SQL – Part 4

Data Manipulation Language
(Advanced SQL Queries)

Advanced SQL Queries – Set Operations

- SQL incorporates several set operations: UNION (set union) and INTERSECT (set intersection), and sometimes EXCEPT (set difference / minus).
- Set operations result in return of a relation of tuples (no duplicates).
- Set operations apply to relations that have the same attribute types appearing in the same order, e.g., list all students who have either a gmail or hotmail email account.

```
(SELECT * FROM STUDENT WHERE Email like '%@gmail.com')
 UNION
(SELECT * FROM STUDENT WHERE Email like '%@hotmail.com');
```

- For example, the following query will not work

```
(SELECT StudentID, Name FROM STUDENT)
 UNION
(SELECT Email FROM STUDENT);
```

Advanced SQL Queries – Join Operations

- When we want to retrieve data from *more than one relations*, we often need to use **join** operations.
- Consider the following queries, which both need a join operation between two relations:

  - List the names of all courses which have been enrolled by at least one student.
  - List all students, and their enrolled courses if any.

STUDENT			
StudentID	Name	DoB	Email

COURSE		
No	Cname	Unit

ENROL				
StudentID	CourseNo	Semester	Status	EnrolDate

Advanced SQL Queries – Inner Join

- **Inner Join**: tuples are included in the result only if there is at least one matching in both relations.
- For the query “list the names of all courses which have been enrolled by at least one student”, we use:

```
SELECT DISTINCT c.Cname
  FROM COURSE c INNER JOIN ENROL e ON c.No=e.CourseNo;
```

COURSE		
No	Cname	Unit
COMP2400	Relational Databases	6
COMP3900	Advanced Database Concepts	6

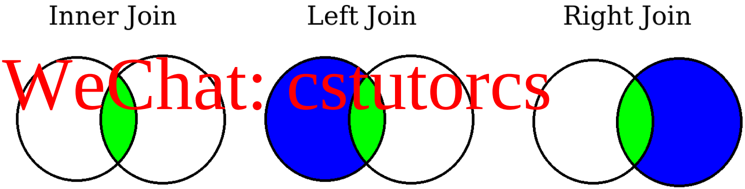
ENROL				
StudentID	CourseNo	Semester	Status	EnrolDate
456	COMP1130	2016 S1	active	25/02/2016
458	COMP1130	2016 S1	active	25/02/2016
456	COMP2400	2016 S2	active	09/03/2016

- Result:

Cname
Relational Databases

Advanced SQL Queries – Outer Join

- **Outer Join** includes **Left Join** and **Right Join**.
- **Left/Right Join**: all tuples of the left/right table are included in the result, even if there are no matches in the relations.



Advanced SQL Queries – Outer Join

- **Left Join**: A left join retains all rows of the left table regardless of whether there is a row that matches on the right table.

ENROL1		
StudentID	CourseNo	Semester
456	COMP1130	2016 S1
457	COMP1130	2016 S1
456	COMP2400	2016 S2

STUDENT			
StudentID	Name	DoB	Email
456	Tom	25/01/1988	tom@gmail.com
458	Peter	20/02/1991	peter@hotmail.com

```
SELECT *
    FROM STUDENT s LEFT JOIN ENROL1 e
                                ON s.StudentID=e.StudentID;
```

StudentID	Name	DoB	Email	StudentID	CourseNo	Semester
456	Tom	25/01/1988	tom@gmail.com	456	COMP1130	2016 S1
456	Tom	25/01/1988	tom@gmail.com	456	COMP2400	2016 S2
458	Peter	20/02/1991	peter@hotmail.com	null	null	null

Advanced SQL Queries – Outer Join

- **Right Join**: A right join retains all rows of the right table regardless of whether there is a row that matches on the left table.

ENROL1

StudentID	CourseNo	Semester
456	COMP1130	2016 S1
457	COMP1130	2016 S1
456	COMP2400	2016 S2

STUDENT

StudentID	Name	DoB	Email
456	Tom	25/01/1988	tom@gmail.com
458	Peter	20/02/1991	peter@hotmail.com

```
SELECT *
 FROM STUDENT s RIGHT JOIN ENROL1 e
                     ON s.StudentID=e.StudentID;
```

StudentID	Name	DoB	Email	StudentID	CourseNo	Semester
456	Tom	25/01/1988	tom@gmail.com	456	COMP1130	2016 S1
null	null	null	null	457	COMP1130	2016 S1
456	Tom	25/01/1988	tom@gmail.com	456	COMP2400	2016 S2

Advanced SQL Queries – Outer Join

- For the query “list all students and their enrolled courses if any”, we can use either of the following statements:

```
SELECT s.*, e.CourseNo, e.Semester
  FROM Student s LEFT JOIN Enrol1 e
                      ON s.StudentID=e.StudentID;
```

```
SELECT s.*, e.CourseNo, e.Semester
  FROM Enrol1 e RIGHT JOIN Student s
                      ON e.StudentID=s.StudentID;
```

- If we have 1000 tuples in Student, then the query result should contain at least 1000 tuples (one tuple in Student may occur multiple times) with the following attributes:

StudentID	Name	DoB	Email	CourseNo	Semester
...	...	...	...	...	...

