COP 4710: Database Systems
Fall 2011

Chapter 5 – Introduction To SQL

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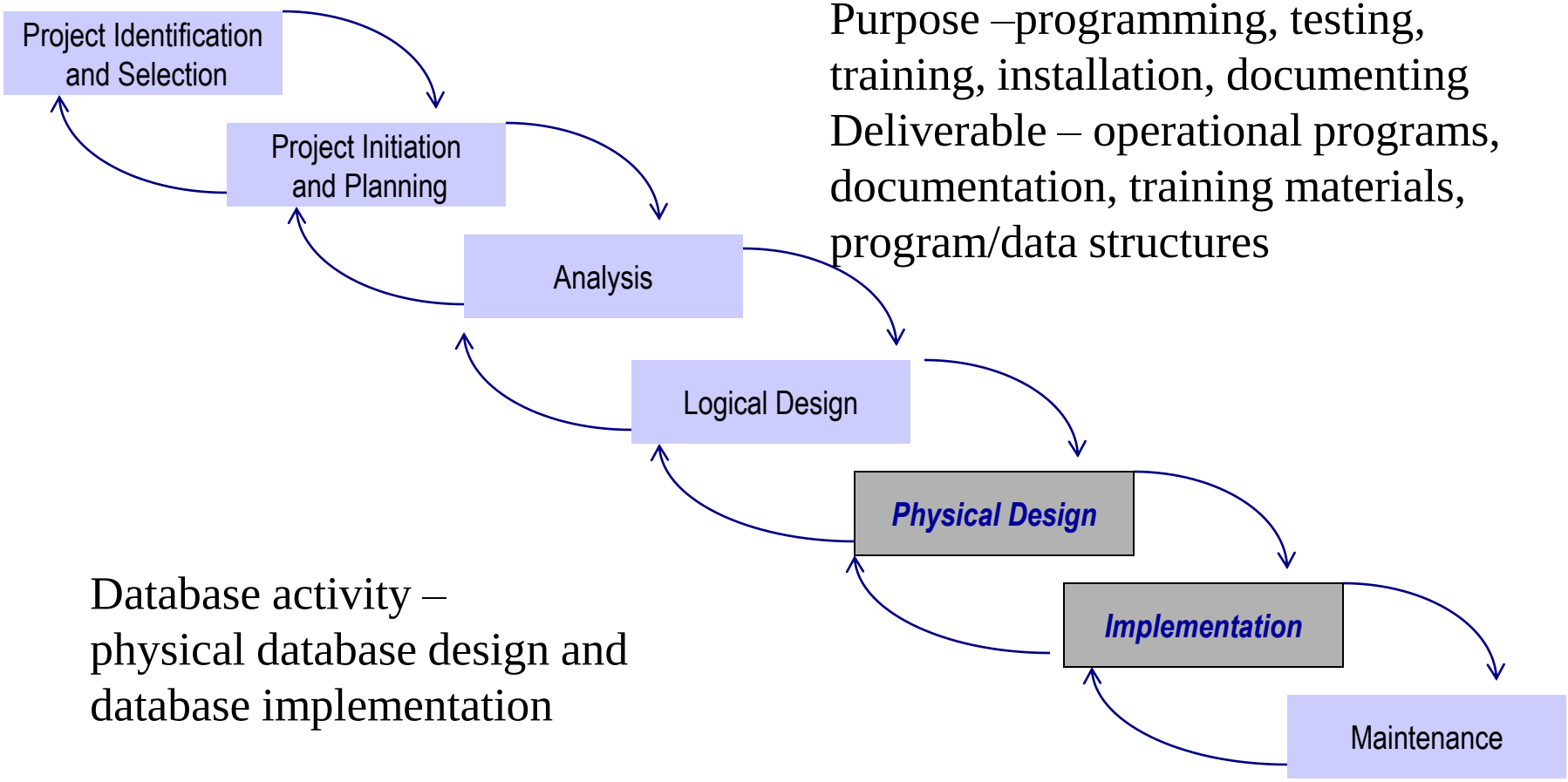
The Physical Design Stage of SDLC



Purpose –programming, testing, training, installation, documenting
Deliverable – operational programs, documentation, training materials, program/data structures

Database activity – physical database design and database implementation

SQL Overview

- SQL ≡ Structured Query Language.
- The standard for relational database management systems (RDBMS).
- SQL: 2007 Standards – Purpose:
  - Specify syntax/semantics for data definition and manipulation.
  - Define data structures.
  - Enable portability.
  - Specify minimal (level 1) and complete (level 2) standards.
  - Allow for later growth/enhancement to standard.
- SQL: 20XX Standard

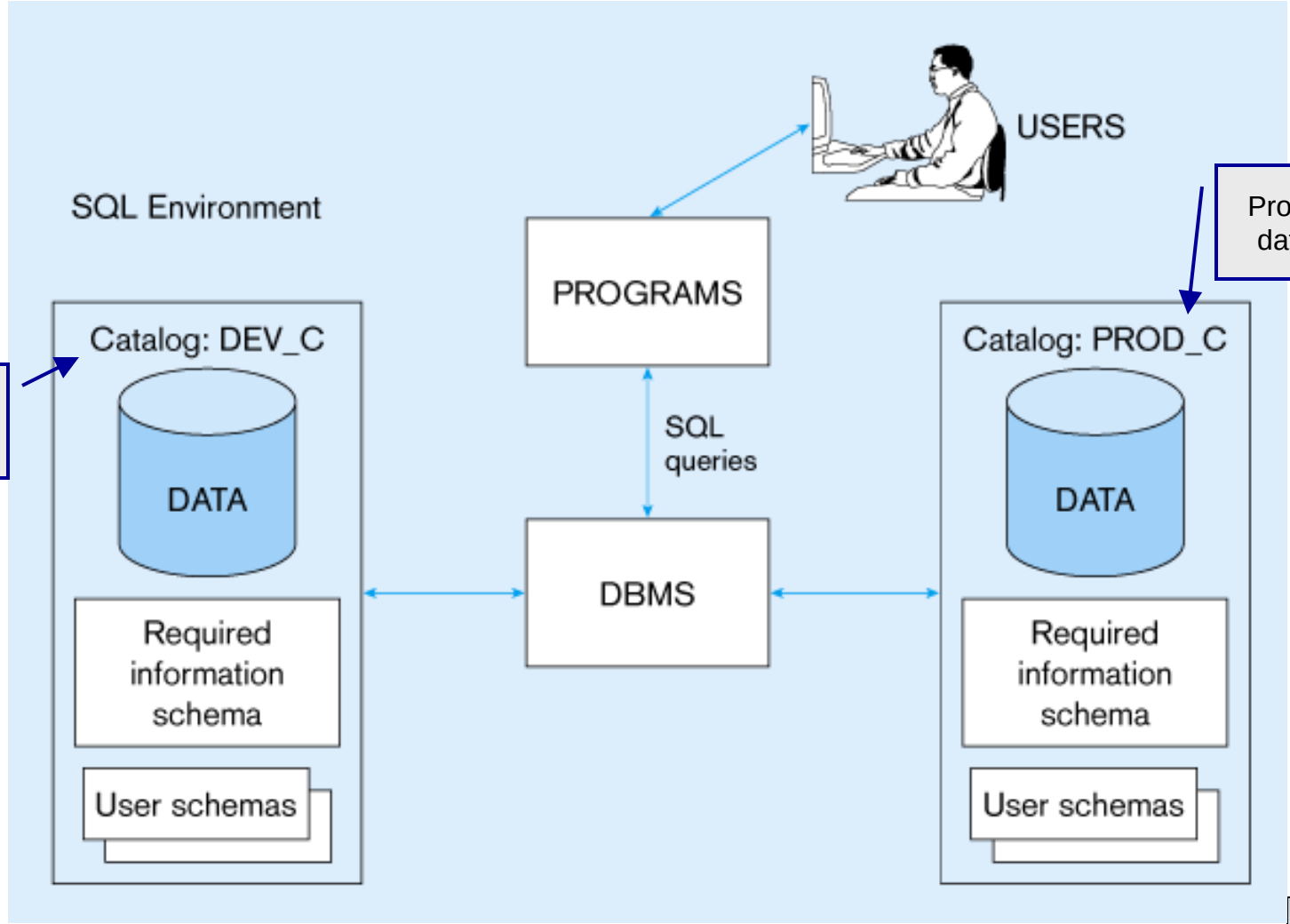
Benefits of a Standardized Relational Language

- Reduced training costs
- Productivity
- Application portability
- Application longevity
- Reduced dependence on a single vendor
- Cross-system communication

The SQL Environment

- Catalog
  - A set of schemas that constitute the description of a database.
- Schema
  - The structure that contains descriptions of objects created by a user (base tables, views, constraints).
- Data Definition Language (DDL)
  - Commands that define a database, including creating, altering, and dropping tables and establishing constraints.
- Data Manipulation Language (DML)
  - Commands that maintain and query a database.
- Data Control Language (DCL)
  - Commands that control a database, including administering privileges and committing data.

