

B561 Advanced Database Concepts
sol Assignment 2
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discussed with Yu Mo

1 Translating SQL queries with query predicates and subquery expressions into safe TRC

We now turn to the problems for this section.

1. • Consider the query ‘Find the bno and title of each book that was bought by exactly one student.’ This query can be expressed as the SQL query

Starting from this SQL query, express the query in safe TRC.

$$\{(b.bno, b.title) \mid Book(b) \wedge (\exists s (Student(s) \wedge Buys(s.sid, b.bno))) \wedge (\forall s_1 \forall s_2 ((Student(s_1) \wedge Student(s_2) \wedge Buys(s_1.sid, b.bno) \wedge Buys(s_2.sid, b.bno)) \rightarrow (s_1 = s_2)))\}$$

2. • Consider the query ‘Find each pair (m, b) where m is a major and b is the bno of a book bought by a student who has major m and such that the price of b is the lowest among the set of books bought by students with major m .’

$$\{(m.major, b.bno) \mid Major(m) \wedge Book(b) \wedge \exists t \in Buys(t.bno = b.bno \wedge \exists hm \in hasMajor(hm.major = m.major \wedge t.sid = hm.sid)) \wedge \neg \exists t_1 \in Buys(b_1 \in Book(t_1.bno = b_1.bno \wedge b_1.price < b.price \wedge \exists hm_1 \in hasMajor(hm_1.sid = t_1.sid \wedge hm_1.major = m.major)))\}$$

2 Expressing queries in (Extended) Safe TRC and Pure SQL with and without subquery expressions

We now turn to the problems for this section.

3. Consider the query ‘Find the bno and title of each book that is bought by a student who is (strictly) younger than each student who majors in Chemistry and who also bought that book.’

- (a) • Express this query in Safe TRC (i.e, with quantifiers ‘ \exists ’ or ‘ \forall ’).

$$\{(b.bno, b.title) \mid book(b) \wedge \exists t \in Buys(\exists s \in Student(s.sid = t.sid \wedge t.bno = b.bno \wedge \forall hm \in hasMajor \forall s_1 \in Student((hm.major = 'Chemistry' \wedge hm.sid = t.sid \wedge s_1.sid = hm.sid \wedge \exists t_1 \in Buys(s_1.sid = t_1.sid \wedge t_1.bno = b.bno)) \rightarrow (s.birthyear > s_1.birthyear))))\}$$

- (b) • Express this query in Extended Safe TRC (i.e, with sub-query expressions).
4. Consider the query ‘*Find each student-book pair (s, b) where s is the sid of a student who majors in CS and who bought each book that costs no more than book b .*’
- (a) • Express this query in Extended Safe TRC (i.e, with sub-query expressions).
5. Consider the query ‘*Find the sid and name of each student who bought all-but-one book that cost strictly more than \$30.*’
- (a) • Express this query in Safe TRC (i.e, with quantifiers ‘ \exists ’ or ‘ \forall ’).

$$\{(s.sid, s.sname) \mid Student(s) \wedge \exists b(book(b) \wedge b.price > 30 \wedge \forall t(Buys(t) \wedge book(b1) \wedge b1.bno \neq b.bno \wedge b1.price > 30 \wedge t.sid = s.sid \wedge t.bno = b1.bno)) \wedge (\neg b2.b3(Book(b2) \wedge Book(b3) \wedge b2.bno \neq b3.bno \wedge (\forall t2(Buys(t2) \wedge book(b21) \wedge b21.bno \neq b.bno \wedge b21.price > 30 \wedge t2.sid = s.sid \wedge t2.bno = b21.bno)) \wedge (\forall t3(Buys(t3) \wedge book(b31) \wedge b31.bno \neq b.bno \wedge b31.price > 30 \wedge t3.sid = s.sid \wedge t3.bno = b31.bno))))))\}$$

Repeat the sub problems of the type ‘a’ through ‘f’ for the following queries

6. • Consider the query ‘*Find the sid and sname of each student who majors in CS and who is (strictly) younger than some other student who also majors in CS.*’
7. • Consider the query ‘*Find each (s, b) pair where s is the sid of a student who bought book b and such that each other book bought by s is a book cited by b .*’
8. • Consider the query ‘*Find each major that is not a major of any person who bought a book with title ‘Databases’ or ‘Philosophy’.*’
9. • Consider the query ‘*Find the bno and title of each book that is bought by a student who majors in CS and who is, among all students who major in CS, the next-to-oldest.*’

