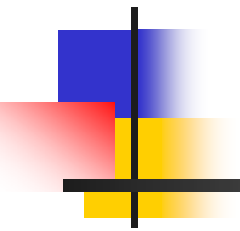
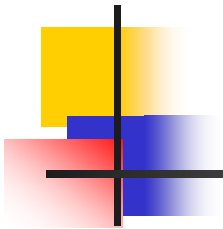


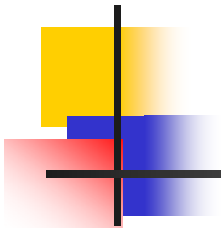
Protection

Chapter 14



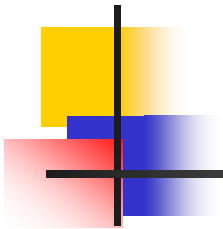
Objectives

- Discuss the goals and principles of protection in a modern computer system
- Explain how protection domains combined with an access matrix are used to specify the resources a process may access
- Examine capability and language-based protection systems



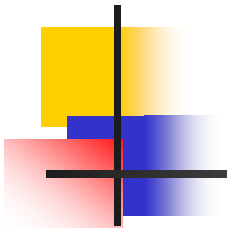
Chapter Outline

- Goals and Principles of Protection
- Policy and Mechanism
- Domain of Protection
- Access Matrix
- Implementation of Access Matrix
- Access Control
- Revocation of Access Rights
- Capability-Based Systems (skip)
- Language-Based Protection (skip)



- Goals and Principles of Protection

- Goals of Protection
  - Operating system consists of a collection of objects, hardware or software
  - Each object has a unique name and can be accessed through a well-defined set of operations.
  - Protection problem - ensure that each object is accessed correctly and only by those processes that are allowed to do so.
- Guiding principle – principle of least privilege
  - Programs, users and systems should be given just enough privileges to perform their tasks

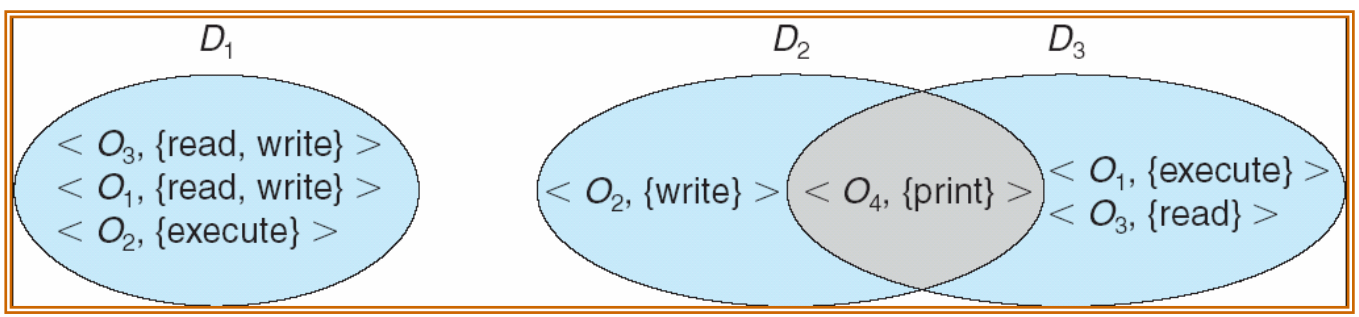


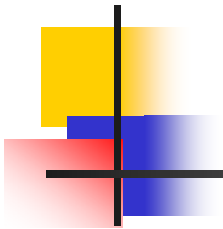
- Policy and Mechanism

- Good to separate protection policy from mechanism
- **Policy**
  - User dictates policy.
  - Who can access what object and in what mode.
- **Mechanism**
  - Operating system provides access-matrix + rules.
  - It ensures that the matrix is only manipulated by authorized agents and that rules are strictly enforced.

