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

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- Object creator automatically gets all privileges on it
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  - DBMS keeps track of who subsequently gains and loses privileges
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  - 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 a privilege deletes corresponding edge 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

Sys
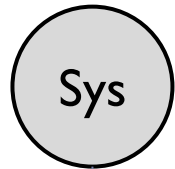
Joe: CREATE TABLE T …

ALLPRIV,
Yes

Joe

Art

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Cal

Bob

Authorization Graph

Sys

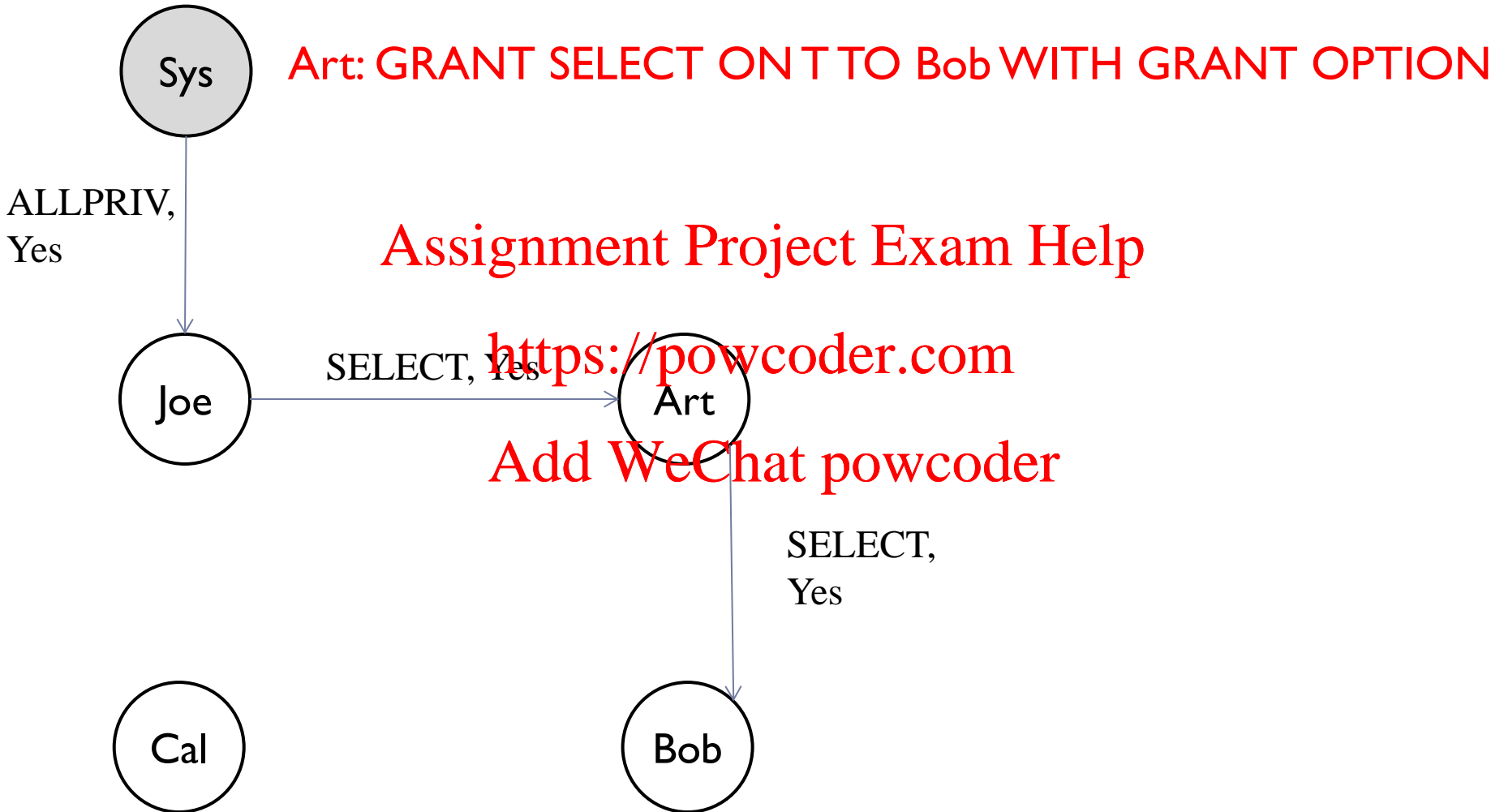Joe: GRANT SELECT ON T TO Art WITH GRANT OPTION

