Section6:
Views, Transactions, Basic Authorization

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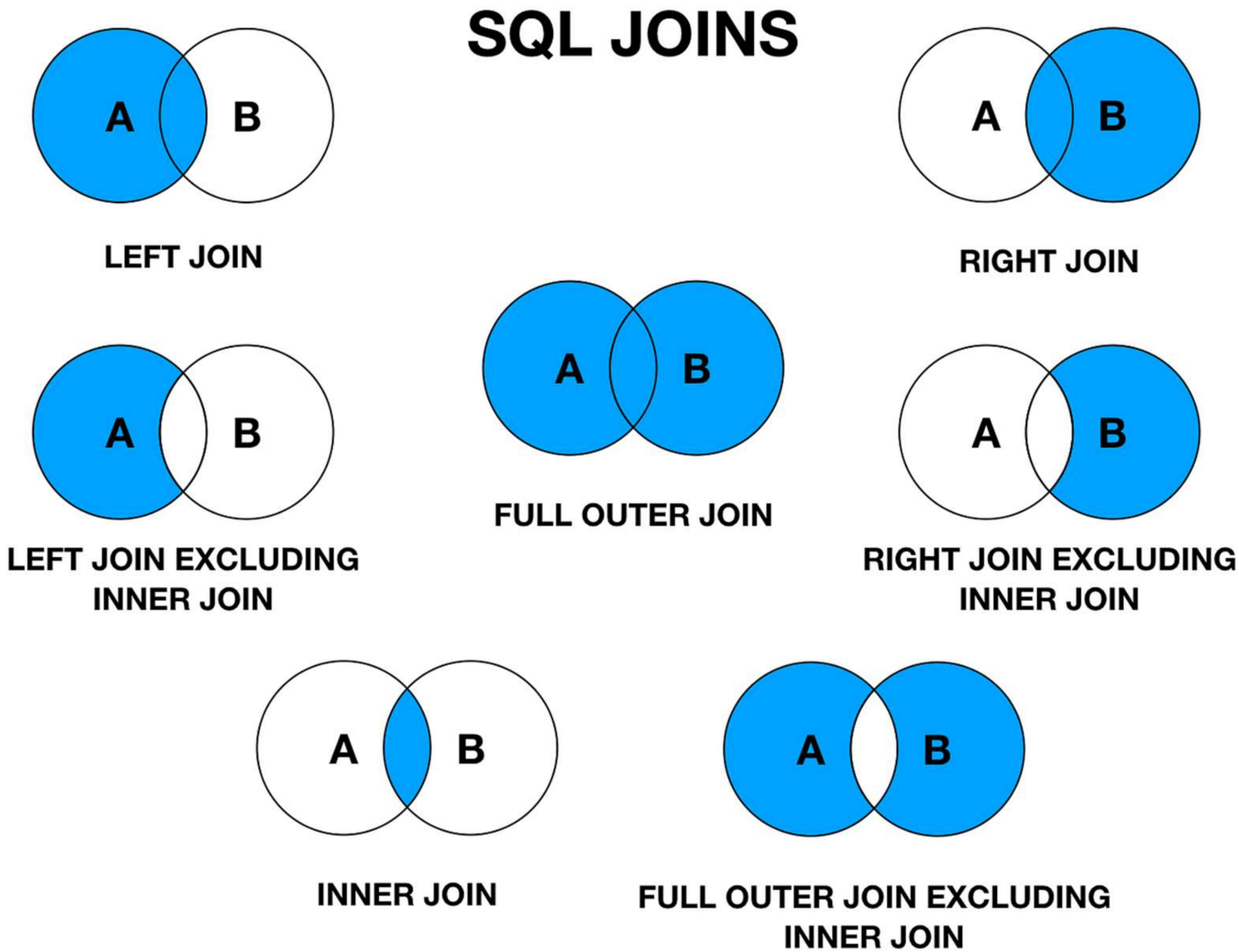
Outline

- Views
- Transactions
- Integrity Constraints
- Domain vs User Defined Type
- Authorization

Joins n SQL


SQL JOINS
A
B
LEFT JOIN
A
B
RIGHT JOIN
A
B
FULL OUTER JOIN
A
B
LEFT JOIN EXCLUDING INNER JOIN
A
B
RIGHT JOIN EXCLUDING INNER JOIN
A
B
INNER JOIN
A
B
FULL OUTER JOIN EXCLUDING INNER JOIN

Outer Join Examples

- Relation *course*

course_id	title	dept_name	credits
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

- Relation *prereq*

course_id	prereq_id
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

- Observe that

  course information is missing CS-347

  prereq information is missing CS-315

Left Outer Join

- *course* **natural left outer join** *prereq*

course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	*null*

- In relational algebra: *course* ⟕ *prereq*

Right Outer Join

- *course* **natural right outer join** *prereq*

course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-347	*null*	*null*	*null*	CS-101

- In relational algebra: *course* ⟖ *prereq*

Full Outer Join

- *course* **natural full outer join** *prereq*

course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	*null*
CS-347	*null*	*null*	*null*	CS-101

- In relational algebra: *course* ⟗ *prereq*

Full Outer Join

- *course* **natural full outer join** *prereq*

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BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	*null*
CS-347	*null*	*null*	*null*	CS-101

- In relational algebra: *course* ⟗ *prereq*

Joined Types and Conditions

- **Join operations** take two relations and return as a result another relation.
- These additional operations are typically used as subquery expressions in the **from** clause
- **Join condition** – defines which tuples in the two relations match.
- **Join type** – defines how tuples in each relation that do not match any tuple in the other relation (based on the join condition) are treated.

