

Database System

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3.3 Data Query Statements

3.3.1 Select statement

- **SELECT** [DISTINCT | ALL]
- { * | [columnExpression [AS newName]] [,...] }
- **FROM** TableName [alias] [, ...]
- [**WHERE** condition]
- [**GROUP BY** columnList]
- [**HAVING** condition]
- [**ORDER BY** columnList]

SELECT Statement

FROM Specifies table(s) to be used.

WHERE Filters rows.

GROUP BY Forms groups of rows with same column value.

HAVING Filters groups subject to some condition.

SELECT Specifies which columns are to appear in output.

ORDER BY Specifies the order of the output.

SELECT Statement

- **Order** of the clauses **cannot** be **changed**.
- Only **SELECT** and **FROM** are **mandatory**.

Case

Estates Agency-Dream of Home

- ◆ **Branch** (branchNo, street, city, postcode)
- ◆ **Staff** (staffNo, fName, lName, position, sex, DOB, salary, branchNo)
- ◆ **Property** (propertyNo, street, city, postcode, type, rooms, rent, ownerNo, staffNo, branchNo)
- ◆ **Client** (clientNo, fName, lName, telNo, prefType, maxRent)
- ◆ **PrivateOwner** (ownerNo, fName, lName, address, telNo)
- ◆ **Viewing** (clientNo, propertyNo, viewDate, comment)

CASE

Estates Agency-Dream of Home

Branch	branchNo	street	city	postcode
--------	----------	--------	------	----------

Staff	staffNo	fName	lName	position	sex	DOB	salary	branchNo
-------	---------	-------	-------	----------	-----	-----	--------	----------

Client	clientNo	fname	lname	preferType	rent	tel	addr
--------	----------	-------	-------	------------	------	-----	------

Property	propertyNo	Street	city	ownerNo	Type	rent	room	staffNo
----------	------------	--------	------	---------	------	------	------	---------

Owner	ownerNo	fname	lname	tel	addr	sex
-------	---------	-------	-------	-----	------	-----

Viewing	propertyNo	clientNo	staffNo	viewDate	comment
---------	------------	----------	---------	----------	---------

Lease	LeaseNo	ownerNo	clientNo	propertyNo	staffNo	Payment	rent
-------	---------	---------	----------	------------	---------	---------	------

Attributes

Branch

Relation

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

Cardinality

Degree

Primary key

Foreign key

Staff

Relation

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

Example 3.8 All Columns, All Rows

List full details of all staff.

```
SELECT staffNo, fName, lName, position,  
       sex, DOB, salary, branchNo  
FROM Staff;
```

- Can use * as an abbreviation for 'all columns':

```
SELECT *  
FROM Staff;
```

Example All Columns, All Rows

Table 5.1 Result table for Example 5.1.

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000.00	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000.00	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000.00	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000.00	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000.00	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000.00	B005

Example 3.9 Specific Columns, All Rows

检索指定的列或属性

Produce a list of **salaries** for all staff, showing only the **staff number**, **first** and **last names**, and **salary**.

SELECT staffNo, fName, lName, salary

FROM Staff;

Result table

staffNo	fName	lName	salary
SL21	John	White	30000.00
SG37	Ann	Beech	12000.00
SG14	David	Ford	18000.00
SA9	Mary	Howe	9000.00
SG5	Susan	Brand	24000.00
SL41	Julie	Lee	9000.00

Example 3.10 Not Use of **DISTINCT**

It can be used to eliminate the duplicates.

e.g. List the property numbers of all properties that have been viewed.

**SELECT propertyNo
FROM Viewing;**

propertyNo
PA14
PG4
PG4
PA14
PG36

Example 3.11 Use of **DISTINCT**

- Use **DISTINCT** to eliminate duplicates:

SELECT DISTINCT propertyNo
FROM Viewing;

propertyNo
PA14
PG4
PG36

若select 后面有多个列:

select **distinct sno, cno** from sc
= distinct (sno,cno)

select **cno, distinct sno** from sc ?

关键字 'distinct' 附近有语法错误。

Example 3.12 Calculated Fields

Produce a list of monthly salaries for all staff, showing staff number, first and last names, and salary details.

```
SELECT staffNo, fName, lName, salary/12  
FROM Staff;
```

+, -, *, /, aggregate functions can be used in SELECT clause.

staffNo	fName	lName	col4
SL21	John	White	2500.00
SG37	Ann	Beech	1000.00
SG14	David	Ford	1500.00
SA9	Mary	Howe	750.00
SG5	Susan	Brand	2000.00
SL41	Julie	Lee	750.00

“虚”列

Example 3.12 Calculated Fields

- To name column, use AS clause:

```
SELECT staffNo, fName, lName,  
        salary/12 AS monthlySalary  
FROM Staff;
```

staffNo	fName	lName	monthlySalary
SL21	John	White	2500.00
SG37	Ann	Beech	1000.00
SG14	David	Ford	1500.00
SA9	Mary	Howe	750.00
SG5	Susan	Brand	2000.00
SL41	Julie	Lee	750.00

Row selection (WHERE clause)

	Predicates(谓词)	Function (功能)	Notes (说明)
1	=,<>(!=),<,<=,>,>=	Comparison search	
	AND, OR, NOT	Compound Comparison search (复合比较查询)	From left to right, NOT>AND>OR () has the highest priority
2	BETWEEN...AND; NOT BETWEEN...AND	Range test (范围查找)	includes the endpoints; Not include the endpoints
3	IN, NOT IN	Set membership	
4	LIKE, NOT LIKE	Pattern match	
5	NULL, IS NULL	NULL test	IS cannot be replaced by '='

Example 3.13 Comparison Search Condition

List all staff with a salary greater than 10,000.

```
SELECT staffNo, fName, lName, position, salary
FROM Staff
WHERE salary > 10000;
```

staffNo	fName	lName	position	salary
SL21	John	White	Manager	30000.00
SG37	Ann	Beech	Assistant	12000.00
SG14	David	Ford	Supervisor	18000.00
SG5	Susan	Brand	Manager	24000.00

Example 3.13

Compound Comparison Search Condition

List addresses of all branch offices in London or Glasgow.

