Security Models

Computer Security Lecture 13

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Outline

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System security policies and models

A **security policy** describes requirements for a system.

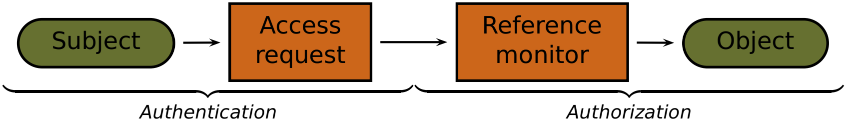
A **security model** is a framework in which a policy can be described.

There are two basic paradigms:

- **access control**
- **information flow control**

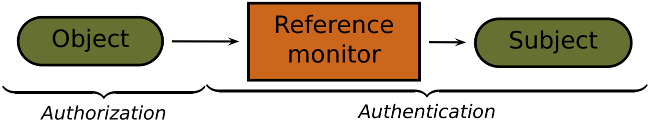
Access control

A guard controls whether a principal (the **subject**) is allowed access to a resource (the **object**).



Information flow control

A guard controls whether information may flow from a resource (the object) to a principal (the subject).



This is the dual notion, sometimes used when confidentiality is the primary concern.

Access operations: modes and rights

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- We will consider the access modes and rights of the influential **Bell-LaPadula** (BLP) model.
  - BLP enforces confidentiality
  - Other models enforce integrity, or a combination

Access operations in BLP

The **access modes** of BLP are:

observe	examine contents of an object
alter	change contents of an object

The **access rights** and their profiles are:

	observe	alter
exec		
read	✓	
append		✓
write	✓	✓

Profiles and names of rights differ between systems, or even for different subject kinds. E.g., sometimes have a delete. In Unix, exec for directories indicates ability to read the directory. The profiles of rights are used to define security properties in the model.

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- The **identity** of subjects is also flexible: e.g., *identity changes* during operations (SUID programs in Unix). Again, this doesn't fit BLP.

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- Example matrix for $S = \{\text{Alice}, \text{Bob}\}$ and three objects:

	`bob.doc`	`edit.exe`	`fun.com`
Alice	$\{\}$	$\{\text{exec}\}$	$\{\text{exec}, \text{read}\}$
Bob	$\{\text{read}, \text{write}\}$	$\{\text{exec}\}$	$\{\text{exec}, \text{read}, \text{write}\}$

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- An **access control list** (ACL) stores the access rights to an object with the object itself. Pros: good fit with object-biased OSes. Cons: difficult to revoke, or find out, permissions of a particular subject (must search all ACLs).

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- In practice, we need more flexibility. We may want *categorizations* as well, for example, describing departments or divisions in an organization. Then individual levels may not be comparable. . .

Security lattices

- A *lattice* is a set L equipped with a partial ordering $\leq$ such every two elements $a, b \in L$ has a *least upper bound* $a \vee b$ and a *greatest lower bound* $a \wedge b$. A finite lattice must have top and bottom elements.

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  - system low is the bottom, dominated by all others.
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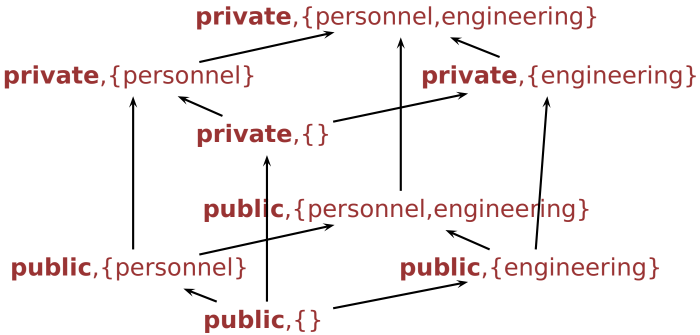
  - for two *subjects* at levels a and b, there is a maximal security level $a \wedge b$ for an *object* which must be readable by both.

A Lattice Construction [Gollmann]

- take a set of *classifications* H and linear ordering $\leq_H$
- take a set C of categories; *compartments* are subsets of C
- *security levels* are pairs (h, c) with $h \in H$ and $c \subseteq C$
- ordering $(h_1, c_1) \leq (h_2, c_2) \iff h_1 \leq h_2, c_1 \subseteq c_2$ gives a lattice.



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- A BLP state is a triple (b, M, f).

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  - $f_O : O \to L$ gives the **classification** of all objects.

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Simple security property

The **ss-property** states for each access $(s, o, a) \in b$ where $a \in \{\text{read}, \text{write}\}$, then $f_O(o) \leq f_S(s)$ (*no read-up*).

Star property

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Together these form the *mandatory access control* policy for BLP.

BLP Discretionary Control and Security

The access control matrix M allows DAC as well.

Discretionary security property

The **ds-property**: for each access $(s, o, a) \in b$, we have that $a \in M_{so}$ (*discretionary access controls are obeyed*).

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- **Definition of Security:** The state (b, M, f) is **secure** if the three properties above are satisfied.

Notice that BLP's notion of security is entirely captured in the current state.

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- Approach 1 works because the current state describes exactly what each subject knows. So if a subject (e.g. a process) is downgraded, it cannot access higher-level material, so may safely write at any lower level than its maximum.
- When subjects are people with high-level clearances, approach 2 works: we trust someone to violate the property in the model, e.g., by publishing part of a secret document.

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(NB: this follows immediately by induction, it has nothing to do with the properties of BLP!)

- The point: we can reduce checking the system for all possible inputs to checking that each kind of possible state transition preserves security. Of course, to do this we need a concrete instance of the model which describes possible transitions.

Outline

Summary

- A **security model** is a framework for formalising **security policies**
- Access control enforcement uses a **reference monitor**
- Operations have access modes used to define properties
- **Bell-LaPadula** (BLP) access control model:
  - For confidentiality
  - Discretionary (DAC) and mandatory (MAC) access
  - MAC via multi-level security lattice
  - ss-property: no read-up
  - $*$-property: no write down, direct or indirect
  - DAC via access control matrix (ds-property)

References

See Chapters 5, 11 (also 7 and 8) of Gollmann, and Parts 2–3 of Bishop.

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Recommended Reading

Chapters 5 and 11 of Gollmann.
Chapters 4 and 8 of Anderson.