ALLPRIV, Yes

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SELECT, Yes

Joe

Art

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Cal

Bob

Authorization Graph

Sys

Art: GRANT SELECT ON T TO Bob WITH GRANT OPTION

ALLPRIV,
Yes

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SELECT, Yes

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Joe

Art

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SELECT,
Yes

Cal

Bob

Authorization Graph

Sys

Bob: GRANT SELECT ON T TO Art WITH GRANT OPTION

ALLPRIV,
Yes

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Joe   SELECT, Yes   Art

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SELECT,
Yes

SELECT,
Yes

Cal   Bob

Authorization Graph

Joe: GRANT SELECT ON T TO Cal WITH GRANT OPTION

Sys

ALLPRIV, Yes

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Joe

SELECT, Yes

Art

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SELECT, Yes

SELECT, Yes

SELECT, Yes

Cal

Bob

Authorization Graph

Sys

Cal: GRANT SELECT ON T TO Bob WITH GRANT OPTION

ALLPRIV,
Yes

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Joe — SELECT, Yes → Art

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SELECT,
Yes

SELECT,
Yes

SELECT,
Yes

Cal — SELECT, Yes → Bob

Authorization Graph

Sys

Joe: REVOKE SELECT on T FROM Art CASCADE

ALLPRIV,
Yes

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Joe

SELECT, Yes

Art

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SELECT,
Yes

SELECT,
Yes

SELECT,
Yes

Cal

SELECT, Yes

Bob

Authorization Graph

Sys
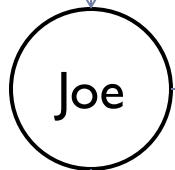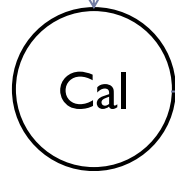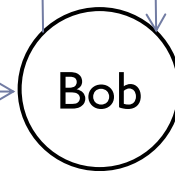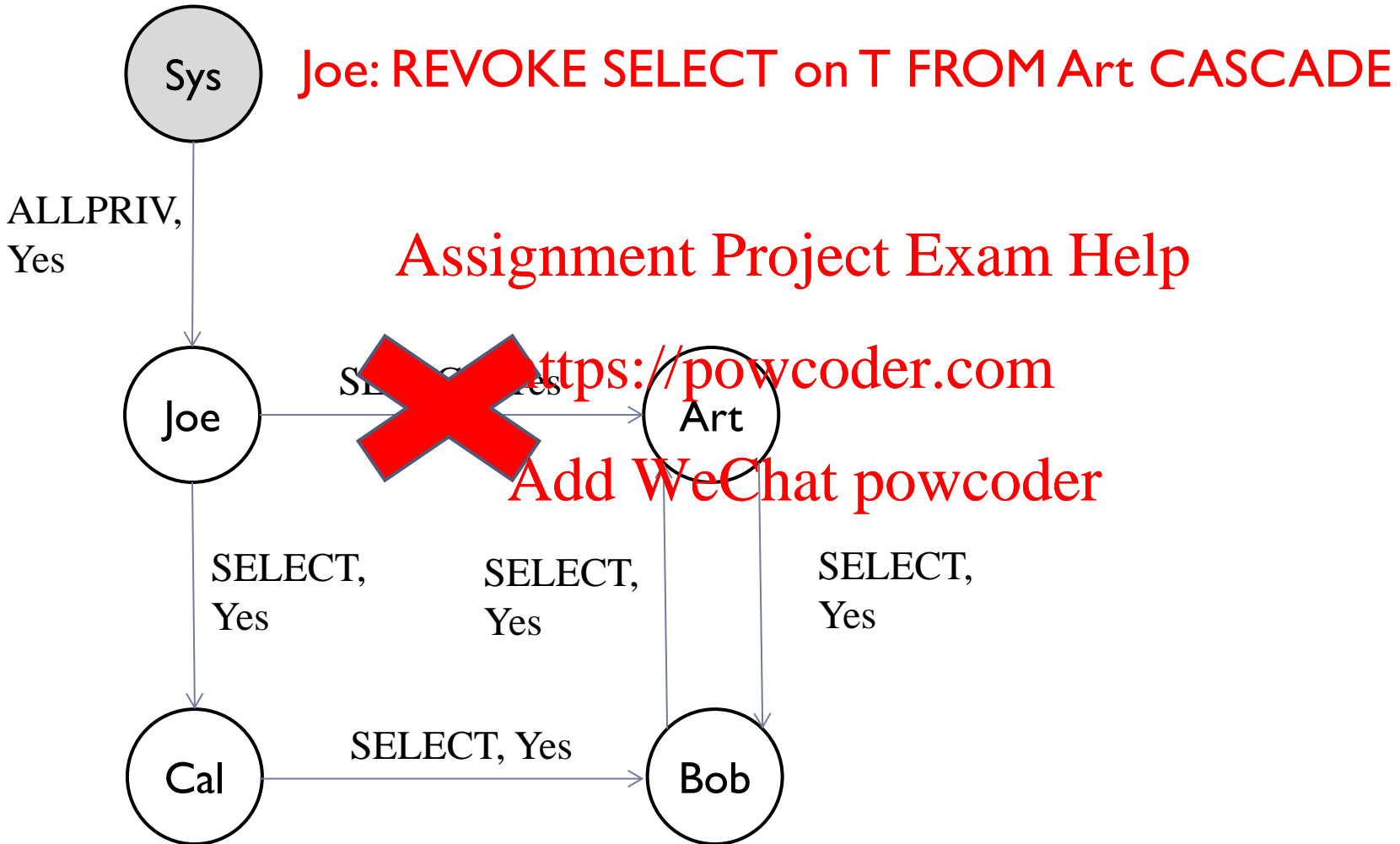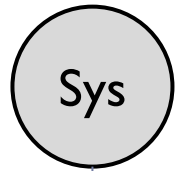
Art, Bob can still access T!

