CIS 4360
Secure Computer Systems

Security Policy Models

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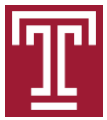
Previous Class

- Concepts
  - Access Control, Subject, Object
- Goals of Access Control
  - Confidentiality, Integrity
- Access Matrix
  - View of Columns: Access Control Lists
  - View of Rows: Capability Lists
- Types of Access Control Policies
  - DAC
  - MAC
  - RBAC



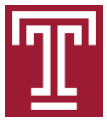
Previous Class

In which scenarios DAC, MAC and RBAC should be used, respectively?

DAC: if the information you create really belongs to you and security is not the top priority, DAC is not a bad choice. It is flexible and convenient. E.g., social networks

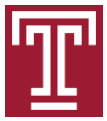
MAC: if the information you create belongs to your employer and it is highly sensitive, MAC is the choice

RBAC: it can enforce DAC or MAC. When employees change jobs, the admin only needs to grant and revoke roles



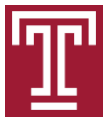
Outline

- Implementation of Policy Models
  - Decoupling Mechanisms and Policies
  - Reference Monitor
- Basics of MAC and Information Flow
- Mandatory Access Control Policy Models
  - Multi-level Security
    - Models for Confidentiality: e.g., Bell-LaPadula Model
    - Models for Integrity: e.g., Biba Model
  - Multi-lateral Security
    - Chinese-wall



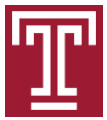
Security Mechanism and Policy

- A security policy dictates what is, and what is not, allowed
- A security mechanism is a method, tool, or procedure for enforcing a security policy
- Therefore, the same mechanism can be used to enforce multiple different policies



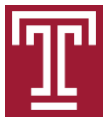
Decoupling Mechanisms and Policies

- When you implement some techniques or tools as the policy-enforcing mechanism, keep in mind that the policy may change. So the mechanism and policies should not be closely coupled
- The mechanism should leave room of flexibility of changing policies
- E.g., even the legislation department changes the traffic rules (policies), the same police (mechanism) can be used



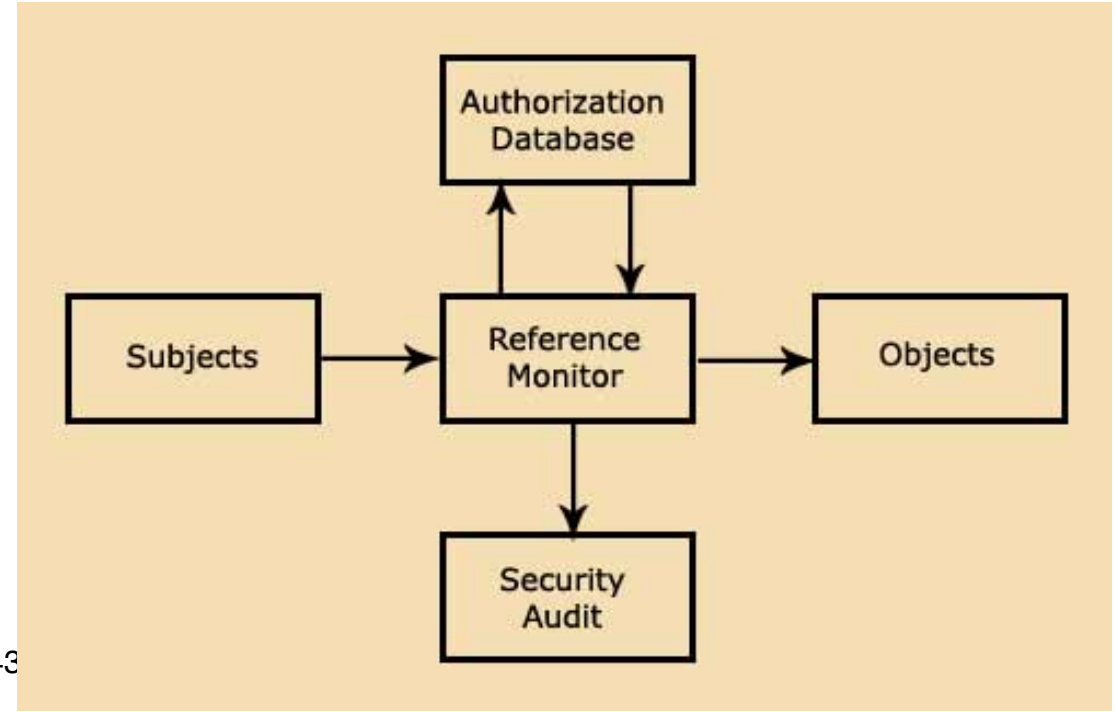
Security Policy Models

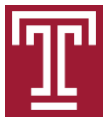
- A Security Policy Model provides a *formal* representation of the access control security policy and its working
- The formalization allows the proof of properties on the security provided by the access control system being designed