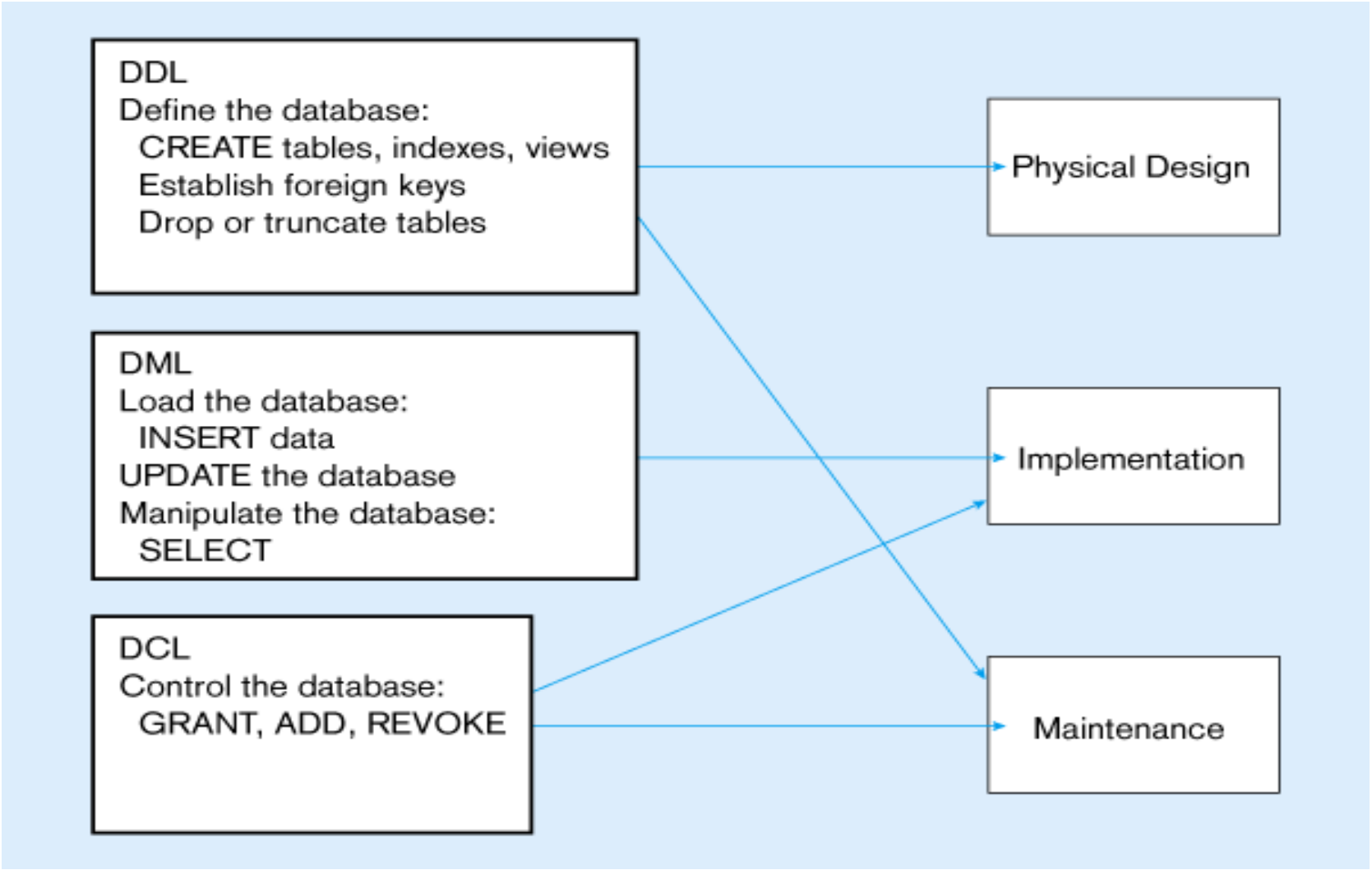
A simplified schematic of a typical SQL environment, as described by the SQL:20xx standard



Some SQL Data Types (from Oracle 11g)

- String types
  - CHAR(n) – fixed-length character data, n characters long Maximum length = 2000 bytes
  - VARCHAR2(n) – variable length character data, maximum 4000 bytes
  - LONG – variable-length character data, up to 4GB. Maximum 1 per table
- Numeric types
  - NUMBER(p,q) – general purpose numeric data type
  - INTEGER(p) – signed integer, p digits wide
  - FLOAT(p) – floating point in scientific notation with p binary digits precision
- Date/time type
  - DATE – fixed-length date/time in dd-mm-yy form

DDL, DML, DCL, and the database development process



SQL Database Definition

- Data Definition Language (DDL)
- Major CREATE statements:
  - CREATE SCHEMA – defines a portion of the database owned by a particular user.
  - CREATE TABLE – defines a table and its columns.
  - CREATE VIEW – defines a logical table from one or more views.
- Other CREATE statements: CHARACTER SET, COLLATION, TRANSLATION, ASSERTION, DOMAIN.

Table Creation

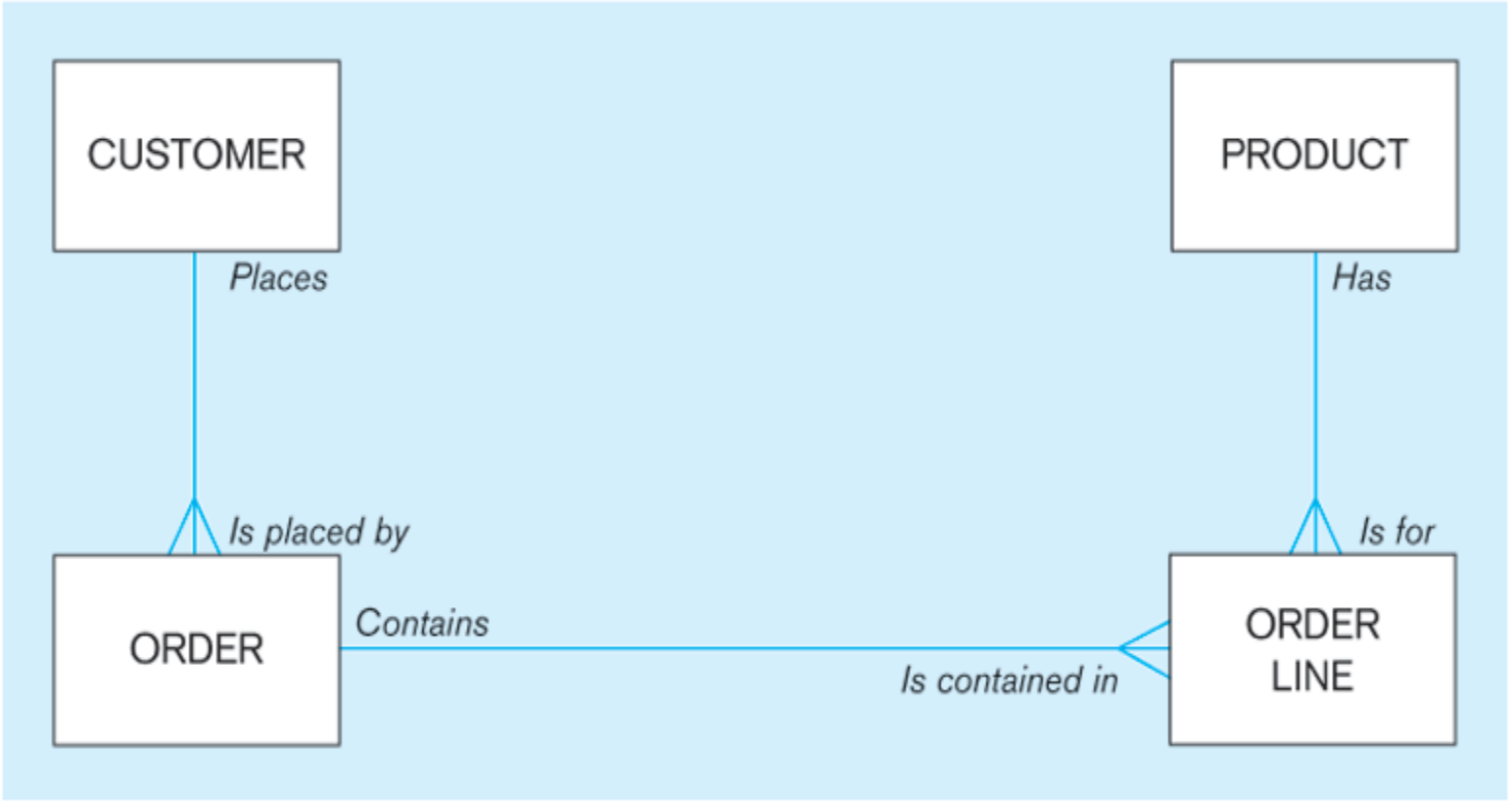
General syntax for CREATE TABLE

```
CREATE TABLE tablename
( {column definition   [table constraint] } . , . .
[ON COMMIT {DELETE | PRESERVE} ROWS] );

where column definition ::=
column_name
        {domain name | datatype [(size)] }
        [column_constraint_clause . . .]
        [default value]
        [collate clause]

and table constraint ::=
        [CONSTRAINT constraint_name]
        Constraint_type [constraint_attributes]
```