No "temporal order" memorized

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Art

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ALLPRIV,
Yes

Joe

SELECT,
Yes

SELECT,
Yes

SELECT,
Yes

Cal

SELECT, Yes

Bob

Another Example

Sys
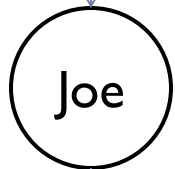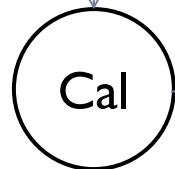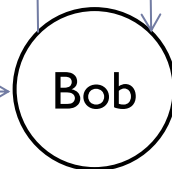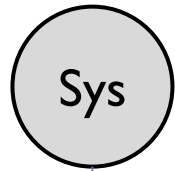
Joe: GRANT INSERT(name) to Art

ALLPRIV,
Yes

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Joe — INSERT(name), No → **Art**

Another Example

Sys
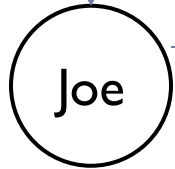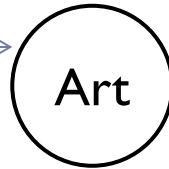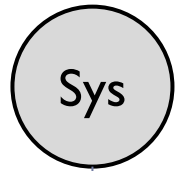
Joe: GRANT INSERT to Art

ALLPRIV,
Yes
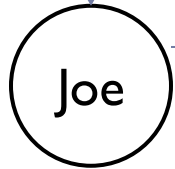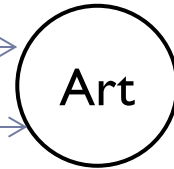
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INSERT(name), No

Joe → Art

INSERT, No

Another Example

Sys

Joe: REVOKE INSERT FROM Art

ALLPRIV, Yes

?

INSERT(name), No

Joe ——————→ Art
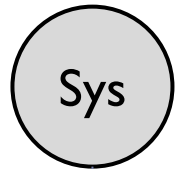
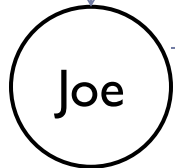INSERT, No

Another Example

Sys
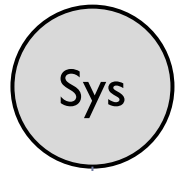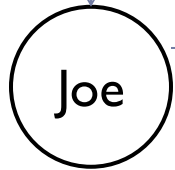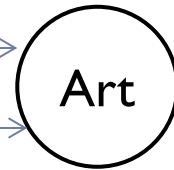
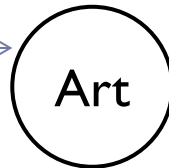Joe: REVOKE INSERT FROM Art

ALLPRIV,
Yes

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Sub-privileges NOT revoked

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Contrast this with granting
same privilege twice!

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INSERT(name), No

Joe → Art

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