Chapter 9
Relational Data Retrieval: SQL

Fundamentals of Database Management Systems

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Overview

- Implemented relational languages:
  - SQL (Structured Query Language)
  - QBE (Query by Example)
  - QUEL (Query Language)
- Both SQL and QBE originated at IBM during the seventies
- SQL is textural and QBE is graphical

SQL

- SQL was the outgrowth of IBM's System R research project
- In the late seventies, SQL became part of the public domain and was first available as a language for a commercial system from Oracle Corporation
- In 1986, the first ANSI (American National Standards Institute) standard for SQL was approved. This standard was later revised modestly in 1989 and significantly in 1992.

Functions

- SQL is the only ANSI standard relational database language
- SQL includes table definition, database update, view definition, and privilege granting

Chapter Objectives

- Describe SQL as a relational data manipulation language 描述 SQL 作為關連資料控制語言
- Explain that you can create and update relational tables using SQL 可以用 SQL 產生和更新表格
- Write SQL SELECT commands to retrieve relational data using a variety of operators, including GROUP BY, ORDER BY, and the built-in functions of AVG, SUM, MAX, MIN, and COUNT

Chapter Objectives

- Write SQL SELECT commands that join relational tables
- Write SQL SELECT subqueries
- Describe a strategy for writing SQL SELECT statements
- Describe the principles of how a relational query optimizer works 描述關連查詢最佳化如何運作

Data Management 資料管理

- Data Definition 資料定義
- Data Manipulation 資料操控

Data Management: Data Definition

- Operationalized with a data definition language (DDL)
- Instructs the DBMS software on what tables will be in the database, what attributes will be in the tables, which attributes will be indexed, etc 指示 DBMS 資料庫中有哪些表格、表格中有哪些屬性、哪些屬性需要索引等

Data Management: Data Manipulation

- Refers to the four basic operations that can and must be performed on data stored in any DBMS 指四種基本操作
  - Data retrieval 資料取得
  - Data update 資料更新
  - Insertion of new records 插入新資料
  - Deletion of existing records 刪除既有資料
- Requires data manipulation language (DML) 需要資料操控語言

SQL

- Structured Query Language 結構化查詢語言
- Incorporates both DDL and DML features 包含 DDL 和 DML 的功能
- Very heavily used in practice today 普遍地使用

Building the Data Structure

- Base tables - actual physical tables in which the data will be stored on the disk
- Created using the CREATE TABLE command 建立表格
- Deleted using the DROP TABLE command 刪除表格

Logical View

- Also just called a view 視界
- May consist of a subset of the columns of a single table, a subset of the rows of a single table, or both 可以是表格的一部份
- May also be the join of two or more base tables 也可以是好幾個表格的組合
- A mapping onto the base table(s) 是一種對應
- Created using the CREATE VIEW command 建立視界

Data Manipulation Operations

- UPDATE - used for updating existing data 更新
- INSERT - used for inserting new rows in tables 新增
- DELETE - used for deleting existing rows in tables 刪除

Introduction: SQL SELECT

- Used for data retrieval 資料查詢
- You specify what data you are looking for rather than provide a logical sequence of steps that guide the system in how to find the data 只說要哪種資料，而不必詳述擷取資料的詳細步驟
- Can be run in either a query or an embedded mode 直接查詢或嵌入其他程式中
- Command will work with Oracle, MS Access, SQL Server, DB2, Informix, etc

The Basic SQL SELECT

SELECT <columns> 欄位
FROM <table> 表格
WHERE <predicates identifying rows to be included>; 條件

General Hardware Company Database (Modified)

SPNUM	SPNAME	COMMPERCT	YEARHIRE	OFFNUM
137	Baker	10	1995	1284
186	Adams	15	2001	1253
204	Dickens	10	1998	1209
361	Carlyle	20	2001	1227

(a) SALESPERSON Table

General Hardware Company Database (Modified)

CUSTNUM	CUSTNAME	SPNUM	HQCITY
0121	Main St. Hardware	137	New York
0839	Jane's Stores	186	Chicago
0933	ABC Home Stores	137	Los Angeles
1047	Acme Hardware Store	137	Los Angeles
1525	Fred's Tool Stores	361	Atlanta
1700	XYZ Stores	361	Washington
1826	City Hardware	137	New York
2198	Western Hardware	204	New York
2267	Central Stores	186	New York

(b) CUSTOMER Table

General Hardware Company Database (Modified)