Join types
inner join
left outer join
right outer join
full outer join

Join conditions
natural
on <predicate>
using $(A_1, A_2, \ldots, A_n)$

Multiple Joins

You can join more than two tables together. First, two tables are joined, then the third table is joined to the result of the previous joining.

TOY AS t

toy_id	toy_name	cat_id
1	ball	3
2	spring	NULL
3	mouse	1
4	mouse	4
5	ball	1

CAT AS c

cat_id	cat_name	mom_id	owner_id
1	Kitty	5	1
2	Hugo	1	2
3	Sam	2	2
4	Misty	1	NULL

OWNER AS o

id	name
1	John Smith
2	Danielle Davis

JOIN & JOIN

```
SELECT
  t.toy_name,
  c.cat_name,
  o.name AS owner_name
FROM toy t
JOIN cat c
  ON t.cat_id = c.cat_id
JOIN owner o
  ON c.owner_id = o.id;
```

toy_name	cat_name	owner_name
ball	Kitty	John Smith
mouse	Kitty	John Smith
ball	Sam	Danielle Davis

JOIN & LEFT JOIN

```
SELECT
  t.toy_name,
  c.cat_name,
  o.name AS owner_name
FROM toy t
JOIN cat c
  ON t.cat_id = c.cat_id
LEFT JOIN owner o
  ON c.owner_id = o.id;
```

toy_name	cat_name	owner_name
ball	Kitty	John Smith
mouse	Kitty	John Smith
ball	Sam	Danielle Davis
mouse	Misty	NULL

LEFT JOIN & LEFT JOIN

```
SELECT
  t.toy_name,
  c.cat_name,
  o.name AS owner_name
FROM toy t
LEFT JOIN cat c
  ON t.cat_id = c.cat_id
LEFT JOIN owner o
  ON c.owner_id = o.id;
```

toy_name	cat_name	owner_name
ball	Kitty	John Smith
mouse	Kitty	John Smith
ball	Sam	Danielle Davis
mouse	Misty	NULL
spring	NULL	NULL

NON-EQUI (Theta) JOIN

You can use a **non-equality** in the ON condition, for example, to show **all different pairs** of rows.

TOY AS a

toy_id	toy_name	cat_id
3	mouse	1
5	ball	1
1	ball	3
4	mouse	4
2	spring	NULL

TOY AS b

cat_id	toy_id	toy_name
1	3	mouse
1	5	ball
3	1	ball
4	4	mouse
NULL	2	spring

```
SELECT
  a.toy_name AS toy_a,
  b.toy_name AS toy_b
FROM toy a
JOIN toy b
  ON a.cat_id < b.cat_id;
```

cat_a_id	toy_a	cat_b_id	toy_b
1	mouse	3	ball
1	ball	3	ball
1	mouse	4	mouse
1	ball	4	mouse
3	ball	4	mouse