Steps in table creation:

1. Identify data types for attributes
2. Identify columns that can and cannot be null
3. Identify columns that must be unique (candidate keys)
4. Identify primary key-foreign key mates
5. Determine default values
6. Identify constraints on columns (domain specifications)
7. Create the table and associated indexes

The following slides create tables for this enterprise data model



Examples of SQL database definition commands

```
CREATE TABLE CUSTOMER_T
              (CUSTOMER_ID              NUMBER(11, 0) NOT NULL,
               CUSTOMER_NAME            VARCHAR2(25) NOT NULL,
               CUSTOMER_ADDRESS         VARCHAR2(30),
               CITY                     VARCHAR2(20),
               STATE                    VARCHAR2(2),
               POSTAL_CODE              VARCHAR2(9),
CONSTRAINT CUSTOMER_PK PRIMARY KEY (CUSTOMER_ID));
```

```
CREATE TABLE ORDER_T
              (ORDER_ID                 NUMBER(11, 0) NOT NULL,
               ORDER_DATE               DATE          DEFAULT SYSDATE,
               CUSTOMER_ID              NUMBER(11, 0),
CONSTRAINT ORDER_PK PRIMARY KEY (ORDER_ID),
CONSTRAINT ORDER_FK FOREIGN KEY (CUSTOMER_ID) REFERENCES CUSTOMER_T(CUSTOMER_ID));
```

```
CREATE TABLE PRODUCT_T
              (PRODUCT_ID               INTEGER       NOT NULL,
               PRODUCT_DESCRIPTION      VARCHAR2(50),
               PRODUCT_FINISH           VARCHAR2(20)
                        CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                                'Red Oak', 'Natural Oak', 'Walnut')),
               STANDARD_PRICE           DECIMAL(6,2),
               PRODUCT_LINE_ID          INTEGER,
CONSTRAINT PRODUCT_PK PRIMARY KEY (PRODUCT_ID));
```

```
CREATE TABLE ORDER_LINE_T
              (ORDER_ID                 NUMBER(11,0)  NOT NULL,
               PRODUCT_ID               NUMBER(11,0)  NOT NULL,
               ORDERED_QUANTITY         NUMBER(11,0),
CONSTRAINT ORDER_LINE_PK PRIMARY KEY (ORDER_ID, PRODUCT_ID),
CONSTRAINT ORDER_LINE_FK1 FOREIGN KEY(ORDER_ID) REFERENCES ORDER_T(ORDER_ID),
CONSTRAINT ORDER_LINE_FK2 FOREIGN KEY (PRODUCT_ID) REFERENCES PRODUCT_T(PRODUCT_ID));
```


Defining attributes and their data types

```
CREATE TABLE PRODUCT_T
        (PRODUCT_ID             INTEGER      NOT NULL,
         PRODUCT_DESCRIPTION    VARCHAR2(50),
         PRODUCT_FINISH         VARCHAR2(20)
                CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                       'Red Oak', 'Natural Oak', 'Walnut')),
         STANDARD_PRICE         DECIMAL(6,2),
         PRODUCT_LINE_ID        INTEGER,
CONSTRAINT PRODUCT_PK PRIMARY KEY (PRODUCT_ID));
```

Domain constraint

```
CREATE TABLE PRODUCT_T
        (PRODUCT_ID             INTEGER     NOT NULL,
         PRODUCT_DESCRIPTION    VARCHAR2(50),
         PRODUCT_FINISH         VARCHAR2(20)
                        CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                                'Red Oak', 'Natural Oak', 'Walnut')),
         STANDARD_PRICE         DECIMAL(6,2),
         PRODUCT_LINE_ID        INTEGER,
CONSTRAINT PRODUCT_PK PRIMARY KEY (PRODUCT_ID));
```

Non-null specification

Identifying primary key

Primary keys can never have NULL values

```
CREATE TABLE ORDER_LINE_T
        (ORDER_ID           NUMBER(11,0) NOT NULL,
         PRODUCT_ID         NUMBER(11,0) NOT NULL,
         ORDERED_QUANTITY   NUMBER(11,0),
CONSTRAINT ORDER_LINE_PK PRIMARY KEY (ORDER_ID, PRODUCT_ID),
CONSTRAINT ORDER_LINE_FK1 FOREIGN KEY(ORDER_ID) REFERENCES ORDER_T(ORDER_ID),
CONSTRAINT ORDER_LINE_FK2 FOREIGN KEY (PRODUCT_ID) REFERENCES PRODUCT_T(PRODUCT_ID));
```

Non-null specifications

Primary key

Some primary keys are composite – composed of multiple attributes

Controlling the values in attributes

```
CREATE TABLE ORDER_T
        (ORDER_ID               NUMBER(11, 0) NOT NULL,
         ORDER_DATE             DATE          DEFAULT SYSDATE,
         CUSTOMER_ID            NUMBER(11, 0),
CONSTRAINT ORDER_PK PRIMARY KEY (ORDER_ID),
CONSTRAINT ORDER_FK FOREIGN KEY (CUSTOMER_ID) REFERENCES CUSTOMER_T(CUSTOMER_ID));

CREATE TABLE PRODUCT_T
        (PRODUCT_ID             INTEGER       NOT NULL,
         PRODUCT_DESCRIPTION    VARCHAR2(50),
         PRODUCT_FINISH         VARCHAR2(20)
                  CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                                'Red Oak', 'Natural Oak', 'Walnut')),
         STANDARD_PRICE         DECIMAL(6,2),
         PRODUCT_LINE_ID        INTEGER,
```

Default value

Domain constraint

Identifying foreign keys and establishing relationships

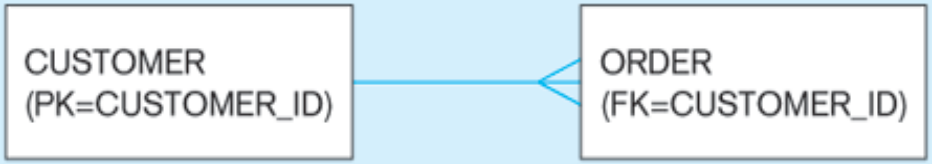
```
CREATE TABLE CUSTOMER_T
        (CUSTOMER_ID            NUMBER(11, 0) NOT NULL,
         CUSTOMER_NAME          VARCHAR2(25) NOT NULL,
         CUSTOMER_ADDRESS       VARCHAR2(30),
         CITY                   VARCHAR2(20),
         STATE                  VARCHAR2(2),
         POSTAL_CODE            VARCHAR2(9),
CONSTRAINT CUSTOMER_PK PRIMARY KEY (CUSTOMER_ID));

CREATE TABLE ORDER_T
         (ORDER_ID              NUMBER(11, 0) NOT NULL,
          ORDER_DATE            DATE          DEFAULT SYSDATE,
          CUSTOMER_ID           NUMBER(11, 0),
CONSTRAINT ORDER_PK PRIMARY KEY (ORDER_ID),
CONSTRAINT ORDER_FK FOREIGN KEY (CUSTOMER_ID) REFERENCES CUSTOMER_T(CUSTOMER_ID));
```

Primary key of parent table

Foreign key of dependent table

Data Integrity Controls

- Referential integrity – constraint that ensures that foreign key values of a table must match primary key values of a related table in 1:M relationships.
- Restricting:
  - Deletes of primary records.
  - Updates of primary records.
  - Inserts of dependent records.



Restricted Update: A customer ID can only be deleted if it is not found in ORDER table.

```
CREATE TABLE CUSTOMER_T
            (CUSTOMER_ID        INTEGER DEFAULT 'C999'   NOT NULL,
             CUSTOMER_NAME      VARCHAR(40)              NOT NULL,
             . . .
CONSTRAINT CUSTOMER_PK PRIMARY KEY (CUSTOMER_ID),
ON UPDATE RESTRICT);
```

Cascaded Update: Changing a customer ID in the CUSTOMER table will result in that value changing in the ORDER table to match.

. . . ON UPDATE CASCADE);

Set Null Update: When a customer ID is changed, any customer ID in the ORDER table that matches the old customer ID is set to NULL.

