Protection

Read from the textbook

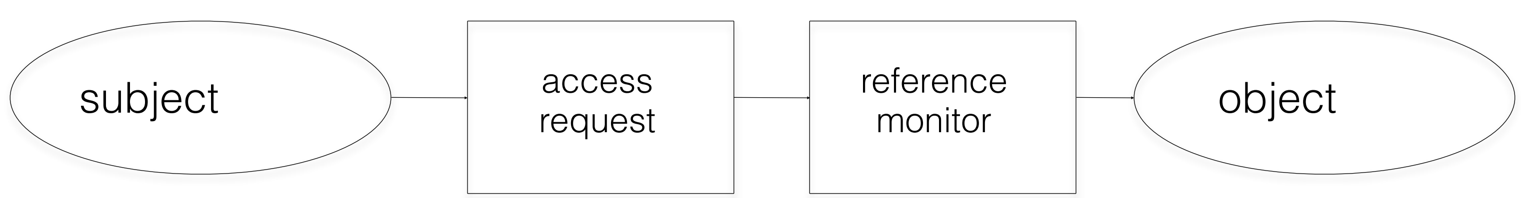
- Ch17.1 Goals of Protection
- Ch17.2 Principles of Protection
- Ch17.4 Domain of Protection
- Ch17.5 Access Matrix

Goal of Protection

- In one protection model, computer 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

Goal of Protection

- Protect against
  - malicious intent
  - stupidity
  - accident
  - errors
- Each object in the system has a number of operations that can be performed on it. Not only do we not want any other access than the permitted operations we would also like to limit access to the minimum required to achieve the allowed goals – the **need to know** principle.
- All accesses to objects should be mediated by a **reference monitor**.



Goal of Protection

- Protection – the **mechanism** of controlling access to resources for programs, processes and users.
- Subjects – the active components in a system that can use resources (users, programs, processes). Also referred to as principals.
- Objects – the resources being used (programs, processes, files, memory, communication channels, devices, databases, semaphores)
- Objects can also be subjects.
- We will assume that we have authenticated the subjects, so what we are concerned with here is how to ensure subjects only access objects in permitted ways. **Authorization**.
- We will look at **authentication** in the security section.

Principles of Protection

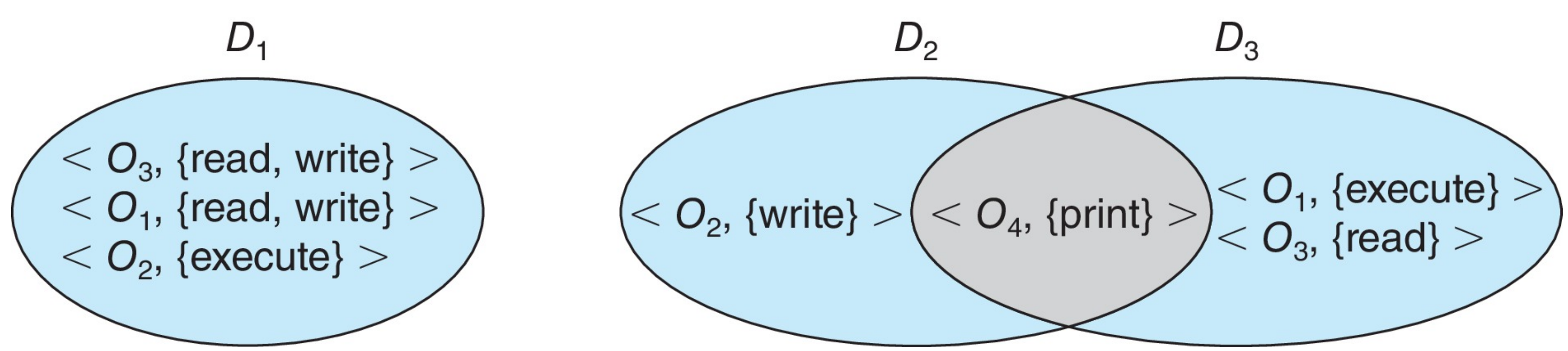
- Guiding principle – **principle of least privilege**
  - Programs, users and systems should be given just enough **privileges** to perform their tasks
  - Properly set **permissions** can limit damage if entity has a bug, gets abused
  - Can be static (during life of system, during life of process)
  - Or dynamic (changed by process as needed) – **domain switching**, **privilege escalation**
  - **Compartmentalization** a derivative concept regarding access to data
    - Process of protecting each individual system component through the use of specific permissions and access restrictions

Examples of Protection

- We have already seen several examples of protection in this course:
  - Privileged instructions – the process must be executing in kernel mode in order to execute without causing an exception.
  - Memory protection – the kernel address space is protected from user level instructions. Similarly one process' address space is protected from access by another.
  - File system – one user's files are protected from access by another user.
- What is the reference monitor in each of these cases, how could it work?

