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Lecture 4
SQL 3 – Select, Grouping data

Objectives

More Complex SQL Queries:

- Nesting Of Queries
- Joined Relation
- Exists Function
- Aggregate Functions
- Grouping – Having Clause

- Ref.: Chapter 7

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Set Operations

- SQL has directly incorporated some set operations
- There is a union operation (UNION), and in *some versions* of SQL there are set difference (MINUS) and intersection (INTERSECT) operations
- The resulting relations of these set operations are sets of tuples; *duplicate tuples are eliminated from the result*
- The set operations apply only to *union compatible relations*; the two relations must have the same attributes and the attributes must appear in the same order

Set Operations - Example

- Find number project in Project or in Works_on relation

```
Select Pnumber From Project
Union
Select Pno From works_on;
```

	PNumber
1	1
2	2
3	3
4	5
5	10
6	20
7	30

Union

	PNo
1	1
2	2
3	3
4	10
5	20
6	30

	PNumber
1	1
2	2
3	3
4	5
5	10
6	20
7	30

Set Operations - Example

- Find number project in Project and in Works_on relation

```
Select Pnumber From Project
Intersect
Select Pno From works_on;
```

	PNumber
1	1
2	2
3	3
4	5
5	10
6	20
7	30

Intersect

	PNo
1	1
2	2
3	3
4	10
5	20
6	30

	PNumber
1	1
2	2
3	3
4	10
5	20
6	30

Set Operations - Example

- Find number project in Project but not in Works_on relation

```
Select Pnumber From Project
 Except
Select Pno From works_on;
```

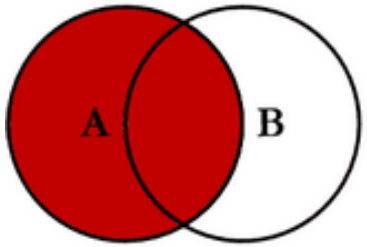
	PNumber
1	1
2	2
3	3
4	5
5	10
6	20
7	30

Except

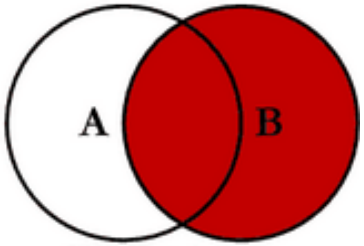
	PNo
1	1
2	2
3	3
4	10
5	20
6	30

	PNumber
1	5

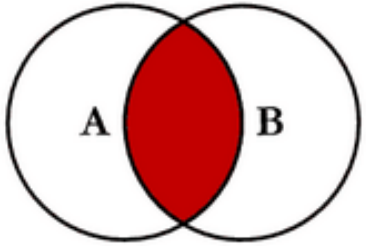
SQL JOINS



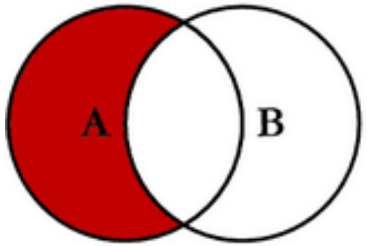

```
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
```



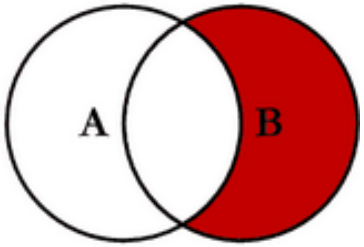

```
SELECT <select_list>
FROM TableA A
RIGHT JOIN TableB B
ON A.Key = B.Key
```



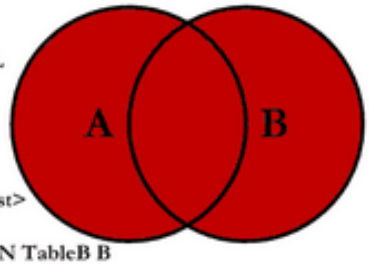

```
SELECT <select_list>
FROM TableA A
INNER JOIN TableB B
ON A.Key = B.Key
```