. . . ON UPDATE SET NULL);

Set Default Update: When a customer ID is changed, any customer ID in the ORDER tables that matches the old customer ID is set to a predefined default value.

. . . ON UPDATE SET DEFAULT);

Relational integrity is enforced via the primary-key to foreign-key match

Changing and Removing Tables

- ALTER TABLE statement allows you to change column specifications:
  - ALTER TABLE CUSTOMER_T ADD (TYPE VARCHAR(2))
- DROP TABLE statement allows you to remove tables from your schema:
  - DROP TABLE CUSTOMER_T

Schema Definition

- Control processing/storage efficiency:
  - Choice of indexes
  - File organizations for base tables
  - File organizations for indexes
  - Data clustering
  - Statistics maintenance
- Creating indexes
  - Speed up random/sequential access to base table data
  - Example
    - CREATE INDEX NAME_IDX ON CUSTOMER_T(CUSTOMER_NAME)
    - This makes an index for the CUSTOMER_NAME field of the CUSTOMER_T table

Insert Statement

- Adds data to a table
- Inserting into a table
  - INSERT INTO CUSTOMER_T VALUES (001, 'Contemporary Casuals', 1355 S. Himes Blvd.', 'Gainesville', 'FL', 32601);
- Inserting a record that has some null attributes requires identifying the fields that actually get data
  - INSERT INTO PRODUCT_T (PRODUCT_ID, PRODUCT_DESCRIPTION,PRODUCT_FINISH, STANDARD_PRICE, PRODUCT_ON_HAND) VALUES (1, 'End Table', 'Cherry', 175, 8);
- Inserting from another table
  - INSERT INTO CA_CUSTOMER_T SELECT * FROM CUSTOMER_T WHERE STATE = 'CA';

Delete Statement

- Removes rows from a table.
- Delete certain rows
  - DELETE FROM CUSTOMER_T WHERE STATE = ‘HI’;
- Delete all rows
  - DELETE FROM CUSTOMER_T;

Update Statement

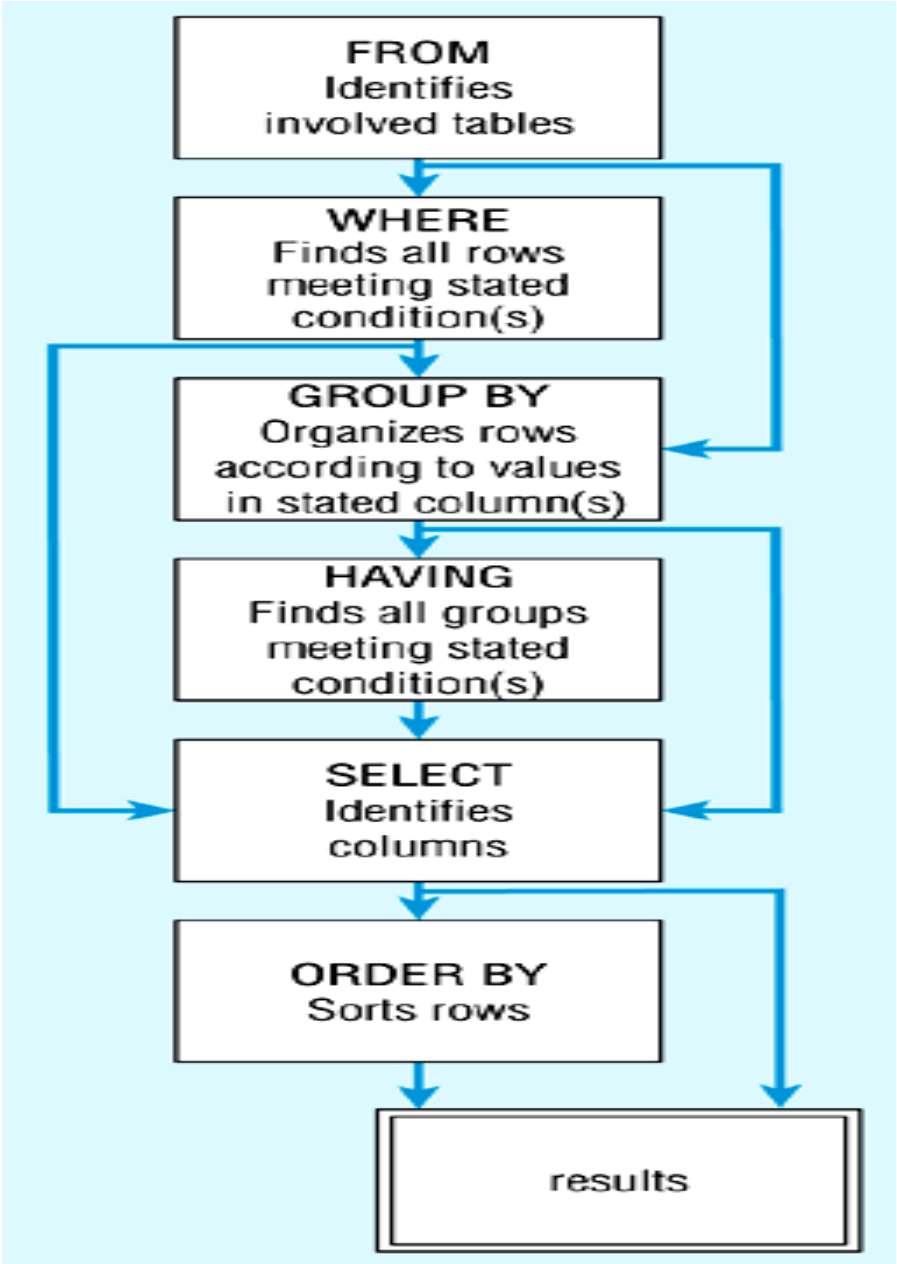
- Modifies data in existing rows

- UPDATE PRODUCT_T SET UNIT_PRICE = 775
  WHERE PRODUCT_ID = 7;

SELECT Statement

- Used for queries on single or multiple tables.
- Clauses of the SELECT statement:
  - SELECT
    - List the columns (and expressions) that should be returned from the query
  - FROM
    - Indicate the table(s) or view(s) from which data will be obtained
  - WHERE
    - Indicate the conditions under which a row will be included in the result
  - GROUP BY
    - Indicate categorization of results
  - HAVING
    - Indicate the conditions under which a category (group) will be included
  - ORDER BY
    - Sorts the result according to specified criteria

SQL statement processing order



SELECT Example

- Find products with standard price less than $275

```
SELECT PRODUCT_NAME, STANDARD_PRICE
FROM PRODUCT_V
WHERE STANDARD_PRICE < 275;
```


SELECT Example using Alias

- Alias is an alternative column or table name.

```
SELECT CUST.CUSTOMER AS NAME,
  CUST.CUSTOMER_ADDRESS
FROM CUSTOMER_V CUST
WHERE NAME = 'Home Furnishings';
```


SELECT Example Using a Function

- Using the COUNT ***aggregate function*** to find totals

```
SELECT COUNT(*) FROM ORDER_LINE_V
WHERE ORDER_ID = 1004;
```

Note: with aggregate functions you can't have single-valued columns included in the SELECT clause

SELECT Example – Boolean Operators

- AND, OR, and NOT Operators for customizing conditions in WHERE clause

```
SELECT PRODUCT_DESCRIPTION, PRODUCT_FINISH,
   STANDARD_PRICE
FROM PRODUCT_V
WHERE (PRODUCT_DESCRIPTION LIKE '%Desk'
OR PRODUCT_DESCRIPTION LIKE '%Table')
AND UNIT_PRICE > 300;
```

Note: the LIKE operator allows you to compare strings using wildcards. For example, the % wildcard in '%Desk' indicates that all strings that have any number of characters preceding the word "Desk" will be allowed

SELECT Example – Sorting Results with the ORDER BY Clause

- Sort the results first by STATE, and within a state by CUSTOMER_NAME

```
SELECT CUSTOMER_NAME, CITY, STATE
FROM CUSTOMER_V
WHERE STATE IN ('FL', 'TX', 'CA', 'HI')
ORDER BY STATE, CUSTOMER_NAME;
```

Note: the IN operator in this example allows you to include rows whose STATE value is either FL, TX, CA, or HI. It is more efficient than separate OR conditions

SELECT Example –
Categorizing Results Using the GROUP BY Clause

- For use with aggregate functions
  - ***Scalar aggregate***: single value returned from SQL query with aggregate function
  - ***Vector aggregate***: multiple values returned from SQL query with aggregate function (via GROUP BY)

```
SELECT STATE, COUNT(STATE)
FROM CUSTOMER_V
GROUP BY STATE;
```

Note: you can use single-value fields with aggregate functions if they are included in the GROUP BY clause.