Advanced SQL Queries – Natural Join

- **Motivation**: An inner join retains all the data of the two tables for , with duplication

-
  ```
  SELECT *
    FROM Student s INNER JOIN Enrol1 e
                                On s.StudentID=e.StudentID;
  ```

Enrol1

StudentID	CourseNo	Semester
456	COMP1130	2016 S1
457	COMP1130	2016 S1
456	COMP2400	2016 S2

Student

StudentID	Name	DoB	Email
456	Tom	25/01/1988	tom@gmail.com
458	Peter	20/02/1991	peter@hotmail.com

- Result:

StudentID	Name	DoB	Email	StudentID	CourseNo	Semester
456	Tom	25/01/1988	tom@gmail.com	456	COMP1130	2016 S1
456	Tom	25/01/1988	tom@gmail.com	456	COMP2400	2016 S2

Advanced SQL Queries – Natural Join

- **Natural Join**: A natural join retains all the data of the two tables for only the matched rows, without duplication.
-
```
    SELECT *
      FROM STUDENT s NATURAL JOIN ENROL1 e;
```

ENROL1

StudentID	CourseNo	Semester
456	COMP1130	2016 S1
457	COMP1130	2016 S1
456	COMP2400	2016 S2

STUDENT

StudentID	Name	DoB	Email
456	Tom	25/01/1988	tom@gmail.com
458	Peter	20/02/1991	peter@hotmail.com

- Result:

StudentID	Name	DoB	Email	CourseNo	Semester
456	Tom	25/01/1988	tom@gmail.com	COMP1130	2016 S1
456	Tom	25/01/1988	tom@gmail.com	COMP2400	2016 S2

Advanced SQL Queries – Natural Join

- **Natural Join**: One kind of inner join in which two relations are joined implicitly by comparing all attributes of the same names in both relations.
- For the query "list all students who have enrolled and their courses", use:

```
SELECT * FROM STUDENT NATURAL JOIN ENROL;
```

ENROL

StudentID	CourseNo	Semester	Status	EnrolDate
456	COMP1130	2016 S1	active	25/02/2016
457	COMP1130	2016 S1	active	25/02/2016

STUDENT

StudentID	Name	DoB	Email
456	Tom	25/01/1988	tom@gmail.com
458	Peter	20/02/1991	peter@hotmail.com

- Result:(STUDENT.StudentID=ENROL.StudentID is used in the query)

StudentID	Name	DoB	Email	CourseNo	Semester	Status	EnrolDate
456	Tom	25/01/1988	tom@gmail.com	COMP1130	2016 S1	active	25/02/2016

Advanced SQL Queries – Subqueries

- **Subqueries** are just queries that are used where a relation is required.
- Subqueries can be specified within the `FROM`-clause (usually in conjunction with aliases and renaming) to create *inline view* (exist only for the query)

- Subqueries can also be specified within the `WHERE`-clause, e.g.,
  - `IN` *subquery* tests if tuple occurs in the result of the subquery
  - `EXISTS` *subquery* tests whether the subquery results in non-empty relation
  - using `ALL`, `SOME` or `ANY` before a subquery makes subqueries usable in comparison formulae
  - in all these cases the condition involving the subquery can be negated using a preceding `NOT`

Subqueries – In

- Recall that, for the query “list all students who have enrolled and their courses”, we have:

```
SELECT *
  FROM STUDENT NATURAL JOIN ENROL;
```

- Now if we want to query: “list all students who have enrolled in a course *that has less than 10 students enrolled* and the CourseNo of these courses”, we have

```
SELECT s.*,e1.CourseNo
  FROM STUDENT s NATURAL JOIN ENROL e1
 WHERE e1.CourseNo IN
              (SELECT e2.CourseNo
                 FROM ENROL e2
             GROUP BY e2.CourseNo
               HAVING COUNT(*)<10);
```

Subqueries – Exists

- For the query: “list all students who have enrolled in at least one course”, we have

```
SELECT s.*
  FROM Student s
 WHERE EXISTS (SELECT *
                 FROM Enrol e
                WHERE s.StudentID=e.StudentID);
```

- For the query: “list all students who have *not* enrolled in any course”, we have

```
SELECT s.*
  FROM Student s
 WHERE NOT EXISTS (SELECT *
                     FROM Enrol e
                    WHERE s.StudentID=e.StudentID);
```

Subqueries – More Complicated

- For the query: “list the courses that have the largest number of students enrolled in Semester 2 2016”, we have

```
SELECT e.CourseNo
  FROM (SELECT e1.CourseNo, COUNT(*) AS NoOfStudents
          FROM Enrol e1
         WHERE e1.Semester = '2016 S2'
         GROUP BY e1.CourseNo) e
 WHERE e.NoOfStudents =
            (SELECT MAX(e2.NoOfStudents)
               FROM (SELECT e1.CourseNo, COUNT(*) AS NoOfStudents
                       FROM Enrol e1
                      WHERE e1.Semester = '2016 S2'
                      GROUP BY e1.CourseNo) e2);
```

Subqueries – More Complicated

- For the query: “list all the courses that have more students enrolled than at least one other course in Semester 2 2016”, we have

```
SELECT e.CourseNo
  FROM (SELECT e1.CourseNo, COUNT(*) AS NoOfStudents
          FROM Enrol e1
         WHERE e1.Semester = '2016 S2'
         GROUP BY e1.CourseNo) e
 WHERE e.NoOfStudents > ANY
            (SELECT e2.NoOfStudents
               FROM (SELECT e1.CourseNo, COUNT(*) AS NoOfStudents
                       FROM Enrol e1
                      WHERE e1.Semester = '2016 S2'
                      GROUP BY e1.CourseNo) e2);
```

Views in SQL

- A view in SQL is a virtual table that is derived from other tables in the same database or previously defined views.
- How to Create Views?
  - Suppose we already have tables STUDENT(StudentID, Name, DoB, Email) and ENROL(StudentID, CourseNo, Semester, Status, EnrolDate). Then we can create a view ENROL1 as follows:

```
CREATE VIEW ENROL1
AS SELECT s.StudentID, s.Name, e.CourseNo, e.EnrolDate
FROM STUDENT s, ENROL e
WHERE s.StudentID=e.StudentID;
```