

Databases

Lecture 9 - Views and Transactions

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18.03.2025

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1. Introduction

1.1 Where are we right now?

- Last time, we looked at the basics of subqueries and views
- Today, we'll be discussing
 - ▶ how we can expand our knowledge of views,
 - ▶ how we can use transactions to increase the safety of our data manipulation statements
 - ▶ how transactions are executed.

1.1 Where are we right now?

1. Introduction

1. Introduction
2. Basics
3. SQL
4. Entity-Relationship-Model
5. Relationships
6. Constraints
8. **Subqueries & Views**
9. **Transactions**
10. Database Applications
11. Integrity, Trigger & Security

1.2 What is the goal of this chapter?

- At the end of this lesson, you should be able to
 - ▶ create views in PostgreSQL and use them effectively and
 - ▶ use transactions to make safe changes, that can be undone if necessary.

2. Repetition

Updating Views

- Views are Relations, just like tables!
- Should make no difference to users

? Question

Can we modify the view's data?

- Depends on type of view!

Basics

- Classify views based on the select:
 - ▶ **Projection View**
 - `SELECT a, b, c ...`
 - ▶ **Selection View**
 - `... WHERE <condition> ...`
 - ▶ **Join View**
 - `FROM tab_a JOIN tab_b ...`
 - **Aggregation View**
 - `SELECT MAX(x) ...`
- Other types and combinations exist

Basics

- A view with a single defining table is updatable if
 - ▶ the view attributes contain the primary key of the base relation,
 - ▶ as well as all attributes with the NOT NULL constraint that have a default value specified
- Views defined on multiple tables using joins are only updatable in special cases
 - ▶ E.g., INSERT and UPDATE for Join Views, if join condition is based on PK-FK
- Views defined using grouping and aggregate functions are not updatable

Generated Tables

```
1 CREATE TABLE <name> AS SELECT
```



- Can create new table based on query
- New table is independent from old table
- Use cases:
 - ▶ Copy table
 - ▶ Copy parts of table

! Memorize

New table does not have all constraints of the parent table!

Generated Tables



Example

```
1 INSERT INTO Underpaid ( lname , fname )
2   SELECT lname , fname **FROM** Employee WHERE salary
   < 1000 ;
```



- WHERE clause belongs to SELECT

Operations

- A transaction bundles several operations into one logical unit
 - ▶ Unit of Work
- Includes one or more database access operations E.g., INSERT, DELETE, UPDATE, SELECT
- Operations must be executed all or none
- Example: Order a hotel room over the internet
 - ▶ Choose and reserve room
 - ▶ Payment
 - ▶ Final booking of the hotel room

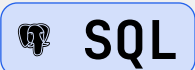
ACID

- Key features of transactions
 - ▶ **Atomicity**: Transaction is executed in whole or not at all
 - ▶ **Consistency**: State of the DB is consistent before and after a transaction
 - ▶ **Isolation**: Transactions do not interfere with other concurrent transactions
 - ▶ **Durability**: Changes are stored permanently in the database and will not get lost

ACID - Atomicity

- Begin of Transaction (**BoT**)
 - ▶ SQL99: START TRANSACTION
 - ▶ PostgreSQL:

```
1 BEGIN;
```



- Commit a transaction: COMMIT;
 - ▶ All operations are made persistent
 - ▶ All changes are visible to other users
- Rollback transaction: ROLLBACK;
 - ▶ DB is in state at **BoT** again

ACID - Consistency

- DB: in consistent state before transaction Also, in consistent state after transaction
- Integrity constraints assure that
- Constraints can be defined as
 - ▶ IMMEDIATE (default in MySQL)
 - are checked immediately after operation
 - ▶ DEFERRED
 - Check at time of commit

ACID - Isolation

- Transactions are isolated from other concurrent transactions
- Concurrent transactions shall behave well

ACID - Isolation: Concurrency Control

- Concurrent operations can lead to problems
 - ▶ Lost Update
 - ▶ Dirty Read
 - Unrepeatable read
 - Phantom tuples