Reference Monitor

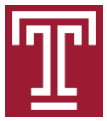
- When implementing the mechanism, a Reference Monitor that satisfies the following requirements is needed
  - Small enough to be verifiable
  - Non-bypassable
  - Tamper-resistant





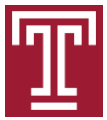
MAC

- A *mandatory access control* (MAC) policy is a means of assigning access rights based on regulations by a central authority
- Goal: To prevent illegitimate information flow
- Idea: Attach a security label to each subject and object; and then perform authorization based on label comparison



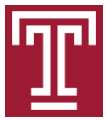
Military Security

- Initially (‘70s) most research in information security was applied to the military domain
- Need to protect information that, if known by an enemy, might damage national security



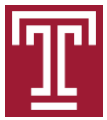
Security Level

- Each subject and each object is assigned a security level
  - E.g., unclassified < confidential < secret < top secret
- A security level
  - for a subject is called a clearance
  - for an object is called a classification
- The clearance assigned to subjects reflects their trustworthiness, and the classification assigned to objects reflects theirs sensitivity



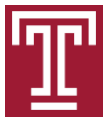
"Need to know" and compartments

- Even one has the "top secret" clearance, it should not mean that she can access everything
- "Need to know": the access authorization is limited to information needed to perform duties
- How to enforce it?
  - Compartmentalization
  - Fewer people know the object, the less probability the information is leaked
- E.g., Manhattan Project



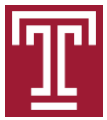
Security Class and the Ordering

- A security class = *(security_level, compartments)*
- E.g., (confidential, {nuclear, missile})
  - Security level: confidential
  - Compartments: {nuclear, missile}
- Ordering relation: $SC_1 = (l_1, c_1)$, $SC_2 = (l_2, c_2)$
  - $SC_1 \leq SC_2$ if $l_1 \leq l_2$ && $c_1 \subseteq c_2$
- Some security classes are incomparable
  - (top_secret, {aircraft}) and (securet, {shelters})



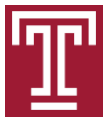
Multi-level Security

- When access control is enforced according to the security levels (and compartments) assigned to subject and objects, it is a Multi-level Security (MLS) system
- A MLS system is typically a Mandatory Access Control system



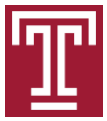
Information flow policies

- Defined by Denning (′76)
- Concerned with the flow of information from one security class to another
- Information flow as an ordering relation
- Instead of a list of axioms governing users′ accesses, it simply require that information transfers obey the ordering relation



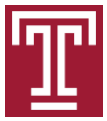
The BLP model

- A model for Confidentiality (i.e., Secrecy)
- Information cannot flow from a high security class to a low one (or an incomparable one)
  - How to define “high” and “low”?
  - Recall $SC_1 \leq SC_2$ if $l_1 \leq l_2$ && $c_1 \subseteq c_2$ where $SC_1 = (l_1, c_1)$, $SC_2 = (l_2, c_2)$



BLP mandatory access rules

- Object *o*'s security class: *SC(o)*
- Subject *s*'s security class: *SC(s)*
- **Simple property (or, No Read Up)**: subject *s* can read object *o* only if *SC(s)* ≥ *SC(o)*
- ***-property (or, No Write Down)**: subject *s* can write object *o* only if *SC(s)* ≤ *SC(o)*
  - Trojan horses leaking information are blocked



