Security and Authorization

CS430/630
Lecture 18

Slides based on "Database Management Systems" 3rd ed, Ramakrishnan and Gehrke

Definitions

- Security policy
  - specifies who is authorized to do what
- Security mechanism
  - allows to enforce a chosen security policy
- Terminology
  - Users = Subjects or Principals
  - Data = Objects
- Two important functions needed to achieve security
  - Authentication (AuthN)
  - Authorization (AuthZ)

Authentication

- Establishing the identity of the user, or who the user is
- Subjects (users) present authentication credentials
  - Username/Password combination – "what user knows"
  - Digital certificates (cryptographic tokens) – "what user has"
  - Biometrics – "what user is"
- Some credential types stronger than others
  - For high-security applications, multi-factor authentication
  - E.g., password + fingerprint

Authorization

- Once we know who the user is, what can s/he access?
  - What objects (data) the subjects is allowed access to?
  - What kind of operations is the subject allowed to perform?
    - Read-only, modify, append
  - Authorization also referred to as access control
- Two main categories of access control
  - Discretionary: object owner decides authorization policy for its objects (Unix system)
  - Mandatory: system-wide rules that dictate who gets to access what (multi-level security, Bell-LaPadula)

Discretionary Access Control

- Based on the concept of access rights or privileges
  - Privileges for objects (tables and views)
  - Mechanisms for granting and revoking privileges
- Object creator automatically gets all privileges on it
  - DBMS keeps track of who subsequently gains and loses privileges
  - DBMS ensures that only requests from users who have the necessary privileges (at the time the request is issued) are allowed

GRANT Command

GRANT privilege_list ON object TO user_list [WITH GRANT OPTION]

- The following privileges can be specified:
  - SELECT
    - can read all columns
    - including those added later via ALTER TABLE command
  - INSERT(col-name)
    - can insert tuples with non-null or non-default values in this column
    - INSERT means same right with respect to all columns
  - DELETE
    - can delete tuples
  - REFERENCES (col-name)
    - can define foreign keys (in other tables) that refer to this column

GRANT Command (contd)

- If a privilege is granted with GRANT OPTION, the grantee can pass privilege on to other users
  - Special ALL PRIVILEGES privilege
- Only owner can execute CREATE, ALTER, and DROP

Examples

GRANT INSERT, SELECT ON Sailors TO Horatio
- Horatio can query Sailors or insert tuples into it

GRANT DELETE ON Sailors TO Yuppy WITH GRANT OPTION
- Yuppy can delete tuples, and also authorize others to do so

GRANT INSERT (*rating*) ON Sailors TO Dustin
- Dustin can insert (only) the *rating* field of Sailors tuples

REVOKE Command

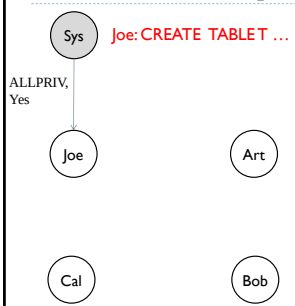
REVOKE [GRANT OPTION FOR] privilege_list ON object
FROM user_list [CASCADE | RESTRICT]

- REVOKE
  - Revokes privileges
- CASCADE: when a privilege is revoked from X, it is also revoked from all users who got it *solely* from X
  - Privilege is said to be ABANDONED
  - A graph with the granting relationship is maintained
- RESTRICT: if revoke causes some privilege to be abandoned, it is NOT executed

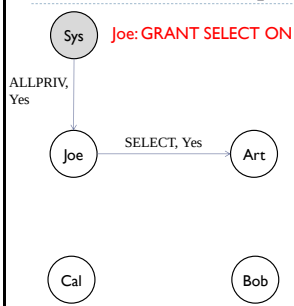
Authorization Graph

- Keeps track of active authorization on objects
  - Each authorization ID (user) corresponds to a node
  - Granting a privilege adds labeled edge to graph
  - Removing privilege deletes one or more edges from graph
  - Special "System" node that originates all privileges
  - Note: it is possible to have multiple edges between same pair of nodes (with same direction)!
- How to determine if access is allowed for an ID?
  - There must be a path from System to that ID formed of privileges equal (or stronger) than the one required