SELECT *

FROM Branch

WHERE city = 'London' OR city = 'Glasgow';

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B003	163 Main St	Glasgow	G11 9QX
B002	56 Clover Dr	London	NW10 6EU

Example 3.14 **Range** Search Condition

List all staff with a salary between 20,000 and 30,000.

```
SELECT staffNo, fName, lName, position, salary  
FROM Staff  
WHERE salary BETWEEN 20000 AND 30000;
```

- **BETWEEN** test includes the endpoints of range.

staffNo	fName	lName	position	salary
SL21	John	White	Manager	30000.00
SG5	Susan	Brand	Manager	24000.00

Example 3.14 **Range** Search Condition

- **BETWEEN** does not add much to SQL's expressive power. Could also write:

```
SELECT staffNo, fName, lName, position, salary  
FROM Staff  
WHERE salary >= 20000 AND salary <= 30000;
```

- Useful, though, for a range of values.

Example 3.14 **Range** Search Condition

- Also a negated version **NOT BETWEEN**.
SELECT staffNo, fName, lName, position, salary
FROM Staff
WHERE salary **NOT BETWEEN** 20000 **AND** 30000;
- **NOT BETWEEN** also does not add much to SQL's expressive power. Could also write:
SELECT staffNo, fName, lName, position, salary
FROM Staff
WHERE salary < 20000 **OR** salary > 30000;
- **NOT BETWEEN** test does not include the endpoints of range.

Example 3.15 Set Membership

List all managers and supervisors.

```
SELECT staffNo, fName, lName, position  
FROM Staff  
WHERE position IN ('Manager', 'Supervisor');
```

staffNo	fName	lName	position
SL21	John	White	Manager
SG14	David	Ford	Supervisor
SG5	Susan	Brand	Manager

Example 3.15 Set Membership

- **IN** does not add much to SQL's expressive power.
- Could have expressed this as:

```
SELECT staffNo, fName, IName, position
FROM Staff
WHERE position='Manager' OR
       position='Supervisor';
```

- **IN** is more efficient when a set contains many values.

Example 3.15 Set Membership

- There is a negated version (**NOT IN**).

```
SELECT staffNo, fName, IName, position
FROM Staff
WHERE position NOT IN
      ('Manager', 'Supervisor');
```

- **NOT IN** also does not add much to SQL's expressive power. Could have expressed this as:

```
SELECT staffNo, fName, IName, position
FROM Staff
WHERE position<>'Manager' AND
      position<>'Supervisor';
```


Example 3.16 Pattern Matching

Find all owners with the string 'Glasgow' in their address.

```
SELECT ownerNo, fName, lName, address, telNo
FROM PrivateOwner
WHERE address LIKE '%Glasgow%';
```

ownerNo	fName	lName	address	telNo
CO87	Carol	Farrel	6 Achray St, Glasgow G32 9DX	0141-357-7419
CO40	Tina	Murphy	63 Well St, Glasgow G42	0141-943-1728
CO93	Tony	Shaw	12 Park Pl, Glasgow G4 0QR	0141-225-7025

Example 3.16 Pattern Matching

◆ SQL has two special **pattern matching symbols**:

- **%**: sequence of **zero** or more characters;
- **_** (underscore): any single character.

◆ **LIKE** '%Glasgow%' means a sequence of characters of any length containing '*Glasgow*'.

Example 3.16 Pattern Matching

- **Sno LIKE '20131678'**

i.e. Sno = '20131678'

If no Pattern-Matching symbol (% , _) :

- **Sno NOT LIKE '20131678'**

i.e. Sno <> '20131678'

Example 3.16 Pattern Matching

```
SELECT Sname, Sno, Ssex  
FROM Student  
WHERE Sname LIKE '王%'; (姓王的)
```

```
SELECT Sname  
FROM Student  
WHERE Sname LIKE '夏侯__';  
(two underscores, 三个汉字)
```

Example 3.16 Pattern Matching

```
SELECT Sname, Sno  
FROM Student  
WHERE Sname LIKE ‘__丽%’; (第2个字为“丽“)
```

```
SELECT Sname  
FROM Student  
WHERE Sname NOT LIKE ‘王%’; (不姓王)
```

Example 3.16 Pattern Matching

◆ Cname LIKE 'DB_Design' **ESCAPE '\'**



“_” itself

◆ Search for the course named 'DB_Design'
查找课程名为“DB_Design”的课程

```
SELECT  Cno, credit  
FROM    C  
WHERE   Cname LIKE 'DB\_Design' ESCAPE '\';
```

```
select * from c  
where cname like 'DB! _%' ESCAPE '!' , OK!
```

在**SQL Server** 中，单引号里 “大小写不敏感”。

Example 3.16 Pattern Matching

- **LIKE '15\%' ESCAPE '\'** i.e. **= '15%'**
 - Search for the course whose name begins with “DB” and the last letter but two is “**i**”.
- 查找以“**DB_**”开头，且倒数第**3**个字符为**i**的课程的具体情况。

SELECT *

FROM C

WHERE Cname LIKE 'DB__%i__' ESCAPE '\';

Lecture 6

Example 3.17 **NULL** Search Condition

List details of all viewings on property PG4 where a comment has not been supplied.

- There are 2 viewings for property PG4, one with and one without a comment.
- Have to test for null explicitly using special keyword **IS NULL**:

```
SELECT  clientNo, viewDate  
FROM    Viewing  
WHERE   propertyNo = 'PG4'  
        AND comment IS NULL;
```

Example 3.17 **NULL** Search Condition

clientNo	viewDate
CR56	26-May-01

- Negated version (IS **NOT NULL**) can test for non-null values.
- **IS** can not be replaced by “=”

Example 3.18 Single Column **Ordering**

- ◆ **ORDER BY** can make the result sort according to one or more columns.
- ◆ Ascending (**ASC, default**) or descending (**DESC**)
- ◆ When sorting, the order of **null** value is determined by the chosen **DBMS**.

