SQL access control and views

- The learning objectives for this week are:
  - Knowing what is the purpose of access control in the database security
  - Knowing what is **discretionary access control**
  - Knowing what is the DBMS access control hierarchy
  - Knowing how to manage users, roles and privileges in the SQL server
  - Knowing the purpose of **SQL views** and how to create them

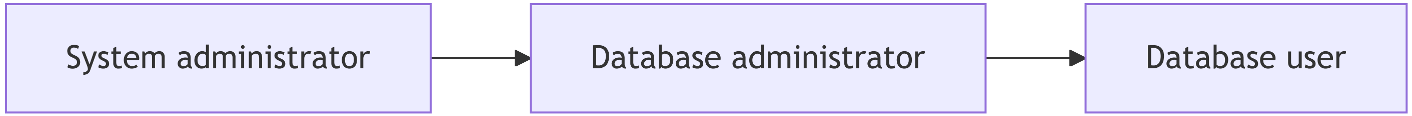
Database security

- Database security is accomplished by **verifying the identity of the database users** (authentication) and **controlling what these users are permitted to do** (authorization)
- User authentication is accomplished with either **SQL authentication** (using a username and password registered to the DBMS) or **operating system authentication** (the DBMS trusts the authentication service of the operating system)
- The typical user authorisation mechanism is called **discretionary access control** (DAC)

Discretionary access control (DAC)

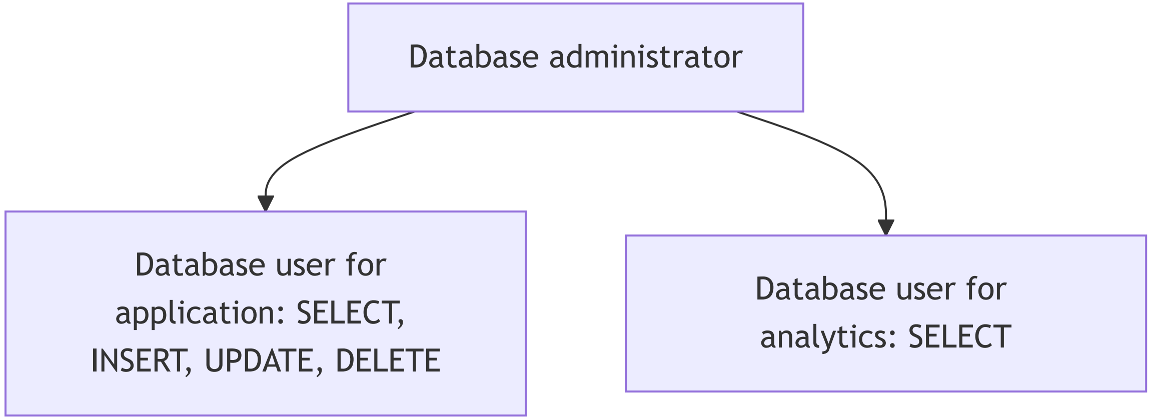
- In **discretionary access control** each user is given appropriate access rights (or privileges) on specific database objects (for example tables)
- Users can obtain certain privileges when they create an object (for example a table) and **they can pass some or all of these privileges to other users** at their discretion
- The ISO SQL Standard leaves many access control details to be **implementation-dependent**
- Different DBMS share many similarities in the access control implementation, but the detailed syntax for specifying access control is **DBMS-specific**
- In the upcoming examples we will learn how to specify access control in the SQL server

DBMS access control hierarchy



- Privileges are granted to an user by another user in a higher **access control hierarchy level**
- At the top of the hierarchy there’s is the **system administrator** user who has access to **everything**
- The system administrator’s username is automatically created when the DBMS is installed
- The system administrator creates databases and usernames for **database administrators**
- Database administrators have all possible privileges on the database they are granted access to

DBMS access control hierarchy


Database administrator
Database user for application: SELECT, INSERT, UPDATE, DELETE
Database user for analytics: SELECT

- Database administrators create usernames for **database users** and grant them different privileges
- For example, certain users can be granted privileges to create database tables and grant privileges to other users for the created tables
- In contrast, certain users can be granted privileges to only retrieve data from the database (`SELECT`)

Users, database roles, and privileges

- **Database users** can be added to **database roles**, inheriting any privileges associated with those roles
- A user **privilege** is a right to execute a particular type of SQL statement (for example `SELECT`, `INSERT`, `UPDATE`), or a right to access another user’s database object
- A privilege can be granted to directly a user or database role
- Database roles make it easier to manage privileges to be granted to a group of users of the same type
- The built-in **PUBLIC** role is contained in every database. Permissions granted to this role are inherited by all other users and roles