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SQL EXECUTION ORDER

Order of a SQL Query

SELECT DISTINCT column, AGGREGATE(column) 5

Window Functions Happen Here
Distinct Applies After This

FROM table1

JOIN table2 1

ON table1.column = table2.column

WHERE constraint_expression 2

GROUP BY column 3

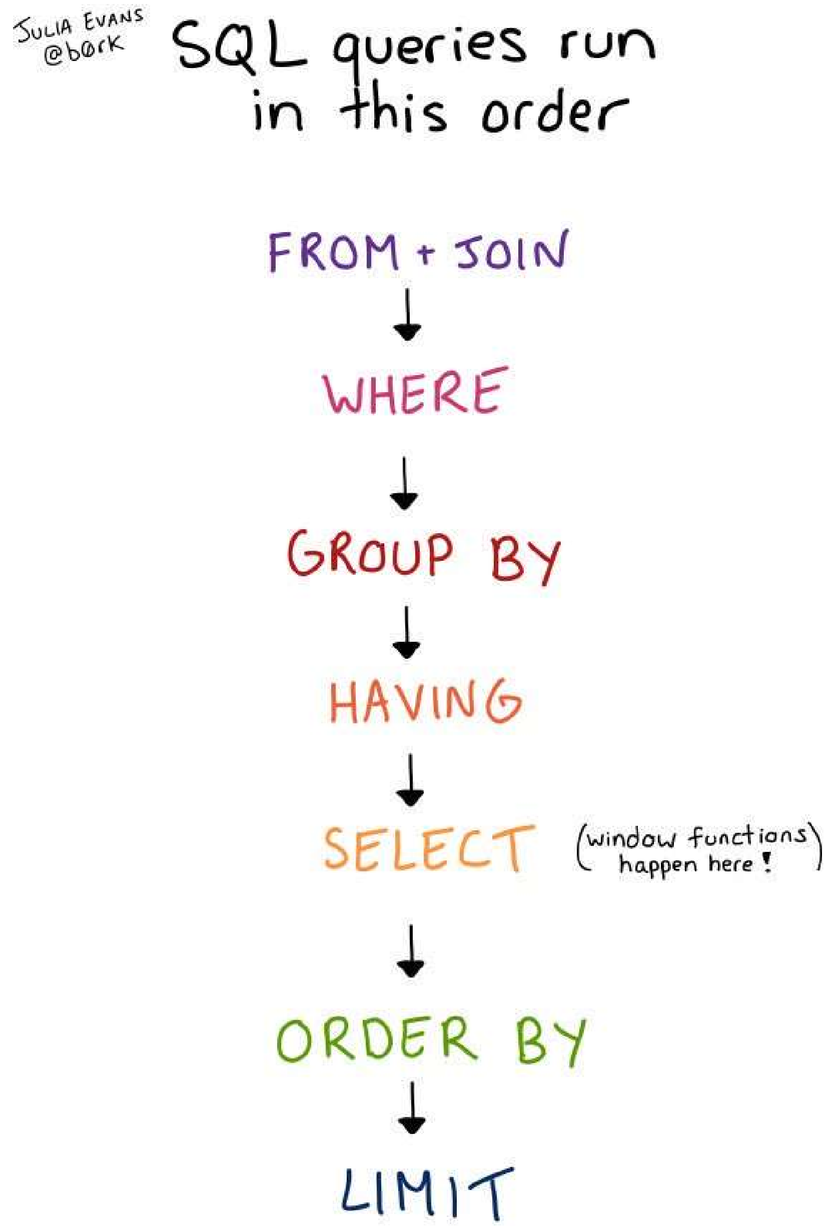
HAVING constraint_expression 4

ORDER BY column ASC/DESC 6

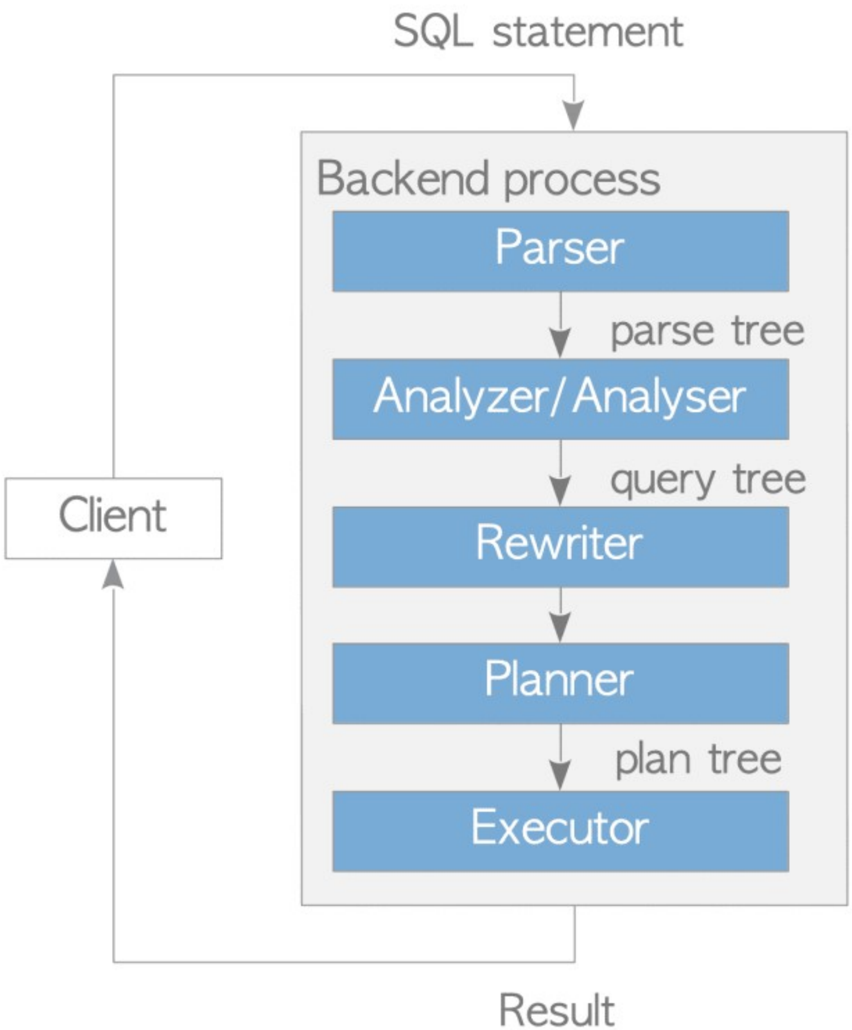
LIMIT count; 7

SQL Execution Order

1. FROM
2. ON
3. JOIN
4. WHERE
5. GROUP BY
6. WITH CUBE or WITH ROLLUP
7. HAVING
8. SELECT
9. Window Functions
10. DISTINCT
11. ORDER BY
12. TOP/LIMIT



Order of a SQL Query – Backend Tasks



Order of a SQL Query - Parser

Action:

- Tokenizes the SQL statement into individual elements (keywords, identifiers, operators).
- Generates a parse tree with nodes representing the structure of the SQL statement.