List the salaries for all staff, arranged in descending order of salary.

```
SELECT staffNo, fName, lName, salary  
FROM Staff  
ORDER BY salary DESC;
```

Example 3.18 Single Column Ordering

```
SELECT staffNo, fName, lName, salary  
FROM Staff  
ORDER BY salary DESC;
```

staffNo	fName	lName	salary
SL21	John	White	30000.00
SG5	Susan	Brand	24000.00
SG14	David	Ford	18000.00
SG37	Ann	Beech	12000.00
SA9	Mary	Howe	9000.00
SL41	Julie	Lee	9000.00

Example 3.19 Multiple Column **Ordering**

Produce abbreviated list (简 表) of properties in order of **property type**.

```
SELECT propertyNo, type, rooms, rent  
FROM Property  
ORDER BY type;
```

Example 3.19 Multiple Column Ordering

Result table with only one Sort key “type”

propertyNo	type	rooms	rent
PL94	Flat	4	400
PG4	Flat	3	350
PG36	Flat	3	375
PG16	Flat	4	450
PA14	House	6	650
PG21	House	5	600

Note: Four flats in this list - as no minor sort key specified, system arranges these rows in any order it chooses.

Example 3.19 Multiple Column Ordering

To arrange in order of rent, specify **minor order**:

```
SELECT propertyNo, type, rooms, rent  
FROM Property  
ORDER BY type, rent DESC;
```

Result table with two Sort keys “**type**” & “**rent**”

propertyNo	type	rooms	rent
PG16	Flat	4	450
PL94	Flat	4	400
PG36	Flat	3	375
PG4	Flat	3	350
PA14	House	6	650
PG21	House	5	600

SELECT Statement - Aggregates

- **ISO standard defines five aggregate functions:**

COUNT returns the number of values in a specified column.

SUM returns the sum of values in a specified column.

AVG returns the average of values in a specified column.

MIN returns the smallest value in a specified column.

MAX returns the largest value in a specified column.

SELECT Statement - Aggregates

- Each operates on a single column of a table and returns a single value.
- **COUNT**, **MIN**, and **MAX** apply to **numeric** and **non-numeric** fields, but **SUM** and **AVG** may be used on **numeric** fields only.
- Can use **DISTINCT** before column name to eliminate duplicates.
- **DISTINCT** has no effect with **MIN/MAX**, but may have with **SUM/AVG**.

SELECT Statement - Aggregates

- Apart from **COUNT(*)**, each function eliminates **nulls** first and operates only on remaining **non-null** values.
- **COUNT(*)** counts all rows of a table, regardless of whether **nulls or duplicate values** occur.

SELECT Statement - Aggregates

- Examples of COUNT

sno	sname	age
s1	ss1	18
s2	ss2	17
s3	ss3	null
s4	ss4	18

Select COUNT(age) as num_age
from s

col1	num_age
4	4

Select Count (*)
from s

col1	col1
3	4

Select COUNT(sname)
from s

col1
4

SELECT Statement - Aggregates

- Examples of AVG (sum)

sno	sname	age
s1	ss1	19
s2	ss2	17
s3	ss3	null
s4	ss4	18

Select AVG(age) as avg_age
from s

col1	avg_age	col1
17	17	18

AVG (age)=17.75 → floor(17.75) =17

Select AVG(sno)
from s

Wrong!

Select AVG(distinct age)
from s

col1
18

SELECT Statement - Aggregates

- Examples of MIN (MAX)

sno	sname	age
s1	ss1	18
s2	ss2	17
s3	ss3	null
s4	ss4	18

Select MIN(age)
from s

as min_age

col1
17

min_age
17

Select MIN(sno)
from s

col1
s1

Select MIN(distinct age)
from s

col1
17

DISTINCT has no effect with MIN/MAX

SELECT Statement - Aggregates

- **Aggregate** functions can be used only in **SELECT** list and in **HAVING** clause.
- **Aggregate** functions cannot be used in **WHERE** clause.
- The following sentence is wrong!

```
SELECT Sno, AVG(Grade)  
FROM SC  
WHERE AVG(Grade)>=90
```

SELECT Statement - Aggregates

- If **SELECT** list includes an aggregate function and there is no **GROUP BY** clause, **SELECT** list cannot reference a column out of an aggregate function. For example, the following is illegal:

```
SELECT staffNo, COUNT(salary)  
FROM Staff;
```

SELECT Statement - Aggregates

```
SELECT staffNo, COUNT(salary)
FROM Staff;
```

staff

staffNo	...	salary
s1		8000
s2		6500
s3		5670
s4		9200

Result table

staffNo	col1
s1	4
s2	4
s3	4
s4	4

Such table has no semantic meaning!

Example 3.20 Use of COUNT(*)

How many properties cost more than £350 per month to rent?

```
SELECT COUNT(*) AS count1  
FROM Property  
WHERE rent > 350;
```

propertyNo	type	rooms	rent
PL94	Flat	4	400
PG4	Flat	3	350
PG36	Flat	3	375
PG16	Flat	4	450
PA14	House	6	650
PG21	House	5	600

count1
5

Example 3.21 Use of COUNT (DISTINCT)

How many different properties viewed in May '19 (2019)?

```
SELECT COUNT (DISTINCT propertyNo)
      AS count1
FROM Viewing
WHERE viewDate BETWEEN '1-May-2019'
      AND '31-May-2019' ;
```

count1
2

Example 3.22 Use of COUNT and SUM

Find the number of Managers and the sum of their salaries.

```
SELECT COUNT(staffNo) AS mycount,  
        SUM(salary) AS mysum  
FROM Staff  
WHERE position = 'Manager';
```

mycount	mysm
2	54000.00

Example 3.23 Use of MIN, MAX, AVG

Find the minimum, the maximum, and the average staff salary.

```
SELECT MIN(salary) AS mymin,  
       MAX(salary) AS mymax,  
       AVG(salary) AS myavg  
FROM Staff;
```

mymin	mymax	myavg
9000.00	30000.00	17000.00

SELECT Statement – Grouping

- ◆ Use **GROUP BY** clause to get sub-totals.
- ◆ **SELECT** and **GROUP BY** closely integrated: each item in **SELECT** list must be *single-valued per group*, and **SELECT** clause may only contain:
 - **column names**
 - **aggregate functions**
 - **constants**
 - **expression involving combinations of the above.**

SELECT Statement - Grouping

- ◆ All column names in SELECT list must appear in GROUP BY clause unless the name is used only in an aggregate function.

```
select c.cno, cname, avg(grade)
from sc, course c
where sc.cno=c.cno
group by c.cno
```

Column 'course.cname' is invalid in the select list because it is not contained in either an aggregate function or the GROUP BY clause.