ACID - Isolation: Concurrency Control

- Lost Update is prevented by SQL
- Transactions: may choose **Isolation Level**
 - ▶ SERIALIZABLE
 - no problems
 - REPEATABLE READ (default in MySQL)
 - Open for phantom tuples
 - READ COMMITTED (default in Oracle, SQL Server)
 - Open for phantom tuples and unrepeatable read
 - READ UNCOMMITTED
 - Open for all problems


ACID - Isolation: Concurrency Control

TRANSACTION ISOLATION LEVELS

explained as if you were building a snowman




if you have more than one process trying to read and/or modify resource - you have concurrency. Isolation Levels dictate what happens in such scenarios.




READ UNCOMMITTED isolation level

Let's build a snowman together! Woohoo!




READ COMMITTED isolation level

I'll build a snowman in my backyard but you can come and see it occasionally m'kay




REPEATABLE READ isolation level

I'll just show you a picture of my snowman but you won't see it until I'm done that's fair



SERIALIZABLE isolation level

You won't even know what I'm building until I'm done! that sucks!



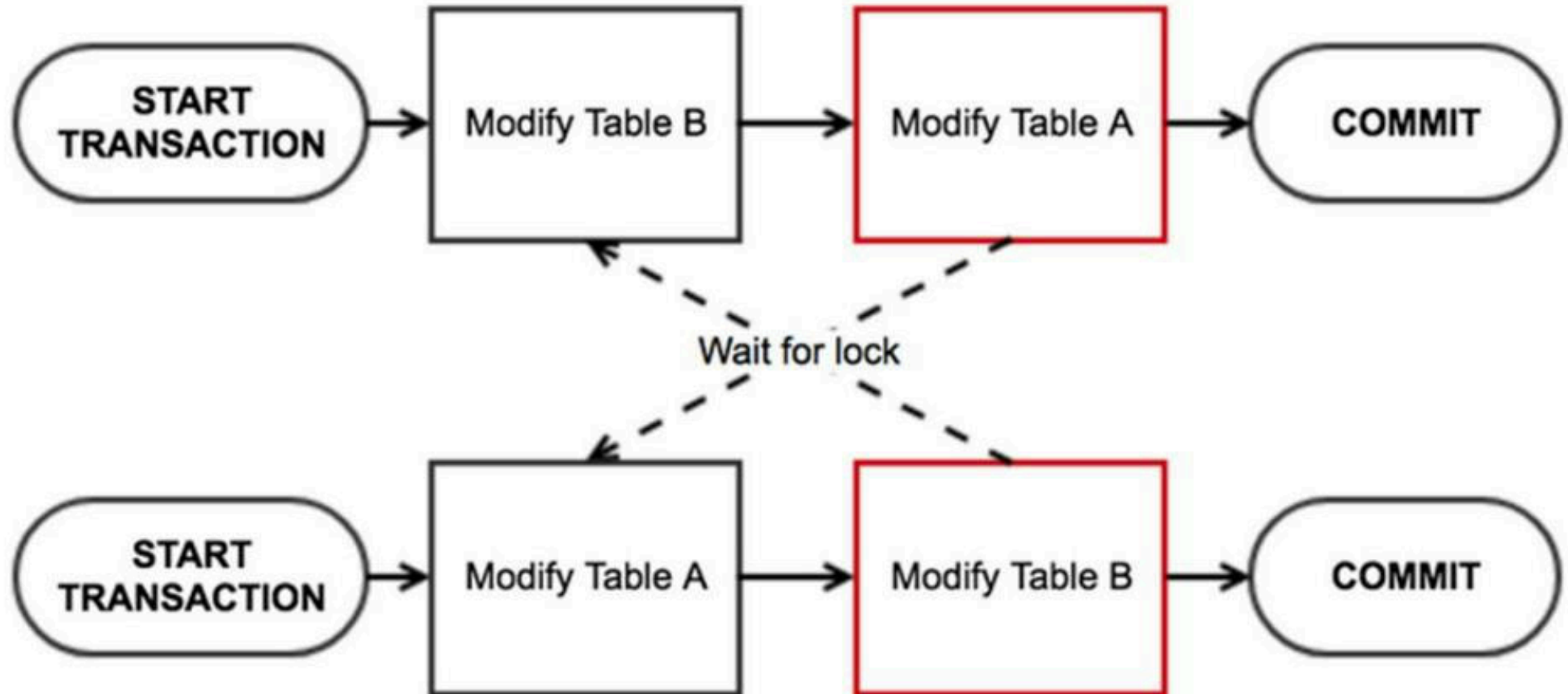
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ACID - Isolation: Concurrency Control

