CSC 742
Database Management Systems

Topic #11: Database Security

Security Goals

- Confidentiality:
  - prevent/deter/detect unauthorized access to information.
- Integrity:
  - prevent/deter/detect unauthorized modification of information
- Availability:
  - prevent/deter/detect unauthorized denial of service.

Security Mechanisms

- Methods to achieve the security goals.
  - Access control
  - Authentication
  - Encryption
  - Intrusion detection
  - Inference control
  - …

Outline

- Access Control in DBMS
  - Discretionary Access Control (DAC)
  - Mandatory Access Control (MAC)

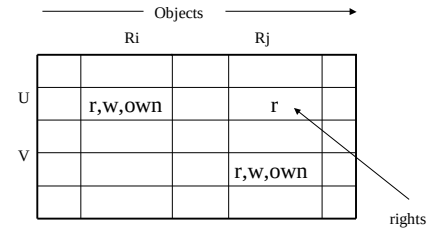
Discretionary Access Control

- Discretionary Access Control (DAC)
  - Allow access rights to be propagated from one subject to another.
  - Possession of an access right by a subject is sufficient to allow access to the object.

DAC in DBMS

- Based on Granting and Revoking of privileges.
- Types of Discretionary Privileges
  - Account level privileges
    - Independent of database content
    - Example:
      - GRANT CREATETAB TO Alice;
  - Relation level privileges
    - Based on Access Matrix Model
    - Related to the database content

Access Matrix Model



DAC in DBMS (Cont'd)

- Relation level privileges
  - Each relation is assigned an *owner account.*
  - The owner of a relation can give privileges on the relation to other users (grant).
  - The owner can take back privileges (revoke).

Examples

- **GRANT** INSERT, DELETE **ON** EMPLOYEE, DEPARTMENT **TO** Alice
- **GRANT** SELECT **ON** EMPLOYEE **TO** BOB **WITH GRANT OPTION**
- **REVOKE** SELECT **ON** EMPLOYEE **FROM** Bob
- **GRANT** SELECT **ON** EMPLOYEE(SALARY) **TO** Bob

View

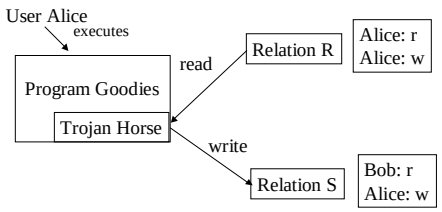
- View mechanism
  - Restrict access only to selected attributes and tuples.
  - Example:

```
CREATE VIEW Researchers AS
    SELECT Name, Bdate, Address
    FROM Employee
    WHERE Department='Research'
GRANT SELECT ON Researchers TO Bob
```


Inherent Weakness of DAC

- Unrestricted DAC allows unexpected information flow which violates security policy.
- The user can be trusted not to do this deliberately. However, it is still possible for Trojan Horse Programs to do so.
  - A *Trojan horse* does what a user expects it to do, but in addition exploits the user's legitimate privilege to cause a security breach.

Trojan Horse Example



The ACLs do not allow B to read R. But B can read the information with the help of the Trojan Horse.

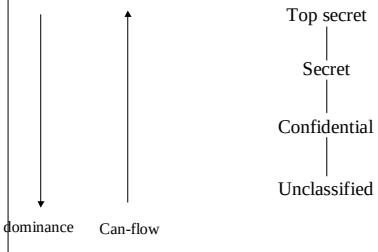
Mandatory Access Control

- Basic idea:
  - put restrictions on access rights.
  - Label both the subjects and the objects.
  - Allow a subject to access an object only when certain constraints are satisfied.

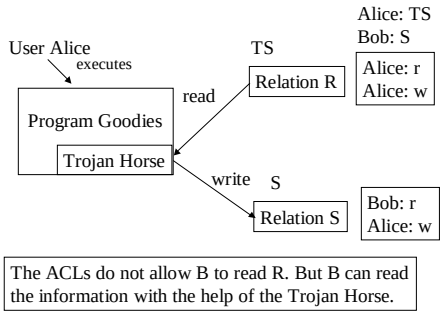
MAC (Cont'd)

- Bell LaPadula (BLP) Model
  - Simple security: Subject S can read object O only if
    - Label(S) dominates label(O).
    - Information can flow from label(O) to label(S)
    - Intuitively, *no read up*
  - Star property: Subjects can write object O only if
    - Label(O) dominates label(S)
    - Information can flow from label(S) to label(O).
    - Intuitively, *no write down.*

BLP Model



Trojan Horse Example Again



The ACLs do not allow B to read R. But B can read the information with the help of the Trojan Horse.

MAC in DBMS

- Attribute values and tuples are considered as objects.
  - Each attribute A is associated with a classification attribute C
  - In some models, a tuple classification attribute TC is added to the relation.
  - Example:
    - Employee (SSN, Name, BDate, Salary) →
    - Employee (SSN, C_{SSN}, Name, C_{Name}, BDate, C_{BDate}, Salary, C_{Salary}, TC)
    - Such a relation is called a multi-level relation.

MAC in DBMS (Cont'd)

- Employee (SSN, C_{SSN}, Name, C_{Name}, BDate, C_{BDate}, Salary, C_{Salary}, TC)
- Apparent key:
  - The set of attributes that would have formed the primary key in a regular (single-level) relation.

Polyinstantiation

- Several tuples can have the same apparent key value but have different attribute values for users at different classification levels.

Employee

SSN	Name	Salary	Performance	TC
111111111 U	Smith U	40000 C	Fair S	S
222222222 C	Brown C	80000 S	Good C	S

Employee (What class C users' see)

SSN	Name	Salary	Performance	TC
111111111 U	Smith U	40000 C	Null C	C
222222222 C	Brown C	Null C	Good C	C

Class C user:

```
UPDATE Employee
SET Performance = 'Excellent'
WHERE SSN='111111111'
```


Employee

SSN	Name	Salary	Performance	TC
111111111 U	Smith U	40000 C	Fair S	S
222222222 C	Brown C	80000 S	Good C	S

Employee (What class C users' see)

SSN	Name	Salary	Performance	TC
111111111 U	Smith U	40000 C	Null C	C
222222222 C	Brown C	Null C	Good C	C

Employee (What class U users' see)

SSN	Name	Salary	Performance	TC
111111111 U	Smith U	Null U	Null U	U

S — C — U

Integrity Constraints for Multi-level relations

- Entity integrity
  - All attributes that are members of the apparent key must not be null and must have the same security class.
  - All other attribute values in the tuple must have a security class greater than or equal to that of the apparent key
- Null integrity
  - If a tuple value at some security level can be derived from a higher-level tuple, then it's sufficient to store the higher-level tuple.

Is this possible?

Employee

SSN	Name	Salary	Performance	TC
111111111 U	Smith U	50000 U	Excellent U	U
111111111 U	Smith U	40000 C	Good C	C
111111111 U	Smith U	40000 C	Fair S	S
222222222 C	Brown C	80000 S	Good C	S