

# Optimizing logical query plans

## Exercises

Academic year 2017-2018

### Algebraic laws

**Exercise 1.** Consider the following relational schema:

- Hotel(id, name, address)
- Room(rid, hid, type, price)
- Booking(hid, gid, date\_from, date\_to, rid)
- Guest(gid, name, address)

Translate the following SQL queries into the relational algebra and use the algebraic laws to improve the query plan.

1. 

```
SELECT R.rid, R.type, R.price
FROM Room R, Booking B, Hotel H
WHERE R.rid = B.rid AND B.hid = H.hid
AND H.name = 'Hilton' AND R.price > 100
```
2. 

```
SELECT G.gid, G.name
FROM Room R, Hotel H, Booking B, Guest G
WHERE H.hid = B.hid AND G.gid = B.gid
AND H.hid = R.hid AND H.name = 'Hilton'
AND date_from >= '1-Oct-2003' AND date_to <= '31-Dec-2003'
```

### Select-project-join expressions and conjunctive queries

**Exercise 2.** Consider the “beer drinkers database” consisting of the following relations:

- Visit(drinker, café)
- Appreciate(drinker, beer)
- Serve(café, beer)

Write both (1) select-project-join expressions and (2) conjunctive queries for the following queries:

1. Give every drinker  $d$  who visits a café that serves a beer appreciated by  $d$ .
2. Give all pairs  $(d, b)$  such that the café  $b$  serves a beer appreciated by  $d$ .

**Exercise 3.** Consider a binary relation  $Q(A, B)$ . Translate the following SQL queries into select-project-join expressions and then into conjunctive queries:

1. `SELECT Q1.A, Q3.B FROM Q Q1, Q Q2, Q Q3  
WHERE Q1.B = Q2.A AND Q2.B = Q3.A`
2. `SELECT Q1.A, Q4.B FROM Q Q1, Q Q2, Q Q3, Q Q4  
WHERE Q1.A = Q2.A AND Q2.B = 'c'  
AND Q3.B = 'c' AND Q3.B = Q4.A`

**Exercise 4.** Consider the relations  $R(A, B)$ ,  $S(C)$ ,  $T(D, E)$ ,  $U(F, G)$ , and  $V(A, B, C)$ . Translate the following conjunctive queries into select-project-join expressions. What is the corresponding SQL query?

1.  $Q_1(x, y) \leftarrow S(x), T(x, 3), U(x, y)$
2.  $Q_2(y) \leftarrow S(x), R(x, y)$
3.  $Q_3(x) \leftarrow V(x, n, s), R(x, a), T(a, 'Boeing'), S(s)$

## Containment and optimization of conjunctive queries

**Exercise 5.** Consider the following conjunctive queries:

- $Q_1(x, y) \leftarrow Q(x, a), Q(a, b), Q(b, y)$
- $Q_2(x, y) \leftarrow Q(x, a), Q(a, b), Q(b, c), Q(c, y)$
- $Q_3(x, y) \leftarrow Q(x, a), Q(a, 1), Q(1, b), Q(b, y)$
- $Q_4(x, y) \leftarrow Q(x, y), Q(y, x)$

Give all pairs  $(Q_i, Q_j)$  such that  $Q_i$  is contained in  $Q_j$ . Are there equivalent queries?

**Exercise 6.** Optimize the following conjunctive queries:

- $Q_1(x, z) \leftarrow R(x, y), R(y, w), R(y, z)$

- $Q_2(x, y) \leftarrow R(x, z), R(y, w), R(a, w), R(x, y)$
- $Q_3(x, y) \leftarrow S(a, b), R(x, 10), R(x, z), R(z, y)$
- $Q_4(x, y) \leftarrow S(y, b), S(b, a), S(c, a), R(c, x)$

**Exercise 7.** Consider the beer drinkers database again:

- Visit(drinker, café)
- Appreciate(drinker, beer)
- Serve(café, beer)