Result:

- **Parse tree with nodes for SELECT, column names, FROM, table name, WHERE clause, and ORDER BY.**

```
SELECT * FROM mytable
```

```
SelectStmt
├ targetList
│ └ ResTarget
│   └ ColumnRef
│     └ A_Star
└ fromClause
  └ RangeVar
    └ relname = mytable
```

```
DELETE FROM abc WHERE id = 1
```

```
DeleteStmt
├ relation
│ └ RangeVar
│   └ relname = abc
└ whereClause
  └ A_Expr
    ├ kind = AEXPR_OP
    └ ...
```

Order of a SQL Query - Analyzer

Action:

- Examines the parse tree.
- Performs semantic analysis.
- Resolves references to tables, columns, and other database objects.

Result:

- Ensures that "employee_id," "first_name," "last_name," "employees," and "department_id" exist in the database schema.
- **Generates a query tree with resolved references.**

Order of a SQL Query - Rewriter

- **Action:**
  - Analyzes the query tree.
  - Applies rules and transformations if necessary.
- **Result:**
  - May **rewrite the query tree to optimize performance** based on rules stored in the pg_rules system catalog.
  - Example: If there's a rule to use an index for the "department_id" filter, the rewriter might modify the query tree accordingly.

Order of a SQL Query - Rewriter

```sql
CREATE TABLE shoelace_log (
    sl_name    text,          -- shoelace changed
    sl_avail   integer,       -- new available value
    log_who    text,          -- who did it
    log_when   timestamp      -- when
);

CREATE RULE log_shoelace AS ON UPDATE TO shoelace_data
    WHERE NEW.sl_avail <> OLD.sl_avail
    DO INSERT INTO shoelace_log VALUES (
                                NEW.sl_name,
                                NEW.sl_avail,
                                current_user,
                                current_timestamp
                            );
```

Order of a SQL Query - Planner

Action:

- Generates an execution plan to minimize the overall cost.
- Considers factors like available indexes, join methods, and other optimization strategies.

Result:

- **Creates an execution plan specifying how to access and process the data efficiently.**
- May involve decisions such as using an index scan for the WHERE clause and sorting the result set based on the "last_name" column.

Order of a SQL Query - Executor

- **Action:**
  - Executes the SQL query based on the generated execution plan.
  - Coordinates with other components like the storage manager, buffer manager, and transaction manager.
- **Result:**
  - Retrieves rows from the "employees" table where "department_id" equals 10.
  - Orders the result set by the "last_name" column.
  - **Produces the final result set** with columns "employee_id," "first_name," and "last_name."

ROLLUP & CUBE

Grouping Set

A **grouping set** is a set of columns by which you group by using the GROUP BY clause.

```
SELECT
    brand,
    segment,
    SUM (quantity)
FROM
    sales
GROUP BY
    GROUPING SETS (
        (brand, segment),
        (brand),
        (segment),
        ()
    );
```

brand	segment	quantity
ABC	Premium	100
ABC	Basic	200
XYZ	Premium	100
XYZ	Basic	300

	brand character varying	segment character varying	sum bigint
1	[null]	[null]	700
2	XYZ	Basic	300
3	ABC	Premium	100
4	ABC	Basic	200
5	XYZ	Premium	100
6	ABC	[null]	300
7	XYZ	[null]	400
8	[null]	Basic	500
9	[null]	Premium	200

Grouping – The Old Way

```
SELECT
    brand,
    segment,
    SUM (quantity)
FROM
    sales
GROUP BY
    brand,
    segment;
```

brand	segment	quantity
ABC	Premium	100
ABC	Basic	200
XYZ	Premium	100
XYZ	Basic	300

	brand character varying	segment character varying	sum bigint
1	[null]	[null]	700
2	XYZ	Basic	300
3	ABC	Premium	100
4	ABC	Basic	200
5	XYZ	Premium	100
6	ABC	[null]	300
7	XYZ	[null]	400
8	[null]	Basic	500
9	[null]	Premium	200

?