CUSTNUM	EMPNUM	EMPNAME	TITLE
0121	27498	Smith	Co-Owner
0121	30441	Garcia	Co-Owner
0933	25270	Chen	VP Sales
0933	30441	Levy	Sales Manager
0933	48285	Morton	President
1525	33779	Baker	Sales Manager
2198	27470	Smith	President
2198	30441	Jones	VP Sales
2198	33779	Garcia	VP Personnel
2198	35268	Kaplan	Senior Accountant

(c) Customer EMPLOYEE Table

General Hardware Company Database (Modified)

PRODNUM	PRODNAME	UNITPRICE
16386	Wrench	12.95
19440	Hammer	17.50
21765	Drill	32.99
24013	Saw	26.25
26722	Pliers	11.50

(d) PRODUCT Table

General Hardware Company Database (Modified)

SPNUM	PRODNUM	QUANTITY
137	19440	473
137	24013	170
137	26722	688
186	16386	1745
186	19440	2529
186	21765	1962
186	24013	3071
204	21765	809
204	26722	734
361	16386	3729
361	21765	3110
361	26722	2738

(e) SALES Table

General Hardware Company Database (Modified)

OFFNUM	TELEPHONE	SIZE
1253	901-555-4276	120
1227	901-555-0364	100
1284	901-555-7335	120
1209	901-555-3108	95

(f) OFFICE Table

General Hardware Company SQL Query Example

"Find the commission percentage and year of hire of salesperson number 186." 找出 186 號推銷員的佣金比例和雇用年份

```
SELECT COMMPERCT, YEARHIRE
FROM SALESPERSON
WHERE SPNUM=186;
```

COMMPERCT	YEARHIRE
15	2001

- The desired attributes are listed in the SELECT clause
- The required table is listed in the FROM clause
- The restriction (predicate) indicating which row(s) is involved is shown in the WHERE clause in the form of an equation

General Hardware Company SQL Query Example, *

"Retrieve the entire record for salesperson 186." 找出推銷員 186 號的所有資料

```
SELECT *
FROM SALESPERSON
WHERE SPNUM=186;
```

SPNUM	SPNAME	COMMPERCT	YEARHIRE	OFFNUM
186	Adams	15	2001	1253

- The "*" indicates that all attributes of the selected row are to be retrieved 星號表示所有欄位

General Hardware Company SQL Query Example

"List the salesperson numbers and salesperson names of those salespersons who have a commission percentage of 10." 找出佣金比例是 10% 的推銷員的編號和姓名

```
SELECT SPNUM, SPNAME
FROM SALESPERSON
WHERE COMMPERCT=10;
```

SPNUM	SPNAME
137	Baker
204	Dickens

- The search argument is nonunique in this query

General Hardware Company SQL Query Example, No WHERE

"List the salesperson number and salesperson name of all of the salespersons." 找出所有推銷員的編號和姓名

SELECT SPNUM, SPNAME FROM SALESPERSON;

SPNUM	SPNAME
137	Baker
186	Adams
204	Dickens
361	Carlyle

- For a Relational Algebra Project operation, there is no need for a WHERE clause to limit which rows of the table are included 沒有用到 where

General Hardware Company SQL Query Example, *

"Retrieve all of the Salespersons." 查出所有推銷員的資料

```
SELECT *
FROM SALESPERSON;
```

SPNUM	SPNAME	COMMPERCT	YEARHIRE	OFFNUM
137	Baker	10	1995	1284
186	Adams	15	2001	1253
204	Dickens	10	1998	1209
361	Carlyle	20	2001	1227

- Retrieves an entire table, that is, the query places no restrictions on either the rows or the attributes

Comparisons

- In addition to equal (=), the standard comparison operators can be used in the WHERE clause
  - Greater than (>) 大於
  - Less than (<) 小於
  - Greater than or equal to (>=) 大於等於
  - Less than or equal to (<=) 小於等於
  - Not equal to (<>) 不等於

General Hardware Company SQL Query Example, <

"List the salesperson numbers, salesperson names, and commission percentages of the salespersons whose commission percentage is less than 12." 找出佣金比例小於 12% 的推銷員的編號、姓名和佣金比例

```
SELECT SPNUM, SPNAME,
COMMPERCT
FROM SALESPERSON
WHERE COMMPERCT < 12;
```

