Washington State University

School of Electrical Engineering and Computer Science

CptS 451 – Introduction to Database Systems

Online

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Homework-3

Relational Algebra

Name: _____Solution_____

Student Number:_____Solution_____

Question:	Max points:	Score:
1 through 10	100	
Total	100	

Question 1.

Consider the following schema (primary key fields are underlined):

Customers (cid, cname, city)
- cid is the unique identifier for the customer
- cname is the name of the customer
- city is the city where customer resides
- cid is the primary key.

Suppliers (sid, sname, city)
- sid is the unique identifier for the supplier
- sname is supplier's name
- city is the city supplier is located
- sid is the primary key

Parts (pid, pname, color)
- pid is the unique identifier for the part
- pname is the part's name
- color is part's color
- pid is the primary key.

Catalog (pid, sid,price) : tuples in the Catalog table correspond to a catalog entries: i.e., parts and their suppliers.
- pid is the id of the part in the catalog entry
- sid is id of the supplier that supplies the part in the catalog
- price is the cost of the part in the catalog
- (sid,pid) is the primary key
- sid is a foreign key referencing Suppliers(sid)
- pid is a foreign key referencing Parts(pid)

Orders (cid,pid, sid, qty) : each tuple in Orders corresponds to an order. Assumes each customer orders a particular part from a supplier once.
- cid is the customer that buys the part
- pid is the part sold
- sid is the supplier that supplies the part
- qty is the number of parts sold in a particular order
- (cid,sid, pid) is the primary key.
- (sid,pid) is a foreign key referencing Catalog (sid,pid)

Based on the above database schema, express the following queries in relational algebra. Assume set semantics for all operations.

You may either write the relational algebra expressions yourselves (handwritten or typed) or you may use the online RelaX relational algebra calculator tool. To use the tool, simply go to the link: https://dbis-uibk.github.io/relax/calc/gist/8bae4cdfe9e03515895e84c944e76d21 and type the relational algebra expressions in the textbox. A sample dataset for the above relations will be automatically loaded when you open the above link. The same data is also available in appendix A. In the tool, you can try the queries and check the output. The expected output for each relational algebra expression is provide in appendix B.

In your submission:
- If you type/handwrite expressions, simply include all expressions in a file. If you handwrite them, make sure that the expressions are readable and clear.

- If you write the expressions using the tool, take a screenshot of the relational algebra tree for each query and paste them in a file. (The RelaX tool uses set semantics, so you don't need to remove duplicates)
Make sure to convert your file to PDF before you submit it.
(Note : Sample data for the above tables are available in Appendix1. The data is given to you to help in writing relational algebra expressions. You don't need to provide the output for the queries.)

1. **(10pts)** Find all distinct parts supplied by Pullman stores. Return "pid"s of those parts.

   Π_{pid} (Catalog ⋈ $\sigma_{city = 'Pullman'}$ (Suppliers))

   Relax query: `Π pid (Catalog ⋈ σ city = 'Pullman' (Suppliers))`

2. **(10pts)**Find the suppliers in **Pullman** who supply a yellow part for less than $11. Return "sid"s and names for those suppliers.

   $\Pi_{sid,sname}$ ($\sigma_{city = 'Pullman' \text{ AND } color = 'yellow' \text{ AND } price<11}$ (Parts ⋈ Catalog ⋈ Suppliers))

   Relax query:
   ```
   Π sid,sname ( σ city = 'Pullman' ∧ color = 'yellow' ∧
     price<11 (Parts ⋈ Catalog ⋈  Suppliers) )
   ```

3. **(10pts)** Find all parts which are provided by some supplier (i.e., they appear in the catalog) but they were never ordered by a customer. Return the "pid"s and names of those parts.

   $\Pi_{pid,pname}$ (Parts ⋈ (Π_{pid} (Catalog) − Π_{pid} (Orders)))

   Relax query:
   ```
   Π pid,pname (Parts ⋈ (Π pid (Catalog) −
   Π pid (Orders)))
   ```

4. **(10pts)** Find all customers who ordered one of the products that Andy ordered. Return names and cities of those customers and the "pid"s of the products they ordered.

   $\Pi_{cname2,city2,pid2}$ (($\rho_{Customer2(cid2,cname3,city3)}$(Customers)) ⋈
   ($\rho_{Orders2(cid2,pid2,sid2,qty2)}$(Orders) ⋈$_{pid2=pid}$ (Orders ⋈ $\sigma_{cname = 'Andy'}$ (Customers))))

   Relax query:
   ```
   Π cname2,city2,pid2 ((ρ cid2←cid, cname2←cname, city2←city
   (Customers)) ⋈
        ((ρ cid2←cid, pid2←pid, sid2←sid, qty2←qty (Orders)) ⋈ pid2 =
   pid (Orders ⋈ (σ cname = 'Andy' (Customers)))))
   ```

5. **(10pts)** Find the suppliers who have received orders from customers who live in the city where that supplier is located. Return "sid"s, names, and cities of those suppliers.

$\Pi_{sid,\ sname,\ city}\ (Customers \bowtie Orders \bowtie Suppliers)$

Relax query: `Π sid, sname, city (Customers ⋈ Orders ⋈ Suppliers)`

6. **(10pts)** Find customers who ordered more than 2 items from a single supplier (i.e., sum of the quantities of all parts customer purchased from the supplier is at least 3) . Return names of the customers,"sid"s of the suppliers, and number of items they ordered.