Granting privileges

- This is the simplified syntax of the `GRANT` statement in SQL Server:

```
GRANT privilegeList ON objectName
TO { authorizationIdList | PUBLIC }
[ WITH GRANT OPTION ]
```

- `privilegeList` consists of one or more of the following privileges separated by commas: `SELECT`, `INSERT`, `UPDATE`, `DELETE`, …
- `objectName` can be any a base table, view etc.
- `authorizationIdList` consists of one or more of following separated by commas: user, role
- `WITH GRANT OPTION` allows privileges to be passed on to other users

Example of granting privileges

- Here is an example, how we can grant `SELECT`, `INSERT`, and `UPDATE` privileges for the user `kalle` on a `Course` table:

```sql
-- user "kalle" is granted privilege to connect to the database
GRANT CONNECT TO kalle
-- user "kalle" is granted privilege
-- to perform SELECT, INSERT and UPDATE statements on the Course table
GRANT SELECT, INSERT, UPDATE ON Course TO kalle
```

Example of users, roles and privileges

- Here is an example, how we can create roles and grant privileges to roles:

```sql
-- Change the database context to the specified database
USE UniversityDatabase
-- 1. Create database roles in the current database
CREATE ROLE student_role
CREATE ROLE teacher_role
-- 2. Grant privileges to database roles
-- Allow the user to connect to the database
GRANT CONNECT TO student_role
GRANT CONNECT TO teacher_role
-- Allow the user to create tables
-- and grant privileges on their own tables to other users/roles
GRANT CREATE TABLE TO student_role WITH GRANT OPTION
-- Grant different privileges on existing tables to different roles
GRANT SELECT, INSERT, UPDATE, DELETE ON Course TO teacher_role
GRANT SELECT ON Course TO student_role
```

Example of users, roles and privileges

- Here is an example, how we can create username and password logins for users and add them to roles:

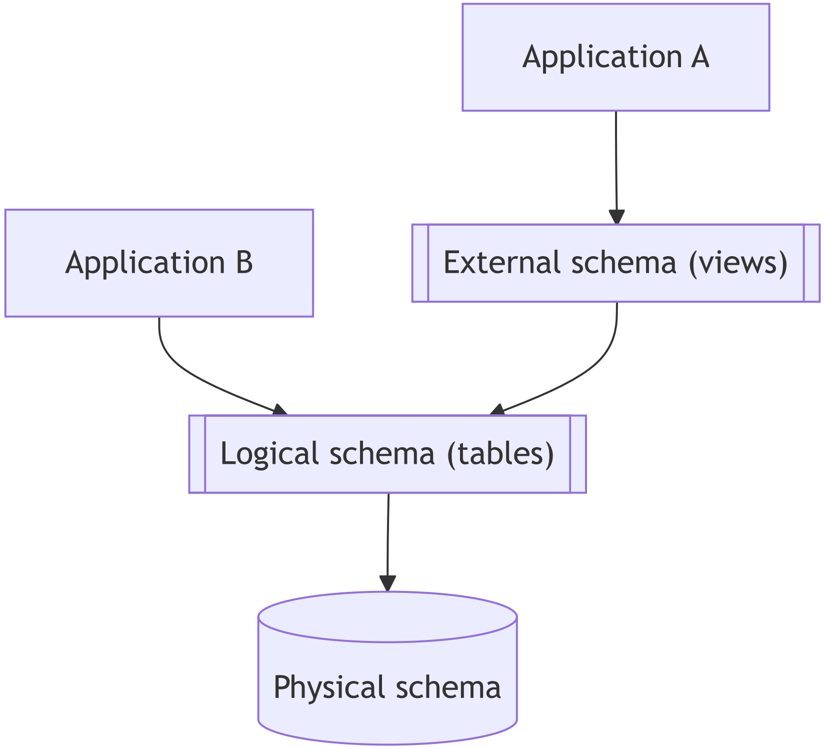
```sql
-- 3. Create DBMS-instance-level login names for the DBMS instance
CREATE LOGIN s001 WITH PASSWORD = 'wekPkuO-52'
CREATE LOGIN h1234 WITH PASSWORD = 'fhhFkhw-12'
-- 4. Create database-level user names based on existing logins
-- Create a new user in the current database
CREATE USER s001 FOR LOGIN s001
CREATE USER kalle FOR LOGIN h1234
-- 5. Add members to database roles
ALTER ROLE student_role ADD MEMBER s001
ALTER ROLE teacher_role ADD MEMBER kalle
```