SPNUM	SPNAME	COMMPERCT
137	Baker	10
204	Dickens	10

General Hardware Company SQL Query Example, >=

"List the customer numbers and headquarters cities of the customers that have a customer number of at least 1700." 找出顧客編號在 1700 號以上的顧客的編號和總部城市

```
SELECT CUSTNUM, HQCITY
FROM CUSTOMER
WHERE CUSTNUM >= 1700;
```

CUSTNUM	HQCITY
1700	Washington
1826	New York
2198	New York
2267	New York

General Hardware Company SQL Query Example: AND

"List the customer numbers, customer names, and headquarters cities of the customers that are headquartered in New York and that have a customer number higher than 1500."
找出總部在紐約而且編號在1500 號以上的顧客的編號、姓名和總部城市

```
SELECT CUSTNUM, CUSTNAME, HQCITY
FROM CUSTOMER
WHERE HQCITY='New York'
AND CUSTNUM>1500;
```

CUSTNUM	CUSTNAME	HQCITY
1826	City Hardware	New York
2198	Western Hardware	New York
2267	Central Stores	New York

- With the AND operator, both conditions have to be satisfied to be included in the result

General Hardware Company SQL Query Example: OR

"List the customer numbers, customer names, and headquarters cities of the customers that are headquartered in New York or that have a customer number higher than 1500." 找出總部在紐約或者編號在 1500 號以上的顧客的編號、姓名和總部城市

```
SELECT CUSTNUM, CUSTNAME, HQCITY
FROM CUSTOMER
WHERE HQCITY='New York'
OR CUSTNUM>1500;
```

CUSTNUM	CUSTNAME	HQCITY
0121	Main St. Hardware	New York
1525	Fred's Tool Stores	Atlanta
1700	XYZ Stores	Washington
1826	City Hardware	New York
2198	Western Hardware	New York
2267	Central Stores	New York

- The OR operator really means one or the other or both

General Hardware Company SQL Query Example: AND, OR

- AND is said to be “higher in precedence” than OR
  先做 AND
- So all ANDs are considered before any ORs are considered

“List the customer numbers, customer names, and headquarters cities of the customers that are headquartered in New York or that satisfy the two conditions of having a customer number higher than 1500 and being headquartered in Atlanta.”

General Hardware Company SQL Query Example: AND, OR

"List the customer numbers, customer names, and headquarters cities of the customers that are headquartered in New York or that satisfy the two conditions of having a customer number higher than 1500 and being headquartered in Atlanta." 找出總部在紐約或者編號在 1500 號以上而且總部在亞特蘭大的顧客的編號、姓名和總部城市

```
SELECT CUSTNUM, CUSTNAME, HQCITY
FROM CUSTOMER
WHERE HQCITY='New York'
OR CUSTNUM>1500
AND HQCITY='Atlanta';
```

CUSTNUM	CUSTNAME	HQCITY
0121	Main St. Hardware	New York
1525	Fred's Tool Stores	Atlanta
1826	City Hardware	New York
2198	Western Hardware	New York
2267	Central Stores	New York

General Hardware Company SQL Query Example: AND, OR

- If you really wanted the OR to be considered first, you could force it by writing the query as: 可以使用括號來變更優先順序

```
SELECT CUSTNUM, CUSTNAME, HQCITY
FROM CUSTOMER
WHERE (HQCITY='New York'
OR CUSTNUM>1500)
AND HQCITY='Atlanta';
```

CUSTNUM	CUSTNAME	HQCITY
0121	Main St. Hardware	New York
1525	Fred's Tool Stores	Atlanta
1826	City Hardware	New York
2198	Western Hardware	New York
2267	Central Stores	New York

General Hardware Company SQL Query Example: BETWEEN

"Find the customer records for those customers whose customer numbers are between 1000 and 1700, inclusive." 找出編號在 1000 和 1700 之間的顧客的資料

```
SELECT *
FROM CUSTOMER
WHERE (CUSTNUM>=1000 AND
CUSTNUM<=1700);
```

```
SELECT *
FROM CUSTOMER
WHERE CUSTNUM BETWEEN
 1000 AND 1700;
```

CUSTNUM	CUSTNAME	SPNUM	HQCITY
1047	Acme Hardware Store	137	Los Angeles
1525	Fred's Tool Stores	361	Atlanta
1700	XYZ Stores	361	Washington

