Operations … SQL Specifics

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Certain SQL specific features

- Functions for computed attributes in projection
- Certain issues related to NULLs,
  - UNKNOWN is third TRUTH value while evaluating SQL expressions
  - IS NULL as additional predicate
- **`UNION/INTERSECT/EXCEPT ALL`** in SQL
- Correlated Sub-Queries
- EXISTS
- Some (relation as BAG) comparison operators

Functions and Operators in SQL

Functions and Operators

- SQL provides various functions and operators that can be used to create a new attribute in resultant relations

- There are typically, type conversion, arithmetic operators, mathematical, and string manipulation operators and functions. For example: substring, upper, lower, sqrt, ln, etc.

- Details for PostgreSQL functions can be seen at: http://intranet.daiict.ac.in/~pm_jat/postgres/html/functions.html.

Examples

```
SELECT ssn,
   fname || ' ' || minit || '. ' || lname AS name,
   current_date-bdate AS age FROM employee;


SELECT essn, hours*50 AS amount FROM works_on;


SELECT upper(fname) AS name, ln(salary) AS x FROM
   employee;
```

Example

```
SELECT * FROM employee
      WHERE upper(fname) = 'FRANKLIN';
```

```
SELECT essn FROM dependent WHERE
  age(d.bdate) > interval '18 years');
```

BETWEEN and LIKE in SQL

- **BETWEEN, LIKE** are used in predicate:
  - **SELECT …. WHERE A BETWEEN 10 TO 20;**
  - **SELECT … WHERE A1 LIKE '%IX%' OR A2 LIKE 'ABC%' OR A3 LIKE '%XYZ';**
  - **SELECT … WHERE A1 LIKE '_X_%';**

- Also: **NOT BETWEEN** and **NOT LIKE**.

Regular Expression Matching in PostgreSQL

- PostgreSQL also allows regular expression matching in string match using IS SIMILAR TO <reg-ex>

Issues with Null Values

Issues with Null Values

- An attribute having NULL could mean either of following-
  - Value is unknown or not available right now
  - Value is not application for the tuple: a employee not having supervisor will have null in this attribute

- Arithmetic expressions (+,-,*,/) involving null values result null value for result

Null Values and Comparisons

- There are more issues with Null value when it appears in a attribute used in WHERE clause of SQL-SELECT
- What should (`r.a < 10`) where r.a happens to be null
- When we compare a NULL value with another value including NULL, result is UNKNOWN.
- In relational operations UNKNOWN is another truth-value like TRUE and FALSE

Truth values for UNKOWN

- **NOT**
  - **NOT UNKOWN -> UNKWON**
- **AND**
  - **TRUE AND UNKOWN -> UNKOWN**
  - **FALSE AND UNKOWN -> FALSE**
  - **UNKWON AND UNKOWN -> UNKOWN**
- **OR**
  - **TRUE OR UNKOWN -> TRUE**
  - **FALSE OR UNKOWN -> UNKOWN**
  - **UNKWON OR UNKOWN -> UNKOWN**

Null Values and Comparisons

- While evaluating WHERE clause tuples with UNKOWN or FALSE truth values are not included in result
- Following query will not include any tuple where either of value in NULL irrespective value in other attribute

```
SELECT * FROM EMPLOYEE WHERE
bdate < DATE '2001-01-01' AND salary > 30000
```

- Following query will not include a tuple only when both are NULL, if one of attribute meets the condition then it will get included in result

```
SELECT * FROM EMPLOYEE WHERE
bdate < DATE ‘2001-01-01’ OR salary > 30000
```

Null Values and Comparisons – IS NULL

- Following will not give desired result. Why? -

```
SELECT * FROM employee
        WHERE superssn = NULL;
```

- This is so because Null = Null is also UNKOWN. For checking an attribute for having NULL value, SQL provides IS NULL (and IS NOT NULL)
- We write as following for such situations –

```
SELECT * FROM employee
    WHERE superssn IS NULL ;
```

Bags and Relational Operations

Relational Operations and multiset (or bag)

- By Definition, relations are set; but implementations may permit duplicate tuples and such relations are called *bags*
- Normally stored relations (base) relations should still be sets, because most relations have PK
- However SQL SELECT results are often bags, possibly because duplicate removal is expensive.
- To get *set* you use DISTINCT keyword