SELECT Statement - Grouping

- ◆ If WHERE is used with GROUP BY, **WHERE is applied first**, then groups are formed from the remaining rows satisfying predicate.
- ◆ ISO considers **two nulls to be equal** for purposes of GROUP BY.

Example 3.24 Use of GROUP BY

Find the number of staff in each branch and their total salaries.

staffNo	name	salary	branchNo	....
s1	John	14000	B003	
s2	Jane	15000	B003	
s3	Lily	28000	B005	
s4	Mary	25000	B003	
s5	Holy	11000	B005	
s6	Kane	9000	B007	

Example 3.24 Use of GROUP BY

staffNo	name	salary	branchNo	....
s1	John	14000	B003	
s2	Jane	15000	B003	
s3	Lily	28000	B005	
s4	Mary	25000	B003	
s5	Holy	11000	B005	
s6	Kane	9000	B007	

Result table for Example 3.24

branchNo	count1	sum1
B003	3	54000.00
B005	2	39000.00
B007	1	9000.00

```
SELECT  branchNo,  
        COUNT(staffNo) AS count1,  
        SUM(salary) AS sum1  
FROM Staff  
GROUP BY branchNo  
ORDER BY branchNo;
```

Restricted Groupings – **HAVING** clause

- ◆ **HAVING** clause is designed for use with **GROUP BY** to restrict groups that appear in final result table.
- ◆ Similar to **WHERE**, but **WHERE** filters individual **rows** whereas **HAVING** filters **groups**.
- ◆ Column names in **HAVING** clause must also appear in the **GROUP BY** list or be contained within an aggregate function.

Example 3.25 Use of HAVING

For each branch with **more than 1** member of staff, find the number of staff in each branch and sum of their salaries.

staffNo	name	salary	branchNo	....
s1	John	14000	B003	
s2	Jane	15000	B003	
s3	Lily	28000	B005	
s4	Mary	25000	B003	
s5	Holy	11000	B005	
s6	Kane	9000	B007	

Result table for Example 3.25

branchNo	count1	sum1
B003	3	54000.00
B005	2	39000.00

Example 3.25 Use of HAVING

staffNo	name	salary	branchNo	....
s1	John	14000	B003	
s2	Jane	15000	B003	
s3	Lily	28000	B005	
s4	Mary	25000	B003	
s5	Holy	11000	B005	
s6	Kane	9000	B007	

```

SELECT branchNo,
       COUNT(staffNo) AS count1,
       SUM(salary) AS sum1
FROM Staff
GROUP BY branchNo
HAVING COUNT(staffNo) > 1
ORDER BY branchNo;
    
```

HAVING COUNT1 > 1 ? No !

branchNo	count1	sum1
B003	3	54000.00
B005	2	39000.00
B007	1	9000.00

Result table for Example 3.25

branchNo	count1	sum1
B003	3	54000.00
B005	2	39000.00

3.3.2 Subqueries

- ◆ Some SQL statements can have a **search block** of 'SELECT-FROM-WHERE' **embedded** within them.
- ◆ A **subselect** can be used in **WHERE** and **HAVING** clauses of an outer **SELECT**, where it is called a **subquery** or **nested query**(子查询或嵌套查询).
- ◆ Subselects may also appear in **INSERT**, **UPDATE**, and **DELETE** statements.

Example 3.26 Subquery with **Equality**

List staff who work in branch at '163 Main St'.

Outer SELECT

```
SELECT staffNo, fName, lName, position  
FROM Staff  
WHERE branchNo = use IN?
```

```
( SELECT branchNo  
  FROM Branch  
  WHERE street = '163 Main St');
```

Inner SELECT

Example 3.26 Subquery with Equality

- ◆ **Inner SELECT** finds branch number for branch at '163 Main St' ('B003').
- ◆ **Outer SELECT** then retrieves details of all staff who work at this branch.
- ◆ **Outer SELECT** then becomes:

```
SELECT staffNo, fName, lName, position  
FROM Staff  
WHERE branchNo = 'B003';
```

Example 3.26 Subquery with Equality

Result table for Example 3.26

staffNo	fName	lName	position
SG37	Ann	Beech	Assistant
SG14	David	Ford	Supervisor
SG5	Susan	Brand	Manager

Example 3.27 Subquery with Aggregate

List all staff whose salary is greater than the average salary, and show by how much.

```
SELECT staffNo, fName, lName, position,  
       salary – (SELECT AVG(salary) FROM Staff) As SalDiff  
FROM Staff  
WHERE salary > ( SELECT AVG(salary) FROM Staff );
```

staffNo	fName	lName	position	salDiff
SL21	John	White	Manager	13000.00
SG14	David	Ford	Supervisor	1000.00
SG5	Susan	Brand	Manager	7000.00

Example 3.27 Subquery with Aggregate

- ◆ **Cannot write 'WHERE salary > AVG(salary)'**
- ◆ **Instead, use subquery to find the average salary (17000), and then use outer SELECT to find those staff with salary greater than this:**

```
SELECT staffNo, fName, lName, position,  
        salary – 17000 As salDiff  
FROM Staff  
WHERE salary > 17000;
```

```
SELECT AVG(salary)  
FROM Staff
```

Example 3.27 Subquery with Aggregate

```
SELECT staffNo, fName, lName, position,  
       salary – AVG(salary) As SalDiff  
FROM Staff  
WHERE salary > AVG(salary)
```

Wrong!

Subquery Rules

- ◆ ORDER BY clause may not be used in a subquery (although it may be used in **outermost** SELECT).
- ◆ Subquery SELECT list must consist of a **single column name** or expression, except for subqueries that use EXISTS.
- ◆ By default, column names refer to table name in FROM clause of the **same level** subquery. It can refer to a table in FROM using an *alias*.
- ◆ When subquery is an operand in a comparison, subquery must appear on **right-hand** side.

Alias

If you specify an *alias* for a table in FROM clause, you must use it, not its original name.

```
select sno, cname, grade  
from sc, course c  
where sc.cno = c.cno
```

Correct !

```
select sno, cname, grade  
from sc, course c  
where sc.cno = course.cno
```

wrong !