- Domain of Protection

- The ability to execute an operation on an object is an **access-right**
- Access-right = <*object-name*, *rights-set*>
  where *rights-set* is a subset of all valid operations that can be performed on the object.
- **Domain** = set of access-rights



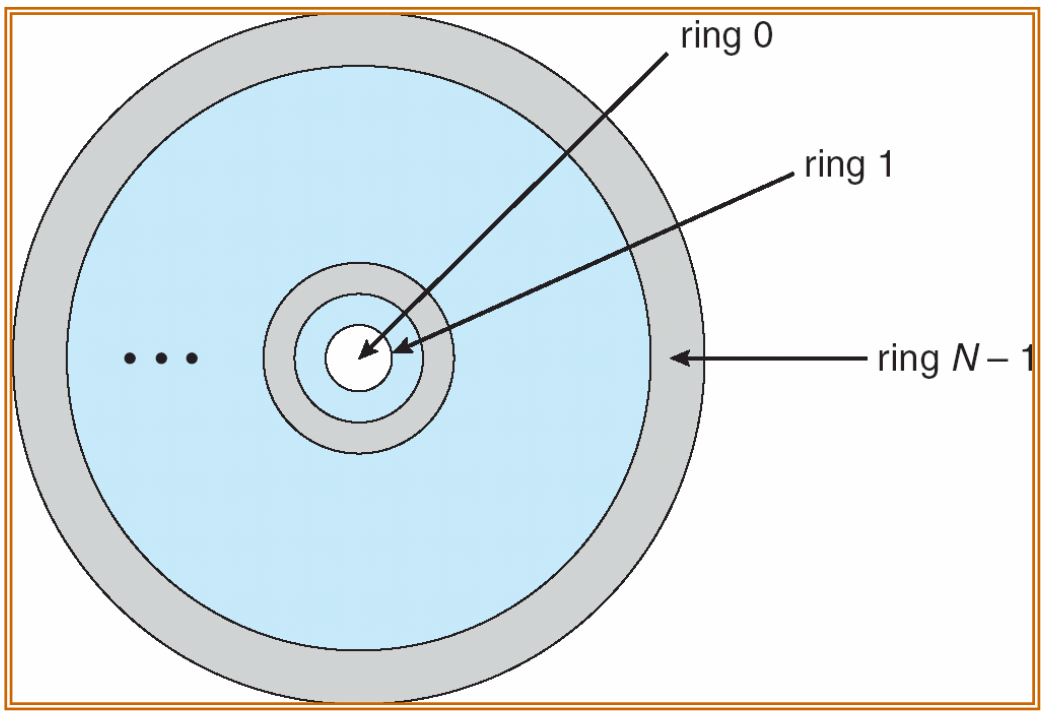


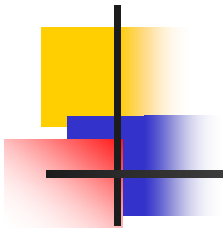
-- Example: Domain Implementation (UNIX)

- System consists of 2 domains:
  - User
  - Supervisor
- UNIX
  - Domain = user-id
  - Domain switch accomplished via file system (dynamic).
    - Each file has associated with it a domain bit (setuid bit).
    - When file is executed and setuid = on, then user-id is set to owner of the file being executed. When execution completes user-id is reset.

-- Example: Domain Implementation (MULTICS)

- Let D_i and D_j be any two domain rings.
- If $j < I \Rightarrow D_i \subseteq D_j$



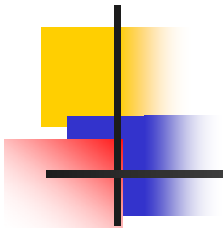


- Access Matrix

- View protection as a matrix (*access matrix*)
- Rows represent domains
- Columns represent objects
- *Access(i, j)* is the set of operations that a process executing in $Domain_i$ can invoke on $Object_j$
- Access matrix design separates mechanism from policy.

... - Access Matrix (static)

domain \ object	F_1	F_2	F_3	printer
D_1	read		read	
D_2				print
D_3		read	execute	
D_4	read write		read write	



-- Use of Access Matrix

- If a process in Domain D_i tries to do "op" on object O_j, then "op" must be in the access matrix.

- Can be expanded to **dynamic** protection.
  - Operations to add, delete access rights.
  - Special access rights:
    - ***owner*** *of* O_i
    - ***copy*** *op from* O_i *to* O_j
    - ***control*** *–* D_i *can modify* D_j *access rights*
    - ***switch*** *- transfer from domain* D_i *to* D_j

-- Access Matrix (Dynamic)

domain \ object	F_1	F_2	F_3	laser printer	D_1	D_2	D_3	D_4
D_1	read		read			switch		
D_2				print			switch	switch
D_3		read	execute					
D_4	read write		read write		switch			

-- Access Matrix with *Copy* Rights

object / domain	F_1	F_2	F_3
D_1	execute		write*
D_2	execute	read*	execute
D_3	execute		

(a)

object / domain	F_1	F_2	F_3
D_1	execute		write*
D_2	execute	read*	execute
D_3	execute	read	

(b)