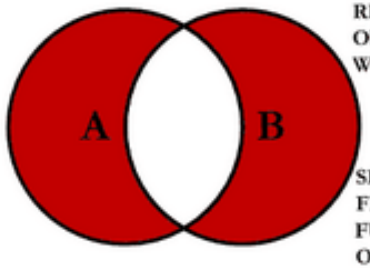

```
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
WHERE B.Key IS NULL
```




```
SELECT <select_list>
FROM TableA A
RIGHT JOIN TableB B
ON A.Key = B.Key
WHERE A.Key IS NULL
```




```
SELECT <select_list>
FROM TableA A
FULL OUTER JOIN TableB B
ON A.Key = B.Key
```




```
SELECT <select_list>
FROM TableA A
FULL OUTER JOIN TableB B
ON A.Key = B.Key
WHERE A.Key IS NULL
OR B.Key IS NULL
```

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Set Operations

- SQL has directly incorporated some set operations
- The resulting relations of these set operations are sets of tuples; *duplicate tuples are eliminated from the result*
- The set operations apply only to *union compatible relations*; the two relations must have the same attributes and the attributes must appear in the same order
- To retain all duplicates use the
  - union all,
  - intersect all
  - except all.

Nesting Of Queries - Subqueries

- A complete SELECT query, called a *nested query*, can be specified within the WHERE-clause of another query, called the *outer query*
  - Many of the previous queries can be specified in an alternative form using nesting

- Retrieve the name and address of all employees who work for the 'Research' department.

```
SELECT  Fname, Lname, Address
   FROM EMPLOYEE
   WHERE Dno IN
              (SELECT Dnumber
                   FROM DEPARTMENT
                   WHERE Dname='Research');
```

```
Select Fname, Lname, Address
       From   Employee E, Department D
       Where  E.Dno = D.Dnumber And D.Dname='Research';
```

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Nesting Of Queries (2)

- The nested query selects the number of the 'Research' department
- The outer query select an EMPLOYEE tuple if its DNO value is in the result of either nested query
- The comparison operator IN compares a value v with a set (or multi-set) of values V, and evaluates to TRUE if v is one of the elements in V
- In general, we can have several levels of nested queries
- A reference to an *unqualified attribute* refers to the relation declared in the *innermost nested query*
- In this example, the nested query is *not correlated* with the outer query

Correlated Nested Queries

- If a condition in the WHERE-clause of a *nested query* references an attribute of a relation declared in the *outer query*, the two queries are said to be *correlated*
  - The result of a correlated nested query is different for each tuple (or combination of tuples) of the relation(s) the outer query
- Retrieve the name of each employee who has a dependent with the same first name as the employee.

```
SELECT E.Fname, E.Lname
    FROM EMPLOYEE AS E
    WHERE E.Ssn IN
          (SELECT Essn
          FROM DEPENDENT
          WHERE Essn = E.Ssn AND E.Fname = Dependent_name);
```

```
SELECT     E.Fname, E.Lname
   FROM    EMPLOYEE E, DEPENDENT D
   WHERE   E.Ssn=D.Essn AND
           E.Fname=D.Dependent_name;
```

Correlated Nested Queries (3)

- The original SQL as specified for SYSTEM R also had a **CONTAINS** comparison operator, which is used in conjunction with nested correlated queries
  - This operator was *dropped from the language*, possibly because of the difficulty in implementing it efficiently
  - Most implementations of SQL do not have this operator
  - The CONTAINS operator compares *two sets of values*, and returns TRUE if one set contains all values in the other set
    - Reminiscent of the division operation of algebra

Correlated Nested Queries (4)

- Retrieve the name of each employee who works on all the projects controlled by department number 5.

```
SELECT Fname, Lname
   FROM EMPLOYEE
   WHERE ((SELECT Pno
                  FROM WORKS_ON
                  WHERE Ssn=Essn)
                  CONTAINS
                       (SELECT Pnumber
                       FROM PROJECT
                       WHERE Dnum=5));
```

Set Comparison – "some/any" Clause

- Find names of employees with salary greater than that of some (at least one) employee in the department 5.

```
Select Distinct E.Fname, E.Lname, E.Salary
    From Employee as E, Employee as E5
    Where E.salary > E5.salary and E5.DNo = 5;
```

- Same query using > **some** clause

```
Select Fname, LName, Salary
    From Employee
    Where salary > Some (Select Salary From Employee
                         Where DNo = 5);
```