CUBE

PostgreSQL CUBE is a subclause of the GROUP BY clause. The CUBE allows you to generate multiple grouping sets (**All Combinations**).

```
CUBE(c1,c2,c3)

GROUPING SETS (
(c1,c2,c3),
(c1,c2),
(c1,c3),
(c2,c3),
(c1), (c2), (c3), () )
```

brand	segment	quantity
ABC	Premium	100
ABC	Basic	200
XYZ	Premium	100
XYZ	Basic	300

brand	segment	sum
ABC	Basic	200
ABC	Premium	100
ABC	(Null)	300
XYZ	Basic	300
XYZ	Premium	100
XYZ	(Null)	400
(Null)	Basic	500
(Null)	Premium	200
(Null)	(Null)	700

Partial Cube :

```
SELECT c1, c2, c3, aggregate (c4)
FROM table_name
GROUP BY c1, CUBE (c1, c2);
```

Rollup

PostgreSQL CUBE is a subclause of the GROUP BY clause. The CUBE allows you to generate multiple grouping sets.()

`Rollup(c1,c2,c3)`

generates only four grouping sets, assuming the hierarchy **c1 > c2 > c3** as follows:

```
GROUPING SETS (
(c1, c2, c3)
(c1, c2)
(c1)
()
)
```

brand	segment	quantity
ABC	Premium	100
ABC	Basic	200
XYZ	Premium	100
XYZ	Basic	300

In this case, the hierarchy is the segment > brand.

segment	brand	sum
Basic	ABC	200
Basic	XYZ	300
Basic	(Null)	500
Premium	ABC	100
Premium	XYZ	100
Premium	(Null)	200
(Null)	(Null)	700

Partial Rollup :

```
SELECT c1, c2, c3, aggregate (c4)
FROM table_name
GROUP BY c1, Rollup (c1, c2);
```

VIEWS

Views

- In some cases, it is not desirable for all users to see the entire logical model (that is, all the actual relations stored in the database.)
- Consider a person who needs to know an instructors name and department, but not the salary. This person should see a relation described, in SQL, by

  select *ID*, *name*, *dept_name*
  from *instructor*

- A **view** provides a mechanism to hide certain data from the view of certain users.
- Any relation that is not of the conceptual model but is made visible to a user as a "virtual relation" is called a **view**.

View Definition

- A view is defined using the **create view** statement which has the form

  create view *v* **as** < query expression >

  where <query expression> is any legal SQL expression. The view name is represented by *v.*
- Once a view is defined, the view name can be used to refer to the virtual relation that the view generates.
- View definition is not the same as creating a new relation by evaluating the query expression
  - Rather, a view definition causes the saving of an expression; the expression is substituted into queries using the view.

View Definition and Use

- A view of instructors without their salary

```
create view faculty as
    select ID, name, dept_name
    from instructor
```

- Find all instructors in the Biology department

```
select name
from faculty
where dept_name = 'Biology'
```

- Create a view of department salary totals

```
create view departments_total_salary(dept_name, total_salary) as
    select dept_name, sum (salary)
    from instructor
    group by dept_name;
```

Views Defined Using Other Views

- One view may be used in the expression defining another view
- A view relation v_1 is said to ***depend directly*** on a view relation v_2 if v_2 is used in the expression defining v_1
- A view relation v_1 is said to ***depend on*** view relation v_2 if either v_1 depends directly to v_2 or there is a path of dependencies from v_1 to v_2
- A view relation v is said to be ***recursive*** if it depends on itself.

Views Defined Using Other Views

- **create view** ***physics_fall_2017*** **as**
  select *course*.*course_id*, *sec_id*, *building*, *room_number*
  from *course*, *section*
  where *course*.*course_id* = *section*.*course_id*
  and *course*.*dept_name* = 'Physics'
  and *section*.*semester* = 'Fall'
  and *section*.*year* = '2017’;

- **create view** ***physics_fall_2017*****_***watson* **as**
  select *course_id*, *room_number*
  from ***physics_fall_2017***
  where *building*= 'Watson';

View Expansion

- Expand the view :

```
create view physics_fall_2017_watson as
   select course_id, room_number
   from physics_fall_2017
   where building= 'Watson'
```

- To:

```
create view physics_fall_2017_watson as
   select course_id, room_number
   from (select course.course_id, building, room_number
        from course, section
        where course.course_id = section.course_id
            and course.dept_name = 'Physics'
            and section.semester = 'Fall'
            and section.year = '2017')
   where building= 'Watson';
```

View Expansion (Cont.)

- A way to define the meaning of views defined in terms of other views.
- Let view v_1 be defined by an expression e_1 that may itself contain uses of view relations.
- View expansion of an expression repeats the following replacement step:

  repeat
  Find any view relation v_i in e_1
  Replace the view relation v_i by the expression defining v_i
  until no more view relations are present in e_1

- As long as the view definitions are not recursive, this loop will terminate

Update of a View

- Add a new tuple to *faculty* view which we defined earlier

  insert into *faculty*

  values ('30765', 'Green', 'Music');

- This insertion must be represented by the insertion into the *instructor* relation
  - Must have a value for salary.
- Two approaches
  - Reject the insert
  - Insert the tuple

    ('30765', 'Green', 'Music', null)

  into the *instructor* relation

Some Updates Cannot be Translated Uniquely

- **create view** *instructor_info* **as**
  select *ID*, *name*, *building*
  from *instructor*, *department*
  where *instructor*.*dept_name* = *department*.*dept_name*;
- **insert into** *instructor_info*
  values ('69987', 'White', 'Taylor');
- Issues
  - Which department, if multiple departments in Taylor?
  - What if no department is in Taylor?