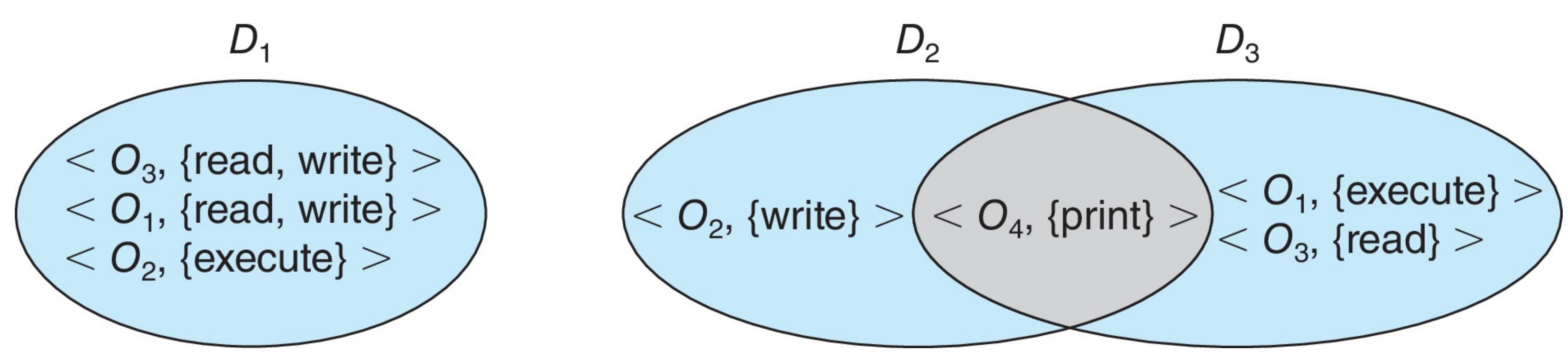
Protection Domains

- Access rights are commonly associated with protection domains.
- A process executes inside a protection domain. The process then has the rights and privileges of the domain.
- Thus many processes can have the same rights if they execute in the same domain.
- There are too many subjects, objects and access rights in a normal system to explicitly keep information about all of them.
- So this combining is the first attempt to decrease the amount of protection information which the system needs to maintain.
- A domain is a collection of ordered pairs
    - <object, rights>



Intersection of Domains

- Domains can overlap.
  - The permission in the overlap is available to both.
- Our programs frequently have to move from one domain to another.
- This switching can only be allowed if the start domain has the permission to change to another domain.
- Domains can be associated with users, locations (e.g. URLs), programs, processes …



Crossing Domains

- Crossing domains is dangerous and is commonly used to attack systems.
- Why do we need it?
  - We want users to have controlled access to resources they don't have direct access to.
  - e.g. a database, particular hardware, networks
- So we give the user access to a program that does have access to the restricted resource.
- The user's domain allows access to the program, the program's domain allows access to the resource.

UNIX

- Domains are associated with users (and the groups they belong to).
- When a program is run it takes on the permissions of the user (both individual and group permissions).
- We can set programs to take on the permissions of the group or owner of the program file instead.
- The program becomes a **setuid** or **setgid** program.

How to setuid

```
-rwxr--r--   1 robert-s staff          21 Oct  8 15:36 program
bash-2.05$ chmod u+s program
-rwsr--r--   1 robert-s staff          21 Oct  8 15:36 program
bash-2.05$ chmod o+x program
-rwsr--r-x   1 robert-s staff          21 Oct  8 15:36 program
```

After these changes anyone (not in my group) can run the *program* file.

When they do so, the process uses my permissions. If it wasn't setuid then the process would have run with their permissions.

This is really dangerous, especially if I am the superuser. If they can start another process from within the *program* process that new process would have my permissions as well.