SELECT Example –
Qualifying Results by Category Using the HAVING Clause

- For use with GROUP BY

```
SELECT STATE, COUNT(STATE)
FROM CUSTOMER_V
GROUP BY STATE
HAVING COUNT(STATE) > 1;
```

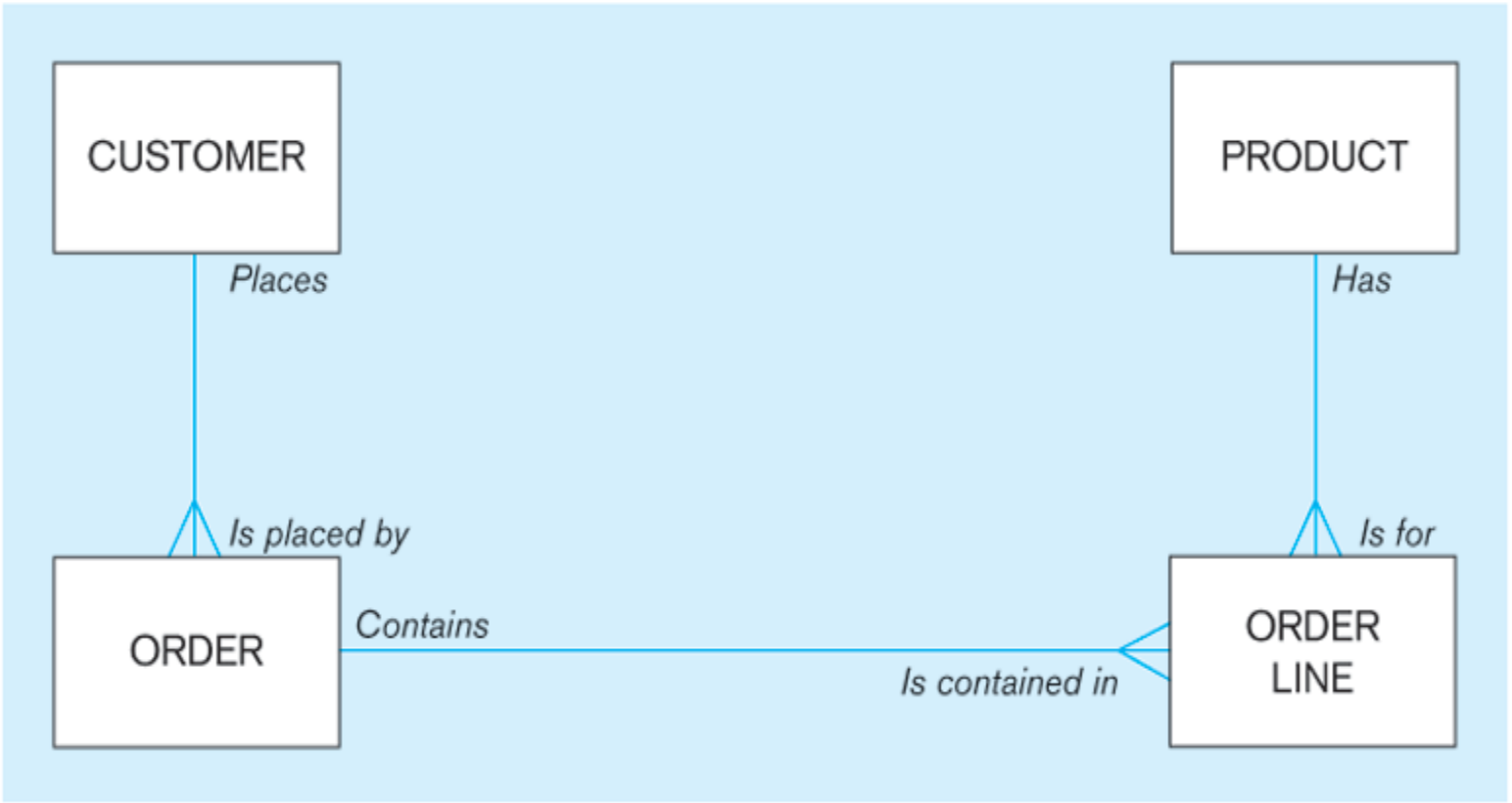
Like a WHERE clause, but it operates on groups (categories), not on individual rows. Here, only those groups with total numbers greater than 1 will be included in final result

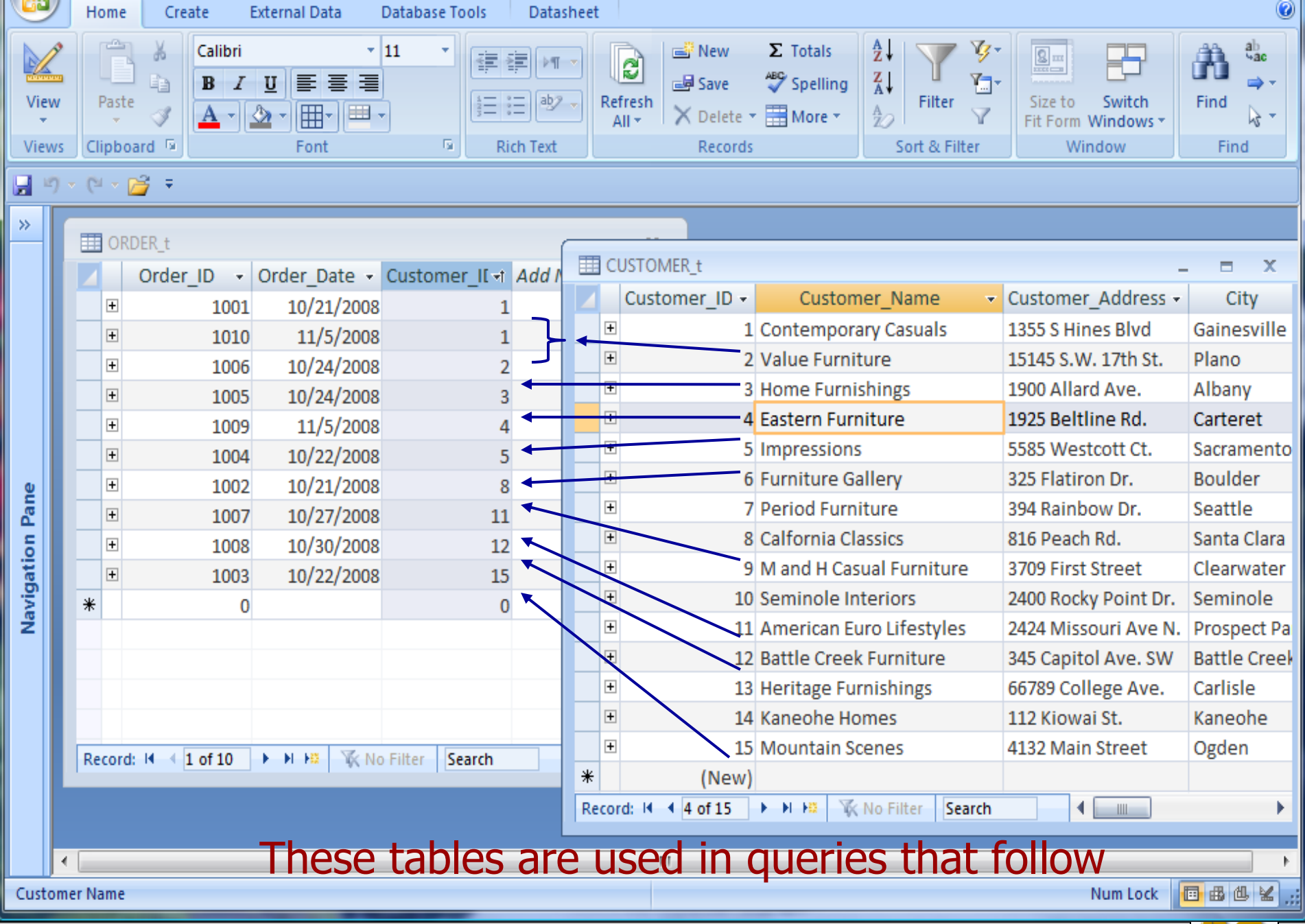
Processing Multiple Tables – Joins

- Join – a relational operation that causes two or more tables with a common domain to be combined into a single table or view
- Equi-join – a join in which the joining condition is based on equality between values in the common columns; common columns appear redundantly in the result table
- Natural join – an equi-join in which one of the duplicate columns is eliminated in the result table
- Outer join – a join in which rows that do not have matching values in common columns are nonetheless included in the result table (as opposed to *inner* join, in which rows must have matching values in order to appear in the result table)
- Union join – includes all columns from each table in the join, and an instance for each row of each table

The common columns in joined tables are usually the primary key of the dominant table and the foreign key of the dependent table in 1:M relationships