- Deadlocks may occur!
 - ▶ Usually are resolved automatically by aborting one transaction

2.2 Transactions

2. Repetition



ACID - Durability

- Once committed, changed data is safe
- Error types
 1. Computer failure
 2. Transaction or system error (constraint violation, $\frac{x}{0}$, blackout, system crash)
 3. Local Errors
 4. Concurrency control enforcement
 5. Disk error (harddisk broken)
 6. Physical problems and catastrophes (fire, earthquake, robbery, ...)

ACID - Durability: Error Handling

- Recovery from transaction failures usually means that the database is **restored** to the most recent consistent state just before the time of failure
- Minor damages due to error types 1-4 from slide “ACID – Durability”
 - ▶ DBMS provides handling
 - Recovery strategy is to identify any changes that may cause an inconsistency in the database
 - Changes are first written to redo logs (files on disk)
 - Written to database files after commit

ACID - Durability: Error Handling

- Extensive damage due to error types 5-6 from slide “ACID – Durability”
 - ▶ Recovery handling restores a past copy of the database from archival storage
 - ▶ Reconstructs a more current state by redoing the operations
 - ▶ Last transactions are lost!
- Solution: Redundancy
 - ▶ RAID (**r** edundant **a** rray of **i** ndependent **d** isks)
 - Data Replication by DBMS

ACID - Durability: Error Handling

- Changes are performed on (replicated to) several database instances
- Master/Slave
 - ▶ Updates only on one instance (master)
 - ▶ Slave: Read only vs. Standby
- Multi-Master
 - ▶ Updates on different instances
 - ▶ Needs conflict resolution strategy