	FName	LName	Salary	DNo
1	John	Smith	30000.00	5
2	Franklin	Wong	40000.00	5
3	Joyce	English	25000.00	5
4	Ramesh	Narayan	38000.00	5
5	James	Borg	55000.00	1
6	Jennifer	Wallace	43000.00	4
7	Ahmad	Jabbar	25000.00	4
8	Alicia	Zelaya	25000.00	4

	Fname	LName	Salary
1	John	Smith	30000.00
2	Franklin	Wong	40000.00
3	Ramesh	Narayan	38000.00
4	James	Borg	55000.00
5	Jennifer	Wallace	43000.00

Set Comparison – "all" Clause

- Find the names of all employees whose salary is greater than the salary of all employees in the department 5.

```
Select Fname, LName, Salary
     From Employee
     Where salary >
          All (Select Salary From Employee
                    Where DNo = 5);
```

	FName	LName	Salary	DNo
1	John	Smith	30000.00	5
2	Franklin	Wong	40000.00	5
3	Joyce	English	25000.00	5
4	Ramesh	Narayan	38000.00	5
5	James	Borg	55000.00	1
6	Jennifer	Wallace	43000.00	4
7	Ahmad	Jabbar	25000.00	4
8	Alicia	Zelaya	25000.00	4

	Fname	LName	Salary
1	James	Borg	55000.00
2	Jennifer	Wallace	43000.00

Test for Empty Relations

- The **exists** construct returns the value **true** if the argument subquery is nonempty.
  - **exists** $r \Leftrightarrow r \neq \emptyset$
  - **not exists** $r \Leftrightarrow r = \emptyset$

•Retrieve the name of all employees who work for the 'Research' department.

```
Select Fname, Lname
  From Employee
  Where Exists (Select * From Department
                Where DNo = Dnumber And Dname='Research' );
```

```
Select   Fname, Lname
  From   Employee
  Where  Dno IN
             (Select Dnumber From Department
             Where   Dname='Research' );
```

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- List the names of employees who have a dependent with the same first name and sex as themselves.

```
Select FName, LName
    From Employee E
    Where Exists
        (Select *  From Dependent D
            Where E.SSN = D.ESSN And
            E.FName = D.Dependent_Name And
            E.Sex = D.Sex);
```

```
Select E.FName, E.Lname
    From Employee E, Dependent D
    Where E.SSN = D.ESSN And
        E.FName = D.Dependent_Name And
        E.Sex = D.Sex;
```

Use of "not exists" Clause

- Find all employees who have taken all projects managed in the department 5.

```
Select E.FName, E.Lname
    From employee E
    Where not exists
    ( (select Pnumber from project where DNum = 5)
        except
    (Select W.Pno From works_on W where W.ESSN = E.SSN));
```

  - First nested query lists all projects managed in department 5.
  - Second nested query lists all projects a particular employee works on

- Note
  - $X - Y = \emptyset \Leftrightarrow X \subseteq Y$
  - Cannot write this query using = all and its variants

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- Query: Give name of employees participating in projects managed by department 5.

	SSN	FName	LName
1	123456789	John	Smith
2	333445555	Franklin	Wong
3	453453453	Joyce	English
4	666884444	Ramesh	Narayan
5	888665555	James	Borg
6	987654321	Jennifer	Wallace
7	987987987	Ahmad	Jabbar
8	999887777	Alicia	Zelaya

	PName	PNumber	PLocation	DNum
1	ProductX	1	Bellaire	5
2	ProductY	2	Sugarland	5
3	ProductZ	3	Houston	5
4	Computerization	10	Stafford	4
5	Reorganization	20	Houston	1
6	Newbenefits	30	Stafford	4

	ESSN	PNo	Hours
1	123456789	1	32.5
2	123456789	2	7.5
3	123456789	3	10.0
4	333445555	2	10.0
5	333445555	3	10.0
6	333445555	10	10.0
7	333445555	20	10.0
8	453453453	1	20.0
9	453453453	2	20.0
10	453453453	3	20.0
11	666884444	3	40.0
12	888665555	20	NULL
13	987654321	20	15.0
14	987654321	30	20.0
15	987987987	10	35.0
16	987987987	30	5.0
17	999887777	10	10.0
18	999887777	30	30.0

