Operating System Protection

OS Protection Mechanism

- Operating system consists of a collection of objects, hardware or software (e.g., files, printers)
- Protection problem - ensure that each object is accessed correctly and only by those processes that are allowed to do so.
- Access-right = \(<\text{object-name}, \text{rights-set}>\)
- Domain = group of processes having the same set of access-rights

Protection Matrix

- View protection as a matrix (protection matrix)
  - Rows represent domains
  - Columns represent objects
  - \(\text{Access}(i,j)\) is the set of operations that a process exercising in Domain\(_i\), can invoke on Object\(_j\).
- Dynamic protection
  - Operations to add, delete access rights

Implementation of Protection Matrix

- The complete protection matrix consumes too much space and frankly it is very sparse.
  - Two ways to condense it
- 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 for each domain Define what operations allowed on what objects.
  - Object 1 = Read
  - Object 4 = Read, Write, Execute
  - Object 5 = Read, Write, Delete, Copy
Access Control Lists

Use of access control lists to manage file access

Revocation of access rights?

Capabilities

- Tagged architecture
  - memory words containing capabilities are tagged
  - user programs can only read those words; only kernel programs can change those words

- Kernel-space capability list
  - user programs use handles (e.g., file descriptors) to refer to them

Passing Capabilities at User-level

- Cryptographically-protected capability
  - a random number (called "check") is generated for each file at creation time and maintained in secrecy
  - capability is formed cryptographically

<table>
<thead>
<tr>
<th>Server</th>
<th>Object</th>
<th>Rights</th>
<th>f(Object, Rights, Check)</th>
</tr>
</thead>
</table>

- Function f() is a one-way function that:
  - it is computationally infeasible to guess what "check" is even when object, rights, and f(object, rights, check) is known.

- Cryptographically-protected capability can be passed around but not tampered

Revocation of Access Rights for Capabilities

- Revocation:
  - total: revoking rights to all processes
  - selective: revoking rights to a selected group of processes (e.g., all processes belonging to a particular user)

  | Capability List – Scheme required to locate capability in the system before capability can be revoked.
  - Indirection
  - Timeout & Reacquisition
  - Back-pointers
ACL vs. Capabilities

- Compare them on:
  - determining access rights for a process
  - determining access rights to an object
  - efficiency of access rights checking

Trusted Systems

- Trusted Computing Base
  - hardware and software for enforcing security rules
  - If the TCB works according to specification, the system security cannot be compromised
- A reference monitor-based TCB:

Formal Models of Secure Systems

- Protection commands: operations that can change protection matrix
- TCB must ensure that protection commands do not move the protection matrix from an authorized state to an unauthorized state

Covert Channels

- Encapsulated server can still leak to collaborator via covert channels
- Covert channels
  - Modulating CPU usage
  - Locking/unlocking files
Protection in UNIX

- Protection domains: users
- Access matrix for files:
  - a simplified access control list
- Protection commands for files:
  - each user can change protection on files it owns
  - superuser can do everything

Protection in Java

- A Java class can be loaded remotely; therefore can be dangerous
  - A class is assigned a protection domain when it is loaded by the JVM
  - The protection domain indicates what operations the class can (and cannot) perform.
- If a library method is invoked that performs a privileged operation, the stack is inspected for access right violation.

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