DB2 Advanced SQL – Working with Complex Queries

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Tony Andrews is currently a trainer, consultant, and technical advisor at Themis, Inc. He teaches courses on SQL, application programming, database design, and performance tuning. He also has more than 23 years experience in the development of IBM DB2 relational database applications. Most of this time, he has provided development and consulting services to Fortune 500 companies and government agencies. For the last 10 years, Tony has been splitting his time between performance and tuning consulting engagements and DB2/SQL training. His main focus is to teach today's developers the ways of RDMS application design, development, and SQL programming -- always with a special emphasis on improving performance. He is a current IBM Champion, and regular speaker at many user groups, IDUG NA, and IDUG EMEA.

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Objectives

By the end of this presentation, developers will have a better understanding of:

- Nested and Common Table Expressions
- Complex Joins
- OLAP Ranking
- Correlated / Non Correlated Subqueries
- Quota Queries
- Relational Difference
- Set Operations
- Merge SQL
- Complex Case Statements

My Experience Shows

- Often times there are multiple ways of getting the same answer in programming. This pertains to SQL also.
- Everyone needs to be stronger in SQL.
- Strong SQL skills greatly enhance one's ability to do performance tuning of queries, programs, and applications.
- There are many new SQL functions available to developers in V8, V9, and V10.

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Table Review

EMP

EMPNO *(PK)*	LASTNAME	FIRSTNME	DEPTNO	JOB	EDLEVEL
000010	HAAS	CHRISTINE	A00	PRES	18
000020	THOMPSON	MICHAEL	B01	MANAGER	18
000030	KWAN	SALLY	C01	MANAGER	20
000050	GEYER	JOHN	E01	MANAGER	16
000060	STERN	IRVING	D11	MANAGER	16
000070	PULASKI	EVA	D21	MANAGER	16
000110	VINCENZO	LUCCHESI	A00	SALESREP	19
000120	SEAN	O'CONNELL	A00	CLERK	14

DEPT

DEPTNO *(PK)*	DEPTNAME	MGRNO *(FK)*	ADMRDEPT	LOCATION
A00	SPIFFY COMPUTER SERVICE DIV.	000010	A00	
B01	PLANNING	000020	A00	
C01	INFORMATION CENTER	000030	A00	
D01	DEVELOPMENT CENTER	*<null>*	A00	
D11	MANUFACTURING SYSTEMS	000060	D01	
D21	ADMINISTRATION SYSTEMS	000070	D01	

Table Review

Scalar Fullselects

Problem #1:

Provide a report of employees with employee detail information along with department aggregate information. Show:

EMPNO	LASTNAME	FIRSTNME	SALARY	DEPTNO	DEPT_AVG_SAL
000010	HAAS	CHRISTINE	52750.00	A00	45312.50

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Scalar Fullselects

This example will require a correlated subquery since each individual piece of data (an employee's EDLEVEL) will need to be compared to an aggregate piece of data (the average EDLEVEL) where the aggregate is determined by information from the individual (the average for the department the employee works in).

Option 1: Scalar Fullselect

```
SELECT E1.EMPNO,
       E1.LASTNAME,
       E1.SALARY
       E1.DEPTNO,
      (SELECT AVG(E2.SALARY)
       FROM EMP  E2
       WHERE E2.DEPTNO = E1.DEPTNO)
                         AS DEPT_AVG_SAL
 FROM EMP E1
 ORDER BY E1.DEPTNO, E1.SALARY
```

Scalar Fullselect came in V8

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Option 1

To add the average to the result, the subquery must be repeated as a scalar fullselect in the SELECT clause. Scalar fullselects were introduced in DB2 Version 8 and may be used as an expression anywhere in the statement provided they only return 1 column and 1 row.

Option 2: Join

Join Provides different optimizer options

```
SELECT E1.EMPNO, E1.LASTNAME,
       E1.DEPTNO, E1.SALARY,
       AVG(E2.SALARY)  AS DEPT_AVG_SAL
 FROM EMP E1  INNER JOIN
      EMP E2  ON E1.DEPTNO  = E2.DEPTNO
 GROUP BY E1.EMPNO, E1.LASTNAME,
          E1.DEPTNO, E1.SALARY
 ORDER BY E1.DEPTNO, E1.SALARY
```


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Option 2

With a join, the optimizer will have all the options of any join process (Nested Loop, Merge Scan, or Hybrid). There also may be a sort specific to the Group By and/or the Order By.

Option 3: Nested Table Expression

```
SELECT E.EMPNO,    E.LASTNAME,    E.DEPTNO,
          E.SALARY,    DAS.DEPT_AVG_SAL
FROM EMP E  INNER JOIN
        (SELECT DEPTNO,
        AVG(SALARY)    AS DEPT_AVG_SAL
        FROM EMP
        GROUP BY DEPTNO )  AS   DAS

     ON E.DEPTNO  = DAS.DEPTNO
ORDER BY E.DEPTNO, E.SALARY
```

Table Expression most likely gets materialized

Option 3

With a table expression containing aggregation and a Group By, most likely will see materialization.