And Some Not at All

- **create view** *history_instructors* **as**
  select *
  from *instructor*
  where *dept_name*= 'History';
- What happens if we insert

  ('25566', 'Brown', 'Biology', 100000)

  into *history_instructors?*

View Updates in SQL

- Most SQL implementations allow updates only on simple views
  - The **from** clause has only one database relation.
  - The **select** clause contains only attribute names of the relation, and does not have any expressions, aggregates, or **distinct** specification.
  - Any attribute not listed in the **select** clause can be set to null
  - The query does not have a **group** by or **having** clause.

Materialized Views

- Certain database systems allow view relations to be physically stored.
  - Physical copy created when the view is defined.
  - Such views are called **Materialized view**:
- If relations used in the query are updated, the materialized view result becomes out of date
  - Need to **maintain** the view, by updating the view whenever the underlying relations are updated.

```
CREATE MATERIALIZED VIEW view_name
AS
query
WITH [NO] DATA;
```

Refreshing data for materialized views

```
REFRESH MATERIALIZED VIEW view_name;
```

Materialized Views

When you refresh data for a materialized view, PostgreSQL locks the entire table therefore you cannot query data against it. To avoid this, you can use the CONCURRENTLY option.

REFRESH MATERIALIZED VIEW CONCURRENTLY view_name;

With CONCURRENTLY option, PostgreSQL creates a temporary updated version of the materialized view, compares two versions, and performs INSERT and UPDATE only the differences.

to refresh it with CONCURRENTLY option, you need to create a UNIQUE index for the view first.

Materialized Views

```
CREATE MATERIALIZED VIEW rental_by_category
AS
 SELECT c.name AS category,
    sum(p.amount) AS total_sales
   FROM (((((payment p
     JOIN rental r ON ((p.rental_id = r.rental_id)))
     JOIN inventory i ON ((r.inventory_id = i.inventory_id)))
     JOIN film f ON ((i.film_id = f.film_id)))
     JOIN film_category fc ON ((f.film_id = fc.film_id)))
     JOIN category c ON ((fc.category_id = c.category_id)))
  GROUP BY c.name
  ORDER BY sum(p.amount) DESC
WITH DATA;
```

TRANSACTIONS

Transactions

- A **transaction** consists of a sequence of query and/or update statements and is a "unit" of work
- The SQL standard specifies that a transaction begins implicitly when an SQL statement is executed.
- The transaction must end with one of the following statements:
  - **Commit work**. The updates performed by the transaction become permanent in the database.
  - **Rollback work**. All the updates performed by the SQL statements in the transaction are undone.
- Atomic transaction
  - either fully executed or rolled back as if it never occurred
- Isolation from concurrent transactions

ACID Properties

Transactions have the following four standard properties, **usually referred to by the acronym ACID**

- **Atomicity** − Ensures that all operations within the work unit are completed successfully; otherwise, the transaction is aborted at the point of failure and previous operations are rolled back to their former state.
- **Consistency** − Ensures that the database properly changes states upon a successfully committed transaction.
- **Isolation** − Enables transactions to operate independently of and transparent to each other.
- **Durability** − Ensures that the result or effect of a committed transaction persists in case of a system failure.

Transaction Control

BEGIN [TRANSACTION] − To start a transaction.

COMMIT − To save the changes, alternatively you can use **END TRANSACTION** command.

ROLLBACK − To rollback the changes.

```
testdb=# BEGIN;
DELETE FROM COMPANY WHERE AGE = 25;
ROLLBACK;
```

Transaction Sample

```sql
BEGIN;

UPDATE accounts
SET balance = balance - 1000
WHERE id = 1;

UPDATE accounts
SET balance = balance + 1000
WHERE id = 2;

COMMIT;
```

Transaction Save Point

```sql
BEGIN;
UPDATE accounts
SET balance = balance - 1500
WHERE id = 1;
/* Set a save point that we can return to */
SAVEPOINT save_1;

UPDATE accounts
SET balance = balance + 1500
WHERE id = 3; -- Wrong account number here! We can rollback to the save point though!
/* Gets us back to the state of the transaction at `save_1` */

ROLLBACK TO save_1;
/* Continue the transaction with the correct account number */
UPDATE accounts
SET balance = balance + 1500
WHERE id = 4;
COMMIT;
```

Setting the Isolation level

```
BEGIN ISOLATION LEVEL
<isolation_level>;
statements
COMMIT;
```

Isolation levels:

- **READ UNCOMMITTED** (will result in `READ COMMITTED` since this level isn't implemented in PostgreSQL)
- **READ COMMITTED**
- **REPEATABLE READ**
- **SERIALIZABLE**

Isolation levels

READ UNCOMMITTED:
Allows transactions to read uncommitted changes.
Not natively supported in PostgreSQL.