- Allows you to specify a range of numeric values in a search 兩種做法都可以

General Hardware Company SQL Query Example: IN

"Find the customer records for those customers headquartered in Atlanta, Chicago, or Washington." 找出總部在亞特蘭大、芝加哥或華盛頓的顧客的資料

```
SELECT *
FROM CUSTOMER
WHERE (HQCITY='Atlanta'
OR HQCITY='Chicago'
OR HQCITY='Washington');
```

```
SELECT *
FROM CUSTOMER
WHERE HQCITY IN ('Atlanta',
'Chicago', 'Washington');
```

CUSTNUM	CUSTNAME	SPNUM	HQCITY
0839	Jane's Stores	186	Chicago
1525	Fred's Tool Stores	361	Atlanta
1700	XYZ Stores	361	Washington

兩種做法都可以

General Hardware Company SQL Query Example: LIKE

"Find the customer records for those customers whose names begin with the letter "A"."
找出姓名開頭是 A 的顧客的資料

```
SELECT *
FROM CUSTOMER
WHERE CUSTNAME LIKE 'A%';
```

CUSTNUM	CUSTNAME	SPNUM	HQCITY
0933	ABC Home Stores	137	Los Angeles
1047	Acme Hardware Store	137	Los Angeles

- "%" character used as a "wildcard" to represent any string of characters 代表任意長度字串的是 %（ % 不正確，請找出正確的符號）

General Hardware Company SQL Query Example: LIKE

"Find the customer records for those customers whose names have the letter "a" as the second letter of their names." 找出姓名第二個字母是 a 的顧客的資料

```
SELECT *
FROM CUSTOMER
WHERE CUSTNAME LIKE '_a%';
```

CUSTNUM	CUSTNAME	SPNUM	HQCITY
0121	Main St. Hardware	137	New York
0839	Jane's Store	186	Chicago

- The single "_" character in the operator LIKE "_a%" specifies that there will be one character followed by "a." 代表一個字母的是 _ （ _ 不正確，請找出正確的符號）

General Hardware Company SQL Query Example: DISTINCT

"Which cities serve as headquarters cities for General Hardware customers?" 找出顧客總部所在城市有哪些

```
SELECT HQCITY
FROM CUSTOMER;
```

```
SELECT DISTINCT HQCITY
FROM CUSTOMER;
```

HQCITY
New York
Chicago
Los Angeles
Los Angeles
Atlanta
Washington
New York
New York
New York

HQCITY
New York
Chicago
Los Angeles
Atlanta
Washington

- Eliminate duplicate rows in a query result 不要重複的資料

General Hardware Company SQL Query Example: ORDER BY

"Find the customer numbers, customer names, and headquarters cities of those customers with customer numbers greater than 1000. List the results in alphabetic order by headquarters cities." 找出編號在 1000 號以上的顧客的編號、姓名和總部城市，並依字母順序排列

```
SELECT CUSTNUM, CUSTNAME, HQCITY
FROM CUSTOMER
WHERE CUSTNUM>1000
ORDER BY HQCITY;
```

CUSTNUM	CUSTNAME	HQCITY
1525	Fred's Tool Stores	Atlanta
1047	Acme Hardware Store	Los Angeles
1826	City Hardware	New York
2198	Western Hardware	New York
2267	Central Stores	New York
1700	XYZ Stores	Washington

- Orders the results of an SQL query by one or more specified attributes

General Hardware Company SQL Query Example: ORDER BY

- The default order for ORDER BY is ascending 預設順序是遞增
- The clause can include the term ASC at the end to make ascending explicit 可以 ASC 表明遞增
- The clause can include DESC for descending order 或以 DESC 表示遞減

General Hardware Company SQL Query Example: AVG

"Find the average number of units of the different products that Salesperson 137 has sold (i.e., the average of the quantity values in the first three records of the SALES table)." 找出推銷員 137 號所賣出產品的平均數量

```
SELECT AVG(QUANTITY)
FROM SALES
WHERE SPNUM=137;
```

AVG(QUANTITY)
443.67

- AVG is a built-in function of SQL 內建函數

General Hardware Company SQL Query Example: SUM

"Find the total number of all products that Salesperson 137 has sold." 找出推銷員 137 號所賣出產品的總數量

```
SELECT SUM(QUANTITY)
FROM SALES
WHERE SPNUM=137;
```

