COMM1822

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Introduction to Databases for Business Analytics

Week 5 Relational Al SQL Joins

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We acknowledge all Aboriginal and Torres St Islander Elders, past and present and thei communities who have shared and practiced their teachings over thousands of years including business practices.

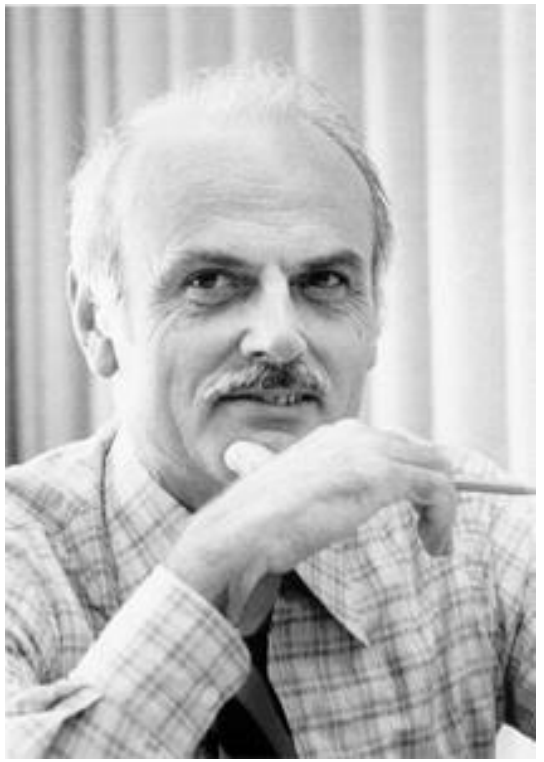
We recognise Aboriginal and Torres Strait Islander people's ongoing leadership and contributions, including to business, education and industry.

UNSW Business School. (2022, May 7). *Acknowledgement of Country* [online video]. Retrieved from https://vimeo.com/369229957/d995d8087f

Relational Languages

- Codd (1970, 1971)'s **relation model** is the conceptual basis for relational databases. The relational model includes **two relational languages**:

1. **Relational algebra** is a **non-procedural, high-level language** that provides a declarative way to specify databas res a definition" to get to certain data.)
2. **Relational calculus** is a **procedur** s a procedural way for specifying queries. (Relational calculu er of steps" to get to certain data.)



- For every expression in the relational algebra there is an equivalent expression in the relational calculus, and vice versa. They are **logically equivalent**.
- **Relational algebra and relational calculus** are **not very user friendly**.
- **SQL** was developed as **user-friendly query** to work with RDBMS.

Relational Algebra

The relational algebra has **operations**. These operations fall into **three main categories**:

1. **Union**, **Intersection** and **Difference**: Boolean operations to define a new relation based on two existing rela
2. **Selection** and **Projection**: rts of a relation.
3. **Cartesian Product / Joins**: Operations that tuples of two relations.

1) Union, Intersection and Difference

- **Union, Intersection and Difference** are operations (or "set operations") on two relations (R and S), both relations should have schemas with **identical sets of attributes** and **identical order of the attributes**.
- **UNION: R ∪ S**
  - The union of R and S is the set of all t
  - In short: *merge the two sets of tuples!*
- **INTERSECTION: R ∩ S**
  - The intersection of R and S is the set of tuples that appear in both
  - In short: *find the common tuples!*
- **DIFFERENCE**: **R - S**
  - The difference of R and S, is the set of tuples that are in R but not in S.
  - In short: *subtract the tuples in S from the tuples in R!*

Question: Is R - S the same as S - R?