READ COMMITTED:
Ensures a transaction sees only committed changes.
Default isolation level in PostgreSQL.
Avoids dirty reads but may allow non-repeatable reads and phantom reads.

Isolation levels

REPEATABLE READ:
Guarantees that within a transaction, the same query produces the same result.
Prevents dirty reads and non-repeatable **(Phantom Read)** reads but may allow phantom reads.

SERIALIZABLE:
Provides the highest isolation level.
Guarantees serializability, preventing dirty reads, non-repeatable reads, and phantom reads.
Can be more resource-intensive due to locking.

INTEGRITY CONSTRAINTS

ADVANCED TOPICS

Integrity Constraints

- Integrity constraints guard against accidental damage to the database, by ensuring that authorized changes to the database do not result in a loss of data consistency.
  - A checking account must have a balance greater than $10,000.00
  - A salary of a bank employee must be at least $4.00 an hour
  - A customer must have a (non-null) phone number

Constraints on a Single Relation

- **not null**
- **primary key**
- **unique**
- **check** (P), where P is a predicate

Not Null Constraints

- **not null**
  - Declare *name* and *budget* to be **not null**

    name **varchar**(20) **not null**
    budget **numeric**(12,2) **not null**

Unique Constraints

- **unique** ($A_1, A_2, \ldots, A_m$)
  - The unique specification states that the attributes $A_1, A_2, \ldots, A_m$ form a candidate key.
  - Candidate keys are permitted to be null (in contrast to primary keys).

The check clause

- The **check** (P) clause specifies a predicate P that must be satisfied by every tuple in a relation.
- Example: ensure that semester is one of fall, winter, spring or summer

create table *section*
(*course_id* **varchar** (8),
sec_id **varchar** (8),
semester **varchar** (6),
year **numeric** (4,0),
building **varchar** (15),
room_number **varchar** (7),
time slot id **varchar** (4),
primary key (*course_id*, *sec_id*, *semester*, *year*),
check (*semester* **in** ('Fall', 'Winter', 'Spring', 'Summer')))

Referential Integrity

- Ensures that a value that appears in one relation for a given set of attributes also appears for a certain set of attributes in another relation.
  - Example: If “Biology” is a department name appearing in one of the tuples in the *instructor* relation, then there exists a tuple in the *department* relation for “Biology”.
- Let A be a set of attributes. Let R and S be two relations that contain attributes A and where A is the primary key of S. A is said to be a **foreign key** of R if for any values of A appearing in R these values also appear in S.

Referential Integrity (Cont.)

- Foreign *keys can be* specified as part of the SQL **create table** statement

  foreign key (*dept_name*) **references** *department*

- By default, a foreign key references the primary-key attributes of the referenced table.
- SQL allows a list of attributes of the referenced relation to be specified explicitly.

  foreign key (*dept_name*) **references** *department* (*dept_name*)

Cascading Actions in Referential Integrity

- When a referential-integrity constraint is violated, the normal procedure is to reject the action that caused the violation.
- An alternative, in case of delete or update is to cascade

    create table *course* (
        (…
        dept_name **varchar**(20),
        foreign key (*dept_name*) **references** *department*
            on delete cascade
            on update cascade,
        . . .)

- Instead of cascade we can use :
    - **set null**,
    - **set default**

Integrity Constraint Violation During Transactions

- Consider:

  create table *person* (
  ID **char**(10),
  name **char**(40),
  mother **char**(10),
  father **char**(10),
  primary key *ID,*
  foreign key *father* **references** *person,*
  foreign key *mother* **references** *person*)

- How to insert a tuple without causing constraint violation?
  - Insert father and mother of a person before inserting person
  - OR, set father and mother to null initially, update after inserting all persons (not possible if father and mother attributes declared to be **not null**)
  - OR defer constraint checking

Complex Check Conditions

- The predicate in the check clause can be an arbitrary predicate that can include a subquery.

  check (*time_slot_id* **in** (**select** *time_slot_id* **from** *time_slot*))

  The check condition states that the time_slot_id in each tuple in the *section* relation is actually the identifier of a time slot in the *time_slot* relation.

  - The condition has to be checked not only when a tuple is inserted or modified in *section* , but also when the relation *time_slot* changes

Assertions

- An **assertion** is a predicate expressing a condition that we wish the database always to satisfy.
- The following constraints, can be expressed using assertions:
- For each tuple in the *student* relation, the value of the attribute *tot_cred* must equal the sum of credits of courses that the student has completed successfully.
- An instructor cannot teach in two different classrooms in a semester in the same time slot
- An assertion in SQL takes the form:

  create assertion <assertion-name> **check** (<predicate>);

Assertions

- We do not Have Subqueries in Check Constraints Postgres!
- We do not Have Assertion in Postgres!