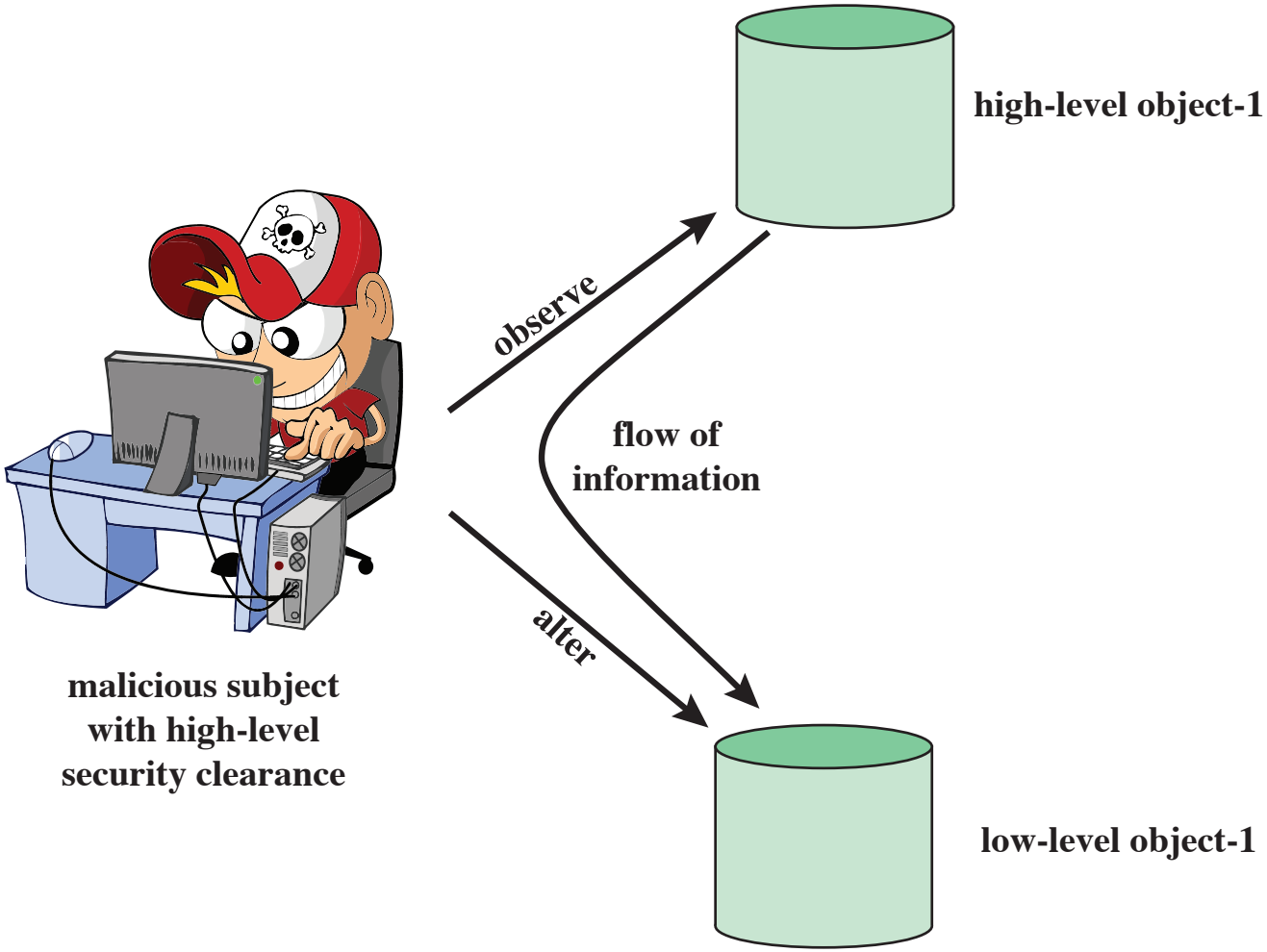
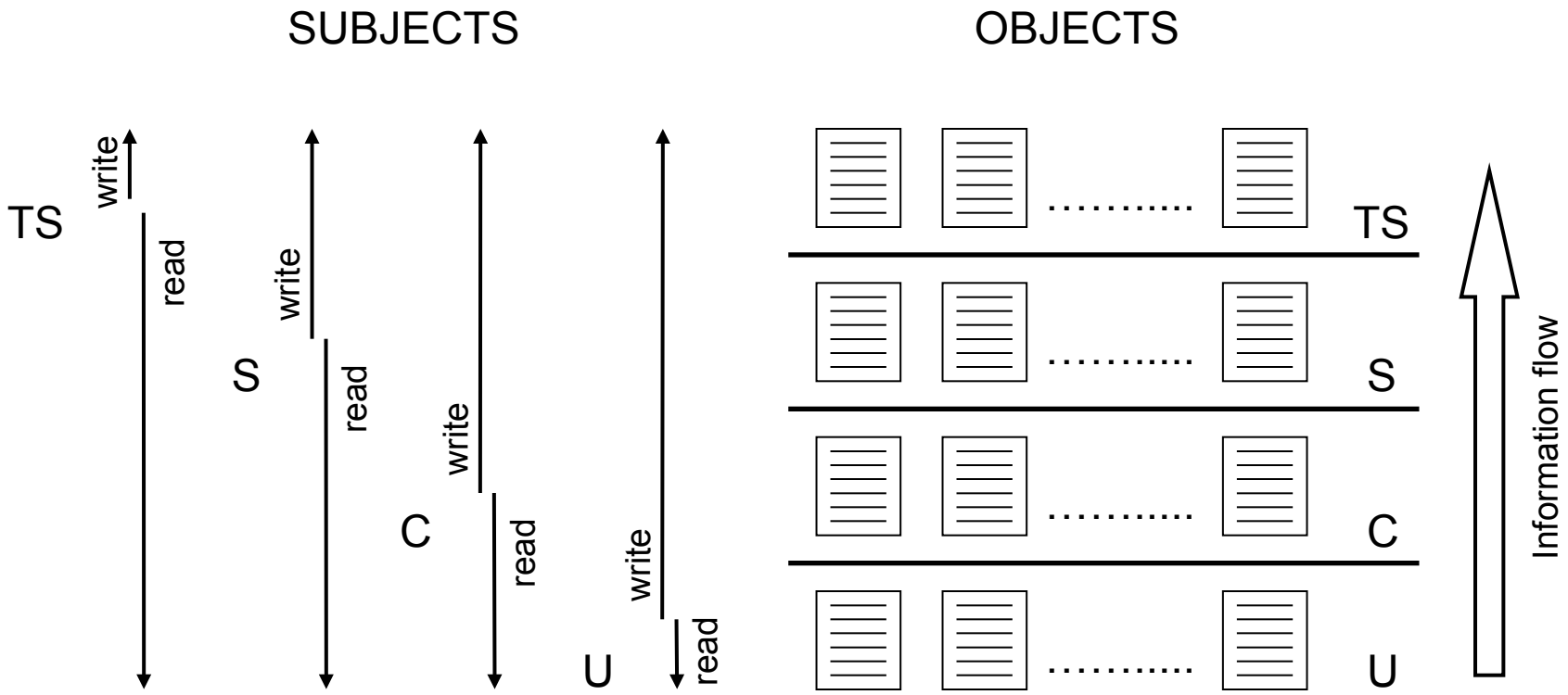
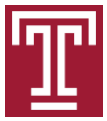