Option 4: Common Table Expression


```
WITH  DEPT_AVG_SAL  AS
    (SELECT DEPTNO,
     AVG(SALARY)    AS DEPT_AVG_SAL
     FROM EMP
     GROUP BY DEPTNO)

   SELECT E.EMPNO,    E.LASTNAME,    E.DEPTNO,
              E.SALARY,    DAS.DEPT_AVG_SAL
   FROM EMP E  INNER JOIN
            DEPT_AVG_SAL DAS  ON E.DEPTNO  = DAS.DEPTNO
   ORDER BY E.DEPTNO, E.SALARY
```


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Option 4

With a table expression containing aggregation and a Group By, most likely will see materialization. With only 1 table expression, there will be no difference between the nested table and the common table.

Table Expressions

Problem #2:

Provide a report of employees whose education levels are higher than the average education level <u>of their respective department</u>.

Example: EMPNO '000010' works in department 'A00'. Is this employee's EDLEVEL > the average of all employees in 'A00'. If so, send their information to the result set.

Table Expressions

This example will require a correlated subquery since each individual piece of data (an employee's EDLEVEL) will need to be compared to an aggregate piece of data (the average EDLEVEL) where the aggregate is determined by information from the individual (the average for the department the employee works in).

Option 1: Correlated Subquery

```
SELECT E1.EMPNO,
       E1.LASTNAME,
       E1.DEPTNO,
       E1.EDLEVEL
 FROM EMP E1
 WHERE E1.EDLEVEL >
          (SELECT AVG(E2.EDLEVEL)
             FROM EMP  E2
            WHERE E2.DEPTNO = E1.DEPTNO)
     AND E1.DEPTNO < 'D01'
```

Join predicate in subquery!

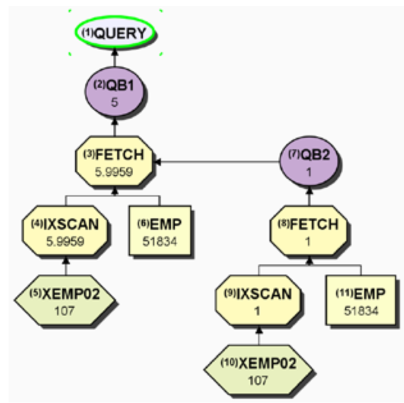
Option 1

This example will require a correlated subquery since each individual piece of data (an employee's EDLEVEL) will need to be compared to an aggregate piece of data (the average EDLEVEL) where the aggregate is determined by information from the individual (the average for the department the employee works in).

Solution Using Correlated Subquery

EMPNO	LASTNAME	DEPTNO	EDLEVEL
000010	HAAS	A00	18
000011	HAAS	A00	18
000030	KWAN	C01	20
000110	LUCCHESI	A00	19

Now try adding the average EDLEVEL into the result…



Correlated Subquery

Here is the solution and the access path graph from IBM Data Studio. Notice that the table is accessed twice. The access path for the correlated subquery will actually be run multiple times.

Adding the Average to the Result

```
SELECT E1.EMPNO,
                E1.LASTNAME,
                E1.DEPTNO,
                E1.EDLEVEL,
           (SELECT AVG(E3.EDLEVEL)
               FROM EMP  E3
             WHERE E3.DEPTNO = E1.DEPTNO) AS AVG
 FROM EMP E1
 WHERE E1.EDLEVEL >
                    (SELECT AVG(E2.EDLEVEL)
                        FROM EMP  E2
                      WHERE E2.DEPTNO = E1.DEPTNO)
           AND E1.DEPTNO < 'D01'
```

Scalar Fullselect came in V8

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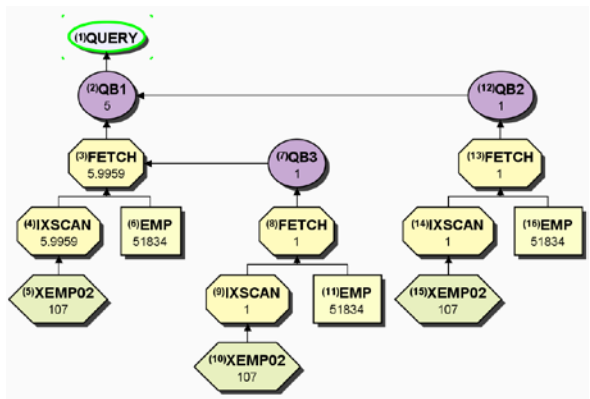
Adding to the SELECT List

To add the average to the result, the subquery must be repeated as a scalar fullselect in the SELECT clause. Scalar fullselects were introduced in DB2 Version 8 and may be used as an expression anywhere in the statement provided they only return 1 column and 1 row.