$\Pi_{cname,sid,numItems}\ (Customers \bowtie (\sigma_{numItems>2}\ (\gamma_{cid,sid,SUM(qty)\rightarrow numItems}\ (Orders))))$

Relax query:

```
Π cname,sid,numItems (Customers ⋈ ( σ numItems>2 (γ cid,sid;
SUM(qty)->numItems (Orders))))
```

7. **(10pts)** Find the customer "cid"s who paid more than $20 on 'green' parts.

$\Pi_{cid}\ (\sigma_{totalCost>20}(\gamma_{cid,SUM(qty*price)\rightarrow totalCost}(Catalog \bowtie Orders \bowtie (\sigma_{color='green'}\ (Parts))))$

Relax query:

```
Π cid (σ totalCost>20 (γ cid;SUM(cost)->totalCost
(Π cid,(qty*price)->cost (Catalog ⋈ Orders ⋈ (σ color='green'
(Parts))))))
```

8. **(10pts)** Find the parts which are supplied by at least 2 different suppliers. Return the "pid"s, names, and colors of those parts.

$\Pi_{pid,pname,color}\ (Parts \bowtie (\sigma_{numSupplier>2}(\gamma_{pid,COUNT(sid)\rightarrow numSupplier}(\Pi_{pid,sid}\ (Catalog)\ ))))$

Relax query:

```
Π pid,pname,color (Parts ⋈ (σ numSupplier>2
(γ pid;COUNT(sid)->numSupplier ( Π pid,sid (Catalog) ))))
```

9. **(10pts)**For each part in the catalog find the supplier that offers the lowest price; give the part name, supplier "sid" and the price supplier sells the part for.

$$\Pi_{pname,sid2,price2}\Big(Parts \bowtie_{\substack{pid=pid2 \\ bestPrice=price2}} \big(\gamma_{pid,MIN(price)\rightarrow bestPrice}\ (Catalog) \bowtie (\rho_{Catalog2(pid2,sid2,price2)}(Catalog))\big)\Big)$$

Relax query:

```
Π pname,sid2,price2 (Parts ⋈ (γ pid;MIN(price)->bestPrice
(Catalog) ⋈ pid=pid2 ∧ bestPrice=price2 (ρ pid2←pid,sid2←sid,
price2←price (Catalog))))
```

10. **(10pts)** Find the number of suppliers in each city.

$\gamma_{city,COUNT(sid)\rightarrow numSupplier}$ (Suppliers)

Relax query: γ `city;COUNT(sid)->numSupplier (Suppliers)`

APPENDIX-A

Customers:

cid	cname	city
c1	John	Pullman
c2	Alli	Pullman
c3	Kelly	Moscow
c4	Tom	Spokane
c5	Sam	Spokane
c6	Andy	Pullman

Suppliers:

sid	sname	city
s1	Best Tools	Pullman
s2	Pullman Tools	Pullman
s3	Acme Tools	Moscow
s4	Parts & More	Pullman
s5	Supply Store	Spokane
s6	Spokane HW Store	Spokane

Parts:

pid	pname	color
p1	Part1	red
p2	Part2	red
p3	Part3	green
p4	Part4	green
p5	Part5	yellow
p6	Part6	red
P7	Part7	red

Catalog:

pid	sid	price
p1	s2	$48
p1	s3	$51
p1	s4	$52
p1	s6	$49
p2	s1	$21
p2	s2	$20
p3	s4	$15
p5	s1	$10
p5	s2	$12
p5	s3	$9
p5	s4	$10

Orders:

p5	s6	$11
p7	s3	$33
p7	s4	$35

cid	pid	sid	qty
c1	p1	s2	3
c1	p3	s4	1
c3	p2	s2	1
c3	p3	s4	2
c3	p5	s3	1
c3	p5	s2	2
c4	p1	s3	3
c4	p2	s2	4
c4	p3	s4	1
c6	p3	s4	1
c6	p5	s3	2
c6	p5	s6	3
c6	p2	s2	3

APPENDIX-B

1.

Catalog.pid
p1
p2
p3
p5
p7

2.

Catalog.sid	**Suppliers.sname**
s1	BestTools
s4	Parts and More

3.

Parts.pid	**Parts.pname**
p7	Part7

4.

Customers.cname	**Customers.city**	**Orders.pid**
John	Pullman	p3
Kelly	Moscow	p2
Kelly	Moscow	p3
Kelly	Moscow	p5
Tom	Spokane	p2
Tom	Spokane	p3
Andy	Pullman	p3

Andy	Pullman	p5
Andy	Pullman	p2

5.

Orders.sid	Suppliers.sname	Customers.city
s2	Pullman Tools	Pullman
s4	Parts and More	Pullman
s3	Acme Tools	Moscow

6.

Customers.cname	Orders.sid	numItems
John	s2	3
Kelly	s2	3
Tom	s3	3
Tom	s2	4
Andy	s6	3
Andy	s2	3

7.

Orders.cid
c3

8.

Parts.pid	Parts.pname	Parts.color
p1	Part1	red
p5	Part5	yellow

9.

Parts.pname	Catalog.sid2	Catalog.price2
Part1	s2	48
Part2	s2	20
Part3	s4	15
Part5	s3	9
Part7	s3	33

10.

Suppliers.city	numSupplier
Pullman	3
Moscow	1
Spokane	2