-- Access Matrix With *Owner* Rights

object / domain	F_1	F_2	F_3
D_1	owner execute		write
D_2		read* owner	read* owner write
D_3	execute		

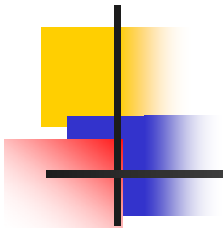
(a)

object / domain	F_1	F_2	F_3
D_1	owner execute		write
D_2		owner read* write*	read* owner write
D_3		write	write

(b)

-- Modified Access Matrix

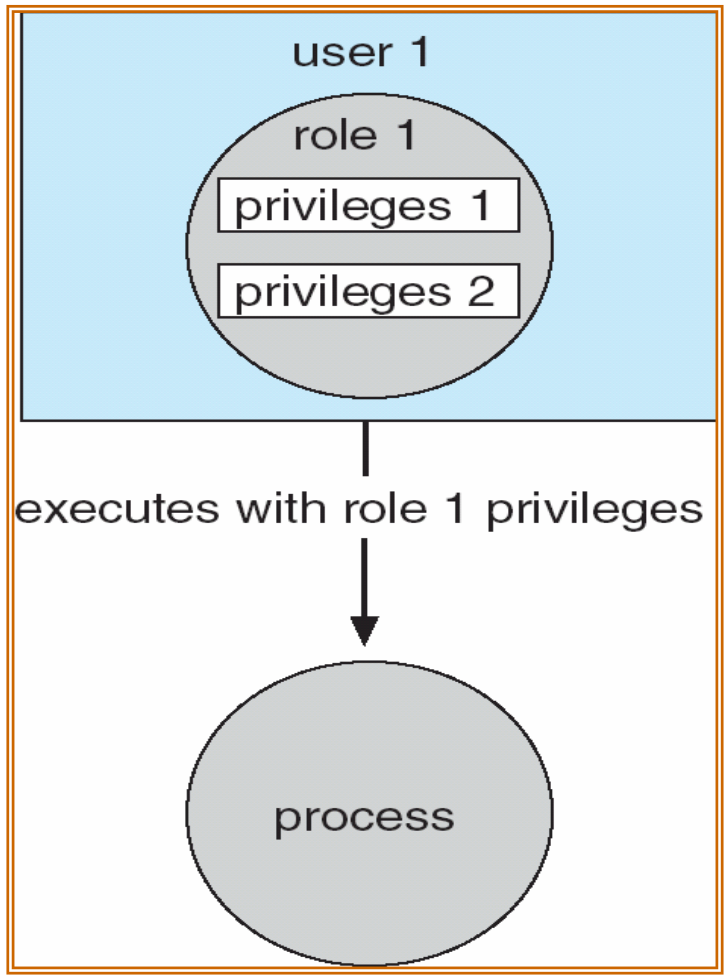
domain \ object	F_1	F_2	F_3	laser printer	D_1	D_2	D_3	D_4
D_1	read		read			switch		
D_2				print			switch	switch control
D_3		read	execute					
D_4	write		write		switch			



- Access Control

- Protection can be applied to non-file resources
- Solaris 10 provides **role-based access control** to implement least privilege
  - Privilege is right to execute system call or use an option within a system call
  - Can be assigned to processes
  - Users assigned roles granting access to privileges and programs

-- Role-based Access Control in Solaris 10



- Implementation of Access Matrix

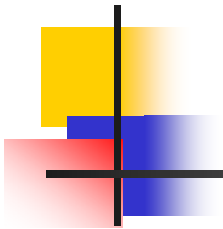
- **Global Table**: Simple but usually too big to be kept in memory and difficult to take advantage of special grouping of objects or domains.

- Each column = **Access-control list** for one object
  Defines who can perform what operation.

  Domain 1 = Read, Write
  Domain 2 = Read
  Domain 3 = Read
  ⋮

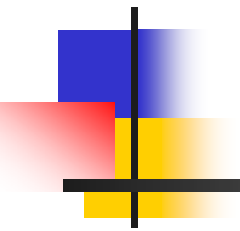
- Each Row = **Capability List** (like a key)
  Fore each domain, what operations allowed on what objects.

  Object 1 – Read
  Object 4 – Read, Write, Execute
  Object 5 – Read, Write, Delete, Copy



- Revocation of Access Rights

- **Access List** – Delete access rights from access list.
  - Simple
  - Immediate
- **Capability List** – Scheme required to locate capability in the system before capability can be revoked.
  - Reacquisition
  - Back-pointers
  - Indirection
  - Keys



End of Chapter 14