R

P_CODE
123456
123457
123458

S

Exercise 1

1

P_CODE
123456
123457
123458

UNION

P_CODE
345678
345679

3

F_NAME
Kaiser
Julia
Alex
Asa

DIFFERENCE

F_NAME
Julia
Shane
Evan
Ben

S

2

F_NAME
Kaiser
Julia
Alex
Asa
Evan

INTERSECT

F_NAME
Julia
Shane
Evan
Ben

R S

4

F_NAME
Julia
Shane
Evan
Ben

DIFFERENCE

F_NAME
Kaiser
Julia
Alex
Asa
Evan

S R

Solution to Exercise 1

1

P_CODE
123456
123457
123458

UNION

P_CODE
345678
345679

yields

P_CODE
123456
123457
123458
345678
345679

3

F_NAME
Kaiser
Julia
Alex
Asa

DIFFERENCE

F_NAME
Julia
Shane
Evan
Ben

yields

F_NAME
Kaiser
Alex
Asa

S

R - S

2

F_NAME
Kaiser
Julia
Alex
Asa
Evan

INTERSECT

F_NAME
Julia
Shane
Evan
Ben

yields

F_NAME
Julia
Evan

R

S

4

F_NAME
Julia
Shane
Evan
Ben

DIFFERENCE

F_NAME
Kaiser
Julia
Alex
Asa
Evan

yields

F_NAME
Shane
Ben

S

R

S - R

2) Selection and Projection

❑ **Selection and Projection** operations are applied to a single relation (R).

❑ **SELECTION**

- Selection (SELECT) returns a relati ., rows in a table) from a specified relation (R) that satisfy a specified condition
- Relational operator is σ. $\sigma_{predicate}$ R

❑ **PROJECTION**

- Projection (PROJECT) returns a relation that contains a list of tuples for selected attributes from a specified relation (R), eliminating duplicates (vertical subset of a table).
- Relational operator is π. $\pi_{attribute\ 1, \ldots attribute\ n}$ R (π = “pi”)

Exercise 2

1. What is the result of: $\sigma_{price < 2.00} R$?
   ("Selection with Price less than 2.00 of R"; "List all tuples with a price less than 2.00")
2. What is the result of $\pi_{Product\ Description,\ Price}\ R$?
   ("Projection with Product Description, Price from R"; "List all tuples showing only description and price")

Solution to Exercise 2

ProductCode	ProductDescription	Price
213345	9v battery	1.92
311452	Power drill	34.99
254467	100W bulb	1.47

- Selection: $\sigma_{\text{price} < 2.00}$ R (“List)

213345	9v battery	1.92
254467	100w bulb	1.47

- Projection: $\pi_{\text{Product Description, Price}}$ R (“List all tuples showing only description and price”)

9v battery	1.92
Power drill	34.99
100w bulb	1.47

3) Cartesian Product and Joins

- **Cross Join** joins (creates and returns) the **Cartesian Product** of two relations R and S. ("$R * S$", "all possible tuple combinations of two relations", "everything joined to everything").
- **Inner Join** returns comb that **fulfil a certain criterion**. This is the most commo
  - An **Equi Join** joins tuples from R and S based on **equali specified attributes**. The join is called a **Theta Join** if a comparison other than "equality" (=) is us ller/less than" (<).
  - A **Natural Join** joins tuples from R and S that **agree in value for whatever attributes are common** to the schemas of R and S. The attributes are not explicitly specified. Hence, "naturally", **attributes in common are used for the join**.
- A Full **Outer Join** returns tuples from both relations with their matching values in the respective other relation (i.e., tuples with no match in the other relation still appears, with NULL values instead of matching values).

Cross Join (Cartesian Product)

- **Cartesian** = “relating to **René Descartes (1596-1650)** and his ideas”. The word comes from the Latinised version (Renatus Cartesius) of the name (René Descartes).

- Descartes made major **analytical geometry**.

A = [x , y , z]

B = [1, 2 , 3]

Cross Join (Cartesian Product)

- **Cross Join (Cartesian Product)**: Select all possible combinations of tuples in R with tuples in S ("$R * S$", "all possible tuple combinations of two relations", "everything joined to everything").

In SQL:

SELECT * FROM R **CROSS JOIN** S; **xplicit** cross join

SELECT * FROM R, S; **mplicit** cross join

Question: Is a **Cross Join** of R, S identical to a **Union** of R, S? Why (not)?

Cross Join (Cartesian Product)

G

	Name	City
x	Mary	Boston
y	Susan	Chicago
z	Betty	Chicago

B

Name	City	
Sam	Chicago	a
James	Dallas	b

x, a

y, a

z, a

x, b

y, b

z, b

Compare to Union

Inner Join

An **Inner Join** returns combined tuples from two relations that have the same value for a defined attribute (match on the attribute). This is the default join type, the most common join type.