Same Scenario As Page 11




Home
Create
External Data
Database Tools
Datasheet
ORDER_t
Order_ID
Order_Date
Customer_ID
1001 10/21/2008 1
1010 11/5/2008 1
1006 10/24/2008 2
1005 10/24/2008 3
1009 11/5/2008 4
1004 10/22/2008 5
1002 10/21/2008 8
1007 10/27/2008 11
1008 10/30/2008 12
1003 10/22/2008 15
0 0
Record: 1 of 10
No Filter
Search
CUSTOMER_t
Customer_ID
Customer_Name
Customer_Address
City
1 Contemporary Casuals 1355 S Hines Blvd Gainesville
2 Value Furniture 15145 S.W. 17th St. Plano
3 Home Furnishings 1900 Allard Ave. Albany
4 Eastern Furniture 1925 Beltline Rd. Carteret
5 Impressions 5585 Westcott Ct. Sacramento
6 Furniture Gallery 325 Flatiron Dr. Boulder
7 Period Furniture 394 Rainbow Dr. Seattle
8 Calfornia Classics 816 Peach Rd. Santa Clara
9 M and H Casual Furniture 3709 First Street Clearwater
10 Seminole Interiors 2400 Rocky Point Dr. Seminole
11 American Euro Lifestyles 2424 Missouri Ave N. Prospect Pa
12 Battle Creek Furniture 345 Capitol Ave. SW Battle Creek
13 Heritage Furnishings 66789 College Ave. Carlisle
14 Kaneohe Homes 112 Kiowai St. Kaneohe
15 Mountain Scenes 4132 Main Street Ogden
(New)
Record: 4 of 15
No Filter
Search
Navigation Pane
These tables are used in queries that follow
Customer Name
Num Lock

Natural Join Example

- For each customer who placed an order, what is the customer's name and order number?

Join involves multiple tables in FROM clause

```
SELECT CUSTOMER_T.CUSTOMER_ID, CUSTOMER_NAME, ORDER_ID
FROM CUSTOMER_T, ORDER_T

WHERE CUSTOMER_T.CUSTOMER_ID = ORDER_T.CUSTOMER_ID;
```

WHERE clause performs the equality check for common columns of the two tables

Outer Join Example (Microsoft Syntax)

- List the customer name, ID number, and order number for all customers. Include customer information even for customers that do have an order

```
SELECT CUSTOMER_T.CUSTOMER_ID, CUSTOMER_NAME,
    ORDER_ID
FROM CUSTOMER_T, LEFT OUTER JOIN ORDER_T
ON CUSTOMER_T.CUSTOMER_ID = ORDER_T.CUSTOMER_ID;
```

LEFT OUTER JOIN syntax with ON keyword instead of WHERE → causes customer data to appear even if there is no corresponding order data

Results

CUSTOMER_ID	CUSTOMER_NAME	ORDER_ID
1	Contemporary Casuals	1001
1	Contemporary Casuals	1010
2	Value Furniture	1006
3	Home Furnishings	1005
4	Eastern Furniture	1009
5	Impressions	1004
6	Furniture Gallery	
7	Period Furnishings	
8	California Classics	1002
9	M & H Casual Furniture	
10	Seminole Interiors	
11	American Euro Lifestyles	1007
12	Battle Creek Furniture	1008
13	Heritage Furnishings	
14	Kaneohe Homes	
15	Mountain Scenes	1003

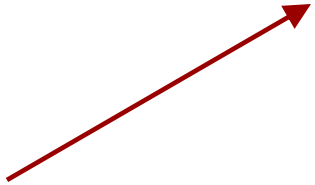
16 rows selected.

Outer Join Example (Oracle Syntax)

- List the customer name, ID number, and order number for all customers. Include customer information even for customers that do have an order

```
SELECT CUSTOMER_T.CUSTOMER_ID, CUSTOMER_NAME, ORDER_ID
FROM CUSTOMER_T,  ORDER_T
WHERE CUSTOMER_T.CUSTOMER_ID = ORDER_T.CUSTOMER_ID(+);
```

Outer join in Oracle uses regular join syntax, but adds (+) symbol to the side that will have the missing data



Multiple Table Join Example

- Assemble all information necessary to create an invoice for order number 1006

Four tables involved in this join

```
SELECT CUSTOMER_T.CUSTOMER_ID, CUSTOMER_NAME,
    CUSTOMER_ADDRESS, CITY, SATE, POSTAL_CODE,
    ORDER_T.ORDER_ID, ORDER_DATE, QUANTITY,
    PRODUCT_NAME, UNIT_PRICE, (QUANTITY * UNIT_PRICE)
FROM CUSTOMER_T, ORDER_T, ORDER_LINE_T, PRODUCT_T
WHERE  CUSTOMER_T.CUSTOMER_ID =
    ORDER_LINE.CUSTOMER_ID      AND ORDER_T.ORDER_ID =
    ORDER_LINE_T.ORDER_ID
            AND ORDER_LINE_T.PRODUCT_ID =
        PRODUCT_PRODUCT_ID
            AND ORDER_T.ORDER_ID = 1006;
```

Each pair of tables requires an equality-check condition in the WHERE clause, matching primary keys against foreign keys

Results from a four-table join

From CUSTOMER_T table

CUSTOMER_ID	CUSTOMER_NAME	CUSTOMER_ADDRESS	CUSTOMER_ CITY	CUSTOMER_ ST	POSTAL_ CODE
2	Value Furniture	15145 S.W. 17th St.	Plano	TX	75094 7743
2	Value Furniture	15145 S.W. 17th St.	Plano	TX	75094 7743
2	Value Furniture	15145 S.W. 17th St.	Plano	TX	75094 7743

ORDER_ID	ORDER_DATE	ORDERED_ QUANTITY
1006	24-OCT-04	1
1006	24-OCT-04	2
1006	24-OCT-04	2

From ORDER_T table

PRODUCT_NAME	STANDARD_PRICE	(QUANTITY* STANDARD_PRICE)
Entertainment Center	650	650
Writer's Desk	325	650
Dining Table	800	1600

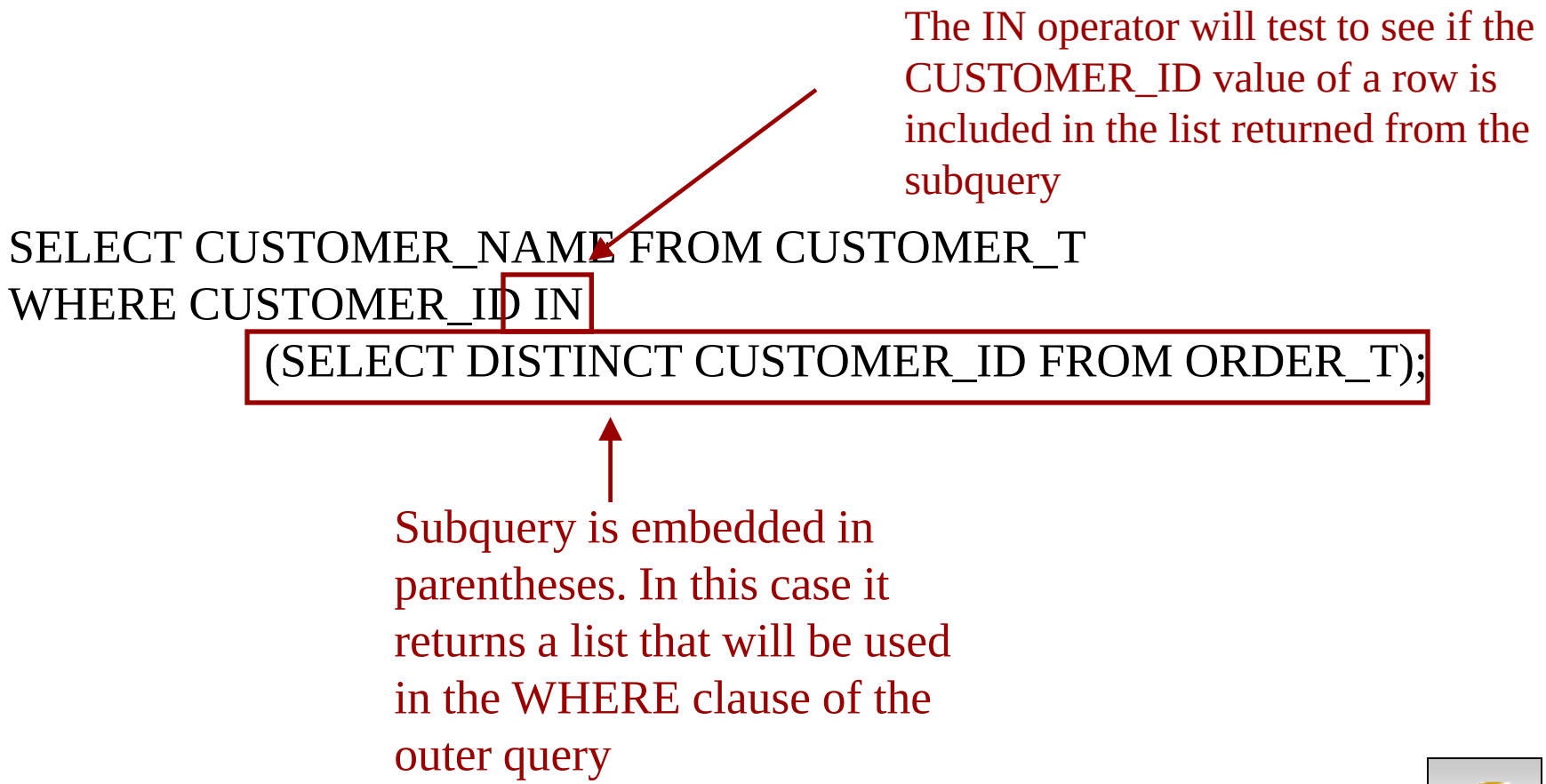
From PRODUCT_T table

Processing Multiple Tables Using Subqueries

- Subquery – placing an inner query (SELECT statement) inside an outer query.
- Options:
  - In a condition of the WHERE clause.
  - As a "table" of the FROM clause.
  - Within the HAVING clause.
- Subqueries can be:
  - Noncorrelated – executed once for the entire outer query.
  - Correlated – executed once for each row returned by the outer query.