无法绑定由多个部分组成的标识符 "course.cno"。

Example 3.28 Nested subquery: use of **IN**

List the properties handled by the staff at '163 Main St'.

```
SELECT propertyNo, street, city, postcode, type, rooms, rent
FROM Property
WHERE staffNo IN
  (SELECT staffNo
   FROM Staff
   WHERE branchNo =
     (SELECT branchNo
      FROM Branch
      WHERE street = '163 Main St'));
```

propertyNo	street	city	postcode	type	rooms	rent
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375
PG21	18 Dale Rd	Glasgow	G12	House	5	600

Lecture 7

ALL and ANY

universal quantifier & existing quantifier

- ◆ ANY and ALL may be used with subqueries that produce a single column, **not** ' * ' .
- ◆ With **ALL**, condition will only be **true** if it is satisfied by **all** values produced by subquery.
- ◆ With **ANY**, condition will be **true** if it is satisfied by **any** values produced by subquery.
- ◆ If subquery is **empty**, **ALL** returns **true**, **ANY** returns **false**.
- ◆ **SOME** may be used in place of **ANY** in ISO standard.

ANY/SOME and ALL

	=	<> or !=	<	<=	>	>=
ANY/ SOME	IN	Meaning- less	<MAX	<=MAX	>MIN	>=MIN
ALL	Meaning- less	NOT IN	<MIN	<=MIN	>MAX	>=MAX

★ <>all ≡ not in

★ =some ≡ in

★ =all、 <>some **meaningless**

IF A=10

A<>all (12,10,34) F **A<>all (12,16,34) T**

A=all (12,10,34) meaningless

A>=all (12,10,34) F **A<=all (12,10,34) T**

A=any (12,10,34) T **A<any (8,16,34) T**

A>any (6,16,34) T **A=any (6,16,34) F**

A<>any (12,16,34) meaningless

Example 3.29 Use of **ANY/SOME**

Find the staff whose salary is larger than the salary of at least one member of staff at branch B003.

```
SELECT staffNo, fName, lName, position, salary
FROM Staff
WHERE salary > SOME
    (SELECT salary FROM Staff
     WHERE branchNo = 'B003');
```

```
SELECT staffNo, fName, lName, position, salary
FROM Staff
WHERE salary > ( SELECT min (salary)
                  FROM Staff
                  WHERE branchNo = 'B003');
```

Example 3.29 Use of **ANY/SOME**

- ◆ Inner query :
SELECT salary FROM Staff
WHERE branchNo = 'B003';
- ◆ produces set {**12000**, **18000**, **24000**} and outer query selects those staff whose salaries are greater than any of the values in this set.

The Result Set

staffNo	fName	lName	position	salary
SL21	John	White	Manager	30000.00
SG14	David	Ford	Supervisor	18000.00
SG5	Susan	Brand	Manager	24000.00

Example 3.30 Use of ALL

Find the staff whose salary is larger than salary of every member of staff at branch B003.

```
SELECT staffNo, fName, lName, position, salary  
FROM Staff
```

```
WHERE salary > ALL
```

```
(SELECT salary  
FROM Staff
```

```
WHERE branchNo = 'B003');
```

{12000, 18000, 24000}

```
SELECT staffNo, fName, lName, position, salary  
FROM Staff
```

```
WHERE salary > (SELECT max (salary)
```

```
FROM Staff
```

```
WHERE branchNo = 'B003');
```

staffNo	fName	lName	position	salary
SL21	John	White	Manager	30000.00

```
select * from sc
```

```
where sno > all ( select sno
```

**Not a numeric value,
Is it correct?**

```
from sc
```

```
group by sno
```

```
having count(cno)>3)
```

Result of subquery

	sno
1	08300010
2	08300012
3	08300015
4	08300020
5	08300030
6	08300050

Result of the above query

	sno	cno	grade	year
1	08300067	802	82	2015
2	08300067	803	76	2015
3	08300067	804	90	2016
4	08300075	803	79	2015
5	08300075	806	68	2016

Non-Correlation subquery

不相关子查询

It has the following features:

1. The non-Correlation subquery can be executed **independently**.
2. The **innermost** subquery is executed **first**, and then its outer query is executed until going to the **outermost** query one by one level.

3.3.3 Multi-Table Queries

- ◆ A major limitation of all previous examples is that the **columns** of the result table must all come **from a single table**.
- ◆ If we need to obtain **information** from more than one table, we can use **subquery** or use a **join**.
- ◆ If the **result columns** come from more than one table, we must use a **join**.

3.3.3 Multi-Table Queries

- ◆ To perform join, include **more than one table** in FROM clause, using **comma** as separator, and typically including a WHERE clause to **specify join column(s)** of **join conditions**.
- ◆ Also possible to use an **alias** for a table named in FROM clause.
- ◆ **Alias** is separated from table name with a **space or 'as'**.
- ◆ Alias can be used to qualify column names when there is ambiguity (歧义).

Alias

If you specify an *alias* for a table in FROM clause, you must use it, not its original name.

```
select sno, cname, grade  
from sc, course c  
where sc.cno = c.cno
```

Correct!

```
select sno, cname, grade  
from sc, course c  
where sc.cno = course.cno
```

wrong!

无法绑定由多个部分组成的标识符
"course.cno"。

Unable to bind the identifier made of multiple parts

Example 3.31 Simple Join

List the names of all clients who have viewed a property along with any comment supplied.

```
SELECT c.clientNo, fName, lName,  
       propertyNo, comment  
FROM Client c, Viewing v  
WHERE c.clientNo = v.clientNo;
```

Example 3.31 Simple Join

```
SELECT c.clientNo, fName, lName, propertyNo, comment
FROM Client c, Viewing v
WHERE c.clientNo = v.clientNo;
```

Client

clientNo	fName	lName	.....
c1	cc1	ccc1	
c2	cc2	ccc2	
c3	cc3	ccc3	
c4	cc4	ccc4	
c5	cc5	ccc5	

Viewing

pNo	clientNo	staffNo	comment	...
p1	c1	s1	good	...
p3	c2	s1	Not bad	
p5	c1	s1	OK	
p2	c3	s2		
p4	c2	s2	OK	
p6	c2	s3		
p9	c1	s4	Very good	
p7	c3	s4		
p8				