	FName	LName
1	John	Smith
2	Joyce	English

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- Or:

```
Select A.FName, A.Lname
From employee A
Where Not Exists
      (Select *
      From Works_On B
      Where B.PNo in
            (Select PNumber
            From Project
            where DNum = 5)  And Not Exists
                  (Select *
                  From Works_On C
                  Where A.SSN = C.ESSN And C.PNo =
                        B.PNo));
```

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Joined Relations Feature in SQL2

- Can specify a "joined relation" in the FROM-clause
  - Looks like any other relation but is the result of a join
  - Allows the user to specify different types of joins (regular "theta" JOIN, NATURAL JOIN, LEFT OUTER JOIN, RIGHT OUTER JOIN, CROSS JOIN, etc)

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Joined Relations Feature in SQL2 (2)

- Examples:

```
SELECT E.Fname, E.Lname, S.Fname, S.Lname
 FROM EMPLOYEE E S
 WHERE E.super_ssn=S.ssn;
```

- can be written as:

```
SELECT E.Fname, E.Lname, S.Fname, S.Lname
 FROM EMPLOYEE E LEFT OUTER JOIN  EMPLOYEE S
      ON E.Super_ssn=S.Ssn);
```

Joined Relations Feature in SQL2 (3)

- Examples:

```
SELECT Fname, Lname, Address
  FROM EMPLOYEE, DEPARTMENT
  WHERE Dname='Research' AND Dnumber=Dno;
```

- could be written as:

```
SELECT Fname, Lname, Address
  FROM (EMPLOYEE JOIN DEPARTMENT ON Dnumber=Dno)
  WHERE Dname='Research';
```

- or as:

```
SELECT Fname, Lname, Address
  FROM (EMPLOYEE NATURAL JOIN EPARTMENT
        AS DEPT(Dname, Dno, Mssn,Msdate)
  WHERE Dname='Research';
```

Joined Relations Feature in SQL2 (4)

- Another Example:

  For every project located in 'Stafford', list the project number, the controlling department number, and the department manager's last name, address, and birthdate.

```
SELECT Pnumber, Dnum, Lname, Bdate, Address
    FROM PROJECT, DEPARTMENT, EMPLOYEE
    WHERE Dnum=Dnumber AND Mgr_ssn=Ssn
              AND Plocation='Stafford';
```

Could be written as follows; this illustrates multiple joins in the joined tables

```
SELECT Pnumber, Dnum, Lname, Bdate, Address
   FROM (PROJECT JOIN DEPARTMENT ON
   (Dnum=Dnumber) JOIN EMPLOYEE ON
   (Mgr_ssn=Ssn) )
   WHERE Plocation='Stafford';
```

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Outer Join

- An extension of the join operation that avoids loss of information.
- Computes the join and then adds tuples form one relation that does not match tuples in the other relation to the result of the join.
- Uses *null* values.
- Three forms of outer join:
  - left outer join
  - right outer join
  - full outer join

Outer Join Examples

- Relation Course

	CourseID	CourseName	DNo	Credit
1	CS110	Basic Programming	SC	3
2	CS210	Data Structured	SC	3
3	BA250	Business Management	BA	3

- Relation GradeReport

	CourseID	Grade
1	CS110	B
2	CS210	A
3	BA140	B

- Observe that

  Course information is missing **BA140**

  GradeReport information is missing **BA250**

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- Course **left outer join** GradeReport
  - In relational algebra: Course ⟕ GradeReport
  - In SQL:

```
Select *
From Course C Left Outer Join GradeReport G On
C.CourseID = G.CourseID;
```

	CourseID	CourseName	DNo	Credit	CourseID	Grade
1	CS110	Basic Programming	SC	3	CS110	B
2	CS210	Data Structured	SC	3	CS210	A
3	BA250	Business Management	BA	3	NULL	NULL

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- Course **Right outer join** GradeReport
  - In relational algebra: Course ⟖ GradeReport
  - In SQL:

```
Select *
From Course C Right Outer Join GradeReport G On
C.CourseID = G.CourseID;
```

	CourseID	CourseName	DNo	Credit	CourseID	Grade
1	CS110	Basic Programming	SC	3	CS110	B
2	CS210	Data Structured	SC	3	CS210	A
3	NULL	NULL	NULL	NULL	BA140	B

