Foundations of Computer Security
Lecture 27: Storing the ACM

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Lecture 27: 1
Storing the ACM

Access Control Matrix

Recall our earlier claim: Any access control policy can be represented by an access control matrix (ACM).

<table>
<thead>
<tr>
<th>subject_1</th>
<th>object_1</th>
<th>...</th>
<th>object_k</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_i, A_j</td>
<td></td>
<td></td>
<td>()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>subject_n</td>
<td>A_i</td>
<td></td>
<td>A_i, A_n</td>
</tr>
</tbody>
</table>

The ACM gives an explicit representation of every access permitted by every subject to every object.

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Representing Access Information

You could build an explicit ACM for any access control system (e.g., BLP, Biba, RBAC, etc). But we usually don’t. Why not?

Three common alternatives exist:

- Maintain a set of rules to compute access permissions “on the fly” based on attributes of subjects and objects.
- Store the permissions with objects. This is called an access control list (ACL).
- Store the permissions with subjects. This is called a capability-based system.

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Access Control List (ACL)

An access control list (ACL) stores permissions with the objects of the system.

It contains pairs of the form < S, P >, listing the set of permissions P that subject S currently holds to the object.

Any request by subject S for access A to object O, means checking whether \( A \in P \) for the pair < S, P > on O’s access control list.

Unix/Linux, Mac OS, and Windows all store all store permissions by ACL.

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Capabilities

Some systems store permissions with subjects rather than objects. These are called *capabilities*.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Obj_1</th>
<th>Obj_2</th>
<th>...</th>
<th>Obj_k</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_1</td>
<td>R</td>
<td>RW</td>
<td></td>
<td>W</td>
</tr>
</tbody>
</table>

Each subject $S$ maintains a collection of pairs $<O, A>$, meaning that $S$ has current permission to perform access $A$ to object $O$. To obtain access, the subject must present an appropriate capability. Thus a capability is a type of “ticket.”

Many capability based systems also permit passing capabilities from one subject to another, under controlled circumstances.

Protecting Capabilities

Possession of a capability is *de facto* evidence of permission. Therefore, no access check is required. But to maintain security, it is necessary to ensure that capabilities can’t be *forged* or *altered*.

Historically, various approaches have been used to protect the integrity of capabilities:

- Extend each memory location with an additional bit indicated whether or not the location contains a capability; only the OS can manipulate capabilities.
- Store capabilities in specially protected memory.

Lessons

- Any access control system can be represented by an access control matrix.
- Storing the matrix explicitly is expensive and usually unnecessary.
- Access information is often stored: implicitly as a series of rules, with each object as an access control list, or with each subject as a collection of capabilities.

Next lecture: Information Theory