ACID - Durability: Error Handling

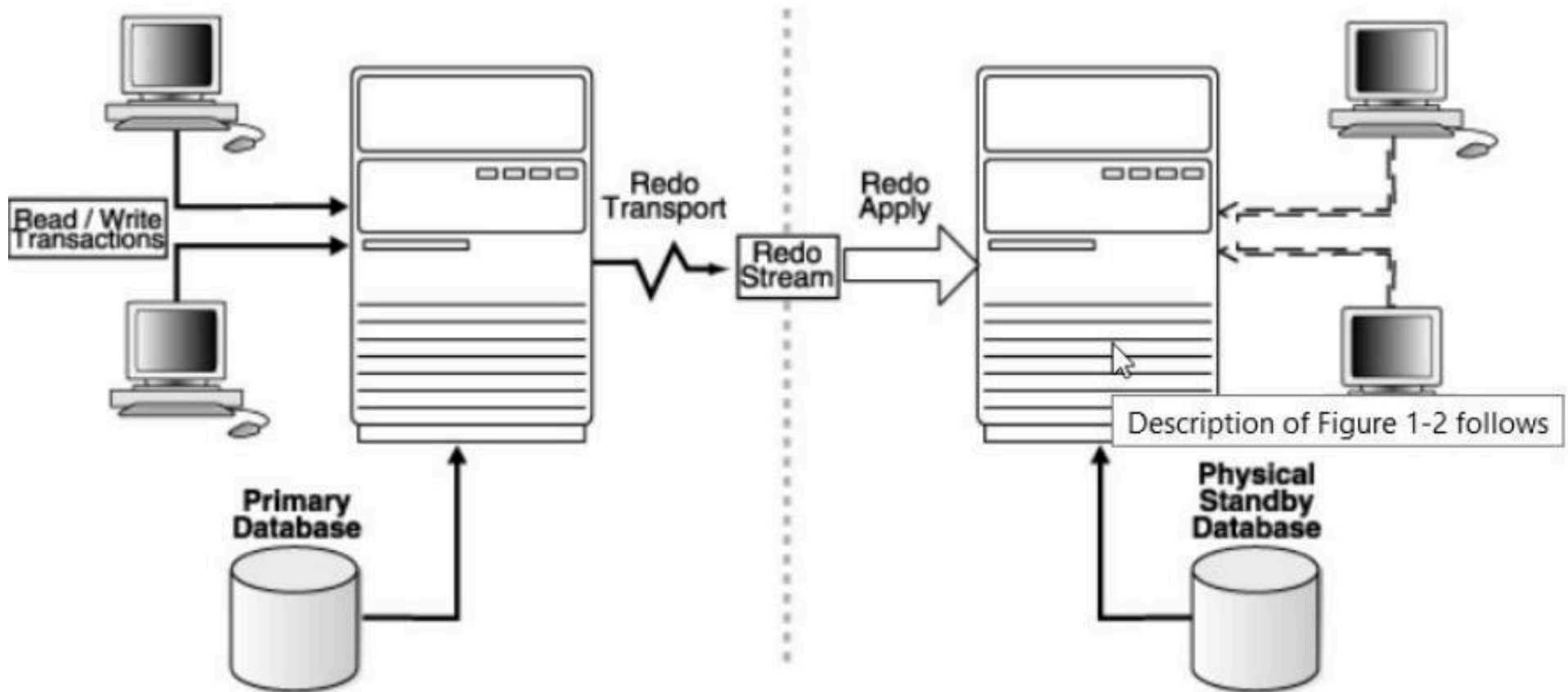
- **Synchronous**
 - ▶ Transaction valid only when committed on all DBs
 - ▶ Safest, but performance impact
 - ▶ May reduce availability of the system
- **Asynchronous**
 - ▶ Transaction valid when committed locally

ACID - Durability: Error Handling

- Low level (disk device)
- Trigger based
 - ▶ Update triggers the replication (SQL level)
- Logfile shipping
 - ▶ Changes are stored in redo logs (as usual)
 - ▶ redo logs are copied to standby DB

ACID - Durability: Error Handling

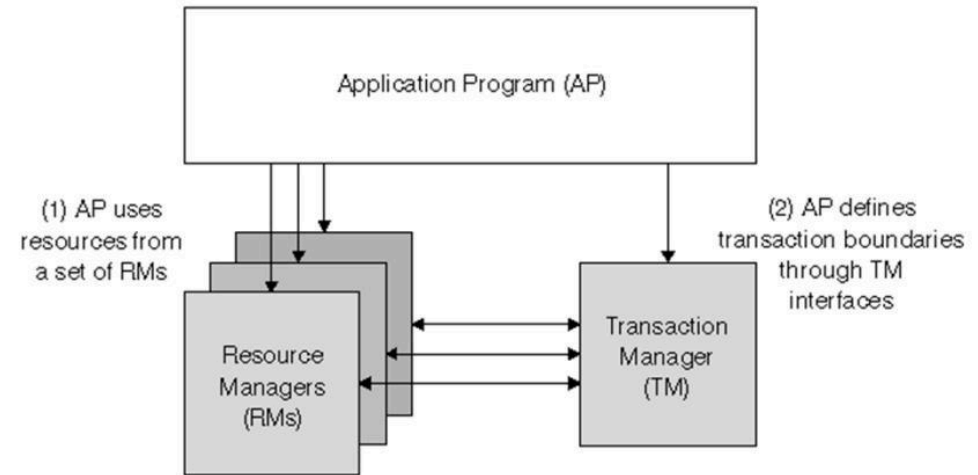
- Oracle
 - ▶ Data Guard
 - Replication on second server, can be used to answer Read-Only queries



- Real Application Cluster (RAC)
 - ▶ Several servers share the same DB

Distributed Transactions

- Transactions not only in a single DBS
- Standardized by X/Open
 - ▶ Transaction Manager: A software component that guarantees transaction properties
 - ▶ Resource Manager: Every resource (e.g., DBS, GUI) that is able to work in a



transactional mode without
providing a transaction
control structure itself

- The Transaction manager coordinates the Resource Manager that take part in the transaction. E.g., different DBS (distributed transactions) that appear as one DBS from outside (transparency!)