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- Course **full outer join** GradeReport
  - In relational algebra: Course ⟗ GradeReport
  - In SQL:

```
Select *
     From Course C Full Outer Join GradeReport G
On C.CourseID = G.CourseID;
```

	CourseID	CourseName	DNo	Credit	CourseID	Grade
1	CS110	Basic Programming	SC	3	CS110	B
2	CS210	Data Structured	SC	3	CS210	A
3	BA250	Business Management	BA	3	NULL	NULL
4	NULL	NULL	NULL	NULL	BA140	B

Aggregate Functions

- Include **COUNT, SUM, MAX, MIN, and AVG**

- Find the maximum salary, the minimum salary, the average salary and numbers of employees.

```
SELECT MAX(Salary), MIN(Salary), AVG(Salary), Count(*)
  FROM   EMPLOYEE;
```

	SSN	Salary	DNo
1	123456789	30000.00	5
2	333445555	40000.00	5
3	453453453	25000.00	5
4	666884444	38000.00	5
5	888665555	55000.00	1
6	987654321	43000.00	4
7	987987987	25000.00	4
8	999887777	25000.00	4

	MaxSal	MinSAl	AvgSal	CountEmp
1	55000.00	25000.00	35125.000000	8

- Some SQL implementations *may not allow more than one function* in the SELECT-clause

Aggregate Functions (2)

- Find the maximum salary, the minimum salary, and the average salary among employees who work for the 'Research' department.

```
SELECT MAX(Salary), MIN(Salary), AVG(Salary)
FROM   EMPLOYEE, DEPARTMENT
WHERE  Dno=Dnumber AND Dname='Research';
```

EMPLOYEE

Salary	Super_ssn	Dno
30000	333445555	5
40000	888665555	5
25000	987654321	4
43000	888665555	4
38000	333445555	5
25000	333445555	5
25000	987654321	4
55000	NULL	1

DEPARTMENT

Dname	Dnumber
Research	5
Administration	4
Headquarters	1

Result?

Aggregate Functions (3)

- Retrieve the total number of employees in the company.

```
SELECT COUNT (*)
  FROM EMPLOYEE;
```

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

Result?

Aggregate Functions (3)

- The number of employees in the 'Research' department.

```
SELECT COUNT (*)
   FROM EMPLOYEE, DEPARTMENT
   WHERE Dno=Dnumber AND  Dname='Research';
```

EMPLOYEE

Fname	Minit	Lname	Dno
John	B	Smith	5
Franklin	T	Wong	5
Alicia	J	Zelaya	4
Jennifer	S	Wallace	4
Ramesh	K	Narayan	5
Joyce	A	English	5
Ahmad	V	Jabbar	4
James	E	Borg	1

DEPARTMENT

Dname	Dnumber
Research	5
Administration	4
Headquarters	1

Result?

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Grouping

- In many cases, we want to apply the aggregate functions to *subgroups of tuples* in a relation
- Each subgroup of tuples consists of the set of tuples that have the *same value* for the *grouping attribute(s)*
- The function is applied to each subgroup independently
- SQL has a **GROUP BY**-clause for specifying the grouping attributes, which *must also appear in the SELECT-clause*

Grouping (2)

- For each department, retrieve the department number, the number of employees in the department, and their average salary.

```
SELECT Dno, COUNT(*), Sum(Salary)
   FROM EMPLOYEE
   GROUP BY Dno;
```

Dno	SSN	Salary
5	123456789	30000.00
5	333445555	40000.00
5	453453453	25000.00
5	666884444	38000.00
1	888665555	55000.00
4	987654321	43000.00
4	987987987	25000.00
4	999887777	25000.00

Dno	(No column name)	(No column name)
1	1	55000.00
4	3	93000.00
5	4	133000.00

Grouping (3)

- For each project, retrieve the project number, project name, and the number of employees who work on that project.

```
SELECT Pnumber, Pname, COUNT (*)
   FROM  PROJECT, WORKS_ON
   WHERE Pnumber=Pno
   GROUP BY  Pnumber, Pname;
```

PName	PNumber	PLocation	DNum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