Modifying database roles and privileges

- Here is an example, how we can remove members and privileges from a role:

```sql
-- Remove member from a database role
ALTER ROLE student_role DROP MEMBER s001
-- Revoke a privilege from a database user or role
REVOKE DELETE ON Course FROM teacher_role
-- Drop a database role
DROP ROLE teacher_role
```

SQL views



- **SQL view** is a virtual table based on a SQL query, which doesn’t store data itself but displays data from one or more underlying tables
- Views act as an external schema, which applications can access with exactly same kind of `SELECT` syntax as with tables
- Views can simplify complex queries, restrict access to sensitive data (e.g., hide certain columns) and present a consistent interface to a changing schema

Benefits of views

- Views promote **logical data independence**: if applications access data through views, underlying table structures can be changed to some extent without having to modify any applications
- Views allow fine-grained **security**: sensitive information in tables can be omited in views making it possible to tailor table visibility to different users in column-level
- Views offer **simplicity and reusability**: complicated SQL queries can be simplified when a view contains a part of the query

How to create views

- View can be created using the `CREATE VIEW` statement:

```
CREATE VIEW ViewName
AS subselect
[ WITH CHECK OPTION ]
```

- The `subselect` contains a `SELECT` statement, which determines the rows of the view:

```
CREATE VIEW SalesEmployee
AS SELECT id, name, title, city AS branch
FROM Employee
WHERE title = 'Salesperson'
```

- The view is like a virtual table, but the **data exists only in ordinary tables**

How to access data in the views

- The view name can be used in an SQL statement **like it was a name of an ordinary table**:

```
SELECT id, name, title, branch FROM SalesEmployee
```

id	name	title	city	salary
1	Alice Smith	Software Engineer	New York	120000
2	**Bob Johnson**	**Salesperson**	**San Francisco**	**95000**
3	Carol Evans	Product Manager	Austin	110000
5	**Emma Brown**	**Salesperson**	**Chicago**	**88000**

id	name	title	branch
2	Bob Johnson	Salesperson	San Francisco
5	Emma Brown	Salesperson	Chicago

Updatable vs. non-updatable views

- View is **updatable** if it is defined by selecting some existing columns and rows from a **single base table**
- The operations (e.g. deleting a row) reflects to the base table

```
-- this will delete the corresponding row in the Employee table
DELETE FROM SalesEmployee WHERE id = 2
```

- View is **non-updatable** if its query involves `JOIN` operations, `GROUP BY` operations, aggregate functions or set operations (e.g. `UNION`)

```
-- non-updatable view
CREATE VIEW SoftwareEngineerEmployee
AS SELECT id, name, team.name AS team_name
FROM Employee
JOIN Team
WHERE title = 'Software Engineer'
```

Inserting rows to views

- When we insert a row to the view, the base table columns which aren't present in the view will have a `NULL` value

```
INSERT INTO SalesEmployee (id, name, title, branch)
VALUES (80, 'Matti Meikäläinen', 'Salesperson', 'Helsinki')
```

id	name	title	city	salary
1	Alice Smith	Software Engineer	New York	120000
2	Bob Johnson	Salesperson	San Francisco	95000
3	Carol Evans	Product Manager	Austin	110000
5	Emma Brown	Salesperson	Chicago	88000
6	**Matti Meikäläinen**	**Salesperson**	**Helsinki**	**NULL**

Restricting non-matching inserts in views

- By default, we can insert rows to a view, which doesn’t satisfy the `WHERE` condition

```sql
CREATE VIEW SalesEmployee
AS SELECT id, name, title, city AS branch
FROM Employee
WHERE title = 'Salesperson'

-- "Office Dog" doesn't satisfy condition WHERE title = 'Salesperson'
INSERT INTO SalesEmployee (id, name, title, branch)
VALUES (80, 'Luna', 'Office Dog', 'Helsinki')
```

- We can disallow inserts, which aren’t included in the view using the `WITH CHECK OPTION`

```sql
CREATE VIEW SalesEmployee
AS SELECT id, name, title, city AS branch
FROM Employee
WHERE title = 'Salesperson'
WITH CHECK OPTION
```

Summary

- In **discretionary access control** each user is given appropriate access rights (or privileges) on specific database objects
- Users can obtain certain privileges when they create an object and they can pass some or all of these privileges to other users at their discretion
- Privileges are granted to an user by another user in a higher **access control hierarchy level**
- The **system administrator** has access to everything and they grant database access to **database administrators**
- **Database users** can be added to **database roles**, inheriting any privileges associated with those roles
- A privilege can be granted with the `GRANT` statement directly to a user or a database role
- **SQL view** is a virtual table based on a SQL query, which doesn’t store data itself but displays data from one or more underlying table