Database Management System

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Overview

- More on SQL
  - The basic commands and functions of SQL
  - How to use SQL for data administration (to create tables, indexes, and views)
  - How to use SQL for data manipulation (to add, modify, delete, and retrieve data)
  - How to use SQL to query a database for useful information

Introduction to SQL

- SQL functions fit into two broad categories:
  - Data definition language
  - Data manipulation language
- American National Standards Institute (ANSI) prescribes a standard SQL
- Several SQL dialects exist

SQL Data Definition Commands

TABLE 7.1 SQL Data Definition Commands

COMMAND OR OPTION	DESCRIPTION
CREATE SCHEMA AUTHORIZATION	Creates a database schema
CREATE TABLE	Creates a new table in the user's database schema
NOT NULL	Ensures that a column will not have null values
UNIQUE	Ensures that a column will not have duplicate values
PRIMARY KEY	Defines a primary key for a table
FOREIGN KEY	Defines a foreign key for a table
DEFAULT	Defines a default value for a column (when no value is given)
CHECK	Validates data in an attribute
CREATE INDEX	Creates an index for a table
CREATE VIEW	Creates a dynamic subset of rows/columns from one or more tables
ALTER TABLE	Modifies a tables definition (adds, modifies, or deletes attributes or constraints)
CREATE TABLE AS	Creates a new table based on a query in the user's database schema
DROP TABLE	Permanently deletes a table (and its data)
DROP INDEX	Permanently deletes an index
DROP VIEW	Permanently deletes a view

SQL Data Manipulation Commands

TABLE 7.2 SQL Data Manipulation Commands

COMMAND OR OPTION	DESCRIPTION
INSERT	Inserts row(s) into a table
SELECT	Selects attributes from rows in one or more tables or views
WHERE	Restricts the selection of rows based on a conditional expression
GROUP BY	Groups the selected rows based on one or more attributes
HAVING	Restricts the selection of grouped rows based on a condition
ORDER BY	Orders the selected rows based on one or more attributes
UPDATE	Modifies an attribute's values in one or more table's rows
DELETE	Deletes one or more rows from a table
COMMIT	Permanently saves data changes
ROLLBACK	Restores data to their original values
COMPARISON OPERATORS	
=, <, >, <=, >=, <>	Used in conditional expressions
LOGICAL OPERATORS	
AND/OR/NOT	Used in conditional expressions
SPECIAL OPERATORS	Used in conditional expressions
BETWEEN	Checks whether an attribute value is within a range
IS NULL	Checks whether an attribute value is null
LIKE	Checks whether an attribute value matches a given string pattern
IN	Checks whether an attribute value matches any value within a value list
EXISTS	Checks whether a subquery returns any rows
DISTINCT	Limits values to unique values
AGGREGATE FUNCTIONS	Used with SELECT to return mathematical summaries on columns
COUNT	Returns the number of rows with non-null values for a given column
MIN	Returns the minimum attribute value found in a given column
MAX	Returns the maximum attribute value found in a given column
SUM	Returns the sum of all values for a given column
AVG	Returns the average of all values for a given column

Data Definition Commands

- The database model
  - A simple database with these tables is used to illustrate commands:
    - CUSTOMER
    - INVOICE
    - LINE
    - PRODUCT
    - VENDOR
  - Focus on PRODUCT and VENDOR tables

Business Rules

- A customer may generate many invoices. Each invoice is generated by one customer.
- An invoice contains one or more invoice lines. Each invoice line is associated with one invoice.
- Each invoice line references one product. A product may be found in many invoice lines. (You can sell more than one hammer to more than one customer)
- A vendor may supply many products. Some vendors do not (yet?) supply products. (For example, a vendor list may include potential vendors.)
- If a product is vendor-supplied, that product is supplied by only a single vendor.
- Some products are not supplied by a vendor. (For example, some products may be produces in-house or bought on the open market.)