Adding the Average to the Result

EMPNO	LASTNAME	DEPTNO	EDLEVEL	AVG
000010	HAAS	A00	18	17
000011	HAAS	A00	18	17
000030	KWAN	C01	20	18
000110	LUCCHESI	A00	19	17



Option 2: Nested Table Expression

```
SELECT E1.EMPNO,
               E1.LASTNAME,
               E1.DEPTNO,
               E1.EDLEVEL,
                DEPTAVG.AVG
FROM EMP E1 JOIN
            (SELECT DEPTNO, AVG(EDLEVEL) AS AVG
               FROM EMP
             WHERE DEPTNO < 'D01'
             GROUP BY DEPTNO) AS DEPTAVG
ON E1.DEPTNO = DEPTAVG.DEPTNO
AND E1.EDLEVEL > DEPTAVG.AVG
```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Option 2 – Nested Table Expression

This query could be rewritten using a nested table expression to eliminate the redundancy. Think about the placement of the DEPTNO < ‘D01’ predicate. It is likely better to place it inside the nested table expression to limit the amount of data materialized (if materialization is required).

Option 3: Common Table Expression

```
WITH DEPTAVG AS
 (SELECT DEPTNO, AVG(EDLEVEL) AS AVG
         FROM EMP
         WHERE DEPTNO < 'D01'
         GROUP BY DEPTNO) AS DEPTAVG

SELECT E1.EMPNO,
         E1.LASTNAME,
         E1.DEPTNO,
         E1.EDLEVEL,
           DEPTAVG.AVG
FROM EMP E1 JOIN
        DEPTAVG
         ON E1.DEPTNO = DEPTAVG.DEPTNO
AND E1.EDLEVEL > DEPTAVG.AVG
```


Option 3 – Common Table Expression

Table Expressions

Problem #3:

Return the department number and the total payroll for the department that has the highest payroll. Payroll will be defined as the sum of all salaries and bonuses for the department.

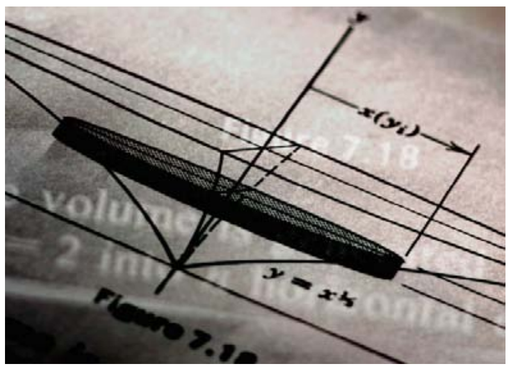

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Table Expressions – Another Problem

An additional layer of complexity arises when multiple levels of aggregation are needed. Here SUM will be needed to find the total payroll for each department and then a MAX will be needed to figure out which is the largest.

Option1: Nested Table Expressions

```
SELECT DEPTNO, DEPT_TOT
       FROM
       (SELECT DEPTNO,
              SUM(SALARY + BONUS) AS DEPT_TOT
              FROM EMP
          GROUP BY DEPTNO) DEPTPAY
WHERE DEPT_TOT =
       (SELECT MAX(TOT2)
         FROM (SELECT DEPTNO,
                     SUM(SALARY + BONUS) TOT2
                     FROM EMP
                 GROUP BY DEPTNO) DEPTPAY2
       )
```


Nested table expressions may be used to solve this problem, but because the MAX is needed in more than one query block, the nested table expression must be repeated.

Option #2: Common Table Expression

```
WITH DEPTPAY AS
        (SELECT DEPTNO,
                SUM(SALARY + BONUS) AS DEPT_TOT
                FROM EMP
          GROUP BY DEPTNO)

SELECT DEPTNO, DEPT_TOT
    FROM DEPTPAY
    WHERE DEPT_TOT = (SELECT MAX(DEPT_TOT)
                                    FROM DEPTPAY)
```

Redundant Expression Eliminated!

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Common Table Expressions are defined outside of the query that uses the table expression and may therefore be used in any query block as shown here. Note that the SQL on this slide is all one query and will return the result from the bottom SELECT.

Ranking

Problem #4:

Return the employees with the top 5 salaries.
Could be 5 employees with different salaries.
Could be many employees having the same salaries.

Ranking

Option #1: Rank() Function

```
SELECT      LASTNAME, SALARY,
            RANK() OVER (ORDER BY SALARY DESC) AS R
FROM EMP
FETCH FIRST ?????? ROWS ONLY
```

How many do we fetch to get all of the top 5 ?

LASTNAME	SALARY	R
HAAS	52750.00	1
HAAS	52750.00	**1**
LUCCHESI	46500.00	**3**
THOMPSON	41250.00	4
GEYER	40175.00	5
Others …..		

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Option #1

The RANK function orders and ranks a result. In this example, the result in being ranked by SALARY in descending sequence, so the highest salary has a rank of 1. When there is a tie, all rows with the value receive the same rank and an appropriate number of ranks are "skipped". In this example, since there were 2 salary values in second place, the value of 3 is skipped.

The result set may be ordered using an ORDER BY for the entire SELECT, and this order need not be the same as the column being ranked. When this is done, 2 sorts may need to be performed to achieve the desired result.