Example 3.31 Simple Join

Joined Table

Result table for Example 3.31

clientNo	fName	lName	pno	comment
c1	cc1	ccc1	p1	good
c2	cc2	ccc2	p3	Not bad
c1	cc1	ccc1	p5	OK
c3	cc3	ccc3	p2	
c2	cc2	ccc2	p4	OK
c2	cc2	ccc2	p6	
c1	cc1	ccc1	p9	Very good
c3	cc3	ccc3	p7	

Example 3.32 Sorting a join

排序连接结果

For each branch, list the **numbers** and **names** of staff who manage properties, and the **properties** they manage.

```
SELECT s.branchNo, s.staffNo, fName,  
       lName, propertyNo  
FROM Staff s, Property p  
WHERE s.staffNo = p.staffNo  
ORDER BY s.branchNo, s.staffNo, propertyNo;
```

Major sort key

Minor sort key

Minor sort key

Example 3.32 Sorting a join

Result table for Example 3.32

branchNo	staffNo	fName	lName	propertyNo
B003	SG14	David	Ford	PG16
B003	SG37	Ann	Beech	PG21
B003	SG37	Ann	Beech	PG36
B005	SL41	Julie	Lee	PL94
B007	SA9	Mary	Howe	PA14

ORDER BY s.branchNo, s.staffNo, propertyNo

Example 3.33 Three-Table Join

For each branch, list **staff** who manage properties, including **city** in which branch is located and **properties** they manage.

```
SELECT b.branchNo, b.city, s.staffNo, fName,  
       lName, propertyNo  
FROM Branch b, Staff s, Property p  
WHERE b.branchNo = s.branchNo  
      AND s.staffNo = p.staffNo  
ORDER BY b.branchNo, s.staffNo, propertyNo;
```


Example 3.33 Three-Table Join

Branch

branchNo	Street	City	Postcode
b1	Rd11	London	...
b2	St20	Glasgow	...
b3	Rd 234	Glasgow	...
b4	St33	Bristol	...

Staff

staffNo	branchNo	.....
s1	b1	
s2	b1	
s3	b2	
s4	b3	
s5	b4	

Property

pno	staffNo	.....
p1	s1	
p3	s1	
p5	s1	
p2	s2	
p4	s2	
p6	s3	
p7	s4	
p9	s4	
p8		

b.branchNo = s.branchNo

AND s.staffNo = p.staffNo

Example 3.33 Three-Table Join

Joined table

Result table for Example 3.33

branchNo	City	staffNo	name	pno
b1	London	s1	Ann	p1
b1	London	s1	Ann	p3
b1	London	s1	Ann	p5
b1	London	s2	Jane	p2
b1	London	s2	Jane	p4
b2	Glasgow	s3	Mark	p6
b3	Glasgow	s4	David	p7
b3	Glasgow	s4	David	p9

Example 3.34 Multiple Grouping Columns 按多个列分组

Find the number of properties handled by each staff member.

```
SELECT staffNo, COUNT(*) AS count2
FROM   Property
GROUP BY staffNo
ORDER BY staffNo;
```

staffNo	count2
s1	3
s2	2
s3	1
s4	2
s5	1

Example 3.34 Multiple Grouping Columns

Find the number of properties handled by each staff member **in each branch**.

Staff

staffNo	branchNo	.....
s1	b1	
s2	b1	
s3	b2	
s4	b3	
s5	b4	

Property

pno	staffNo	.....
p1	s1	
p3	s1	
p5	s1	
p2	s2	
p4	s2	
p6	s3	
p7	s4	
p9	s4	
p8	s5	

Example 3.34 Multiple Grouping Columns

Join **property** and **staff** table.

branchNo	staffNo	pno
b1	s1	p1
b1	s1	p3
b1	s1	p5
b1	s2	p2
b1	s2	p4
b2	s3	p6
b3	s4	p7
b3	s4	p9
b4	s5	p8

Example 3.34 Multiple Grouping Columns

```
SELECT s.branchNo, s.staffNo, COUNT(*) AS count1  
FROM Staff s, Property p  
WHERE s.staffNo = p.staffNo
```

```
GROUP BY s.branchNo, s.staffNo == GROUP BY s.staffNo  
ORDER BY s.branchNo, s.staffNo;
```

branchNo	staffNo	count1
b1	s1	3
b1	s2	2
b2	s3	1
b3	s4	2
b4	s5	1

Computing a Join

The **procedure** for generating results of a join are:

1. Form **Cartesian product** of the tables named in FROM clause.
2. If there is a **WHERE** clause, apply the search condition to each row of the product table, **retaining those rows that satisfy the condition**.
3. For each remaining row, determine the value of each item in **SELECT** list to produce a single row in the result table.
4. If **DISTINCT** has been specified, eliminate any duplicate rows from the result table.
5. If there is an **ORDER BY** clause, sort the result table as required.

e.g. $R \times S$

Number of tuples(rows)
in $R \times S$ is called

Cardinality (基数), is
equal to the product of two
numbers of rows.

Number of attributes
(columns) is called

Degree (元数), is equal to
the sum of two numbers of
columns.

R

A	B	C
a	b	c
b	c	e
e	d	c

S

C	D
c	d
e	f

$R \times S$

A	B	R.C	S.C	D
a	b	c	c	d
a	b	c	e	f
b	c	e	c	d
b	c	e	e	f
e	d	c	c	d
e	d	c	e	f

3.3.4 EXISTS and NOT EXISTS

- ◆ **EXISTS** and **NOT EXISTS** are for use only with subqueries.
- ◆ Produce a simple **true/false** result.
- ◆ **True** if and only if there exists at least **one row** in the result table returned by the subquery.
- ◆ **False** if the subquery returns an **empty** result table.
- ◆ **NOT EXISTS** is the opposite of **EXISTS**.

EXISTS and NOT EXISTS

(the third person singular)

- Since (NOT) EXISTS check only for **existence** or **non-existence** of rows in the subquery result table, the column name of subquery is meaningless.
- It is common for subqueries following the form:
(NOT) EXISTS (SELECT * FROM ...)