3 Expressing queries in Relational Algebra and RA SQL

10. Reconsider the query in Problem 1 ‘*Find the bno and title of each book that was bought by exactly one student.*’

- (a) • Express this query in Relational Algebra in standard notation.

let E denote:

$$\pi_{t_1.bno}(T_1 \bowtie_{t_1.sid \neq t_2.sid \wedge t_1.bno = t_2.bno} T_2)$$

Then the solution is:

$$\pi_{bno,title}(B \bowtie_{B.bno = T.bno} T) - \pi_{bno,title}(E \bowtie B_1)$$

11. Reconsider the query in Problem 2 ‘*Find each pair (m, b) where m is a major and b is the bno of a book bought by a student who has major m and such that the price of b is the lowest among the set of books bought by students with major m .*’

- (a) • Express this query in Relational Algebra in standard notation.

Let E denote

$$T \bowtie B \bowtie hM$$

Then the solution is

$$\pi_{E.major, E.bno}(E) - \pi_{E_1.major, E_1.bno}(E_1 \bowtie_{E_1.major = E_2.major \wedge E_1.price > E_2.price} E_2)$$

12. Reconsider the query in Problem 3 ‘*Find the bno and title of each book that is bought by a student who is (strictly) younger than each student who majors in Chemistry and who also bought that book.*’

- (a) • Express this query in Relational Algebra in standard notation.

Let E denote

$$T \bowtie S$$

Let F denote

$$S \bowtie T \bowtie (\pi_{sid}(\sigma_{major='Chemistry'}(hM)))$$

Then, the solution is:

$$\pi_{bno, title}((\pi_{bno}(E) - \pi_{E_1.bno}(E \bowtie_{E_1.bno=E_2.bno \wedge E_1.birthyear \leq E_2.birthyear} F)) \bowtie B)$$

13. Reconsider the query in Problem 4 ‘*Find each student-book pair (s, b) where s is the sid of a student who majors in CS and who bought each book that costs no more than book b .*’
 - (a) • Express this query in Relational Algebra in standard notation.
14. Reconsider the query in Problem 5 ‘*Find the sid and name of each student who bought all-but-one book that cost strictly more than \$30.*’
 - (a) • Express this query in Relational Algebra in standard notation.

The remaining problems in this section are practice problems (indicated with a red bullet ●).

Repeat parts (a) and (b) for these queries.

15. ● Consider the query ‘*Find the sid and sname of each student who majors in 'CS' and who is (strictly) younger than some other student who also majors in 'CS'.*
16. ● Consider the query ‘*Find each (s,b) pair where s is the sid of a student who bought book b and such that each other book bought by s is a book cited by b.*
17. ● Consider the query ‘*Find each major that is not a major of any person who bought a book with title 'Databases' or 'Philosophy'.*
18. ● Consider the query ‘*Find the bno and title of each book that is bought by a student who majors in CS and who is, among all students who major in CS, the next-to-oldest.*

4 Expressing constraints using Relational Algebra

We now turn to the problems in this section.

19. • Among the books that cite a book, there are books that cite the same set of other books.

$$\pi_{c.bno1}(C) \times \pi_{c.bno1}(C_3) - \pi_{C_1.bno1, C_2.bno1}(\sigma_{C_1.bno2 \neq C_2.bno2}(C_1 \times C_2)) \neq \emptyset$$

20. • Some student who majors only bought books that where bought by students who major in Math.

$$\pi_{sid}(hM) - \pi_{sid}(T - \pi_{sid}(hM) \times (\pi_{bno}(B \bowtie T \bowtie (\pi_{sno}(\sigma_{major='Math'}(hM_1))))) \neq \emptyset$$

21. • There are pairs of majors that have no common students who have those majors.

$$\pi_{M_1.major, M_2.major}(M_1 \times M_2) - \pi_{hM_1.major, hM_2.major}(hM_1 \bowtie_{hM_1.sid \neq hM_2.sid \wedge hM_1.major = hM_2.major} hM_2) \neq \emptyset$$

22. • Attribute ‘sid’ in the relation hasMajor is a foreign key referencing the primary key ‘sid’ in the relation Student.

$$\pi_{sid}(hasMajor) \subseteq \pi_{sid}(Student)$$