Option #1: Rank() Function

```
WITH RANK_TBL AS
 (SELECT LASTNAME, SALARY,
  RANK() OVER (ORDER BY SALARY DESC)  AS RANK_NUM
  FROM THEMIS90.EMP)

  SELECT *
  FROM RANK_TBL
  WHERE RANK_NUM < 6
;
```

LASTNAME	SALARY	R
HAAS	52750.00	1
HAAS	52750.00	**1**
LUCCHESI	46500.00	**3**
THOMPSON	41250.00	4
GEYER	40175.00	5

Option #2: Dense_Rank() Function

```
SELECT      LASTNAME, SALARY,
     DENSE_RANK() OVER (ORDER BY SALARY DESC) AS R
FROM EMP
```

LASTNAME	SALARY	R
HAAS	52750.00	1
HAAS	52750.00	**1**
LUCCHESI	46500.00	**2**
THOMPSON	41250.00	3
GEYER	40175.00	4
KWAN	38250.00	5
Others …		

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Option #2

The DENSE_RANK function orders and ranks a result. In this example, the result in being ranked by SALARY in descending sequence, so the highest salary has a rank of 1. When there is a tie, all rows with the value receive the same rank and no ranks are “skipped”. In this example, there were 2 salary values for first, then the next value becomes rank = 2.

The result set may be ordered using an ORDER BY for the entire SELECT, and this order need not be the same as the column being ranked. When this is done, 2 sorts may need to be performed to achieve the desired result.

Option #2: Dense_Rank() Function

```
WITH RANK_TBL AS
 (SELECT LASTNAME, SALARY,
  DENSE_RANK() OVER (ORDER BY SALARY DESC)  AS RANK_NUM
  FROM THEMIS90.EMP)

  SELECT *
  FROM RANK_TBL
  WHERE RANK_NUM < 6
;
```

LASTNAME	SALARY	R
HAAS	52750.00	1
HAAS	52750.00	**1**
LUCCHESI	46500.00	**2**
THOMPSON	41250.00	3
GEYER	40175.00	4
KWAN	38250.00	5

Note: 6 rows make the top 5

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Option #3: Quota Queries

Find the 5 *highest* salaries:

```
SELECT      LASTNAME, SALARY
  FROM      EMP  E
WHERE       5  >
            (SELECT COUNT(*)
               FROM EMP  E1
             WHERE E1.SALARY > E.SALARY)
ORDER BY SALARY DESC
```

LASTNAME	SALARY
HAAS	52750.00
HAAS	52750.00
LUCHESSI	46500.00
THOMPSON	41250.00
GEYER	40175.00

Option #3

Quota query is the name given to the general class of problems seeking to return a ranked list of the highest or lowest values of some column or columns. The top 10 customers; the 15 highest salaries in the company; the 25 employees with the shortest tenure; are representative quota queries.

SQL solutions involving many levels of nested subselect (or many joins) are also impractical for all but the simplest quota. The following example shows a subselect solution for finding the 2 highest salaries on the EMP table:

```
SELECT EMPNO, SALARY
FROM EMP
WHERE SALARY = (SELECT MAX(SALARY)
            FROM   EMP)
  0R SALARY = (SELECT MAX(SALARY)
            FROM   EMP
            WHERE SALARY <> (SELECT MAX(SALARY)
                         FROM   EMP));
```

If the 10 highest salaries were required, this template would take on a prohibitive level of complexity. The queries on the facing page solve the problem using a counting solution. The inner select counts the number of salaries greater than the salary being considered for the result. Since no one makes more than the highest salary, a count of 0 to 4 would indicate the employee in the outer query was among the top 5.

Option #3: Quota Queries - Duplicates

```
SELECT      LASTNAME, SALARY
  FROM      EMP  E
WHERE       5  > (SELECT COUNT(DISTINCT SALARY)
                  FROM EMP  E1
                  WHERE E1.SALARY > E.SALARY)
ORDER BY SALARY DESC
```

LASTNAME	SALARY
HAAS	52750.00
HAAS	52750.00
LUCHESSI	46500.00
THOMPSON	41250.00
GEYER	40175.00
KWAN	38250.00

Dealing with Duplicates

This query addresses duplicate salaries by elimination of duplicates during COUNT(DISTINCT) processing. Eliminating the duplicate salaries is only one way of interpreting the semantics of the top 5 salaries. If 5 people in the company made the same salary and it was coincidentally the maximum salary, should the result only contain these employees? By removing the duplicates we are implying the top 5 *different* salaries. Other questions regarding semantics, such as, *suppose there were only 4 employees; should the result be empty; should the query return only the 4 employees, should it be an error;* must be considered and built into the solution.

Restricted Quotas

PROBLEM #5:

Find all employees who major in math (MAT) and computer science (CSI).

EMPMAJOR TABLE

EMPNO	MAJOR
E1	MAT
E1	CSI
E2	MAT
E3	CSI
E4	ENG

Restricted Quotas

Restricted quotas filter rows based on a certain condition before performing the required ranking. Either by grouping or counting or both, a condition is associated with a count. Those groups having the expected count are qualified to the condition.