List of SQL-Standard Features that not implemented in Postgres:

https://www.postgresql.org/docs/current/unsupported-features-sql-standard.html

F291		UNIQUE predicate	
F301		CORRESPONDING in query expressions	
F403		Partitioned join tables	
F451		Character set definition	
F461		Named character sets	
F492		Optional table constraint enforcement	
F521		Assertions	
F671		Subqueries in CHECK constraints	intentionally omitted

User-Defined Types

- **create type** construct in SQL creates user-defined type

  create type *Dollars* **as numeric (12,2) final**

- Example:

  create table *department*
  (*dept_name* **varchar** (20),
  building **varchar** (15),
  budget Dollars);

Domains

- **create domain** construct in SQL-92 creates user-defined domain types

  create domain *person_name* **char**(20) **not null**

- Types and domains are similar. Domains can have constraints, such as **not null**, specified on them.
- Example:

  create domain *degree_level* **varchar**(10)
  constraint *degree_level_test*
  check (**value in** ('Bachelors', 'Masters', 'Doctorate'));

AUTHORIZATION

Authorization

- We may assign a user several forms of authorizations on parts of the database.
  - **Read** - allows reading, but not modification of data.
  - **Insert** - allows insertion of new data, but not modification of existing data.
  - **Update** - allows modification, but not deletion of data.
  - **Delete** - allows deletion of data.
- Each of these types of authorizations is called a **privilege**. We may authorize the user all, none, or a combination of these types of privileges on specified parts of a database, such as a relation or a view.

Authorization (Cont.)

- Forms of authorization to modify the database schema
  - **Index** - allows creation and deletion of indices.
  - **Resources** - allows creation of new relations.
  - **Alteration** - allows addition or deletion of attributes in a relation.
  - **Drop** - allows deletion of relations.

Authorization Specification in SQL

- The **grant** statement is used to confer authorization

  grant <privilege list> **on** <relation or view > **to** <user list>
- <user list> is:
  - a user-id
  - **public**, which allows all valid users the privilege granted
  - A role (more on this later)
- Example:
  - **grant select on** *department* **to** Amit, Satoshi
- Granting a privilege on a view does not imply granting any privileges on the underlying relations.
- The grantor of the privilege must already hold the privilege on the specified item (or be the database administrator).

Privileges in SQL

- **select**: allows read access to relation, or the ability to query using the view
  - Example: grant users U_1, U_2, and U_3 **select** authorization on the *instructor* relation:

    grant select on *instructor* **to** U_1, U_2, U_3
- **insert**: the ability to insert tuples
- **update**: the ability to update using the SQL update statement
- **delete**: the ability to delete tuples.
- **all privileges**: used as a short form for all the allowable privileges

Revoking Authorization in SQL

- The **revoke** statement is used to revoke authorization.

  revoke <privilege list> **on** <relation or view> **from** <user list>
- Example:

  revoke select on *student* **from** U_1, U_2, U_3
- <privilege-list> may be **all** to revoke all privileges the revokee may hold.
- If <revokee-list> includes **public,** all users lose the privilege except those granted it explicitly.
- If the same privilege was granted twice to the same user by different grantees, the user may retain the privilege after the revocation.
- All privileges that depend on the privilege being revoked are also revoked.

Roles

- A **role** is a way to distinguish among various users as far as what these users can access/update in the database.
- To create a role we use:

  create a role <name>
- Example:
  - **create role** instructor
- Once a role is created we can assign “users” to the role using:
  - **grant** <role> **to** <users>

Roles Example

- **create role** instructor;
- **grant** *instructor* **to** Amit**;**
- Privileges can be granted to roles:
  - **grant select on** *takes* **to** *instructor*;
- Roles can be granted to users, as well as to other roles
  - **create role** *teaching_assistant*
  - **grant** *teaching_assistant* **to** *instructor*;
    - *Instructor* inherits all privileges of *teaching_assistant*
- Chain of roles
  - **create role** *dean*;
  - **grant** *instructor* **to** *dean*;
  - **grant** *dean* **to** Satoshi;

Authorization on Views

- **create view** *geo_instructor* **as**
  (**select** *
  from *instructor*
  where *dept_name* = 'Geology');
- **grant select on** *geo_instructor* **to** *geo_staff*
- Suppose that a *geo_staff* member issues
  - **select** *
    from *geo_instructor*;
- What if
  - *geo_staff* does not have permissions on *instructor?*
  - Creator of view did not have some permissions on *instructor?*

Other Authorization Features

- **references** privilege to create foreign key
  - **grant reference** (*dept_name*) **on** *department* **to** Mariano;
  - Why is this required?
- transfer of privileges
  - **grant select on** *department* **to** Amit **with grant option**;
  - **revoke select on** *department* **from** Amit, Satoshi **cascade**;
  - **revoke select on** *department* **from** Amit, Satoshi **restrict**;
  - And more!

Create User/Role Sample

-- 1. Creating a User

- CREATE USER john WITH PASSWORD 'john_password';

-- 2. Defining a Role

- CREATE ROLE sales_team;

-- 3. Assigning User to Role

- ALTER USER john SET ROLE sales_team;

-- 4. Granting Permission to Role

- GRANT SELECT ON TABLE sales_data TO sales_team;

End of Chapter 4