

OS Security

Mandatory Access Control

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A short recap

- ▶ Traditional UNIX security uses discretionary access control (DAC)
- ▶ Each user decides about access permissions of his/her files
- ▶ Root can access all files
- ▶ Modern attack scenarios:
 - ▶ User runs malware, malware sends private data through Internet (confidentiality)
 - ▶ User runs malware, malware modifies user's files (integrity)
- ▶ DAC cannot prevent this kind of attack
- ▶ System-wide and more fine-grained control needed to limit scope of such an attack

Mandatory access control

- ▶ A system implements *mandatory access control* (MAC) if the protection state can only be modified by trusted administrators via trusted software.
- ▶ Trusted administrator defines policies, for example, to determine which processes are allowed to access which files.
- ▶ Users cannot disable this.

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 - ▶ **Secret**
 - ▶ **Confidential**
 - ▶ **Unclassified**

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 - ▶ **Unclassified**
- ▶ Users are assigned *clearance levels*
- ▶ Processes are assigned *security levels*

Bell-LaPadula rules

Simple Security Property

A subject (user, process) must not be able to read an object above its clearance level (e.g., a user with clearance “confidential” must not be able to read a file with security level “secret”).

No read-up

Bell-LaPadula rules

Simple Security Property

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No read-up

The ★ Property

A subject (process) must not write to an object below its security level (e.g., a process with level “secret” must not write to a file with level “unclassified”).

No write-down

Tranquility

How is the security level of a process defined?

Strong tranquility

Security level of a process never changes. Set it once at startup, typically to the user's clearance level.

Weak tranquility

Security level of a process never changes *in a way that it violates the security policy*. Typically start with low level, and increase as the process reads higher-level information.

Typically desirable: weak tranquility

Bell-LaPadula example - weak tranquility

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Extensions to Bell-LaPadula

- ▶ Sometimes Bell-LaPadula is combined with categories to capture “need to know”
- ▶ Example: “nuclear”, “intelligence”, “submarine”, “airforce”
- ▶ Compartments are subsets of the set of categories
- ▶ Subjects and objects are assigned compartments, e.g.,
 - ▶ User `user1`: {“intelligence”, “airforce”}
 - ▶ File `file1`: {“intelligence”}
 - ▶ File `file2`: {“airforce, submarine”}
- ▶ Subject with clearance compartment S is allowed to read an object with compartment O , if $O \subseteq S$
- ▶ Example:
 - ▶ `user1` is allowed to read `file1`
 - ▶ `user1` is not allowed to read `file2`

Bell-LaPadula comments

- ▶ Only confidentiality is protected
- ▶ Actual write level is not defined by Bell-LaPadula (only minimal level)
- ▶ No automated way to declassify information (i.e., reduce the level)
- ▶ In principle, users can write above their clearance

Biba model

- ▶ Introduced by Kenneth J. Biba in 1975
- ▶ Model to protect integrity
 - ▶ Complement of secrecy in Bell-LaPadula
- ▶ Assign to all objects and users *integrity levels*, typically:
 - ▶ **Crucial**
 - ▶ **Very important**
 - ▶ **Important**
- ▶ Prevents “pollution” of information with higher integrity level

Biba rules

Simple Integrity

A subject (user, process) must not read an object below its integrity level (e.g., a user with level “crucial” must not read a file with level “very important”).

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The ★ Integrity Property

A subject (user, process) must not be able to write to an object above its integrity level (e.g, a process with clearance “important” must not be able to write to a file with integrity level “very important”).

No write-up

Linux Security Modules

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- ▶ Hooks to module functions when accessing security-critical resources
- ▶ In recent kernels, hooks defined in `include/linux/lsm_hooks.h`

Criticism of LSM

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- ▶ LSM provides hooks only for access control
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- ▶ “Stacking” multiple security modules is problematic

Implementations of LSM

- ▶ AppArmor
- ▶ Linux Intrusion Detection System (LIDS)
- ▶ POSIX capabilities
- ▶ Simplified Mandatory Access Control Kernel (Smack)
- ▶ TOMOYO
- ▶ Security-Enhanced Linux (SELinux)

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 2. Role-based access control
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- ▶ Provides three kinds of MAC mechanisms:
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 2. Role-based access control
 3. Multi-level security (MLS)
- ▶ All approaches are *additional* to UNIX DAC: first check file permissions, if those allow access additionally check MAC rules.

Type Enforcement

- ▶ Everything (processes, files, sockets, etc) has a security context (a label) in the format:

`user:role:type(:level)`

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 - ▶ `ps -Z` shows processes with security context
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 - ▶ `netstat -Z` shows security context of network sockets
- ▶ All access has to be explicitly granted, using allow rules:
`allow source_type target_type : object_class permissions;`
- ▶ Example:
`allow user_t bin_t : file {read execute getattr};`

“A process with domain type (source type) `user_t` can read, execute, or get attributes for a file object with object type (target type) of `bin_t`.”

Type Enforcement ctd.

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- ▶ Various ways to change this behavior
- ▶ Most important, transition rules:
`type_transition source_type target_type : class new_type;`
- ▶ Example:
`type_transition httpd_t httpd_sys_script_exec_t : \
 process httpd_sys_script_t;`

“When the httpd daemon running in the domain `httpd_t` executes a program of the type `httpd_sys_script_exec_t`, such as a CGI script, the new process is given the domain of `httpd_sys_script_t`”

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- ▶ There is no way in DAC to prevent another user `bdu` to make all his files readable for the webserver!
- ▶ There is no way to prevent `root` from *any* file access using DAC

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“Can’t we just create a user `http` and give this user file access (using UNIX permissions) to only what the webserver needs?”

- ▶ There is no way in DAC to prevent another user `bdw` to make all his files readable for the webserver!
- ▶ There is no way to prevent `root` from *any* file access using DAC
- ▶ SELinux can limit the damage malware or an attacker can do