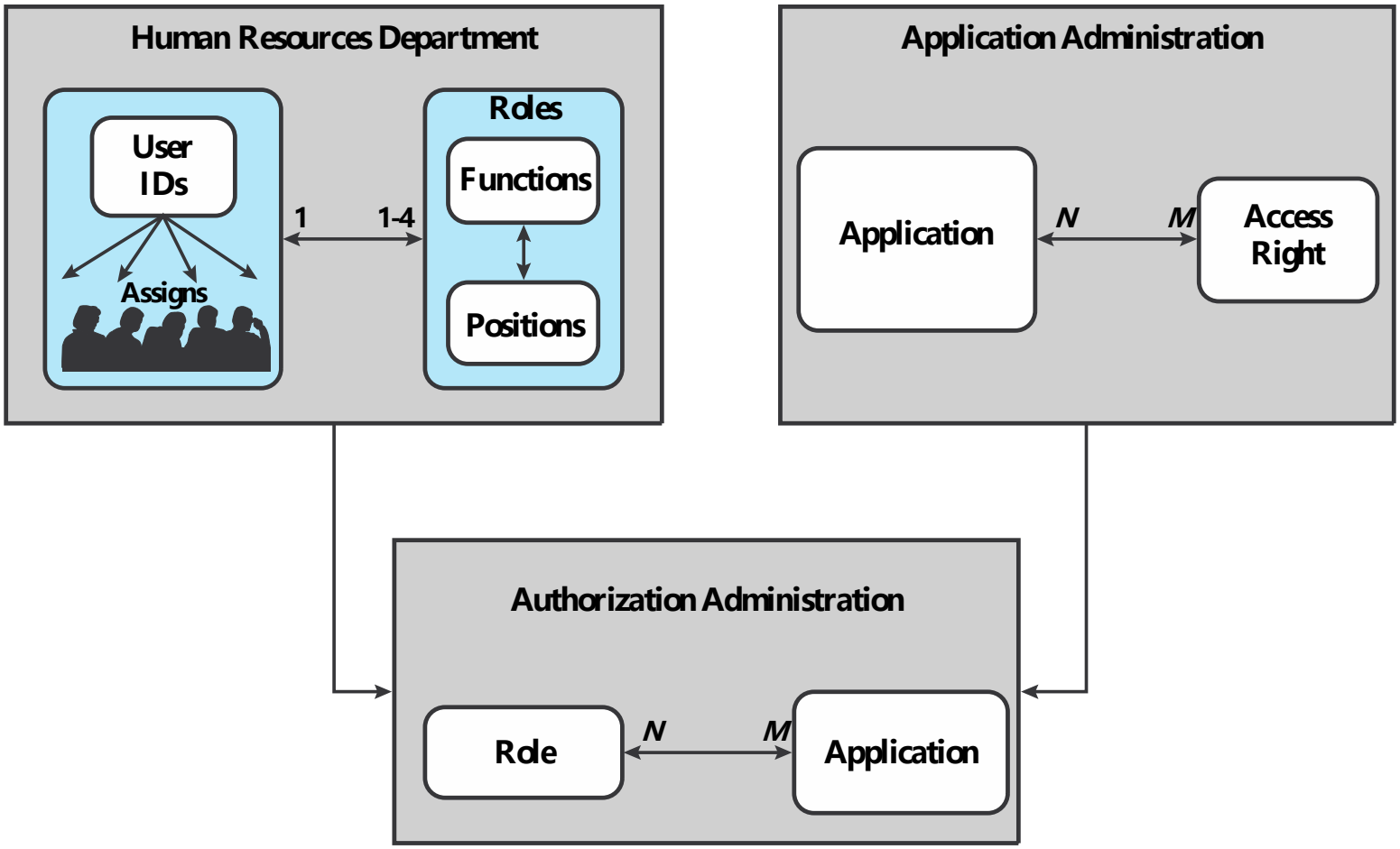


Figure 4.14 Example of Access Control Administration

Summary

- Access control principles
  - Access control context
  - Access control policies
- Subjects, objects, and access rights
- Discretionary access control
  - Access control model
  - Protection domains
- UNIX file access control
  - Traditional UNIX file access control
  - Access control lists in UNIX
- Role-based access control
  - RBAC reference models
- Attribute-based access control
  - Attributes
  - ABAC logical architecture
  - ABAC policies
- Identity, credential, and access management
  - Identity management
  - Credential management
  - Access management
  - Identity federation
- Trust frameworks
  - Traditional identity exchange approach
  - Open identity trust framework
- Bank RBAC system

作业

- 英文教材（第四版）P165-167
- Questions 4.1, 4.2
- Problems 4.1, 4.8, 4.9