Weekly exercises IN3020 and IN4020
Week 4

May 23, 2022

1 Review

1. Why do we need to extend the definition of projection? Examples?

   Solution: To allow computation with attributes, to rename attributes and use constants (e.g., NULL).

2. When is $\times$ defined?

   Solution: $R \times S$ is defined when R and S have no common attribute names.

3. What is $\bowtie_\theta$? How can you express $\bowtie_\theta$ using σ and $\bowtie$?

   Solution: Join + selection. $\bowtie_\theta \equiv \sigma_\theta(R \bowtie S)$

4. Discuss the different types of inner join operations.

   Solution:

   - $\bowtie$ combines only the combination that have the same values in the attributes with the same name (and datatype).
   - We have defined theta-join to be the joint operation of natural join and selection using one of the operators $(=, \neq, <, >, \leq, \geq)$.

5. What is the anti-join ($\triangleleft$ and $\triangleright$) and the semi-join ($\ltimes$ and $\rtimes$)?

   Solution:

   - $R \ltimes S$ is the relation that contains all tuples in R that join with S
   - $R \rtimes S$ is the relation that contains all tuples in S that join with R
   - $R \triangleright S$ is the relation that contains all tuples in R that do not join with S

- $R \triangleleft S$ is the relation that contains all the tuples in S that do not join with S
- **Note:** Used in `exists`, `in` and `not exists` queries. Such operations can also be useful in distributed systems to avoid transferring more data than we need to perform a join.

6. Discuss the different types of outer joins.

   Solution:

   - $R \rtimes S$ is he relation that contains all combinations of tuples in R with a tuple in S that agree on common attributes. All dangling tuples in R are extended with NULL
   - $R \ltimes S \equiv S \rtimes R$
   - $R \rtimes S \equiv R \rtimes S \cup R \ltimes S$

7. Which of the following operators are idempotent? Why or why not?
   δ, π_L, σ_C, γ_L

   Solution: δ, π_L and σ_C

2 Relational Algebra for sets and bags

Here are two bag relations:

```
R[A,B]: [(1,2), (3,4), (1,2), (3,5), (4,5)]
S[A,B]: [(1,2), (3,5), (3,6), (4,5), (1,3), (4,5)]
```

And two relations:

```
T[A,B]: {(1,2), (3,4), (3,5), (4,5)}
U[A,B]: {(1,2), (3,5), (3,6), (4,5), (1,3)}
```

Compute the following expressions:

1. $\sigma_{A=3}(R \cup^b S)$

   Solution:
   $[(3,4),(3,5),(3,5),(3,6)]$

2. $\sigma_{A=3}(T \cup U)$

   Solution: $[(3,4),(3,5),(3,6)]$

3. $\sigma_{A=3}(T \cup^b U)$

   Solution: $[(3,4),(3,5),(3,5),(3,6)]$

4. $S \setminus R$

Solution: $[(3,6),(1,3),(4,5)]$

5. $U \setminus T$

   Solution: $[(3,6),(1,3)]$

6. $\pi^b_A(R)$

   Solution: $[(1),(3),(1),(3),(4)]$

7. $\pi_A(R)$

   Solution: This is undefined because R is not a set.

8. $\pi^b_A(T)$

   Solution: $[(1),(3),(3),(4)]$

9. $\pi_A(T)$

   Solution: $[(1),(3),(4)]$

3 Relation algebra computations

Here are two relations:

```
R[A,B]: {(1,2), (3,4), (1,3), (3,5), (4,5)}
S[B,C]: {(1,2), (3,5), (3,6), (4,5), (1,3), (4,6)}
```

Compute the following:

1. $\pi_{A^2,B^2,A+B}(R)$

   Solution: $[(1,4,3),(9,16,7),(1,9,4),(9,25,8),(16,25,9)]$

2. $\pi_{B-1,C+1}(S)$

   Solution: $[(0,3),(2,6),(2,7),(3,6),(0,4),(3,7)]$

3. $\pi_{A,B,\text{NULL}\to C}(R)$

   Solution:

A	B	C
1	2	NULL
3	4	NULL
1	3	NULL
3	5	NULL
4	5	NULL

4. $(S \cup^b S)$

Solution:
$[(1,2),(3,5),(3,6),(4,5),(1,3),(4,6),(1,2),(3,5),(3,6),(4,5),(1,3),(4,6)]$

5. $(S \cup S)$

   Solution: $[(1,2),(3,5),(3,6),(4,5),(1,3),(4,6)]$

6. $\delta(R \cup^b (\rho_{B \to A,C \to B}(S)))$

   Solution: $\{(1,2),(3,4),(1,3),(3,5),(4,5),(3,6),(4,6)\}$

7. $\gamma_{A,AVG(B)}(R)$

   Solution: $[(1,2.5),(3,4.5),(4,5)]$

8. $\gamma_{B,SUM(C)}(S)$

   Solution: $[(1,5),(3,11),(4,11)]$

4 Expression of operators

Consider the same two relations:

```
R[A,B]
S[B,C]
T[C,D]
```

1. Express the following Relational Algebra expression by using a theta-join:
   $\pi_{A,C}(\sigma_{A>100}(R \bowtie S))$

   Solution: $\pi_{A,C}(R \bowtie_{A>100} S)$

2. Express the following Relational Algebra expression using a theta-join:
   $\pi_A(\sigma_{A>B \wedge B>4}(R \bowtie S))$

   Solution:
   $\pi_A(R \bowtie_{A>BB>4} S)$

3. One can express δ a using the γ operator. How?

   Solution: $\delta(R) \equiv \gamma_{A_1,A_2,\ldots,A_n}(R)$

4. Express without anti-join:
   $R \triangleright S$

   Solution:
   $R \setminus \pi_{A,B}(R \bowtie S)$
   or $R \setminus (R \ltimes S)$

5 Constraints

In this exercise, consider four relations with the following schemas (the domains and the meaning of the attributes are as expected):

```
Product[manufacturer,model,type]
PC[model,speed,ram,hd,price]
Laptop[model,speed,ram,hd,screen,price]
Printer[model,color,type,price]
```

1. Express that `model` in `PC` is a foreign key referencing `model` in `Product`.

   Solution: $\delta(\pi_{model}(PC)) \subseteq \delta(\pi_{model}(Product))$

2. Express the constraint that no manufacturer of PCs can also produce printers.

   Solution:
   $\delta(\pi_{manufacturer}(\sigma_{type=pc}(Product)))$
   $\cap$
   $\delta(\pi_{manufacturer}(\sigma_{type=printer}(Product))) = \emptyset$