Option #1: Restricted Quotas

PROBLEM #5: Find all employees who major in math (MAT) and computer science (CSI).

EMPMAJOR

EMPNO	MAJOR
E1	MAT
E1	CSI
E2	MAT
E3	CSI
E4	ENG

```
SELECT     EMPNO
  FROM     EMPMAJOR
WHERE      MAJOR  IN  ('MAT', 'CSI')
GROUP BY   EMPNO
HAVING     COUNT(*) = 2
```

Solution 1

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Option 1 retrieves employees who major in math or computer science. A given employee appearing in the result before the grouping has 1 row or 2 rows. Only groups with count = 2 result from employees who major in both.

Option #2: Restricted Quotas

PROBLEM #5: Find all employees who major in math (MAT) and computer science (CSI).

EMPMAJOR

EMPNO	MAJOR
E1	MAT
E1	CSI
E2	MAT
E3	CSI
E4	ENG

```
SELECT DISTINCT EMPNO
FROM     EMPMAJOR  EM
WHERE  2 = (SELECT COUNT(*)
              FROM EMPMAJOR  EM2
              WHERE EM.EMPNO =
                    EM2.EMPNO
              AND EM2.MAJOR  IN
                    ('MAT', 'CSI'))
```

Solution 2

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Option 2 uses the template from the previous example as a model. For a given employee evaluated in the outer query, the inner query returns the rows for that employee restricted to math or computer science. As in solution 1, a count of 2 indicates that the employee majors in both.

Option #3: Restricted Quotas

PROBLEM #5: Find all employees who major in math (MAT) and computer science (CSI).

EMPMAJOR

EMPNO	MAJOR
E1	MAT
E1	CSI
E2	MAT
E3	CSI
E4	ENG

```
SELECT EMPNO
FROM EMPMAJOR AS EMP1
  JOIN EMPMAJOR AS EMP2
    ON EMP1.EMPNO = EMP2.EMPNO
  WHERE EMP1.MAJOR = 'MAT'
     AND EMP2.MAJOR = 'CSI';
```

Solution 3

This problem could also be solved with a self-join. Although not a quota query template, this solution is a straightforward approach to AND conditions posed on a single table.

Relational Divide

Problem #6:

Find employees who work on *all* activities between 90 and 110

EMPPROJACT Table (partial data)

EMPNO	PROJNO	ACTNO
000130	IF1000	90
000130	IF1000	100
000140	**IF1000**	**90**
000140	**IF2000**	**100**
000140	**IF2000**	**100**
000140	**IF2000**	**110**
000140	**IF2000**	**110**
000150	MA2112	60
000150	MA2112	180

ACT Table (partial data)

ACTNO	ACTDESC
90	ADM QUERY SYSTEM
100	TEACH CLASSES
110	DEVELOP COURSES

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Relational Divide

The problem on this page is part of a general set of problems known as set divide problems. Set divide problems represent the notion of FORALL quantification. *In this problem, an employee will be on the result table, if FORALL activities between 90 and 110, there exists a row on EMPPROJACT identifying that employee*. Employee 140 satisfies this property, but 130 and 150 do not.

SQL doesn't support a divide operator, nor does it support direct FORALL quantification. Only EXISTS is supported in SQL. Therefore we must use a double negative to form the equivalent complement using EXISTS.

Option #1: Relational Divide

PROBLEM #6: Find employees who work on all activities between 90 and 110.

```
SELECT EPA.EMPNO
FROM EMPPROJACT EPA
WHERE EPA.ACTNO BETWEEN 90 AND 110
GROUP BY EPA.EMPNO
HAVING COUNT(DISTINCT ACTNO) =
        (SELECT COUNT(*)
          FROM ACT  A
         WHERE A.ACTNO BETWEEN 90 AND 110)
```

The number of activities this person works

…is equal to the number of activities

EMPNO
000140

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Option #1

This solution uses a quota approach similar to the problem involving employee majors presented earlier. Rows of EMPROJACT are grouped resulting in 1 row per employee. The count of the distinct ACTNOs that an employee works on is compared to the total count of the rows on the ACT table that meet the criteria to provide the answer.

Option #2: Relational Divide

```
SELECT EMPNO
FROM EMP E
WHERE NOT EXISTS
         (SELECT ACTNO
            FROM ACT A
          WHERE ACTNO BETWEEN 90 AND 110
               AND NOT EXISTS
                    (SELECT 1
                       FROM EMPPROJACT EPA
                    WHERE E.EMPNO = EPA.EMPNO
                       AND A.ACTNO = EPA.ACTNO
                    ) )
```

EMPNO
000140

There *isn't* an activity (between 90 and 110)

...that this employee *doesn't* work

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Option #2

This solution is the standard, most flexible template for the divide problem. The 2 NOT EXISTS correspond to the double negative derived earlier and give rise to the name *double double* for the general class of solutions using this approach.
The search of all customers is the outermost level (E level). Since the E level is dependent on a NOT EXIST, an employee will go to the result if the search at the next level (A level) is empty. The search at the A level will be empty if the search at the EPA level (also a NOT EXISTS predicate) always finds a match.