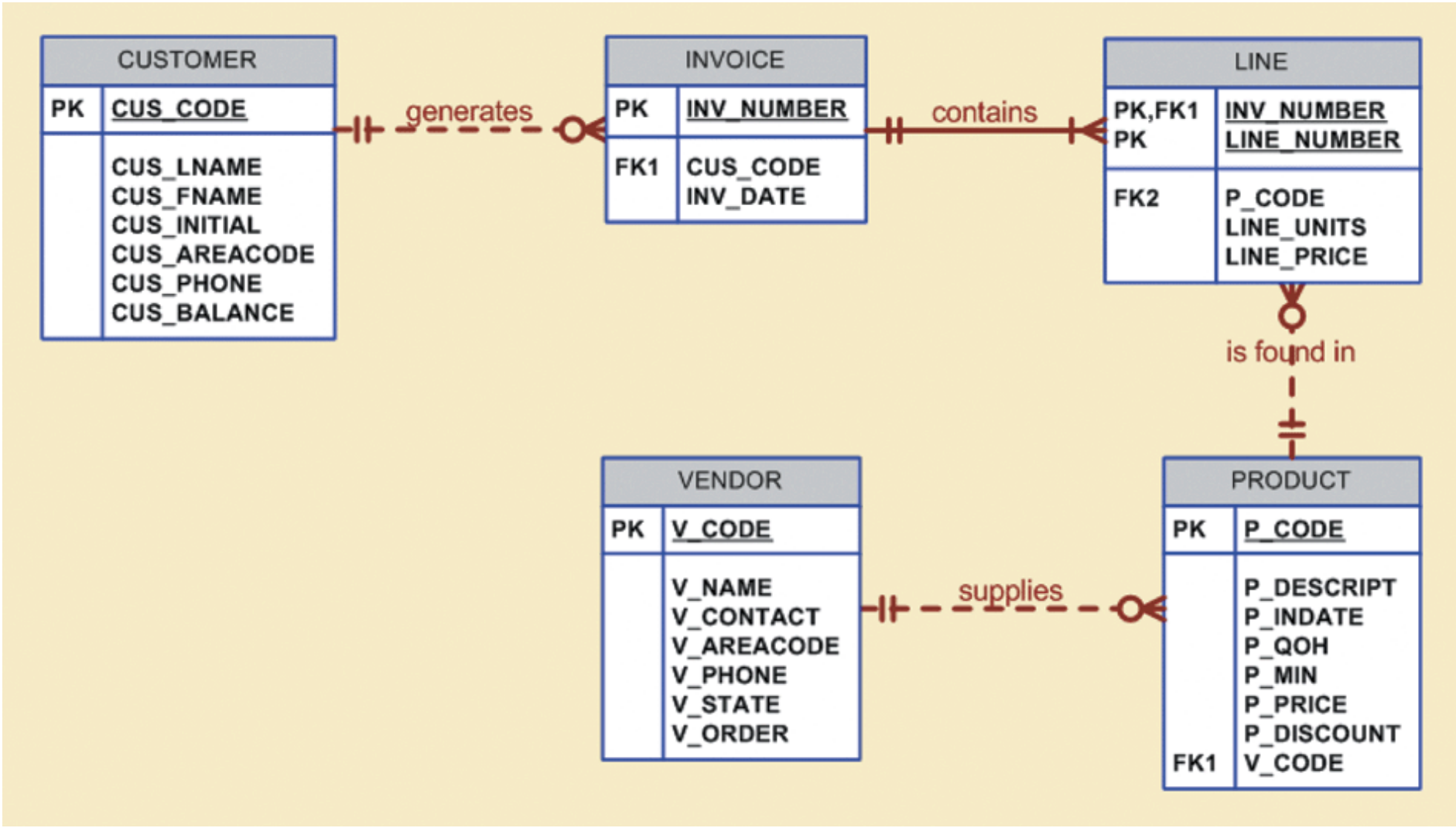

CUSTOMER
PK
CUS_CODE
CUS_LNAME
CUS_FNAME
CUS_INITIAL
CUS_AREACODE
CUS_PHONE
CUS_BALANCE
generates
INVOICE
PK
INV_NUMBER
FK1
CUS_CODE
INV_DATE
contains
LINE
PK,FK1
PK
INV_NUMBER
LINE_NUMBER
FK2
P_CODE
LINE_UNITS
LINE_PRICE
is found in
VENDOR
PK
V_CODE
V_NAME
V_CONTACT
V_AREACODE
V_PHONE
V_STATE
V_ORDER
supplies
PRODUCT
PK
P_CODE
P_DESCRIPT
P_INDATE
P_QOH
P_MIN
P_PRICE
P_DISCOUNT
FK1
V_CODE

Table name: VENDOR **Database name: Ch07_SaleCo**

V_CODE	V_NAME	V_CONTACT	V_AREACODE	V_PHONE	V_STATE	V_ORDER
21225	Bryson, Inc.	Smithson	615	223-3234	TN	Y
21226	SuperLoo, Inc.	Flushing	904	215-8995	FL	N
21231	D&E Supply	Singh	615	228-3245	TN	Y
21344	Gomez Bros.	Ortega	615	889-2546	KY	N
22567	Dome Supply	Smith	901	678-1419	GA	N
23119	Randsets Ltd.	Anderson	901	678-3998	GA	Y
24004	Brackman Bros.	Browning	615	228-1410	TN	N
24288	ORDVA, Inc.	Hakford	615	898-1234	TN	Y
25443	B&K, Inc.	Smith	904	227-0093	FL	N
25501	Damal Supplies	Smythe	615	890-3529	TN	N
25595	Rubicon Systems	Orton	904	456-0092	FL	Y

Table name: PRODUCT

P_CODE	P_DESCRIPT	P_INDATE	P_QOH	P_MIN	P_PRICE	P_DISCOUNT	V_CODE
11QER/31	Power painter, 15 psi., 3-nozzle	03-Nov-07	8	5	109.99	0.00	25595