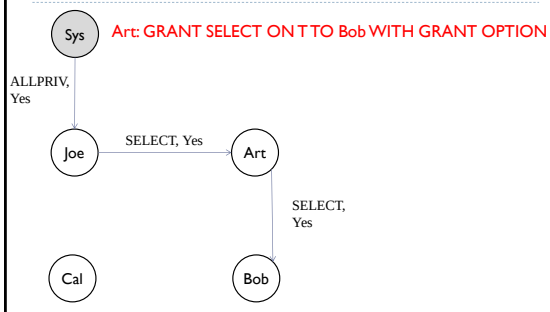
Authorization Graph



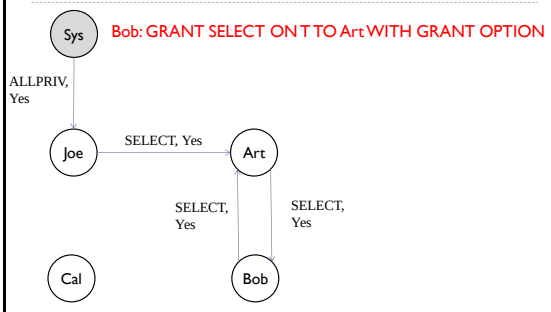
Authorization Graph



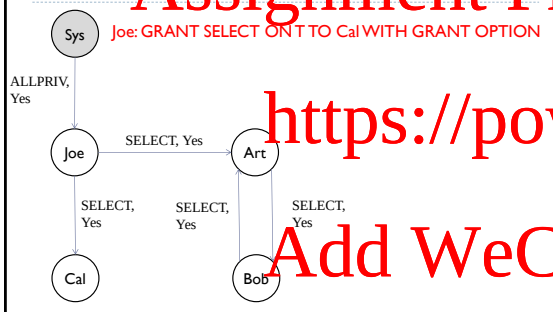
Authorization Graph



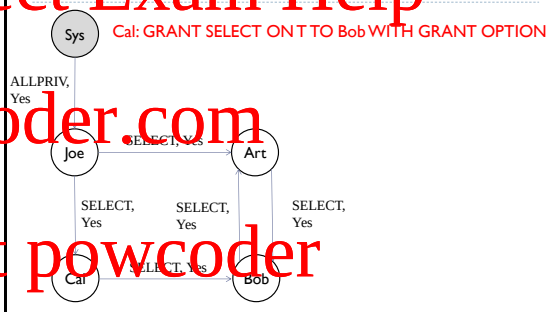
Authorization Graph



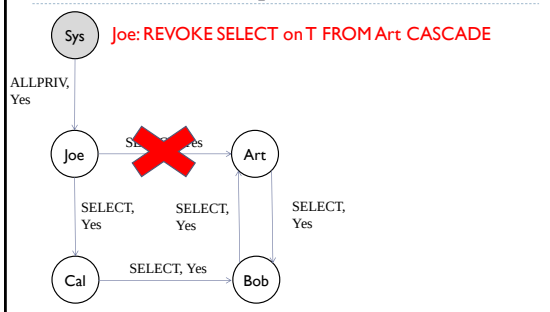
Authorization Graph



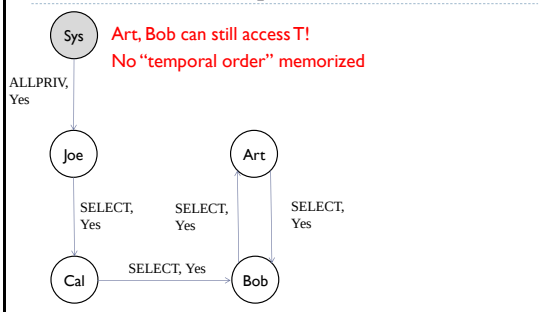
Authorization Graph



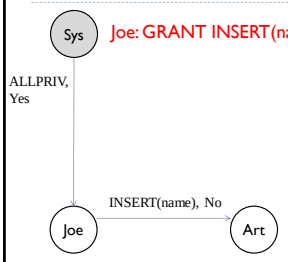
Authorization Graph



Authorization Graph



Another Example



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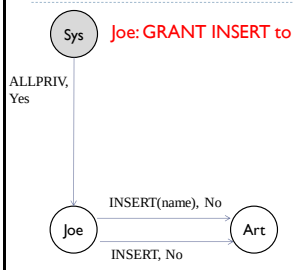

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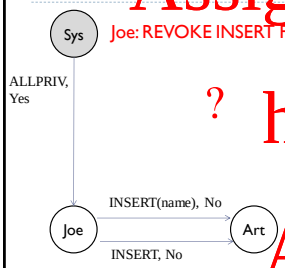

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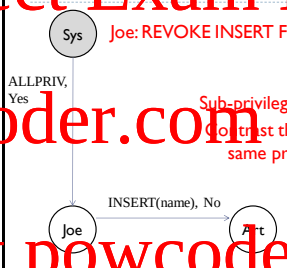

Security at the Level of a Field!

- Can create a view that only returns one field of one tuple
  - Then grant access to that view accordingly
- Allows for *arbitrary* granularity of control, *but*:
  - Tedious to specify and maintain policies
  - Performance is unacceptable
    - Too many view creations and look-ups
- Another solution
  - Attach labels to subjects and objects
  - Create rules of access based on labels

Mandatory Access Control

- Based on system-wide policies that cannot be changed by individual users (even if they own objects)
  - Each DB object is assigned a security class
  - Each subject (user or user program) is assigned a clearance for a security class
  - Rules based on security classes and clearances govern who can read/write which objects.
- Many commercial systems do not support mandatory access control
  - Some specialized versions do
    - e.g., those used in military applications

Bell-LaPadula Model

- Security classes:
  - Top secret (TS)
  - Secret (S)
  - Confidential (C)
  - Unclassified (U):
  - TS > S > C > U
- Each object (O) and subject (S) is assigned a class
  - S can read O only if class(S) >= class(O) (Simple Security Property or No Read Up)
  - S can write O only if class(S) <= class(O) (*-Property or No Write Down)

Intuition

- Idea is to ensure that information can never flow from a higher to a lower security level
- The mandatory access control rules are applied in addition to any discretionary controls that are in effect