带有 EXISTS 谓词的子查询

带有 EXISTS 谓词的子查询不返回任何数据，只产生逻辑真值 “true” 或假值 “false”。

若子查询结果为非空，则父查询的 WHERE 子句返回真值，否则，返回假值。

由 EXISTS 引出的子查询（相关子查询），其目标列表表达式通常都用 *，因为带 EXISTS 的子查询只返回真值或假值，给出列名无实际意义。

与 EXISTS 对应的是 NOT EXISTS 谓词。

Example 3.35 Query using EXISTS

Find all staff who work in a London branch office.

```
SELECT staffNo, fName, lName, position  
FROM Staff s  
WHERE EXISTS  
    (SELECT *  
     FROM Branch b  
     WHERE s.branchNo = b.branchNo  
           AND city = 'London');
```

s.branchNo = b.branchNo AND city = 'London

Staff

	staffNo	fName	lName	branchNo	position
→	SL19	丁岩	Crane	B001	.....
→	SL20	王爽	Kite	B003	.....
→	SL21	John	White	B002	Manager
→	SL23	赵立	Lee	B001	.....

Branch

	branchNo	city	.....		staffNo	fName	lName	position
→	B001	Paris						
→	B002	London			SL21	John	White	Manager
→	B003	Bristol						

Correlation subquery

It has the following features:

1. The Correlation subquery can **not** be executed **independently**.
2. The execution procedure is similar to that of **loop** statement in high-level programming language. The **outermost** subquery is executed **first**, then **go inside** the second level outer query until going to the innermost query **one by one level**. (in the opposite direction to Non-Correlation subquery)

Example 3.35 Query using EXISTS

```
( SELECT * FROM Branch b  
  WHERE s.branchNo = b.branchNo AND city = 'London');
```

- ◆ Note, the first search condition **s.branchNo = b.branchNo** is necessary.
- ◆ If omitted, we would get all staff records listed out because subquery:

```
SELECT * FROM Branch  
WHERE city='London'
```

would always be true and query would be:

```
SELECT staffNo, fName, lName, position  
FROM Staff  
WHERE true;
```

Example 3.35 Query using EXISTS

We could also write this query using join construct:

```
SELECT staffNo, fName, lName, position  
FROM Staff s, Branch b  
WHERE s.branchNo = b.branchNo AND  
       city = 'London';
```


Example 3.36: Find the students who take all the courses and list their names. (相当于查询这样的学生，没有一门课是他不选的)

```
select sn    from s
where not exists
    ( select *    from c
      where not exists
          (select *    from sc
           where s.sno=sc.sno
               and sc.cno=c.cno) ) ;
```

S (1st level)

sno	sn	age	sex
s1	丁岩	19	M
s2	王爽	17	F
s3	李红	18	F
s4	赵立	21	M



C (2nd level)

cno	cn	T
c1	DB	li
c2	Maths	liu
c3	DS	zhang

SC (3rd level)

sno	cno	G
s1	c1	79
s1	c3	85
s2	c1	60
s2	c2	83
s2	c3	90
s3	c1	95
s3	c2	80
s4	c1	75
s4	c2	85

Result set is:

sno	sn
s2	王爽

Another solution?

Select s.sno, sname

From s, sc

Where s.sno=sc.sno

Group by s.sno, sname

Having count(cno) =

(select count(*) from c)

Example 3.37 : Find the students who take all the courses which S3 takes, and list their student numbers.
(相当于查询学号X, 对所有课程Y, 只要S3选修了课程Y, 则学生X也选修了Y)

```
select distinct x.sno
from sc as x (Here the alias is necessary)
where not exists
( select *
  from sc as y
  where y.sno='s3' and not exists
    (select *   from sc as z
      where x.sno=z.sno
        and z.cno=y.cno));
```

x (1st level)

sno	cno	G
s1	c1	79
s1	c3	85
s2	c1	60
s2	c2	83
s2	c3	90
s3	c1	95
s3	c2	80
s4	c1	75
s4	c2	85

y (2nd level)

sno	cno	G
s1	c1	79
s1	c3	85
s2	c1	60
s2	c2	83
s2	c3	90
s3	c1	95
s3	c2	80
s4	c1	75
s4	c2	85

z (3rd level)

sno	cno	G
s1	c1	79
s1	c3	85
s2	c1	60
s2	c2	83
s2	c3	90
s3	c1	95
s3	c2	80
s4	c1	75
s4	c2	85

Another solution?

select sno

from sc

where cno in

(select cno from sc
where sno='s3')

group by sno

having count(cno)= (**> does not work**)

(select count(cno)
from sc
where sno='s3');

Result set is:

sno
s2
s3
s4

where cno in

(select cno from sc
where sno='s3')

sc

sno	cno	G
s1	c1	79
s1	c3	85
s2	c1	60
s2	c2	83
s2	c3	90
s3	c1	95
s3	c2	80
s4	c1	75
s4	c2	85

After the above
where clause



Filtered out



Filtered out



sno	cno	G
s1	c1	79
s2	c1	60
s2	c2	83
s3	c1	95
s3	c2	80
s4	c1	75
s4	c2	85

3.3.5 Union, Intersect, and Difference (Except)

- ◆ SQL can use normal set operations of Union, Intersection, and Difference to combine results of two or more queries into a single result table.
- ◆ **Union** of two tables, A and B, is a table containing all rows in either A or B or both.
- ◆ **Intersection** is a table containing all rows common to both A and B.
- ◆ **Difference** is a table containing all rows in A but not in B.

3.3.5 Union, Intersect, and Difference (Except)

◆ Two tables must be *union compatible*.

- The **numbers** of columns in two tables should be the same.
- The corresponding **columns** should get values from the same domain.

