Protection

How to Track Objects/Rights in Domains?

- 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 executing in Domain\( i \) can invoke on Object\( j \)
- Dynamic protection
  - Operations to add, delete access rights

<table>
<thead>
<tr>
<th>Domain</th>
<th>File1</th>
<th>File2</th>
<th>File3</th>
<th>File4</th>
<th>File5</th>
<th>File6</th>
<th>Printer1</th>
<th>Printer2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Read</td>
<td>Read</td>
<td>Read</td>
<td>Read</td>
<td>Read</td>
<td>Read</td>
<td>Read</td>
<td>Read</td>
</tr>
<tr>
<td>2</td>
<td>Read</td>
<td>Read</td>
<td>Write</td>
<td>Write</td>
<td>Write</td>
<td>Write</td>
<td>Write</td>
<td>Write</td>
</tr>
<tr>
<td>3</td>
<td>Read</td>
<td>Read</td>
<td>Execute</td>
<td>Write</td>
<td>Write</td>
<td>Write</td>
<td>Write</td>
<td>Write</td>
</tr>
</tbody>
</table>

Operating System Protection

- 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.
  - a general type of security problem
- Domain = group of processes having the same set of access-rights
  - what is a domain in traditional UNIX?
  - when process domain switches occur in traditional UNIX?

Implementation of Protection

- 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
- What does traditional UNIX do?
Access Control Lists

Use of access control lists to manage file access

Revocation of access rights?

Capabilities

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

- Tagged architecture
  - memory words containing capabilities are tagged; user programs can only read those words; only kernel programs can change those words
  - the protection system kernel does not need to track capabilities and capabilities can be passed by memory sharing

Cryptographically-protected Capabilities

- 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.

- Compared with tagged capabilities, cryptographically-protected capability
  - does not require new hardware support
  - can be passed around between distributed machines

Revocation of Access Rights for Capabilities

- Revocation:
  - change the secret check number?

- total: revoking rights to all processes
- selective: revoking rights to a selected group of processes (e.g., all processes belonging to a particular user)
  - Timeout & Reacquisition
ACL vs. Capabilities

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

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

<table>
<thead>
<tr>
<th>Objects</th>
<th>Compiler</th>
<th>Mailbox 7</th>
<th>Secret</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eric</td>
<td>Read</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Execute</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Henry</td>
<td>Read</td>
<td>Read</td>
<td>Write</td>
</tr>
<tr>
<td></td>
<td>Execute</td>
<td>Read</td>
<td>Write</td>
</tr>
<tr>
<td>Robert</td>
<td>Read</td>
<td>Read</td>
<td>Write</td>
</tr>
</tbody>
</table>

- 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

- Covert channels
  - Modulating CPU usage
  - Locking/unlocking files

Encapsulated server can still leak to collaborator via covert channels
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.

Disclaimer

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