13-Q2/P2	7.25-in. pwr. saw blade	13-Dec-07	32	15	14.99	0.05	21344
14-Q1/L3	9.00-in. pwr. saw blade	13-Nov-07	18	12	17.49	0.00	21344
1546-QQ2	Hrd. cloth, 1/4-in., 2x50	15-Jan-08	15	8	39.95	0.00	23119
1558-QW1	Hrd. cloth, 1/2-in., 3x50	15-Jan-08	23	5	43.99	0.00	23119
2232/QTY	B&D jigsaw, 12-in. blade	30-Dec-07	8	5	109.92	0.05	24288
2232/QWE	B&D jigsaw, 8-in. blade	24-Dec-07	6	5	99.87	0.05	24288
2238/QPD	B&D cordless drill, 1/2-in.	20-Jan-08	12	5	38.95	0.05	25595
23109-HB	Claw hammer	20-Jan-08	23	10	9.95	0.10	21225
23114-AA	Sledge hammer, 12 lb.	02-Jan-08	8	5	14.40	0.05	
54778-2T	Rat-tail file, 1/8-in. fine	15-Dec-07	43	20	4.99	0.00	21344
89-WRE-Q	Hicut chain saw, 16 in.	07-Feb-08	11	5	256.99	0.05	24288
PVC23DRT	PVC pipe, 3.5-in., 8-ft	20-Feb-08	188	75	5.87	0.00	
SM-18277	1.25-in. metal screw, 25	01-Mar-08	172	75	6.99	0.00	21225
SW-23116	2.5-in. wd. screw, 50	24-Feb-08	237	100	8.45	0.00	21231
WR3/TT3	Steel matting, 4'x8'x1/6", .5" mesh	17-Jan-08	18	5	119.95	0.10	25595

Creating the Database

- Two tasks must be completed:
  - Create database structure
  - Create tables that will hold end-user data
- First task:
  - RDBMS creates physical files that will hold database
  - Differs substantially from one RDBMS to another