Distributed Transactions

Savepoints

- There are operations that may be expensive to execute time consuming
- If certain constraints fail within transaction execution, then maybe these constraints may not fail in a second attempt (e.g., time dependent)
- So “fall back” points can be defined, which are called **savepoints**
- It is possible to rollback up to a savepoint and restart transaction execution from this point on

2.2 Transactions

Savepoints

2. Repetition

2.2 Transactions

2. Repetition

Code

```
UPDATE STUDENT SET STUDENT_NAME = 'Mathew' WHERE STUDENT_NAME = 'Mahtwe';  
SAVEPOINT S1;  
UPDATE STUDENT SET AGE = 15 WHERE STUDENT_ID = 100;  
ROLLBACK to S1;
```

STUDENT			
STUDENT_ID	STUDENT_NAME	Address	Age
100	Joseph	Troy	22
101	Mahtwe	Lakeside Village	23
102	Jacob	Fraser Town	22

STUDENT			
STUDENT_ID	STUDENT_NAME	Address	Age
100	Joseph	Troy	22
101	Mathew	Lakeside Village	23
102	Jacob	Fraser Town	22



STUDENT			
STUDENT_ID	STUDENT_NAME	Address	Age
100	Joseph	Troy	15
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3. Integrity, Trigger and Security

Integrity Constraints

- Static Constraints
 - ▶ Conditions on states
 - ▶ Conditions must be fulfilled before and after operations
 - ▶ Used until now
 - Primary Key
 - Foreign Key
 - UNIQUE, NOT NULL, CHECK
- Dynamic Constraints (**Assertions**)
 - ▶ Integrity conditions that affect multiple tables
 - ▶ Conditions on state transitions

3.1 Basics

3. Integrity, Trigger and Security



Example

status of order → new
→ payed → processing
→ shipped

Integrity Constraints

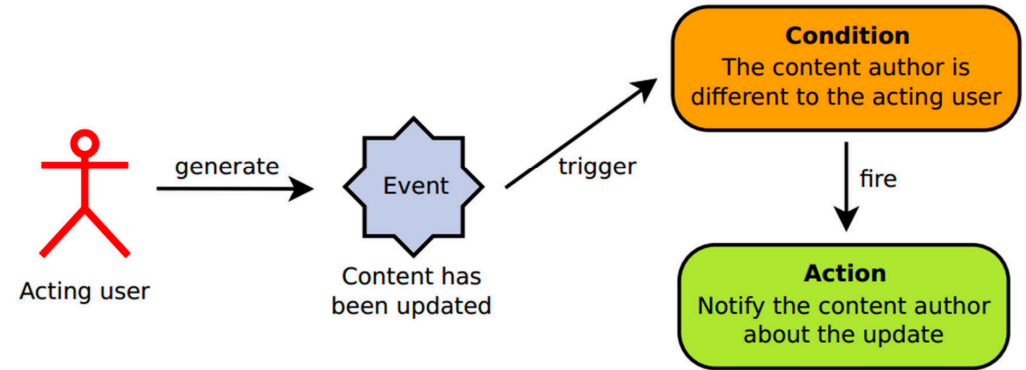
- Assertions have been part of the SQL since SQL-92 (DDL)
- Not supported by most DBMS (e.g., MySQL, Postgres and Oracle)
- If the concept of assertions is to be simulated TRIGGER
- Concept:
 - ▶ Whenever anything is modified in the database, the assertion checks its condition
 - ▶ If the SELECT-statement gives a non-empty result, the operation that has triggered the assertion is denied

