Weekly exercises IN3020 and IN4020
Week 3

February 13, 2022

1 Review

1. List the operations of relational algebra we have seen this week and briefly state the purpose of each.

   Solution:

   - Selection σ_C: select tuples that satisfy some condition
   - Projection π_L: select columns
   - Cartesian Product $R \times S$: combine tuples from one relation with the tuples of another relation in all possible ways.
   - Union $R \cup S$: set-theoretic union
   - Difference $R \setminus S$: set-theoretic difference
   - Renaming ρ_N: Rename attributes

2. When are the $\cup$ and $\setminus$ operations defined on two relations R and S?

   Solution: They are defined only when R and S have the same attributes names with the same datatypes.

3. Can you imagine some cases when we need to use the ρ operator to specify the query unambiguously?

   Solution: Many possible answers. One typical case is with natural join where the attributes we want to join have different names or that attributes we want to join on have the same name.

4. What do we mean with a commutative operation? Give an example of a commutative operation from relational algebra.

   Solution: An operation is commutative if changing the order of the operands does not change the result. Union and Cartesian product are

commutative operations
E.g., $R \cup S \cup T = S \cup R \cup T$.

5. What do we mean with an associative operation? Give an example of an associate operation from relational algebra.

   Solution: When we apply the operation on three or more elements and the grouping (where we put the parenthesis) does not affect the result, we call the operation associative. Union and Cartesian product are associative operations.
   E.g., $(R \cup S) \cup T = R \cup (S \cup T)$.

6. What do we mean with an idempotent operation? What if the operation is unary? And binary? Give one example of an idempotent operation from relational algebra.

   Solution: An unary idempotent operation is an operation that gives the same result if applied multiple times (on the same input). A binary operation is idempotent if $e \; op \; e = e$. Union is a binary idempotent operation.
   E.g., $R \cup R = R$.
   Selection and projection are unary idempotent operations.
   E.g., $\pi_L(\pi_L(R))$

2 Relation algebra computations

Here are two relations:
`R[A,B]`: $\{(1,2),(3,4),(4,5)\}$
`S[C,D]`: $\{(1,2),(3,5),(3,6),(4,5),(5,6)\}$

Using our basic Relational Algebra for sets using named perspective, compute the following:

1. $\pi_A(R)$

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

2. $\pi_B(S)$

   Solution: $\pi_B(S)$ is not defined because B is not an attribute in S. This is due to how we define projection in our relational algebra and it could have been defined differently.

3. $\sigma_{A=1}(R)$

   Solution: $\{(1,2)\}$

4. $R \bowtie S$

   Solution: $R \bowtie S \equiv R \times S$ because there are no common attributes.

5. $(\rho_{B\to C}(R)) \bowtie S$

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

6. $\sigma_{D=5}(\rho_{A\to C}(R)) \bowtie S$

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

3 Relation algebra expression

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]
```

Express the following queries as relational algebra expressions using the following relational algebra operators: $(\sigma, \pi, \times, \cup, \setminus, \rho, \bowtie,)$.

1. The PC models that have speed at least 2.50

   Solution: $\pi_{model}(\sigma_{speed\geq 2.50}(PC))$

2. The manufacturers that sell printers, but not PC's

   Solution:
   $\pi_{manufacturer}\left(\sigma_{type='printer'}(Product)\right) \setminus \pi_{manufacturer}\left(\sigma_{type='pc'}(Product)\right)$

3. The manufacturers that sell PCs but not laptops

   Solution:
   $\pi_{manufacturer}\left(\sigma_{type='pc'}(Product)\right) \setminus \pi_{manufacturer}\left(\sigma_{type='laptop'}(Product)\right)$

4. The manufacturers that make laptops with a hard disk of at least 500 GB

   Solution: $\pi_{manufacturer}(\sigma_{hd\geq 500}(Laptop) \bowtie Product)$

5. The model numbers and prices of all products made by manufacturer hp.

   Solution:
   $\pi_{model,price}\left(\sigma_{manufacturer='hp'}(PC \bowtie Product)\right)$
   $\cup$
   $\pi_{model,price}\left(\sigma_{manufacturer='hp'}(Laptop \bowtie Product)\right)$
   $\cup$
   $\pi_{model,price}\left(\sigma_{manufacturer='hp'}((\rho_{type\to ptype}(Printer)) \bowtie Product)\right)$

We need to rename type in the printer-part. If we don't rename, the natural join will also match `|type|`from `|Products|`with `|type|`in |Printer|.