



# SD202: Databases

Advanced SQL and PostgreSQL features

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Views

Table inheritance

Transactions and Concurrency

# Views

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## Views: definition

- You can define a **view** to represent the result of a complex query:

```
CREATE VIEW Movie_with_actor AS
SELECT DISTINCT Movie.id, title FROM Movie, Actor_in_movie
WHERE Movie.id = Actor_in_movie.movie;
```

- View definition: simply a SELECT query as usual.
- You can then use the view as if it were a **regular table**

- Logical schema: **Employee** entity, every employee is either **Secretary** or **Professor**
- This is **specialization** (complete and disjoint)
- Physical schema: one **Secretary** table and one **Professor** table
- The **Employee** table is their union, projected on the common attributes
- Instead of storing it, we can define it with a **view**

# Advantages of views

What are views good for?

- **Logical independence:** you can change the definition of the view in an application without changing the rest of the code
- Can be used to restrict **access rights** (only allow users to see a specific view)
- Can be switched easily to a **materialized view** for performance

Views can be a “fix” to address **problems with the schema**, or to **redefine the logical schema** from the physical one

## Materialized views

```
CREATE MATERIALIZED VIEW Movie_with_actor ...
```

Must then be manually updated with:

```
REFRESH MATERIALIZED VIEW Movie_with_actor ...
```

How to make the view refresh **automatically**? Workaround:

- Make the materialized view a **regular table**
- Define **triggers** to update it in the right way whenever the underlying tables are changed

## Example of maintaining a materialized view

- Logical schema: **Employee** entity, each employee is **Secretary** or **Professor**
- Physical schema: one **Secretary** table and one **Professor** table
- The **Employee** table is their union, projected on the common attributes
- How to reflect updates from **Professor** and **Secretary**?
  - When a tuple is **inserted** in either table, **insert** its projection in **Professor**
  - When a tuple is **modified**, also **modify** the projection
  - When a tuple is **deleted**, also **delete** it
  - We assume that no tuple in **Employee** corresponds to two tuples in **Professor** and **Secretary** (common key)
  - **Question**: can we accept updates to **Employee**? how to reflect them?
- Other common use case: maintaining an **aggregate**, e.g., a sum



## Stored procedures

You can write **custom procedures** in PostgreSQL

```
CREATE OR REPLACE PROCEDURE transfer
  (origin INT, destination INT, amount DECIMAL)
LANGUAGE plpgsql
AS $$
BEGIN
SET TRANSACTION ISOLATION LEVEL SERIALIZABLE;
UPDATE Account SET balance = balance - amount WHERE id = origin;
UPDATE Account SET balance = balance + amount WHERE id = destination;
COMMIT;
END; $$
```

Also possible to write **custom functions**, custom **aggregation operators**...

# Why use stored procedures

- For **triggers** (see later)
- To factor some application logic **in the database** for consistency across applications
- For **performance** (execute code closer to the data)
  - Stored procedures can be written **in C**

# Triggers

- Procedures can be created as **triggers** to be automatically run whenever data is changed
  - Whenever a **table** is modified
  - For **every modified tuple** in a table
  - Can be run **before** or **after** the operation or **instead of** the operation
- Possible uses:
  - Complex **consistency check**, or **normalization/reformatting**
  - Recomputing **auxiliary tables**, automatically creating **dependent data**
  - Manually updating an **aggregate** (e.g., a sum)
  - Manually **log** database operations

Views

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# Table inheritance

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## Table inheritance

You can define tables that **refine** another table (inherit from it)

```
CREATE TABLE Employee (id SERIAL PRIMARY KEY, name VARCHAR, salary INT);
CREATE TABLE Professor (field VARCHAR) INHERITS (Employee);
CREATE TABLE Secretary (building VARCHAR) INHERITS (Employee);
INSERT INTO Employee(name, salary) VALUES ('John', 424);
INSERT INTO Professor(name, salary, field) VALUES ('Patricia', 343, 'CS');
INSERT INTO Secretary(name, salary, building) VALUES ('Simon', 252, 'A');
SELECT * FROM Professor;
SELECT * FROM Secretary;
SELECT * FROM Employee;
SELECT * FROM ONLY Employee;
```

## Table inheritance subtleties

- Tables can inherit from multiple tables
- Deleting a parent table **cascades** to the tables that inherit from it
- **Warning:** uniqueness constraints and keys do not take inheritance into account!

```
INSERT INTO Professor(id, name, salary, field) VALUES
  (3, 'Paula', '454', 'CS');
SELECT * FROM Employee;
-- id's are no longer unique!
```

- **Warning:** inserting in a “parent” table does not work

```
-- This does not work
INSERT INTO Employee(name, salary, field) VALUES
  ('Priscilla', '4242', 'CS');
```

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# Transactions and Concurrency

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## Reminder on ACID

SQL guarantees the **ACID properties**:

- **Atomicity**: a transaction block is either completely executed or not executed at all
- **Consistency**: the database always satisfies the integrity constraints
- **Isolation**: if there are multiple transactions, they happen as if one had taken place before the other
- **Durability**: once executed, transactions will not be lost

# Transactions

- **Default:** every query (`SELECT`, `INSERT`, etc.) is a transaction
- We can manually define a **transaction block** with `BEGIN ... COMMIT`
- **Start** a transaction with `BEGIN`, and issue queries
- To **perform** the transaction, use `COMMIT`
- To **abort** the transaction, use `ROLLBACK`
- To define a **savepoint**, use `SAVEPOINT label`
- To **roll back** to a savepoint, use `ROLLBACK TO SAVEPOINT label`

**Exercise:** Can you think of a use case for transactions?

## Challenges with single transactions

To correctly support transactions (one at a time) we must:

- **Prepare** the effects of the transaction, and **atomically** commit them
- Make sure the commits are **durable**, even if the hardware fails
- Be able to **revert** the effects of the transaction
- With save points, be able to revert its **partial effects**

# Challenges with concurrent transactions

- **Transactions:** a sequence of read/write database operations
- These transactions are not **ordered** a priori (e.g., one may arrive while another is running)
- We want to execute them in parallel for **performance**
- Problems:
  - Two transactions can access the **same data item at the same time**
  - Even if individual operations do not conflict, the **sequence of operations** of a transaction may be affected by other transactions
- Strongest **ACID** guarantees: **serializability**
  - What will happen is **consistent** with a **serial ordering** of the transactions
  - **Challenge:** Parallelize as much as possible while respecting this

# Concurrency

- Satisfying serializability is **complicated** and may cause transactions to:
  - **wait** for another transaction to complete, possibly **deadlock**
  - **fail** if we have started to execute it, but another transaction affected its data
- PostgreSQL supports **several transaction isolation levels** relaxing serializability
- Each level describes which kinds of **anomalies** may take place
- **More restrictive** isolation means:
  - worse **performance**
  - more **failures**, but
  - less **inconsistency problems**
- Also supports **explicit locking** in transactions (in addition to these mechanisms)

# Replication and clustering

- Having **more than one server** has several uses:
  - **partition** the data if it is large
  - do **load balancing** to use multiple servers
  - evaluate a query on multiple servers **in parallel**
  - have **failover** servers for high availability
- PostgreSQL has some support to propagate changes from a main database to read-only **failovers**
- PostgreSQL **did not focus** initially on replication and clustering
- Many **third party** solutions