SQL and Multiset (or Bag)

- SET operations, that are UNION, INTESECT, and EXCEPT in SQL yield their result as SET, that means duplicates are removed
- SQL however provides options by which you can have bag results by adding ALL keyword to operation name, i.e. UNION ALL, EXCEPT ALL or so.
- Let us see an example-

UNION/INTERSECT/EXCEPT ALL in SQL

- Compare result of following queries:

```
SELECT superssn FROM employee; --Q1
SELECT mgrssn FROM department; --Q2

SELECT superssn FROM employee
UNION
SELECT mgrssn FROM department; --Q3

SELECT superssn FROM employee
UNION ALL
SELECT mgrssn FROM department; --Q4
```

R

superssn
102
101
101
102
101
(Null)
108
108

S

mgrssn
101
102
108

R UNION S

superssn
101
102
108
(Null)

R UNION ALL S

superssn
102
101
101
102
101
(Null)
108
108
101
102
108

R	superssn
	102
	101
	101
	102
	101
	(Null)
	108
	108

S	mgrssn
	101
	102
	108

R EXCEPT S	superssn
	(Null)

R EXCEPT ALL S	superssn
	101
	101
	102
	108
	(Null)

UNION/INTESECT/EXCEPT ALL in SQL

- UNION ALL
  - count of an element e in result is sum of count in R and S
- INTERSECT ALL
  - min(count-r, count-s) of an element in R and S, is taken as result
- EXCEPT ALL:
  - Every occurrence of an element e in S decreases its count in R by one.

Sub-queries in SQL

Subquery in SQL

- A Query that is part of another query is *subquery*. A subquery may also have subquery, and so forth upto any level

- A subquery in SQL is written as a *query expression* enclosed in parentheses, and is in following form-
  "(SELECT ... FROM …)"
  as a part of some existing query

- Result of sub-query is again a relation;

Subquery in FROM clause

- FROM clause of SQL SELECT can have a sub-query, as following-

```
SELECT e.ssn, fname, dno, dname
FROM employee AS e NATURAL JOIN (SELECT
mgrssn AS ssn, dno, dname FROM
department) AS dept;
```

- In queries like above naming to relation returned by subquery is required, even if the relation name is not used; and that is the only relation as in query below-

```
SELECT * FROM (SELECT mgrssn AS ssn,
dno, dname FROM department) AS dept;
```

Subquery in WHERE clause

- We have seen sub-query in **IN**, as
  WHERE ... IN (SELECT ...)

- For example,
  SELECT * FROM employee WHERE ssn IN
  (SELECT essn FROM works_on);

Subquery in WHERE clause

- When used in where clause and a sub-query returns a single column, single tuple relation, it can be interpreted as single value as following
- **SELECT pname FROM project**
  WHERE dno = (SELECT dno FROM department
  WHERE dname ='Research');
- Note: resultant relation of sub-query is getting compared with a attribute value – appropriate conversion takes place;
  - Has a underlying assumption that sub-query return a single tuple

Execution of Subquery

- **SUB-Query may not execut for every tuple of outer query**
- Consider the query below-

```
SELECT pname FROM project
WHERE dno = (SELECT dno FROM department
WHERE dname ='Research');
```

- It is to typically executed as following: Execute inner query, and let us say returns **5**, and then places it in outer query, and the query to be executed becomes following -

```
SELECT pname FROM project
WHERE dno = 5;
```

Execution of Subquery

- **SUB-Query may not execute for every tuple of outer query**
- Consider another query-

```
SELECT * FROM student WHERE
progid IN (SELECT pid FROM program
                WHERE did = 'EE' );
```

- Typically, after execution of inner query, outer query may be translated to:

```
SELECT * FROM student WHERE
progid IN (BEC, BEE);
```

Correlated Sub-Queries

Correlated Sub-Queries

- When inner query makes a reference to tuple of outer query then it is correlated sub-query. Consider following query -

- List employees, whose salary is more than department average:

```
SELECT ssn, fname FROM employee as e
WHERE salary > (SELECT AVG(salary) FROM
employee WHERE dno = e.dno)
```

Execution of Correlated Sub-Queries

- Consider same query

```
SELECT ssn, fname FROM employee as e
WHERE salary > (SELECT AVG(salary)
FROM employee WHERE dno = e.dno)
```

- Logically, it is as following: For each tuple of outer query, execute inner query.
- Note that it can not be executed once for all tuples of outer query, as the case be with un-related inner query, and we have to execute **SUB-Query for every tuple of outer query**
- This is identified problem with correlated sub-queries.