The query compiler has computed the following logical query plan:

$$\begin{aligned} & \pi_{B_1.\text{drinker}} \sigma_{B_1.\text{cafe}=B_2.\text{cafe}} \sigma_{B_2.\text{drinker}=L_1.\text{drinker}} \\ & \quad \sigma_{L_1.\text{beer}=L_2.\text{beer}} \sigma_{L_2.\text{drinker}=\text{Jan}} \sigma_{L_1.\text{beer}=S.\text{beer}} \sigma_{S.\text{cafe}=B_2.\text{cafe}} \\ & \quad (\rho_{B_1}(\text{Visit}) \times \rho_{B_2}(\text{Visit})) \\ & \quad \times \rho_S(\text{Serve}) \times \rho_{L_1}(\text{Appreciate}) \times \rho_{L_2}(\text{Appreciate}) \end{aligned}$$

Optimize this plan by removing redundant joins.

## Integrated exercises

**Exercise 8.** Consider the following relational schema, containing information on employees (Emp), departments (Dept), and finances (Finance):

- Emp(eid, did, sal, hobby)
- Dept(did, dname, floor, phone)
- Finance(did, budget, sales, expenses)

For each of the following SQL statements:

1. Translate the query into the relational algebra.
2. Remove redundant joins from the select-project-join subexpressions in the obtained logical query plan.
3. Make use of the algebraic laws to further optimize the obtained expression.

1. 

```
SELECT MAX(E.sal)
FROM Emp E
WHERE E.eid IN
(SELECT E1.eid
```

```

        FROM Emp E1, Emp E2, Dept D1, Dept D2, Finance F
        WHERE F.budget = 100 AND E1.did = D1.did AND E1.did = F.did
            AND E2.did = D2.did AND E2.did = F.did
            AND D1.floor = 1 AND D2.dname = 'CID'
    )
GROUP BY E.hobby

2. SELECT D.floor
FROM Dept D, Emp E
WHERE
    (D.floor = 1
    OR D.floor IN
        ( SELECT D2.floor FROM Dept D2, Finance F1
          WHERE F1.budget > 150 AND D2.did = F1.did)
    )
AND E.did = D.did
AND E.did IN (SELECT F2.did FROM Finance F2, Emp E2
              WHERE F2.did = E.did AND E2.did = D.did
              AND E2.eid = E.eid AND F2.expenses = 300)

3. SELECT F.budget, E.eid
FROM Emp E, Dept D, Finance F
WHERE E.did = D.did AND D.did = F.did
    AND E.hobby = 'yodeling'
    AND D.floor NOT IN
        ( SELECT D2.floor FROM Dept D2, Finance F2
          WHERE NOT D2.dname = 'CID'
            OR (F2.did = D2.did AND F2.expenses >= ALL
                (SELECT MAX(F3.expenses)
                 FROM Finance F3
                 WHERE F3.budget = F.budget
                )
            )
        )
    )
)

```

**Exercise 9.** Consider the following relational schema:

- Suppliers(sid, sname, city)
- Supply(sid, pid)
- Parts(pid, pname, price)

For each of the following SQL statements:

1. Translate the query into the relational algebra.

2. Remove redundant joins from the select-project-join subexpressions in the obtained logical query plan.
3. Make use of the algebraic laws to further optimize the obtained expression.

1. 

```
SELECT S.sname, P.pname
FROM Suppliers S1, Suppliers S2, Parts P, Supply Y
WHERE S1.sid = Y.sid AND S2.sid = Y.sid AND Y.pid = P.pid
AND S2.city = 'Madison' AND P.price <= 100
```
2. 

```
SELECT S.sname, S.city
FROM Suppliers S, Parts P, Supply Y
WHERE S.sid = Y.sid AND Y.pid = P.pid
AND P.price IN
(SELECT P2.price FROM Parts P2, Supply Y2
WHERE Y2.pid = P2.pid and Y2.sid = S.sid)
```
3. 

```
SELECT MAX(P.price), S.sname
FROM Parts P, Suppliers S
WHERE S.city = 'Ham'
AND (P.Price, S.city) IN
(SELECT P2.Price, S2.city FROM Parts P2, Supply Y, Suppliers S2
WHERE P2.pid = Y.sid AND Y.pid = S2.pid
AND S.sid = S2.sid AND P.pid = P2.pid)
GROUP BY S.sname
```