Mandatory Access Control

COS 316: Principles of Computer System Design

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**Last Times - Discretionary Access Control**

*Discretionary Access Control* - *[Access] controls are discretionary in the sense that a subject with a certain access permission is capable of passing that permission (perhaps indirectly) on to any other subject (unless restrained by mandatory access control).*

- Trusted Computer System Evaluation Criteria, 1985 (the “Orange Book”)

- Most prevalent form of access control system
- **Access Control Lists**
  - Restrict access to objects based on the identity of subjects
  - Subjects can pass object contents after reading
- **Capabilities**
  - Restrict access to objects based on possession of a capability
  - Capabilities can be passed directly to other subjects
  - Subjects can pass object contents after reading
Who enforces policy under DAC?

Legend
- FBI
- SNCC

What might go wrong?
Who enforces policy under DAC?

Legend

- FBI
- SNCC

Which components enforce policy?

- Guard
  - Repo 1
  - Repo 2

- Only repository collaborators can read code from private repositories.
- Only repository collaborators can comment on repositories.
Who enforces policy under DAC?

Legend

- Trusted Computing Base

App

WWW

- Read repo 1 code
- Write comment to repo 2

Guard

- Only repository collaborators can read code from private repositories.
- Only repository collaborators can comment on repositories.

Repo 1

Repo 2
Limitations of Discretionary Access Control

- Discretionary: *subjects* of the access control system also control access policies
  - In UNIX, owners determine read/write/execute access for themselves, group, and “other”
  - Subject can pass capabilities to anyone
- More subtle: no attempt to control what subjects *do* with data
  - UNIX process reads ~/.ssh/id_rsa and writes output to public log
- This is *one* reason it sufficient to compromise a single high privilege application, not whole system, in order to extract private data
The non-interference property

Informally:

A program is non-interferent if it’s transformations of data in low security domains (low) are not influenced by data in higher security domains (high)
The non-interference property

$M$, a memory state including low and high memory, $M_H$ and $M_L$, respectively

$P: (M) \rightarrow M^*$, a non-interference program execution over a memory state resulting in a new memory state, if:

$\forall M1,M2 \text{ s.t. } M1_L = M2_L$

$\land P(M1) \rightarrow M1^*$

$\land P(M2) \rightarrow M2^*$

$\Rightarrow M1^*_L = M2^*_L$
Enforcing Non-Interference with DAC

Discretionary Access Control policies can enforce non-interference by completely partitioning the system.

If this kind of looks like two virtual machines it’s because this is usually how virtual machine monitors control access to hardware!
Enforcing Non-Interference with DAC

Discretionary Access Control policies can enforce non-interference by completely partitioning the system, or with careful, static sharing.
Mandatory Access Control (MAC)

- Goal: data secrecy & integrity don’t rely on trusting applications at all
- All resource accesses governed by a global policy
- Subjects cannot change or circumvent global policy
- Typically policy articulated in terms of data sources and sinks
- E.g.
  - label data with its sensitivity
  - define permitted flows between labels
  - Permit operations as long as information flow rules are not violated
A simple security label lattice
Implementing MAC

There are very few MAC systems used in practice:

- SELinux - an extension to Linux originating from the NSA
  - Used in Android
- Mandatory Integrity Control - a Windows kernel subsystem limited to integrity
- TrustedBSD (in development)

But lots of research systems
Implementing MAC

One general approach:

- Assign a security label to object (file, network endpoint, console, etc)
- Assign a *floating* label to subjects (running processes)
  - “Floating” because it changes dynamically
- Whenever moving/copying data, check that source label *can flow to* sink label
- Allow subject to “raise” its floating label, but not to “lower” it
Permissible, because write couldn’t involve secret data
Permissible, because write could only involve data secret to Repo 2
Prohibited, because write to Repo 1 could involve data secret to Repo 2.
Prohibited, because write could involve data secret from **Repo 2** or **Repo 1**
Mandatory Access Control in Practice

- Dates back to at least 1983
  - Defined in the DoDs *Trusted Computer System Evaluation Criteria* (aka the Orange Book)
- Very powerful guarantee!
  - Security policies on data *do not* rely on application correctness
- Why is it not more prevalent?
Why isn’t MAC more prevalent?

- Complexity: implementing MAC can be hard to get right
- Performance: lattice checks can be slow
- Flexibility: by design, applications cannot get around security policy
- Simplicity: MAC is harder to administer

Next time: Hails, a research system that address above problems in Web platforms.

*Sound interesting? Come do research with me!*