SUM(QUANTITY)
1331

- SUM is a built-in function of SQL

General Hardware Company SQL Query Example: MAX

"What is the largest number of units of Product Number 21765 that any individual salesperson has sold?" 產品 21765 號所賣出的最大一宗是多少個

```
SELECT MAX(QUANTITY)
FROM SALES
WHERE PRODNUM=21765;
```

MAX(QUANTITY)
3110

- MAX is a built-in function of SQL

General Hardware Company SQL Query Example: MIN

"What is the smallest number of units of Product Number 21765 that any individual salesperson has sold?" 產品 21765 號所賣出的最小一宗是多少個

```
SELECT MIN(QUANTITY)
FROM SALES
WHERE PRODNUM=21765;
```

MIN(QUANTITY)
809

- MIN is a built-in function of SQL

General Hardware Company SQL Query Example: COUNT

"How many salespersons have sold Product Number 21765?" 有多少推銷員曾經賣出產品 21765 號

```
SELECT COUNT(*)
FROM SALES
WHERE PRODNUM=21765;
```

COUNT(*)
3

- COUNT counts the number of rows that satisfy a set of criteria

General Hardware Company SQL Query Example: GROUP BY

"Find the total number of units of all products sold by each salesperson." 找出各推銷員所賣出的產品的總量

```
SELECT SPNUM, SUM(QUANTITY)
FROM SALES
GROUP BY SPNUM;
```

SPNUM	SUM(QUANTITY)
137	1331
186	9307
204	1543
361	9577

- Used when calculations are to be made on several different groups of rows

General Hardware Company SQL Query Example: HAVING

"Find the total number of units of all products sold by each salesperson whose salesperson number is at least 150. Only include salespersons whose total number of units sold is at least 5000." 找出編號在 150 號以上的各推銷員所賣出的產品總量，請只列出總量在 5000 個以上的結果

```
SELECT SPNUM, SUM(QUANTITY)
FROM SALES
WHERE SPNUM>=150
GROUP BY SPNUM
HAVING SUM(QUANTITY)>=5000;
```

SPNUM	SUM(QUANTITY)
186	9307
361	9577

- HAVING limits the results of a GROUP BY based on the values calculated for each group with the built-in functions
  請注意 HAVING 和 WHERE 的不同

The Join

- SQL SELECT allows you to join two or more tables 使用 JOIN 來連結兩個以上的表格
- Two specifications must be made in the SELECT statement
  - The tables to be joined must be listed in the FROM clause 把用到的表格放在 FROM 子句中
  - The join attributes in the tables being joined must be declared and matched to each other in the WHERE clause 指定對應的欄位 (Foreign Key)
- A table name qualifier is required when different tables have an attribute with the same name 如果欄位名稱相同，必須另外指定表格名稱

General Hardware Company SQL Query Example: Join

"Find the name of the salesperson responsible for Customer Number 1525." 找出負責顧客 1525 號的推銷員姓名

```
SELECT SPNAME
FROM SALESPERSON, CUSTOMER
WHERE SALESPERSON.SPNUM=CUSTOMER.SPNUM
AND CUSTNUM=1525;
```

SPNAME
Carlyle

General Hardware Company SQL Query Example: Join

"List the names of the products of which salesperson Adams has sold more than 2,000 units." 找出推銷員 Adams 曾賣出過 2000 個以上的產品的名稱

```
SELECT PRODNAME
FROM SALESPERSON, PRODUCT, SALES
WHERE SALESPERSON.SPNUM=SALES.SPNUM
AND SALES.PRODNUM=PRODUCT.PRODNUM
AND SPNAME='Adams'
AND QUANTITY>2000;
```

PRODNAME
Hammer
Saw

Inner join

- Most common join operation
  - Take the Cartesian Product
  - Eliminate records that violate the join condition
- Implicit join notation
  - select * from salesperson, customer where salesperson.spnum = customer.spnum;
  - 建立的查詢不能修改資料
- Explicit join notation
  - select * from salesperson inner join customer on salesperson.spnum = customer.spnum;
  - 建立的查詢可以修改資料

Subqueries 子查詢

- One SELECT statement is “nested” within another 巢狀架構
- Nesting can go on through several levels of SELECT statements with each successive SELECT statement contained in a pair of parentheses 可以有許多層
- The innermost SELECT statement is executed first, and its results are then provided as input to the SELECT statement at the next level up 最裡面的一層先做