3.1 Basics

3. Integrity, Trigger and Security

Integrity Constraints - ECA

- ECA rules
 - ▶ on event (E)
 - ▶ under certain conditions (C)
 - ▶ perform actions (A)



Trigger Syntax

```
1  CREATE SQL
2      [DEFINER = user]
3      TRIGGER trigger_name
4      trigger_time trigger_event
5      ON tbl_name FOR EACH ROW
6      [trigger_order]
7      trigger_body
8  trigger_time: { BEFORE | AFTER }
9  trigger_event: { INSERT | UPDATE | DELETE }
10 trigger_order: { FOLLOWS | PRECEDES } other_trigger_name
```

Excursion Delimiter

- A PostgreSQL client program such as pgadmin or psql program uses the delimiter (“;”) to separate statements and executes each statement separately
- However, a stored procedure consists of multiple statements separated by a semicolon (“;”)
- If you use a PostgreSQL client program to define a stored procedure that contains semicolon characters, the PostgreSQL client program will not treat the whole stored procedure as a single statement, but many statements.

- Therefore, you must redefine the delimiter temporarily so that you can pass the whole stored procedure to the server as a single statement.
- To redefine the default delimiter, you use the delimiter command

Excursion Delimiter

- In short: A delimiter is a separator between commands



Example

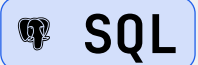
```
1 delimiter |
2 ...
3 |
4 delimiter ;
```



In the code block between “delimiter” and “delimiter;” the delimiter is changed to “|” (instead of “;”)

Excursion Delimiter: Example

```
1 delimiter |
2 CREATE TRIGGER SALARY_VIOLATION
3 BEFORE INSERT ON EMPLOYEE
4 FOR EACH ROW
5 BEGIN
6     IF NEW.SALARY > (SELECT SALARY
7                     FROM EMPLOYEE
8                     WHERE SSN = NEW.SUPER_SSN )
9     THEN SET NEW.Salary = (SELECT SALARY
10                           FROM EMPLOYEE
```



3.1 Basics

3. Integrity, Trigger and Security

```
11          WHERE SSN =  
12      NEW.SUPER_SSN ) - 1;  
13  END IF;  
14  |  
15  delimiter;
```

Events

- Triggers can react on events
 - ▶ DML: INSERT, UPDATE, DELETE
 - Most common trigger types
 - ▶ DDL: CREATE, ALTER, DROP
 - ▶ DB: startup, shutdown, logon of a user
- No COMMIT triggers

Types

- Time of execution, relative to event
 - ▶ BEFORE
 - ▶ AFTER
- INSTEAD OF
- Statement trigger
 - ▶ Once per statement
 - ▶ Even if no row is affected!
 - ▶ Default trigger type
- Row trigger

3.1 Basics

- For every affected row
- Syntax: FOR EACH ROW

3. Integrity, Trigger and Security

Order of Trigger

- Before Statement Trigger (once!)
- For every row affected:
 - ▶ Before row trigger
 - ▶ DML operation
 - ▶ Immediate integrity checks
 - ▶ After row trigger
- After Statement Trigger (once!)

Transition Variables

- Row triggers can access old and new tuples
 - ▶ PostgreSQL
 - :old or old → NULL for INSERT
 - :new or new → NULL for DELETE
 - Oracle
 - ▶ NEW and OLD
 - ▶ Before row triggers:
 - Can even modify new!

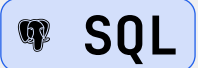
Use Cases

- Constraints on state transitions
- Audit
 - ▶ When was a record last modified?
- Integrity checks with error correction
 - ▶ Change :new
- Maintain redundant data
- Updateable views
 - ▶ INSTEAD OF

Trigger: Example

- Audit insertion of new persons


```
1 DROP TRIGGER IF EXISTS emp_insert;
2 CREATE TRIGGER emp_insert AFTER INSERT ON employee
3 FOR EACH ROW
4 INSERT INTO EMPLOYEE_LOG (ESSN, INSERT_DATE) VALUES
  ( NEW.ssn , NOW() ) ;
```