The Database Schema

- Authentication
  - DBMS verifies that only registered users are able to access database
  - Log on to RDBMS using user ID and password created by database administrator
- Schema
  - Group of database objects that are related to each other

Data Types

- Data type selection is usually dictated by nature of data and by intended use
- Supported data types:
  - Integer, Smallint, Decimal(L,D)
  - Char(L), Varchar(L)
  - Date, Time
  - Real, Double, Float
  - Many other supported data types can be found by typing: help create table; in mysql CLI

Creating Table Structures

- Use one line per column (attribute) definition
- Use spaces to line up attribute characteristics and constraints
- NOT NULL specification - it ensures that data entry must be made i.e. user is not allowed to leave the attribute empty.
- UNIQUE specification - it creates a unique index to avoid duplicated values in a column.

Creating Table Structures (continued)

- Primary key attributes contain both a NOT NULL and a UNIQUE specification
- RDBMS will automatically enforce referential integrity for foreign keys
- Command sequence ends with semicolon
- The entire table definition is enclosed in parenthesis.

SQL Constraints

- NOT NULL constraint
  - Ensures that column does not accept nulls
- UNIQUE constraint
  - Ensures that all values in column are unique
- DEFAULT constraint
  - Assigns value to attribute when a new row is added to table
- CHECK constraint
  - Validates data when attribute value is entered by checking a specified condition exists.

SQL Indexes

- When primary key is declared, DBMS automatically creates unique index
- Often need additional indexes
- Using CREATE INDEX command, SQL indexes can be created on basis of any selected attribute
- Composite index
  - Index based on two or more attributes
  - Often used to prevent data duplication

Benefits of Indexing

A Duplicated Test Record

EMP_NUM	TEST_NUM	TEST_CODE	TEST_DATE	TEST_SCORE
110	1	WEA	15-Jan-2008	93
110	2	WEA	12-Jan-2008	87
111	1	HAZ	14-Dec-2007	91
111	2	WEA	18-Feb-2008	95
111	3	WEA	18-Feb-2008	95
112	1	CHEM	17-Aug-2007	91

- Store employee's test scores
- An employee can take test only once on a given date.
- Primary key: EMP_NUM + TEST_NUM
- Use unique composite index i.e.

```
CREATE UNIQUE INDEX test_ui1 ON test(emp_num, test_code, test_date);
```

Data Manipulation Commands

- INSERT (covered)
- SELECT (covered)
- UPDATE (covered)
- DELETE (covered)
- COMMIT
- ROLLBACK

Adding Table Rows

- INSERT
  - Used to enter data into table
  - Syntax:
    - INSERT INTO *columnname*
      VALUES (*value1*, *value2*, … , *valueN*);

Adding Table Rows (continued)

- When entering values, notice that:
  - Row contents are entered between parentheses
  - Character and date values are entered between apostrophes
  - Numerical entries are not enclosed in apostrophes
  - Attribute entries are separated by commas
  - A value is required for each column
- Use NULL for unknown values

Saving Table Changes

- Changes made to table contents are not physically saved on disk until:
  - Database is closed
  - Program is closed
  - COMMIT command is used
- Syntax:
  - COMMIT [WORK];
- Will permanently save any changes made to any table in the database

Listing Table Rows

- SELECT
  - Used to list contents of table
  - Syntax:
    - SELECT *columnlist*
    - FROM *tablename*;
- Columnlist represents one or more attributes, separated by commas
- Asterisk can be used as **wildcard** character to list all attributes

Updating Table Rows

- UPDATE
  - Modify data in a table
  - Syntax:

    UPDATE *tablename*
    SET *columnname = expression* [, *columnname = expression*]
    [WHERE *conditionlist*];
- If more than one attribute is to be updated in row, separate corrections with commas

Restoring Table Contents

- ROLLBACK
  - Undoes changes since last COMMIT
  - Brings data back to pre-change values
- Syntax:
  - ROLLBACK;
- COMMIT and ROLLBACK only work with commands to add, modify, or delete table rows