SELECT * FROM R **IN** is is an **explicit** inner join

ON R.attribute = S.attri

Tip: One way to think of an Inner Join s Join (Cartesian Product) with all tuples removed that do *not* match on the defined attribute.

Inner Join

G

Name	City
Mary	Boston
Susan	Chicago
Betty	Chicago

B

Name	City
Sam	Chicago
James	Dallas

Inner Join/Equi-Join:

```
SELECT * FROM G INNER JOIN B ON G.CITY = B.CITY;
```


- An **equi join** is a **join** with a **join** condition containing an equality operator.
- A **theta join** is when other comparison operators are used (<=, >=, <, >).

Inner Join & Natural Join

A **natural join** joins tuples based on all attributes with identical names in the two relations.

TableA

Column1	Column2
1	2

TableB

Column1	Column3
1	3

Natural Join
(All common columns)
Here only Column1

A **Natural Join** joins 2 tables on the basis of all common columns

An **Inner Join** joins 2 tables on the basis of common columns mentioned in the ON clause

a.Column1	a.Column2	b.Column1	b.Column3
1	2	1	3

Inner Join
on Column1

Full Outer Join

Full Outer Join: Selects and joins tuples from two tables that match on a defined attribute. If there is no match for a tuple, the tuple will still appear with missing attributes shown as NULL.


```
SELECT * FROM R
FULL OUTER JOIN S
ON R.attribute = S.attribute
```

Full Outer Join

Left Outer Join

Left Outer Join : Select and joins tuple from the “left” table (R) with tuples from the “right” table (S) on defined attributes. If there is no match, the attributes from the right side will contain NULL values.


```
SELECT * FROM R
LEFT OUTER JOIN S
ON R.attribute = S.attribute
```

Left Outer Join

G

Name	City
Mary	Boston
Susan	Chicago
Betty	Chicago
Nancy	Null
Anne	Denver

B

Name	City
Sam	Chicago
James	Dallas
John	Boston
Henry	Boston
George	Null

Right Outer Join

Right Outer Join : Select and joins tuple from the “left” table (R) with tuples from the “right” table (S) on defined attributes. If there is no match, the attributes from the left side will contain NULL values.


```
SELECT * FROM R
RIGHT OUTER JOIN S
ON R.attribute = S.attribute
```

Right Outer Join

G

Name	City
Mary	Boston
Susan	Chicago
Betty	Chicago
Nancy	Null
Anne	Denver

B

Name	City
Sam	Chicago
James	Dallas
John	Boston
Henry	Boston
George	Null

Full Outer Join, Left Outer Join and Right Outer Join

Exercise 3

Table: R

P_CODE	PRICE
AA	5.99
BB	22.75

Table: S

STORE	AISLE	SHELF
23	W	5
24	K	9
25	Z	6

Dimension of T: Dim(T) = (No. of rows in T, No. of columns in T)

Dim($R * S$) = (2 x 5)

Build the Cartesian Product of $R * S$.

Solution to Exercise 3

Table: R

P_CODE	PRICE
AA	5.99
BB	22.75

Dim(R) = (2, 2)

Table: S

STORE	AISLE	SHELF
23	W	5
24	K	9
25	Z	6

Dim(S) = (3, 3)

Table: $R * S$

P_CODE	PRICE	STORE	AISLE	SHELF
AA	5.99	23	W	5
		24	K	9
		25	Z	6
BB		23	W	5
BB	22.75	24	K	9
BB	22.75	25	Z	6

Dim($R * S$) = (6, 5)

Exercise 4

- Apply natural (inner) join, left outer join, right outer join and full outer join on ***Std_Name***.

Table 1

Table 2

Solution to Exercise 4

Inner Join/ Natural join

Std_Name	Tutor_Name
Mr. Brown	Reed R.
Mr. Green	Yeo, J.
Ms. White	Yeo, J.

Left Outer Join

Std_Name	Subject
Mr. Brown	SADF
Ms. White	BDM
Ms. Pink	BDM

Solution to Exercise 4

Right Outer Join

Std_Name	Tutor_Name
Mr. Brown	Reed R.
Mr. Green	Yeo, J.
Ms. White	Yeo, J.

Std_Name	Subject
Mr. Brown	SADF
Ms. White	BDM
Ms. Pink	BDM

Full Outer Join

Questions

Source: petcare.com.au