The EPA level always return exactly 1 row (if the employee at the E level works on an activity at the A level) or will be empty (if the employee at the E level does not work the activity at the A level).

A non match at the EPA level returns TRUE to the A level which immediately returns FALSE to the E level rejecting that employee.

Distinct Options

Problem #7:

Find employees who are currently working on a project or projects. Employees working on projects will have a row(s) on the EMPPROJACT table.

EMP TABLE	EMPPROJACT TABLE		
HAAS	HAAS	MA2100	10
KWAN	HAAS	MA2100	20
…	KWAN	IF1000	90
…	KWAN	IF2000	100
	…		

Distinct Options

Distinct often times causes sorts to take place of the final result set to look for and eliminate any duplicate rows. At times, there are choices that can also handle duplicates without executing the Distinct.

Option #1: Distinct Options

PROBLEM #7: Find employees who are currently working on a project or projects.

```
SELECT DISTINCT E.EMPNO, E.LASTNAME
  FROM EMP E, EMPPROJACT EPA
  WHERE E.EMPNO  = EPA.EMPNO
Or
SELECT E.EMPNO, E.LASTNAME
  FROM EMP E, EMPPROJACT EPA
  WHERE E.EMPNO  = EPA.EMPNO
  GROUP BY E.EMPNO, E.LASTNAME
```

Distinct to get rid of duplicates

Group By to get rid of duplicates

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Option #1

There are sort enhancements for both ‘Distinct’ and ‘Group By’ with no column function. This was already available prior to V9 with ‘Group By’ and a column function. It now handles the duplicates more efficiently in the input phase, elimination a step 2 passing of data to a sort merge.

Prior to V9, ‘Distinct’ could only use a unique index to avoid a sort. ‘Group By’ could use both unique and non unique. Now V9 ‘Distinct’ may take advantage of non unique indexes to avoid a sort in order to handle duplicates.

Sometimes, if one of the tables has no columns being selected from it, it can then be moved to a subquery.

Option #2: Distinct Options

PROBLEM #7: Find employees who are currently working on a project or projects.

```
SELECT E.EMPNO, E.LASTNAME
  FROM EMP E
  WHERE E.EMPNO IN
      (SELECT EMPNO
        FROM EMPPROJACT EPA)
```

'In' non correlated subquery

Option #2

This 'In' subquery will build a list of values for the EMP 'In' predicate, and sort those values in ascending order at the same time
as getting rid of duplicate values.

New in V9 are optimizer enhancements that sometimes takes an 'In' subquery and:
 - Materialize the list of values into a workfile, and feeds the EMP table in a Nested

Loop Join Process
 - Transforms the 'In' non correlated subquery to a correlated subquery.

V9 calls this 'Global query Optimization'

Option #3: Distinct Options

PROBLEM #7: Find employees who are currently working on a project or projects.

```
SELECT E.EMPNO, E.LASTNAME
  FROM EMP E
  WHERE EXISTS
      (SELECT 1
        FROM EMPPROJACT EPA
        WHERE EPA.EMPNO = E.EMPNO)
```

'Exists' correlated subquery

Option #3

This 'Exists' subquery will be checked for each employee in the EMP table. A flag gets sent on the join stating for each employee value whether that value exists or not in the EMPPROJACT table.

Because the subquery will get executed multiple times, you want to make sure an index exists on the join column(s).

Set Operations

- Union / Union All
- Intersect / Intersect All
- Except / Except All

Set Operations

SQL Supports three set operations for combining and comparing the results of two selects. UNION combines two result sets vertically. INTERSECT and EXCEPT may be used for comparing two results vertically. All three operations require that the result sets being processed are compatible, that is, they have the same number of columns and compatible data types.

Intersect / Intersect ALL

```
SELECT LASTNAME
  FROM NA_EMP

INTERSECT

SELECT LASTNAME
  FROM SA_EMP
```

Finds records where all selected columns match

Order of the tables with INTERSECT does not matter.

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Intersect

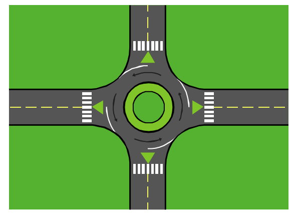
Both of the following queries will return the same results.

1) **SELECT LASTNAME**
   FROM NA_EMP
   INTERSECT
   SELECT LASTNAME
   FROM SA_EMP

2) **SELECT LASTNAME**
   FROM SA_EMP
   INTERSECT
   SELECT LASTNAME
   FROM NA_EMP

Intersect / Intersect ALL

SELECT #1		SELECT #2
Abbot	X	Baker
Jones	→	Jones
Smith	→	Jones
Smith	→	Smith
Smith	X	Smith



INTERSECT

LASTNAME
Jones
Smith

INTERSECT ALL

LASTNAME
Jones
Smith
Smith

This example demonstrates the difference between INTERSECT and INTERSECT ALL. Since Smith occurs three times in the first select but only twice in the second, INTERSECT ALL considers that there are two matches.