ESSN	PNo	Hours
123456789	1	32.5
123456789	2	7.5
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
453453453	1	20.0
453453453	2	20.0
666884444	3	40.0
888665555	20	NU...
987654321	20	15.0
987654321	30	20.0
987987987	10	35.0
987987987	30	5.0
999887777	10	10.0
999887777	30	30.0

Pnumber	Pname	(No column name)
1	ProductX	2
2	ProductY	3
3	ProductZ	2
10	Computerization	3
20	Reorganization	3
30	Newbenefits	3

The HAVING-clause

- Sometimes we want to retrieve the values of these functions for only those *groups that satisfy certain conditions*

- The **HAVING**-clause is used for specifying a selection condition on groups (rather than on individual tuples)

The HAVING-clause (2)

- For each project *on which more than two employees work*, retrieve the project number, project name, and the number of employees who work on that project.

```
SELECT Pnumber, Pname, COUNT(*)
   FROM PROJECT, WORKS_ON
   WHERE Pnumber=Pno
   GROUP BY Pnumber, Pname
    HAVING COUNT (*) > 2;
```

Pnumber	Pname	(No column name)
1	ProductX	2
2	ProductY	3
3	ProductZ	2
10	Computerization	3
20	Reorganization	3
30	Newbenefits	3

Pnumber	Pname	(No column name)
2	ProductY	3
10	Computerization	3
20	Reorganization	3
30	Newbenefits	3

Summary of SQL Queries

- A query in SQL can consist of up to six clauses, but only the first two, SELECT and FROM, are mandatory. The clauses are specified in the following order:

```
SELECT      <attribute list>
   FROM     <table list>
   [WHERE   <condition>]
       [GROUP BY <grouping attribute(s)>
       [HAVING <group condition>]]
   [ORDER BY  <attribute list>];
```

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Summary of SQL Queries (2)

- The SELECT-clause lists the attributes or functions to be retrieved
- The FROM-clause specifies all relations (or aliases) needed in the query but not those needed in nested queries

- The WHERE-clause specifies the conditions for selection and join of tuples from the relations specified in the FROM-clause
- GROUP BY specifies grouping attributes
- HAVING specifies a condition for selection of groups

- ORDER BY specifies an order for displaying the result of a query
  - A query is evaluated by first applying the WHERE-clause, then GROUP BY and HAVING, and finally the SELECT-clause

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Views in SQL

- A view is a “virtual” table that is derived from other tables
- Allows for limited update operations
  - Since the table may not physically be stored
- Allows full query operations
- A convenience for expressing certain operations

Specification of Views

- SQL command: **`CREATE VIEW`**
  - a table (view) name
  - a possible list of attribute names (for example, when arithmetic operations are specified or when we want the names to be different from the attributes in the base relations)
  - a query to specify the table contents

SQL Views: An Example

- Specify a different WORKS_ON table

```
CREATE VIEW v_WORKSON AS
SELECT Fname, Lname, Pname, Hours
    FROM EMPLOYEE, PROJECT, WORKS_ON
    WHERE Ssn=Essn AND Pno=Pnumber;
```

- Using a Virtual Table
  - We can specify SQL queries on a newly create table (view):

```
SELECT Fname, Lname
        FROM v_WORKSON
        WHERE Pname='Seena';
```

Drop view

- When no longer needed, a view can be dropped:

```
DROP v_WORKSON;
```

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Efficient View Implementation

- Query modification:
  - Present the view query in terms of a query on the underlying base tables
- Disadvantage:
  - Inefficient for views defined via complex queries
    - Especially if additional queries are to be applied to the view within a short time period

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Efficient View Implementation

- View materialization:
  - Involves physically creating and keeping a temporary table
- Assumption:
  - Other queries on the view will follow
- Concerns:
  - Maintaining correspondence between the base table and the view when the base table is updated
- Strategy:
  - Incremental update

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Update Views

- Update on a single view without aggregate operations:
  - Update may map to an update on the underlying base table
- Views involving joins:
  - An update *may* map to an update on the underlying base relations
    - Not always possible

Un-updatable Views

- Views defined using groups and aggregate functions are not updateable
- Views defined on multiple tables using joins are generally not updateable
- **`WITH CHECK OPTION`**: must be added to the definition of a view if the view is to be updated
  - To allow check for updatability and to plan for an execution strategy

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