Trigger: Example

- Salary of new persons

```
1 delimiter |
2 CREATE PROCEDURE output
3     (in ssn char(9), in old_sal DECIMAL(10,2),
4      in new_sal DECIMAL(10,2), in diff_sal DECIMAL(10,2))
5 BEGIN
6     INSERT INTO EMPLOYEE_SALDIFF VALUES ( ssn , old_sal ,
7     new_sal, diff_sal);
8 END
8 |
```

 SQL

```
9 delimiter;
```

Problems

- Cascading triggers
 - ▶ Trigger actions cause other triggers to fire
- Execution order
 - ▶ Result of high-level operation must be independent hereof!
- “Mutating Tables”

Problems

- Hard to implement
 - ▶ Transaction save!
 - ▶ Multi-session save
- Hard to debug
 - ▶ Update may lead to insert in another table
 - ▶ ... can cause for example constraint violation
 - ▶ Which statement failed?

3.1 Basics

Assignment: Webshop

3. Integrity, Trigger and Security

3.1 Basics

- Suppose the following relations in your database
- In the table `Price_History` we want to track on how the prices of the products of table `Product` develop over time. Table `Price_History` has four attributes:
 - ▶ The record ID `PHID`
 - ▶ The reference to table `Product` with the foreign key `PID`
 - ▶ The current price `Price`

3. Integrity, Trigger and Security

Table `Product`

<u>PID</u>	Price	Description
1	0.50	red apple
2	0.60	green apple
3	1.20	red pepper
4	1.10	green pepper
...

Table `Product_History`

<u>PHID</u>	PID (FK)	Price	Change_Date
1	1	0.50	02.06.2021
2	3	1.20	02.06.2021
3	2	0.60	03.06.2021
4	4	1.10	04.06.2021
...

- ▶ The date `Change_Date`, where we store the date of the change

3.1 Basics

Assignment: Webshop

3. Integrity, Trigger and Security

3.1 Basics

1. INSERT trigger: We want to get an INSERT with the current (start) price in table Price_History when we do an INSERT in the table Product. This is triggered when an INSERT on our table product is done (AFTER).
2. DELETE trigger: Furthermore, in case of a DELETE, all records of the deleted product in the table Price_History should be deleted as well.

3. Integrity, Trigger and Security

Table Product

<u>PID</u>	Price	Description
1	0.50	red apple
2	0.60	green apple
3	1.20	red pepper
4	1.10	green pepper
...

Table Product_History

<u>PHID</u>	PID (FK)	Price	Change_Date
1	1	0.50	02.06.2021
2	3	1.20	02.06.2021
3	2	0.60	03.06.2021
4	4	1.10	04.06.2021
...

3. UPDATE trigger: If a price of a product is changed, this change should also result in an entry in the table `Price_History`.

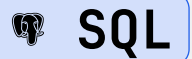
Permissions

- DBMS are multi-user systems
- You need permissions to do anything with the DB:
 - ▶ login
 - ▶ CREATE table, DROP table, etc.
 - ▶ SELECT
 - ▶ INSERT, UPDATE, DELETE
- Permissions can be GRANTED and REVOKED

GRANT and REVOKE

- Permissions can be GRANTED and REVOKED

```
1 GRANT <privilege_name> ON <object_name>  
2 TO { <user_name> | PUBLIC | <role_name> } [ WITH GRANT  
OPTION ] ;
```



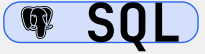
- GRANT

```
1 GRANT SELECT ON tab_a TO user_a;  
2 GRANT UPDATE ON tab_b TO user_a;
```



- REVOKE

```
1 REVOKE SELECT ON tab_a FROM user_a;
```



Least Privilege Principle

- A user should have exactly the permissions necessary to do the work
 - ▶ ... and not more!
- Important for web applications
 - ▶ anonymous end users
 - ▶ not trustworthy
- Limit the possible damage of attacks

Assignment: Webshop

1. Create a user student which is allowed to query and insert the table Product.
2. Revoke the insert privilege from a user student.

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