Subquery Example

- Show all customers who have placed an order.



Correlated vs. Noncorrelated Subqueries

- Noncorrelated subqueries:
  - Do not depend on data from the outer query.
  - Execute once for the entire outer query.
- Correlated subqueries:
  - Make use of data from the outer query.
  - Execute once for each row of the outer query.
  - Can use the EXISTS operator.

Processing a noncorrelated subquery

1. The subquery executes and returns the customer IDs from the ORDER_T table
2. The outer query on the results of the subquery

```
SELECT CUSTOMER_NAME
    FROM CUSTOMER_T
        WHERE CUSTOMER_ID IN
            (SELECT DISTINCT CUSTOMER_ID
             FROM ORDER_T);
```

1. The subquery (shown in the box) is processed first and an intermediate results table created:

CUSTOMER_ID
1
8
15
5
3
2
11
12
4

9 rows selected.

No reference to data in outer query, so subquery executes once only

2. The outer query returns the requested customer information for each customer included in the intermediate results table:

CUSTOMER_NAME
Contemporary Casuals
Value Furniture
Home Furnishings
Eastern Furniture
Impressions
California Classics
American Euro Lifestyles
Battle Creek Furniture
Mountain Scenes

9 rows selected.

These are the only customers that have IDs in the ORDER_T table

Correlated Subquery Example

- Show all orders that include furniture finished in natural ash

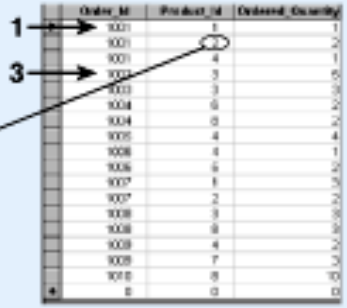
The EXISTS operator will return a TRUE value if the subquery resulted in a non-empty set, otherwise it returns a FALSE

```
SELECT DISTINCT ORDER_ID FROM ORDER_LINE_T
WHERE  EXISTS
   (SELECT * FROM PRODUCT_T
     WHERE PRODUCT_ID = ORDER_LINE_T.PRODUCT_ID
     AND PRODUCT_FINISH = 'Natural ash');
```

The subquery is testing for a value that comes from the outer query

Processing a correlated subquery

```
SELECT DISTINCT ORDER _ID FROM ORDER _LINE _T
WHERE EXISTS
        (SELECT *
          FROM PRODUCT _T
                WHERE PRODUCT _ID = ORDER _LINE _T.PRODUCT _ID
                      AND PRODUCT _FINISH = 'Natural Ash');
```



Subquery refers to outer-query data, so executes once for each row of outer query

	Product_ID	Product_Description	Product_Finish	Standard_Price	Product_Line_Id
▶	1	End Table	Cherry	$175.00	10001
	2	Coffee Table	Natural Ash	$200.00	20001
	3	Computer Desk	Natural Ash	$375.00	20001
	4	Entertainment Center	Natural Maple	$650.00	30001
	5	Writer's Desk	Cherry	$325.00	10001
	6	8-Drawer Dresser	White Ash	$750.00	20001
	7	Dining Table	Natural Ash	$800.00	20001
	8	Computer Desk	Walnut	$250.00	30001
*	(AutoNumber)			$0.00	

Note: only the orders that involve products with Natural Ash will be included in the final results

1. The first order ID is selected from ORDER _LINE _T: ORDER _ID =1001.
2. The subquery is evaluated to see if any product in that order has a natural ash finish. Product 2 does, and is part of the order. EXISTS is valued as *true* and the order ID is added to the result table.
3. The next order ID is selected from ORDER _LINE _T: ORDER _ID =1002.
4. The subquery is evaluated to see if the product ordered has a natural ash finish. It does. EXISTS is valued as true and the order ID is added to the result table.
5. Processing continues through each order ID. Orders 1004, 1005, and 1010 are not included in the result table because they do not include any furniture with a natural ash finish. The final result table is shown in the text on page 303.

Another Subquery Example

- Show all products whose price is higher than the average

Subquery forms the derived table used in the FROM clause of the outer query

One column of the subquery is an aggregate function that has an alias name. That alias can then be referred to in the outer query

```
SELECT PRODUCT_DESCRIPTION, STANDARD_PRICE,  AVGPRICE
FROM
     (SELECT AVG(STANDARD_PRICE) AVGPRICE FROM PRODUCT_T),
     PRODUCT_T
     WHERE STANDARD_PRICE > AVG_PRICE;
```

The WHERE clause normally cannot include aggregate functions, but because the aggregate is performed in the subquery its result can be used in the outer query's WHERE clause

SQL Join Operations

- The SQL join operations merge rows from two tables and returns the rows that:

  1. Have common values in common columns (natural join) or,
  2. Meet a given join condition (equality or inequality) or,
  3. Have common values in common columns or have no matching values (outer join).

- We've already examined the basic form of an SQL join which occurs when two tables are listed in the FROM clause and the WHERE clause specifies the join condition.

- An example of this basic form of the join is shown on the next page.

SQL Join Operations (cont.)

```
SELECT P_CODE, P_DESCRIPT, P_PRICE, V_NAME
   FROM PRODUCT, VENDOR
   WHERE PRODUCT.V_CODE = VENDOR.V_CODE;
```

- The FROM clause indicates which tables are to be joined. If three or more tables are specified, the join operation takes place two tables at a time, starting from left to right.
- The join condition is specified in the WHERE clause. In the example, a natural join is effected on the attribute V_CODE.
- The SQL join syntax shown above is sometimes referred to as an "old-style" join.
- The tables on pages 55 and 56, summarize the SQL join operations.

SQL Cross Join Operation

- A cross join in SQL is equivalent to a Cartesian product in standard relational algebra. The cross join syntax is:

```
SELECT column-list
    FROM table1, table2;
```

old style syntax

```
SELECT column-list
    FROM table1 CROSS JOIN table2;
```

new style syntax

SQL Natural Join Operation

- The natural join syntax is:

```
SELECT column-list
    FROM table1 NATURAL JOIN  table2;
```

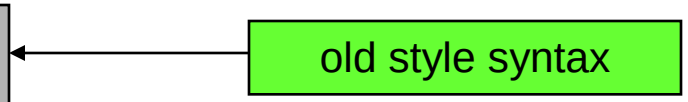
new style syntax

- The natural join will perform the following tasks:
  - Determine the common attribute(s) by looking for attributes with identical names and compatible data types.
  - Select only the rows with common values in the common attribute(s).
  - If there are no common attributes, return the cross join of the two tables.

SQL Natural Join Operation (cont.)

- The syntax for the old-style natural join is:

```
SELECT column-list
    FROM table1,  table2
    WHERE table1.C1 = table2.C2;
```



- One important difference between the natural join and the "old-style" syntax is that the natural join does not require the use of a table qualifier for the common attributes. The two SELECT statements shown on the next page are equivalent.

SQL Natural Join Operation (cont.)

```
SELECT CUS_NUM, CUS_LNAME,
            INV_NUMBER, INV_DATE
  FROM  CUSTOMER, INVOICE
  WHERE  CUSTOMER.CUS_NUM = INVOICE. CUS_NUM;
```

old style syntax

```
SELECT CUS_NUM, CUS_LNAME,
            INV_NUMBER, INV_DATE
   FROM  CUSTOMER NATURAL JOIN INVOICE;
```

old style syntax

Join With Using Clause

- A second way to express a join is through the USING keyword. This query will return only the rows with matching values in the column indicated in the USING clause. The column listed in the USING clause must appear in both tables.
- The syntax is:

```
SELECT column-list
    FROM table1 JOIN  table2 USING (common-column);
```


Join With Using Clause (cont.)