S1 (sno: **char(4)**, sname:char (10), age: smallint) **No!**
S2 (sno: **char(5)**, sname:char (10), age: smallint)

S1 (sno: char(4), sname:char (10), age: smallint, **sex: char**)
S2 (sno: char(4), sname:char (10), age: smallint) **No!**

S1 (sno: char(4), sname:char (10), age: smallint)
S2 (snum: char(4), name:char (10), s_age: smallint) **Yes!**

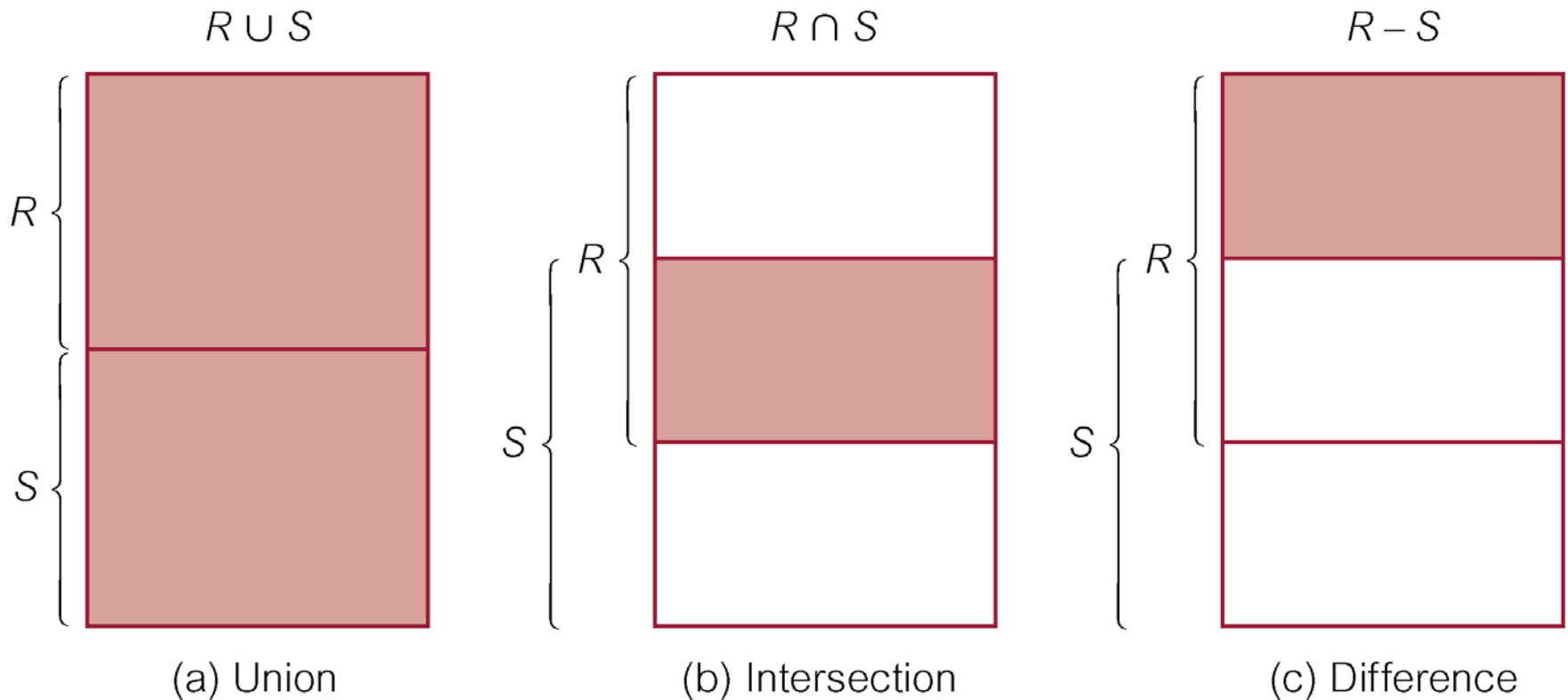
Union, Intersect, and Difference (Except)

◆ Format of set operator clause in each case is:

op [ALL] [CORRESPONDING [BY {column1
[, ...]}]]

- ◆ If **CORRESPONDING BY** specified, set operation performed on the named column(s).
- ◆ If **CORRESPONDING** specified but **not BY** clause, operation performed on **common columns**.
- ◆ If **ALL** specified, result can include **duplicate rows**.

Union, Intersect, and Difference (Except)



Example 3.38 Use of UNION

List all cities where there is either a branch office or a property.

```
(SELECT city  
FROM Branch  
WHERE city IS NOT NULL)  
UNION  
(SELECT city  
FROM Property  
WHERE city IS NOT NULL);
```

Example 3.38 Use of UNION

– Or

```
(SELECT *  
FROM Branch  
WHERE city IS NOT NULL)  
UNION CORRESPONDING BY city  
(SELECT *  
FROM Property  
WHERE city IS NOT NULL);
```

Example 3.38 Use of UNION

- Produces result tables from both queries and merges both tables together.

Table 5.32 Result table for Example 5.32.

city
London
Glasgow
Aberdeen
Bristol

Example 3.39 Use of INTERSECT

**(SQL Server 2000 does not support,
but version 2008 does. DB2 dose.)**

**List all cities where there is both a
branch office and a property.**

```
(SELECT city FROM Branch)  
INTERSECT  
(SELECT city FROM Property);
```

Example 3.39 Use of INTERSECT

- Or

(SELECT * FROM Branch)

INTERSECT CORRESPONDING BY city

(SELECT * FROM Property);

city
Aberdeen
Glasgow
London

Example 3.39 Use of INTERSECT

- Could rewrite this query without INTERSECT operator:

```
SELECT b.city  
FROM Branch b, Property p  
WHERE b.city = p.city;
```

- Or:

```
SELECT DISTINCT city FROM Branch b  
WHERE EXISTS  
( SELECT * FROM Property p  
  WHERE p.city = b.city );
```

Example 3.39 Use of INTERSECT

- Or

```
SELECT DISTINCT city  
FROM Branch  
WHERE city IN  
(SELECT city FROM Property );
```

Example 3.40 Use of EXCEPT

(SQL Server 2000 does not support ,
but version 2008 does.
DB2 supports the first format.)

List of all cities where there is a branch office but no
properties.

(SELECT city FROM Branch)

EXCEPT

(SELECT city FROM Property);

- Or

(SELECT * FROM Branch)

EXCEPT CORRESPONDING BY city

(SELECT * FROM Property);

city
Bristol

Example 3.40 Use of EXCEPT

- Could rewrite this query without EXCEPT:

```
SELECT DISTINCT city FROM Branch  
WHERE city NOT IN  
  (SELECT city FROM Property );
```

- Or

```
SELECT DISTINCT city FROM Branch b  
WHERE NOT EXISTS  
  ( SELECT * FROM Property p  
    WHERE p.city = b.city );
```