General Hardware Company SQL Query Example: Subquery

"Find the name of the salesperson responsible for Customer Number 1525." 找出負責顧客 1525 號的推銷員姓名

```
SELECT SPNAME
FROM SALESPERSON
WHERE SPNUM=
      (SELECT SPNUM
      FROM CUSTOMER
      WHERE CUSTNUM=1525);
```

SPNAME
Carlyle

- Subquery as an alternative to join 和前面 JOIN 範例的結果相同

General Hardware Company SQL Query Example: Subquery

"Which salespersons with salesperson numbers greater than 200 have the lowest commission percentage of any such salesperson?" (We'll identify salespersons by their salesperson number.) 編號 200 號以上佣金比例最低的是誰

```
SELECT SPNUM
FROM SALESPERSON
WHERE SPNUM>200
AND COMMPERCT=
        (SELECT MIN(COMMPERCT)
        FROM SALESPERSON)
        WHERE SPNUM>200);
```

- A subquery is required 必須使用子查詢

SPNUM
204

A Strategy for Writing SQL SELECT Commands

- Determine what the result of the query is to be and write the needed attributes and functions in the SELECT clause 把需要的欄位寫在 SELECT 子句中
- Determine which tables of the database will be needed for the query and write their names in the FROM clause 把需要的表格寫在 FROM 子句中
- If the query involves a join, begin constructing the WHERE clause by equating the join attributes from the tables that are in the FROM clause 寫出 JOIN 的條件
- Continue filling in the details of the WHERE clause, the GROUP BY clause, and any subqueries 寫出其他的條件

Example - Good Reading Bookstores

PUBNAME	CITY	COUNTRY	TELEPHONE	YRFOUND

PUBLISHER Table

AUTHORNUM	AUTHORNAME	YEARBORN	YEARDIED

AUTHOR Table

BOOKNUM	BOOKNAME	PUBYEAR	PAGES	PUBNAME

BOOK Table

CUSTNUM	CUSTNAME	STREET	CITY	STATE	COUNTRY

CUSTOMER Table

BOOKNUM	AUTHORNUM

WRITING Table

BOOKNUM	CUSTNUM	DATE	PRICE	QUANTITY

SALE Table

Sample Queries

"Find the book number, book name, and number of pages of all of the books published by London Publishing Ltd. List the results in order by book name."
找出由 London Publishing Ltd. 所印行的書籍的編號、名稱和頁數，請把結果依書名排序

```
SELECT BOOKNUM, BOOKNAME, PAGES
FROM BOOK
WHERE PUBNAME='London Publishing
Ltd.' ORDER BY BOOKNAME;
```

Sample Queries

"How many books of at least 400 pages does Good Reading Bookstores carry that were published by publishers based in Paris, France?" 由法國巴黎的出版社所印行的 400 頁以上的書有幾本

```
SELECT COUNT(*)
FROM PUBLISHER, BOOK
WHERE PUBLISHER.PUBNAME=BOOK.PUBNAME
AND CITY='Paris'
AND COUNTRY='France'
AND PAGES>=400;
```

Sample Queries

"List the publishers in Belgium, Brazil, and Singapore that publish books written by authors who were born before 1920." 找出有發行由 1920 年以前出生的作者所寫的書的比利時、巴西、或新加坡的出版社

```
SELECT DISTINCT PUBNAME
FROM PUBLISHER, BOOK, WRITING, AUTHOR
WHERE PUBLISHER.PUBNAME=BOOK.PUBNAME
AND BOOK.BOOKNUM=WRITING.BOOKNUM
AND WRITING.AUTHORNUM=AUTHOR.AUTHORNUM
AND COUNTRY IN ('Belgium', 'Brazil', 'Singapore')
AND YEARBORN<1920;
```

Sample Queries

"How many books did each publisher in Oslo, Norway; Nairobi, Kenya; and Auckland, New Zealand, publish in 2001?" 在 2001 年位於挪威奧斯陸、肯亞乃洛比、或紐西蘭奧克蘭的出版社各發行了多少種書

```
SELECT PUBNAME, CITY, COUNTRY, COUNT(*)
FROM PUBLISHER, BOOK
WHERE PUBLISHER.PUBNAME=BOOK.PUBNAME
AND ((CITY='Oslo' AND COUNTRY='Norway')
        OR (CITY='Nairobi' AND COUNTRY='Kenya')
        OR (CITY='Auckland' AND COUNTRY='New
Zealand')) AND PUBYEAR=2001
GROUP BY PUBNAME;
```