Deleting Table Rows

- DELETE
  - Deletes a table row
  - Syntax:

    DELETE FROM *tablename*
    [WHERE *conditionlist*];
- WHERE condition is optional
- If WHERE condition is not specified, all rows from specified table will be deleted

Inserting Table Rows with a SELECT Subquery

- INSERT
  - Inserts multiple rows from another table (source)
  - Uses SELECT subquery
  - **Subquery**: query embedded (or nested) inside another query
  - Subquery executed first
  - Syntax:

    INSERT INTO *tablename1* SELECT *columnlist* FROM *tablename2*;

SELECT Queries

- Fine-tune SELECT command by adding restrictions to search criteria using:
  - Conditional restrictions
  - Arithmetic operators
  - Logical operators
  - Special operators

Selecting Rows with Conditional Restrictions

- Select partial table contents by placing restrictions on rows to be included in output
  - Add conditional restrictions to SELECT statement, using WHERE clause
- Syntax:

  SELECT *columnlist*
  FROM *tablelist*
  [WHERE *conditionlist*] ;

Arithmetic Operators: The Rule of Precedence

- Perform operations within parentheses
- Perform power operations
- Perform multiplications and divisions
- Perform additions and subtractions

The Arithmetic Operators

ARITHMETIC OPERATOR	DESCRIPTION
+	Add
-	Subtract
*	Multiply
/	Divide
^	Raise to the power of (some applications use ** instead of ^)

Logical Operators: AND, OR, and NOT

- Searching data involves multiple conditions
- Logical operators: AND, OR, and NOT
- Can be combined
  - Parentheses placed to enforce precedence order
    - Conditions in parentheses always executed first
- **Boolean algebra**: mathematical field dedicated to use of logical operators
- NOT negates result of conditional expression

Special Operators

- BETWEEN: checks whether attribute value is within a range
- IS NULL: checks whether attribute value is null
- LIKE: checks whether attribute value matches given string pattern
- IN: checks whether attribute value matches any value within a value list
- EXISTS: checks if subquery returns any rows

Advanced Data Definition Commands

- All changes in table structure are made by using ALTER command
- Three options
  - ADD adds a column
  - MODIFY changes column characteristics
  - DROP deletes a column
- Can also be used to:
  - Add table constraints
  - Remove table constraints

Changing a Column's Data Type

- ALTER can be used to change data type
- Some RDBMSs do not permit changes to data types unless column is empty

Changing a Column's Data Characteristics

- Use ALTER to change data characteristics
- Changes in column's characteristics permitted if changes do not alter the existing data type

Adding a Column
Dropping a Column

- Use ALTER to add column
  - Do not include the NOT NULL clause for new column
- Use ALTER to drop column

Advanced Data Updates

- UPDATE command updates only data in existing rows
- If relationship between entries and existing columns, can assign values to slots
- Arithmetic operators useful in data updates

Copying Parts of Tables

- SQL permits copying contents of selected table columns
  - Data need not be reentered manually into newly created table(s)
- First create the table structure
- Next add rows to new table using table rows from another table

PART table attributes copied from the PRODUCT table

PART_CODE	PART_DESCRIPT	PART_PRICE	V_CODE
11QER/31	Power painter, 15 psi., 3-nozzle	109.99	25595
13-Q2/P2	7.25-in. pwr. saw blade	14.99	21344
14-Q1/L3	9.00-in. pwr. saw blade	17.49	21344
1546-QQ2	Hrd. cloth, 1/4-in., 2x50	39.95	23119
1558-QVV1	Hrd. cloth, 1/2-in., 3x50	43.99	23119
2232/QTY	B&D jigsaw, 12-in. blade	109.92	24288
2232/QWE	B&D jigsaw, 8-in. blade	99.87	24288
2238/QPD	B&D cordless drill, 1/2-in.	38.95	25595
23109-HB	Claw hammer	9.95	21225
23114-AA	Sledge hammer, 12 lb.	14.4	
54778-2T	Rat-tail file, 1/8-in. fine	4.99	21344
89-WRE-Q	Hicut chain saw, 16 in.	256.99	24288
PVC23DRT	PVC pipe, 3.5-in., 8-ft	5.87	
SM-18277	1.25-in. metal screw, 25	6.99	21225
SW-23116	2.5-in. wd. screw, 50	8.45	21231
WR3/TT3	Steel matting, 4'x8'x1/6", .5" mesh	119.95	25595