Once again, a duplicate is considered any record in the result where the values for all selected columns are the same.

Exists 1 ….

```
SELECT N.LASTNAME
  FROM NA_EMP N
  WHERE EXISTS
     (SELECT 1
      FROM SA_EMP S
      WHERE S.LASTNAME
         = N.LASTNAME
```

LASTNAME
Jones
Smith
Smith
Smith
Smith

Exists 2 …

```
SELECT S.LASTNAME
 FROM SA_EMP S
 WHERE EXISTS
    (SELECT 1
      FROM NA_EMP N
      WHERE N.LASTNAME
          = S>LASTNAME)
```

LASTNAME
Jones
Jones
Smith
Smith

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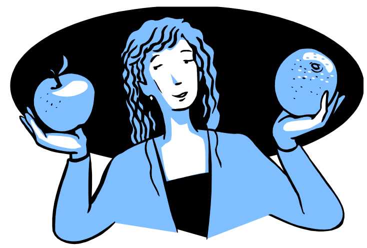
Other Options

Intersect is not the same as Exists logic as can be seen in the example. Exists checks one at a time whereas the intersect logic looks at all of the same name as a group in each table and compares.

Except / Except ALL

SELECT #1	SELECT #2
Abbot	Baker
Jones	Jones
Smith	Jones
Smith	Smith
Smith	Smith



EXCEPT

LASTNAME
Abbot

EXCEPT ALL

LASTNAME
Abbot
Smith

Except

This example demonstrates the difference between EXCEPT and EXCEPT ALL. Smith is not returned using EXCEPT, since there are Smiths in the second result. Using EXCEPT ALL, however, one Smith is returned since there were three in the first result, but only two in the second.

Notice that EXCEPT and EXCEPT ALL will produce a different result if the SELECTs are reversed. Order is important!

Not Exists 1 ….

```
SELECT N.LASTNAME
  FROM NA_EMP N
  WHERE NOT EXISTS
    (SELECT 1
     FROM SA_EMP S
     WHERE S.LASTNAME
        = N.LASTNAME
```

LASTNAME
Abbot

Not Exists 2 …

```
SELECT S.LASTNAME
 FROM SA_EMP S
    WHERE NOT EXISTS
   (SELECT 1
    FROM NA_EMP N
    WHERE N.LASTNAME
         = S>LASTNAME)
```

LASTNAME
Baker

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Other Options

SELECT FROM MERGE

```
SELECT ITEMNAME, UPD_IND FROM FINAL TABLE
(MERGE INTO ITEM I
  INCLUDE (UPD_IND CHAR(1))
  USING (VALUES (1, 'SOCKET') )
    AS NEWITEM (ITEMNO, ITEMNAME)
 ON I.ITEMNO = NEWITEM.ITEMNO
 WHEN MATCHED THEN
  UPDATE SET ITEMNAME = NEWITEM.ITEMNAME,
          UPD_IND = 'U'
 WHEN NOT MATCHED THEN
  INSERT (ITEMNO,ITEMNAME,UPD_IND)
   VALUES (NEWITEM.ITEMNO, NEWITEM.ITEMNAME,'I') )
```


SELECT from MERGE

When using from a MERGE statement, it may be desirable to determine whether an INSERT or UPDATE operation was performed. This may be accomplished by using the INCLUDE clause to create an indicator variable. In the example shown, an INCLUDE column is created called UPD_IND. When an update is performed, the UPD_IND is set to a “U”. When an insert is performed, the UPD_IND is set to an “I”. This value may be returned to the application via the SELECT.

Counting With CASE

Provide a list of total number of males and total number of females.

```
SELECT SEX, COUNT(*)
FROM  EMP
GROUP BY SEX
```

SEX	2
F	14
M	19

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CASE Statement

The CASE statement may be used in conjunction with column functions to translate ranges of values into categories. In this example, CASE is being used to supply a value of 1 or 0 for 3 separate columns in a result set that are then summed.

Counting With CASE

Provide a list of total number of males and total number of females.

```
SELECT
  SUM(CASE WHEN SEX = 'F' THEN 1 ELSE 0 END)
                                         AS NUM_FEMALES,
  SUM(CASE WHEN SEX = 'M' THEN 1 ELSE 0 END)
                                         AS NUM_MALES
FROM  EMP
```

NUM_FEMALES	NUM_MALES
14	19

Counting with CASE

Counting With CASE

```
SELECT
SUM (CASE WHEN SALARY < 20000
                THEN 1 ELSE 0 END ) AS LOW,
SUM (CASE WHEN SALARY BETWEEN 20000 AND 45000
                THEN 1 ELSE 0 END ) AS MID,
SUM (CASE WHEN SALARY > 45000
                THEN 1 ELSE 0 END ) AS HI
FROM        EMP
```