Sample Queries

"Which publisher published the book that has the earliest publication year among all of the books that Good Reading Bookstores carries?" 有最早發行年份的出版社是哪些家

```
SELECT DISTINCT PUBNAME
FROM BOOK
WHERE PUBYEAR=
        (SELECT MIN(PUBYEAR)
        FROM BOOK);
```

Example - World Music Association

ORCHNAME	CITY	COUNTRY	MUSICDIR

ORCHESTRA Table

MUSNUM	MUSNAME	INSTRUMENT	ANNSALARY	ORCHNAME

MUSICIAN Table

MUSNUM	DEGREE	UNIVERSITY	YEAR

DEGREE Table

COMPOSERNAME	COUNTRY	DATEBIRTH

COMPOSER Table

COMPOSITIONNAME	COMPOSERNAME	YEAR

COMPOSITION Table

ORCHNAME	COMPOSITIONNAME	COMPOSERNAME	YEAR	PRICE

RECORDING Table

Sample Queries

"What is the total annual salary cost for all of the violinists of the Berlin Symphony Orchestra?" 所有柏林交響樂團的小提琴手的總年薪是多少

```
SELECT SUM(ANNSALARY)
FROM MUSICIAN
WHERE ORCHNAME='Berlin Symphony Orchestra'
AND INSTRUMENT='Violin';
```

Sample Queries

"Make a single list, in alphabetic order of all of the universities attended by the cellists of India." 列出印度的大提琴手所唸的大學，請依字母順序排列

```
SELECT DISTINCT UNIVERSITY
FROM ORCHESTRA, MUSICIAN, DEGREE
WHERE ORCHESTRA.ORCHNAME=MUSICIAN.ORCHNAME
AND MUSICIAN.MUSNUM=DEGREE.MUSNUM
AND INSTRUMENT='Cello'
AND COUNTRY='India'
ORDER BY UNIVERSITY;
```

Sample Queries

"What is the total annual salary cost for all of the violinists of each orchestra located in Canada? Only include in the result those orchestras whose total annual salary for its violinists is in excess of $150,000." 位於加拿大的樂團的小提琴手的總年薪是多少，請只列出總年薪超過 $150000 的樂團

```
SELECT ORCHNAME, SUM(ANNSALARY)
FROM ORCHESTRA, MUSICIAN
WHERE ORCHESTRA.ORCHNAME=MUSICIAN.ORCHNAME
AND COUNTRY='Canada'
AND INSTRUMENT='Violin'
GROUP BY ORCHNAME
HAVING SUM(ANNSALARY)>150,000;
```

Sample Queries

"What is the name of the most highly paid pianist?" 薪水最高的鋼琴家是誰

```
SELECT MUSNAME
FROM MUSICIAN
WHERE INSTRUMENT='Piano'
AND ANNSALARY=
        (SELECT MAX(ANNSALARY)
        FROM MUSICIAN
        WHERE INSTRUMENT='Piano');
```

Sample Queries

"What is the name of the most highly paid pianist of any orchestra in Australia?" 澳洲薪水最高的鋼琴家是誰

```
SELECT MUSNAME
FROM MUSICIAN, ORCHESTRA
WHERE
MUSICIAN.ORCHNAME=ORCHESTRA.ORCHNAME
AND INSTRUMENT='Piano'
AND COUNTRY='Australia'
AND ANNSALARY=
        (SELECT MAX(ANNSALARY)
        FROM MUSICIAN, ORCHESTRA
        WHERE
MUSICIAN.ORCHNAME=ORCHESTRA.ORCHNAME
        AND INSTRUMENT='Piano'
        AND COUNTRY='Australia');
```

Example - Lucky Rent-A-Car

MANUFNAME	COUNTRY	SALESREPNAME	SALESREPPHONE

MANUFACTURER Table

CARNUM	MODEL	YEAR	CLASS	MANUFNAME

CAR Table

REPAIRNUM	CARNUM	DATE	PROCEDURE	MILEAGE	REPAIRTIME

MAINTENANCE Table

CUSTNUM	CUSTNAME	CUSTADDR	CUSTPHONE

CUSTOMER Table

CARNUM	CUSTNUM	RENTALDATE	RETURNDATE	COST

RENTAL Table

Sample Queries

"List the manufacturers whose names begin with the letter C or the letter D and that are located in Japan." 列出開頭字母是 C 或 D 的日本製造商

```
SELECT MANUFNAME
FROM MANUFACTURER
WHERE (MANUFNAME LIKE 'C%'
OR MANUFNAME LIKE 'D%')
AND COUNTRY='Japan';
```