Adding Primary and Foreign Key Designations

- When table is copied, integrity rules do not copy
  - Primary and foreign keys manually defined on new table
- User ALTER TABLE command
  - Syntax:

    ALTER TABLE *tablename* ADD PRIMARY KEY(*fieldname*);
  - For foreign key, use FOREIGN KEY in place of PRIMARY KEY

Deleting a Table from the Database

- DROP
  - Deletes table from database
  - Syntax:

    DROP TABLE *tablename*;
- Can drop a table only if it is not the "one" side of any relationship
  - Otherwise RDBMS generates an error message
  - Foreign key integrity violation

Advanced SELECT Queries

- Logical operators work well in the query environment
- SQL provides useful functions that:
  - Count
  - Find minimum and maximum values
  - Calculate averages, etc.
- SQL allows user to limit queries to:
  - Entries having no duplicates
  - Entries whose duplicates may be grouped

Ordering a Listing

- ORDER BY clause useful when listing order important
- Syntax:

  SELECT *columnlist*
  FROM *tablelist*
  [WHERE *conditionlist*]
  [ORDER BY *columnlist* [ASC | DESC]];
- Ascending order by default

Listing Unique Values

- DISTINCT clause produces list of only values that are different from one another
- Example:

```
SELECT DISTINCT V_CODE
FROM     PRODUCT;
```

- Access places nulls at the top of the list
  - Oracle places it at the bottom
  - Placement of nulls does not affect list contents

Aggregate Functions

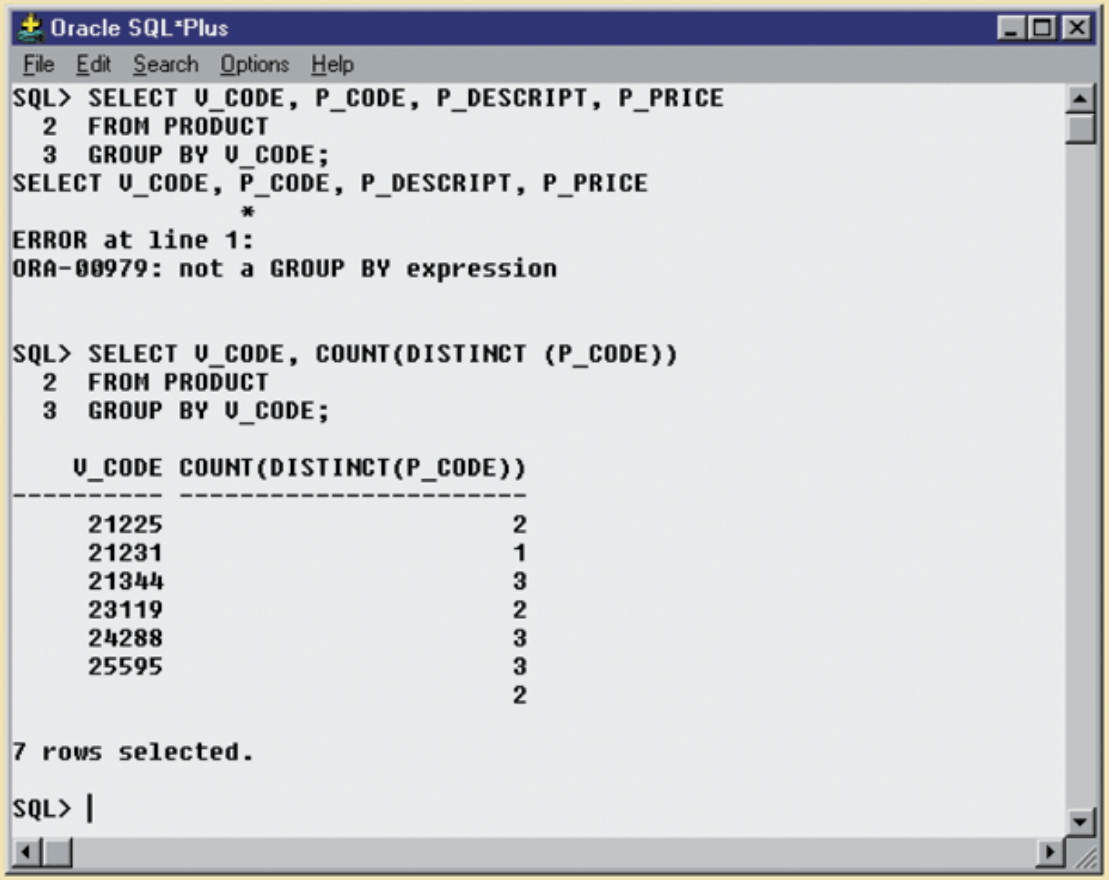
- COUNT function tallies number of non-null values of an attribute
  - Takes one parameter: usually a column name
- MAX and MIN find highest (lowest) value in a table
  - Compute MAX value in inner query
  - Compare to each value returned by the query
- SUM computes total sum for any specified attribute
- AVG function format similar to MIN and MAX