Correlated Sub-Queries could be expensive to execute – therefore should be avoided

- Correlated queries are expensive to execute, and can be avoided; for example the previous example
- **SELECT ssn, fname FROM employee as e WHERE salary > (SELECT AVG(salary) FROM employee WHERE dno = e.dno)**
- can be re-written as-

```
SELECT ssn, fname, salary FROM employee as e
NATURAL JOIN (SELECT dno, AVG(salary) as
avg_sal FROM employee GROUP BY dno) as av
WHERE salary > av.avg_sal;
```

more Correlated Sub-queries

- List down employees having salary greater than their immediate supervisors.

```
select * from employee as e1 where e1.salary >
(select salary from employee as e2 where e2.ssn =
e1.superssn);
```

- Select employees having dependents older than 18 years:

```
SELECT * FROM employee AS e WHERE ssn IN (SELECT
essn FROM dependent AS d WHERE essn = e.ssn AND
age(d.bdate) > interval '18 years');
```

- Attempt re-writting them without correlated query.

EXISTS and NOT EXISTS in SQL

- Checks for emptiness of a relation and returns true or false.
- **`EXISTS(r)`** can be interpreted as “is there some tuple exists in relation r”
- **`EXISTS(r)`** returning true says that argument relation r is not empty
- Similarly, **`NOT EXISTS(r)`** returning true says that argument relation r empty

Example EXISTS

- **SELECT ssn FROM employee AS e WHERE EXISTS (SELECT * FROM dependent AS d WHERE d.essn = e.ssn AND age(d.bdate) > interval '18 years');**

SQL- EXISTS and IN

- While they might appear to be serving similar purposes, semantically are different.
- Both appear as part of predicate in WHERE clause of SELECT
- IN:
  - Syntax: **`x IN ( r )`**
  - Meaning: checks existence of tuple x in relation r, if found returns true, other wise false. Normally x is a scalar value and r is a single column relation.
- EXISTS:
  - Syntax: **`EXISTS ( r )`**
  - Meaning: checks if r is a non empty relation. Returns true if the relation has at least one tuple, otherwise false.
- In both above cases **`r`** is a *relational expression* resulting a relation.

Compare a values with a bag of values (SQL)

- For example consider following two queries [Find out employee who have salary greater some or all employees of dno = 4]

SELECT ssn, fname FROM employee WHERE salary

> SOME (SELECT salary FROM employee WHERE dno = 4);

SELECT ssn, fname FROM employee WHERE salary

> ALL (SELECT salary FROM employee WHERE dno = 4);

Compare a values with a bag of values (SQL)

- Note the equivalences:

SELECT ssn, fname FROM employee WHERE salary
> SOME (SELECT salary FROM employee WHERE dno = 4); and

SELECT ssn, fname FROM employee WHERE salary
> (SELECT min(salary) FROM employee WHERE dno = 4);

SELECT ssn, fname FROM employee WHERE salary
> ALL (SELECT salary FROM employee WHERE dno = 4); and

SELECT ssn, fname FROM employee WHERE salary
> (SELECT max(salary) FROM employee WHERE dno = 4);

Compare a values with a bag of values (SQL)

- Comparative operators could be, one of following-

  >SOME, >=SOME, <=SOME, <SOME, =SOME, <>SOME

  >ALL, >=ALL, <=ALL, <ALL, =ALL, <>ALL

- Note: it can be easily proved that

  =SOME is identical to **IN**, and
  <>SOME is not identical to **NOT IN**

  = ALL is not identical to **IN**

  <> ALL (mean = NONE) and is same as **NOT IN**, and
  Earlier versions of SQL used **ANY** for **SOME**; today both keywords are used as synonymous.

Sub-queries in Update statements

- **UPDATE employee**
  SET salary = salary * 1.1
  WHERE ssn IN (...);

- **DELETE employee**
  WHERE ssn = (...);