Sample Queries

"What was the average mileage of the cars that had tune-ups in August 2003?" 在 2003 年 8 月維修的汽車的平均里程數是多少

```
SELECT AVG(MILEAGE)
FROM MAINTENANCE
WHERE PROCEDURE='Tune-Up'
AND DATE BETWEEN 'AUG-01-2003' AND 'AUG-31-2003';
```

Sample Queries

"How many different car models do manufacturers in Italy make?" 義大利的製造商生產多少種汽車

```
SELECT COUNT(DISTINCT MODEL)
FROM MANUFACTURER, CAR
WHERE
MANUFACTURER.MANUFNAME=CAR.MANUFNAME
AND COUNTRY='Italy';
```

Sample Queries

"How many repairs were performed on each car manufactured by Superior Motors during the month of March 2004? Only include cars in the result that had at least three repairs." 在 2004 年 3 月由 Superior Motors 生產的汽車各維修了多少次，請只列出維修 3 次以上的汽車

```
SELECT CAR.CARNUM, COUNT(*)
FROM CAR, MAINTENANCE
WHERE CAR.CARNUM=MAINTENANCE.CARNUM
AND MANUFNAME='Superior Motors'
AND DATE BETWEEN 'MAR-01-2004' AND 'MAR-31-2004'
GROUP BY CAR.CARNUM
HAVING COUNT(*)>=3;
```

Sample Queries

"List the cars of any manufacturer that had an oil change in January 2004 and had at least as many miles as the highest mileage car manufactured by Superior Motors that had an oil change that same month." 列出在 2004 年 1 月更換機油而且里程數大於或等於同月更換機油的 Superior Motors 出廠汽車的最高里程數的汽車

```
SELECT MAINTENANCE.CARNUM
FROM MAINTENANCE
WHERE PROCEDURE='Oil Change'
AND DATE BETWEEN 'JAN-01-2004' AND 'JAN-31-2004'
AND MILEAGE>=
        (SELECT MAX(MILEAGE)
        FROM CAR, MAINTENANCE
        WHERE CAR.CARNUM=MAINTENANCE.CARNUM
        AND PROCEDURE='Oil Change'
        AND DATE BETWEEN 'JAN-01-2004' AND 'JAN-31-2004'
        AND MANUFNAME='Superior Motors');
```

Relational Query Optimizer

- Relational DBMS Performance
- Relational Query Optimizer Concepts 查詢最佳化

Relational Query Optimizer: Relational DBMS Performance

- The speed with which the required data can be retrieved
- Performance regarding joins is a particular problem JOIN 是問題所在
- Solutions
  - Tuning of the database structure, physical database design 改進資料庫結構
  - Relational query optimizer software that evaluates each SQL SELECT statement and determines an efficient way to satisfy it 使用最佳化軟體評估 SELECT 指令

Relational Query Optimizer: Concepts

- All major SQL processors include a query optimizer 大部分軟體包含最佳化查詢功能
- Using a query optimizer, SQL attempts to figure out the most efficient way of answering a query, prior to actually responding to it
- The query optimizer uses the relational catalog, an internal database 使用內部資料庫和目錄

Query Optimizer Considerations

- Which attributes have indexes built over them? 哪些欄位有索引
- How many rows does each table have? 各表格有多少筆資料
- Which attributes are unique? 哪些屬性是獨特的
- How many records of a table are really needed for a particular join? 做 JOIN 時究竟需要多少筆資料
- Which join algorithm is best for this query? 哪種 JOIN 的方法最好

Join Algorithms

- Nested-loop join
  - A Cartesian product
  - One of the two tables is selected for the outer loop and the other for the inner loop 一個表格當內圈，一個表格當外圈
  - Each of the records of the outer loop is chosen in succession, and, for each, the inner loop table is scanned for matches on the join attribute 先選定外圈的一筆資料，再掃瞄內圈的資料

Join Algorithms

- Merge-scan join
  - More efficient than the nested-loop join 更有效率
  - Can only be used if certain conditions are met 需要滿足特定條件
    - Each of the two join attributes has to be in sorted order, or 做 JOIN 的屬性已經排序
    - Each of the two join attributes has to have an index built over it 做 JOIN 的屬性編好索引