setuid Precautions

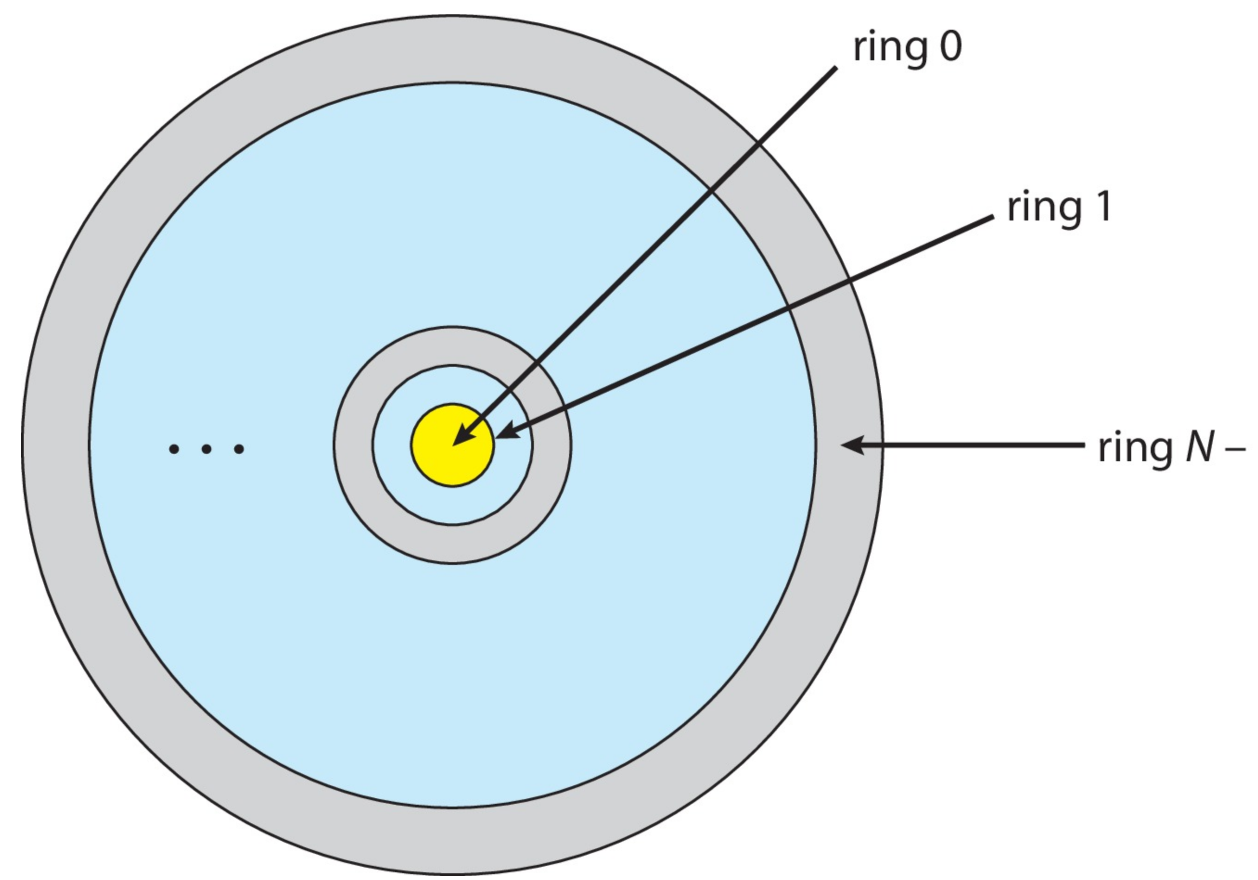
- Restrict the uid
  - Don't use “root”; if necessary make a new user for the program.
- Reset the uid before calling exec
- Or any call that might call exec.
- Close unnecessary files before calling exec
  - If a privileged file was open it would still be accessible.
- If the program must be setuid “root” then use a restricted root directory e.g. chroot(“/usr/hi”)
  - Then only files beneath /usr/hi can be reached.
- Invoke subprograms using their full pathnames.
  - If the path gets altered it may invoke another program (but the privileges remain)

Multics Protection Ring Structure

Let D_i and D_j be any two domain rings.

If $j < i \Rightarrow D_i \subseteq D_j$

A process executing in D_j has more privileges than one executing in D_i.



Multics Segments

- Each file is loaded as a segment. It has associated permissions – read, write, execute – and a ring number (the ring it runs in or is loaded into).
- Access to other segments depends on both the current ring number, the ring number of the other segment and the type of access required.
- The current ring number is maintained when a lower permission ring is entered by a process.
- Sometimes a lower permission segment needs to access a segment in a higher permission ring.
- There are specified entry points which allow this – more access is allowed under controlled conditions.

Other Approaches to Domain Switches

- Special directories – programs in these directories run with the access privileges associated with the directory.
  - This is safer than setuid programs because all privileged processes must be in these directories rather than scattered all around the system.
- Have server processes running with the necessary privileges – the normal user processes send messages to the server process when they need the privileged access.
- Of course a system call is a change of domain and the hardware guarantees that when the call returns the domain reverts to its previous status.
- All such techniques require great care.

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$_j$

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

Changing Permissions

- When an object is created a new column is added and the permissions are set (usually by the creator/owner).
- The domains are objects as well.
- This way we can control access to the domains.
- Transfer to another domain – switch e.g. a process executing in D2 can switch to D3 or D4

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			

Changing in a Column

- Copy right "*" signifies the permission can be copied. Can only work on the same object/column.
- Owner right means any values on the object/column can be changed.

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		
D_2		owner read* write*	read* owner write*
D_3		write	write

(b)

Changing in a Row

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			

- The control right allows one domain to remove rights from another domain.

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 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)

Before Next Time

Read from the textbook

- Ch17.6 Implementation of the Access Matrix
- Ch17.7 Revocation of Access Rights
- Ch17.10 Capability-Based Systems

You may want to see the Wikipedia entries on:

- http://en.wikipedia.org/wiki/Confused_deputy_problem
- http://en.wikipedia.org/wiki/Capabilities
- http://en.wikipedia.org/wiki/Selinux