Grouping Data

- Frequency distributions created by GROUP BY clause within SELECT statement
- Syntax:

```
SELECT      columnlist
FROM        tablelist
[WHERE      conditionlist]
[GROUP BY   columnlist]
[HAVING     conditionlist]
[ORDER BY   columnlist [ASC | DESC] ] ;
```

Incorrect and correct use of the GROUP BY clause



Virtual Tables: Creating a View

- **View** is virtual table based on SELECT query
- Create view by using CREATE VIEW command
- Special characteristics of relational view:
  - Name of view can be used anywhere a table name is expected
  - View dynamically updated
  - Restricts users to only specified columns and rows
  - Views may be used as basis for reports

Joining Database Tables

- Joining tables is the most important distinction between relational database and other DBs
- Join is performed when data are retrieved from more than one table at a time
  - Equality comparison between foreign key and primary key of related tables
- Join tables by listing tables in FROM clause of SELECT statement
  - DBMS creates Cartesian product of every table

Joining Tables with an Alias

- Alias identifies the source table from which data are taken
- Alias can be used to identify source table
- Any legal table name can be used as alias
- Add alias after table name in FROM clause
  - FROM *tablename alias*

Recursive Joins
Outer Joins

- Alias especially useful when a table must be joined to itself
  - Recursive query
  - Use aliases to differentiate the table from itself
- Two types of outer join
  - Left outer join
  - Right outer join

Summary

- SQL commands can be divided into two overall categories:
  - Data definition language commands
  - Data manipulation language commands
- The ANSI standard data types are supported by all RDBMS vendors in different ways
- Basic data definition commands allow you to create tables, indexes, and views

Summary (continued)

- DML commands allow you to add, modify, and delete rows from tables
- The basic DML commands:
  - SELECT, INSERT, UPDATE, DELETE, COMMIT, and ROLLBACK
- SELECT statement is main data retrieval command in SQL

Summary (continued)

- WHERE clause can be used with SELECT, UPDATE, and DELETE statements
- Aggregate functions
  - Special functions that perform arithmetic computations over a set of rows
- ORDER BY clause
  - Used to sort output of SELECT statement
  - Can sort by one or more columns
  - Ascending or descending order

Summary (continued)

- Join output of multiple tables with SELECT statement
  - Join performed every time you specify two or more tables in FROM clause
  - If no join condition specified, DBMX performs Cartesian product
- Natural join uses join condition to match only rows with equal values in specified columns
- Right outer join and left outer join select rows with no matching values in other related table