LOW	MID	HI
7	23	3

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Table Pivoting

```
SELECT JOB,
       SUM(CASE WHEN DEPTNO = 'A00' THEN 1 ELSE 0 END) AS A00,
       SUM(CASE WHEN DEPTNO = 'B01' THEN 1 ELSE 0 END) AS B01,
       SUM(CASE WHEN DEPTNO = 'C01' THEN 1 ELSE 0 END) AS C01,
       SUM(CASE WHEN DEPTNO = 'D11' THEN 1 ELSE 0 END) AS D11,
       SUM(CASE WHEN DEPTNO = 'D21' THEN 1 ELSE 0 END) AS D21,
       SUM(CASE WHEN DEPTNO = 'E01' THEN 1 ELSE 0 END) AS E01,
       SUM(CASE WHEN DEPTNO = 'E11' THEN 1 ELSE 0 END) AS E11,
       SUM(CASE WHEN DEPTNO = 'E21' THEN 1 ELSE 0 END) AS E21
FROM EMP
GROUP BY JOB
```

JOB	A00	B01	C01	D11	D21	E01	E11	E21
ANALYST	0	0	2	0	0	0	0	0
CLERK	1	0	0	0	5	0	0	0
DESIGNER	0	0	0	8	0	0	0	0
FIELDREP	0	0	0	0	0	0	0	3
MANAGER	0	1	1	1	1	1	1	1
OPERATOR	0	0	0	0	0	0	4	0
PRES	2	0	0	0	0	0	0	0
SALESREP	1	0	0	0	0	0	0	0

Table Pivoting

The CASE expression may also be used in conjunction with column functions to change a result from a vertical to horizontal display. In this example a GROUP BY on JOB, DEPTNO would have provided one row for each combination of JOB and DEPTNO with a count. If a tabular result is desired with one column's values as the columns on the table and another for the rows, the result may be pivoted with the CASE statement. CASE must be used to evaluate every desired department.

New DB2 V8 SQL Features

Following are some of the new SQL features in DB2 V8:

1) More Stage 1 predicates
2) Multi Row Fetch, Update, and Insert
3) Multiple Distincts
4) Expressions in the 'Group By'
5) Common Table Expression
6) Dynamic Scrollable Cursors
7) Sequences versus Identity Columns
8) Materialized Query Tables (MQTs)
9) Recursive SQL
10) More efficient use of indexes. Forward and Backward scans
11) New XML functions and datatypes
12) New 'Get Diagnostics' for warning and error information
13) Select from an Insert statement
14) Scalar Fullselect within a 'Select', 'Case', Update, etc.

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DB2 V8 Features

New DB2 V9 SQL Features

Following are some of the new SQL features in DB2 V9:

1) Set operations ‘Intersect’ and ‘Except’
2) Merge statement for ‘Upsert’ processing. Insert or Update
3) OLAP features for Ranking and Numbering of data
4) Native SQL Stored Procedures
5) ‘Instead of’ Triggers
6) New support and SQL for XML data
7) Optimization Service Center (OSC)
8) Distinct sort avoidance with non unique indexes
9) Indexing on Expressions
10) Statistics on Views
11) Skipped locked data
12) Truncate statement

DB2 9 Features

Native SQL: No ‘C’ compilation. Fully integrated into DB2, Versioning

Instead of Triggers: Used on views.

Truncate: Options to bypass and ‘delete’ triggers, ‘Drop’ its storage. Fast delete. Useful when deleting tables on a nightly basis for nightly refreshes. Very fast delete.

Skip Locked Data: You can use the SKIP LOCKED DATA option with cursor stability (CS) isolation and read stability (RS) isolation. However, you cannot use SKIP LOCKED DATA with uncommitted read (UR) or repeatable read (RR) isolation levels.

New DB2 V9 SQL Features

Following are some of the new SQL features in DB2 V9:

13) Array host variables now supported for stored procedures
14) Timestamp auto update for inserts and Updates
15) Optimistic locking
16) New DECFLOAT datatype
17) Select from Update or Delete getting old or new values
18) Fetch First, Order BY within subqueries
19) REOPT AUTO (Dynamic SQL)
20) Data Studio for Native Stored Procedures

Optimistic locking: Built in timestamp automatically updated by DB2. Allows for checking that a row has not changed when updating from the last time it was selected.

REOPT Auto: The ideas behind REOPT(AUTO) is to come up with the optimal access path in the minimum number of prepares.

New DB2 V10 SQL Features

Following are some of the new SQL features in DB2 V10:

1) OLAP Moving Sum, Count, and Average
2) Extended Null Indicators
3) New timestamp Precisions
4) Currently Committed Data
5) SQL Pl Enhancements
6) XML Enhancements
7) Row Permissions
8) Column Masking
9) Temporal Tables

DB2 10 Features

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Finally! A book of DB2 SQL tuning tips for developers, specifically designed to improve performance.

DB2 SQL developers now have a handy reference guide with tuning tips to improve performance in queries, programs and applications.

Thank You for allowing us at Themis to share some of our experience and knowledge!

- We hoped that you learned something new today
- We hope that you are a little more inspired to code with performance in mind

"I have noticed that when the developers get educated, good SQL programming standards are in place, and program walkthroughs are executed correctly, incident reporting stays low, CPU costs do not get out of control, and most performance issues are found before promoting code to production."

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