Figure 13.1 Information Flow Showing the Need for the *-property

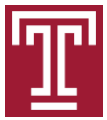
BLP information flow





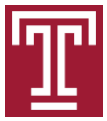
Limitations of the BLP Model

- Sometimes “illegal” information flow is desired
  - E.g., a teacher (high security class) may create a file called “paper”, which should be read by students (low security class)
  - E.g., a teacher may comment on the answers submitted by a student
  - Both are not disallowed in the BLP Model
  - Therefore in practice a declassifying component is needed
- BLP only provides confidentiality
  - In some cases, integrity is the main concern



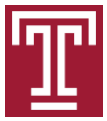
The Biba Model

- Provides the protection for integrity
  - Information cannot flow from a low security class to a high one
- **Simple property (or, No Read Down)**: subject *s* can read object *o* only if $SC(s) \leq SC(o)$
- ***-property (or, No Write Up)**: subject *s* can write object *o* only if $SL(s) \geq SL(o)$
- *Invocation property: s_1 can invoke s_2 only if $SL(s_1) \geq SL(s_2)$*
- *Example*
  - *Security level: soldier < captain < general*
  - A captain should not trust an order forged by a soldier
  - An order issued by a general cannot be modified by a caption



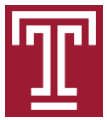
Multi-Lateral Security

- Instead of enforcing vertical information flow rules, multi-lateral security prevents information from flowing across departments
- Classic Model: the Chinese Wall Model
- Goal: to prevent conflict of interest
  - E.g., in a financial consultant company, an employee who has read the documents of Bank A (to provide advices) should not access those of Bank B

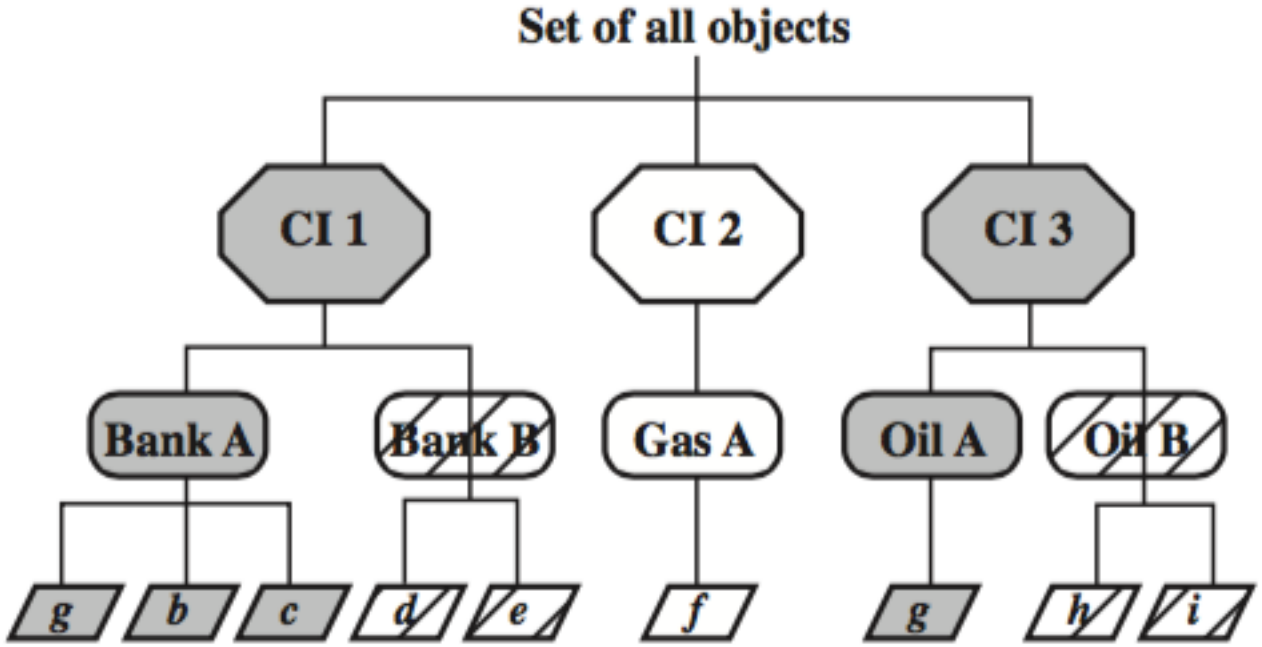


Multi-Lateral Security

- A Dataset (DS): all objects that belong to the same corporation
- Conflict of Interest (CI) class: All datasets whose corporations are in competition
- A subject S can read on object O only if
  - O is in the same DS as an object accessed by S, or
  - O belongs to a CI from which S has not yet accessed any information

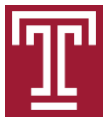


Example: Multi-Lateral Security



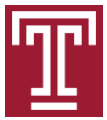
(b) John has access to Bank A and Oil A

- Once John has accessed the objects of Bank A, he is not allowed to access those of Bank B, as the two Banks belong to the same CI



Summary

- Bell-LaPadula (BLP) Secrecy Model
  - No read up
  - No write down
- Biba Integrity Model
  - No read down
  - No write up
- Chinese Wall Model
  - If you have accessed a corporation, you cannot read data from its competitors



Writing Assignments

- Can a user cleared for (S, {dog, cat, pig}) access to documents classified in the following ways under the BLP model?
  - (TS, {dog})
  - (S, {dog})
  - (S, {dog, cow})
  - (S, {monkey})
  - (C, {dog, pig, cat})
  - (C, { })
- Can BLP and Biba be enforced in the same system?