- An example:

```
SELECT  INV_NUMBER, P_CODE, P_DESCRIPT, LINE_UNITS,
        LINE_PRICE
  FROM  INVOICE JOIN LINE USING (INV_NUMBER)
        JOIN PRODUCT USING (P_CODE);
```

- As was the case with the natural join command, the JOIN USING does not required the use of qualified names (qualified table names). In fact, Oracle 11g will return an error if you specify the table name in the USING clause.

Join On Clause

- Both the NATURAL JOIN and the JOIN USING commands use common attribute names in joining tables.
- Another way to express a join when the tables have no common attribute names is to use the JOIN ON operand. This query will return only the rows that meet the indicated condition. The join condition will typically include an equality comparison expression of two columns. The columns may or may not share the same name, but must obviously have comparable data types.
- The syntax is:

```
SELECT column-list
    FROM table1 JOIN  table2 ON join-condition;
```

Join On Clause (cont.)

- An example:

```
SELECT INVOICE.INV_NUMBER, P_CODE, P_DESCRIPT, LINE_UNITS, LINE_PRICE
  FROM INVOICE JOIN LINE ON INVOICE.INV_NUMBER = LINE.INV_NUMBER
       JOIN PRODUCT ON LINE.P_CODE = PRODUCT.P_CODE;
```

- Notice in the example query, that unlike the NATURAL JOIN and the JOIN USING operation, the JOIN ON clause requires the use of table qualifiers for the common attributes. If you do not specify the table qualifier you will get a "column ambiguously defined" error message.

- Keep in mind that the JOIN ON syntax allows you to perform a join even when the tables do not share a common attribute name.

Join On Clause (cont.)

- For example, to general a list of all employees with the manager's name you can use the recursive query shown below which utilizes the JOIN ON clause.

```
SELECT E.EMP_MGR, M.EMP_LNAME, E.EMP_NUM, E.EMP_LNAME
   FROM EMP E JOIN EMP M ON E.EMP_MGR = M.EMP_NUM
   ORDER BY E.EMP_MGR;
```


Outer Joins

- We saw the forms for the LEFT OUTER JOIN and the RIGHT OUTER JOIN in the previous set of notes.
- There is also a FULL OUTER JOIN operation in SQL. A full outer join returns not only the rows matching the join condition (that is, rows with matching values in the common column(s)), but also all the rows with unmatched values in either side table.
- The syntax of a full outer join is:

```
SELECT column-list
    FROM table1 FULL [OUTER] JOIN  table2 ON join-condition;
```

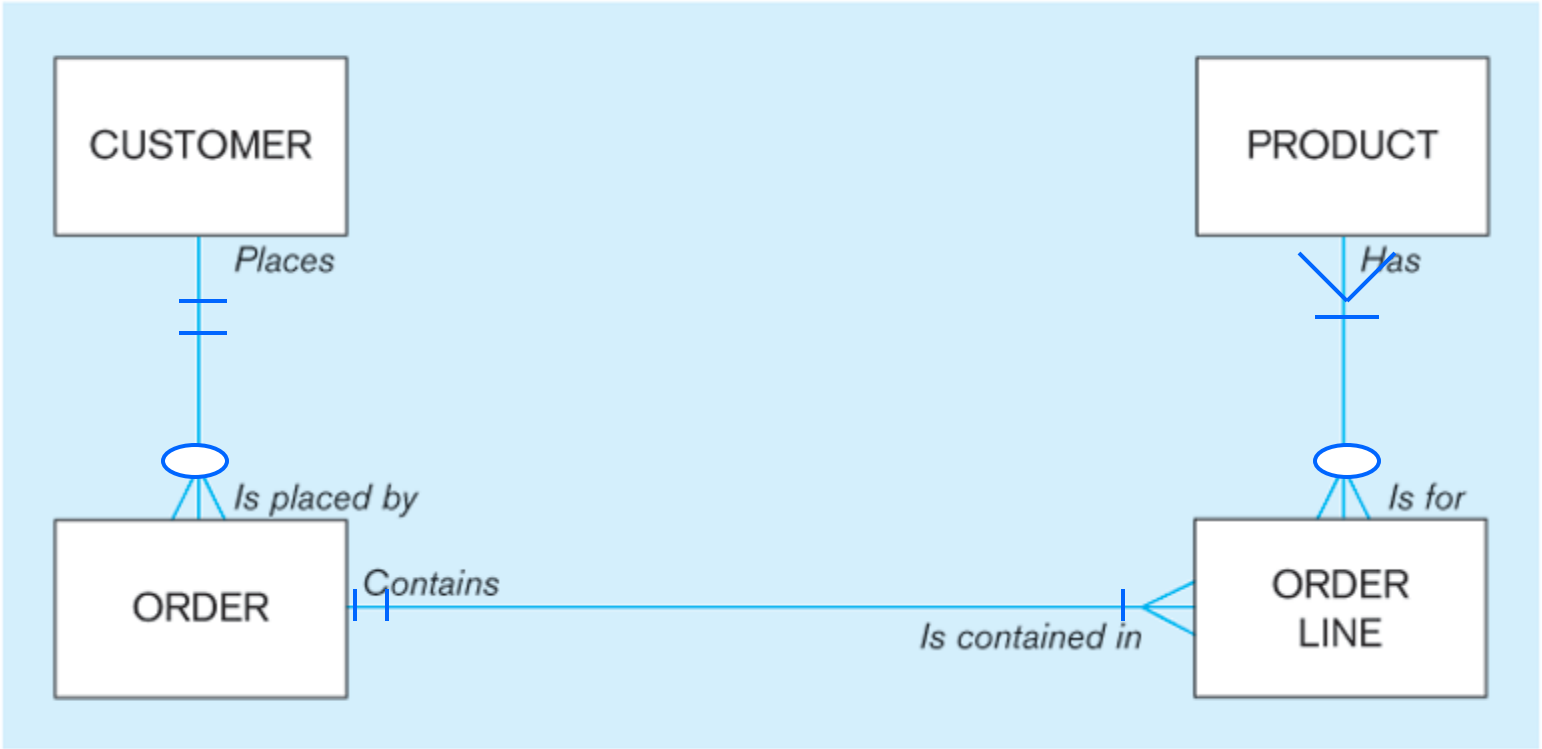
Outer Joins (cont.)

- The following example will list the product code, vendor code, and vendor name for all products and include all the product rows (products without matching vendors) and also all vendor rows (vendors without matching products):

```
SELECT  P_CODE, VENDOR.V_CODE, V_NAME
    FROM VENDOR FULL OUTER JOIN PRODUCT
            ON VENDOR.V_CODE = PRODUCT.V_CODE;
```


Outer Joins (cont.)

- The following example will hopefully illustrate how outer joins work. Shown below is the ERD for the database:



Outer Joins (cont.)

- Suppose that we want to run the query: For each customer, what is the customer's id, name and order number?
- Notice that the ERD states that a customer may not place any orders, so when joining the customer table with the order table those customers without an order will not participate in the join if a natural join is used. However, a left outer join will include those customers who have not placed an order.
- Look at the instance data on the next page.

Outer Joins (cont.)

Order_T Table

Order_ID	Order_Date	Customer_ID	Add New Field
1001	10/21/2008	1	
1002	10/21/2008	8	
1003	10/22/2008	15	
1004	10/22/2008	5	
1005	10/24/2008	3	
1006	10/24/2008	2	
1007	10/27/2008	11	
1008	10/30/2008	12	
1009	11/5/2008	4	
1010	11/5/2008	1	
0		0	

Part of the Customer_T Table

Customer_ID	Customer_Name	Customer_Address	City
1	Contemporary Casuals	1355 S Hines Blvd	Gainesvi
2	Value Furniture	15145 S.W. 17th St.	Plano
3	Home Furnishings	1900 Allard Ave.	Albany
4	Eastern Furniture	1925 Beltline Rd.	Carteret
5	Impressions	5585 Westcott Ct.	Sacrame
6	Furniture Gallery	325 Flatiron Dr.	Boulder
7	Period Furniture	394 Rainbow Dr.	Seattle
8	Calfornia Classics	816 Peach Rd.	Santa Cl
9	M and H Casual Furniture	3709 First Street	Clearwat
10	Seminole Interiors	2400 Rocky Point Dr.	Seminol
11	American Euro Lifestyles	2424 Missouri Ave N.	Prospect
12	Battle Creek Furniture	345 Capitol Ave. SW	Battle Cr
13	Heritage Furnishings	66789 College Ave.	Carlisle
14	Kaneohe Homes	112 Kiowai St.	Kaneohe
15	Mountain Scenes	4132 Main Street	Ogden

Note that customer #'s 6, 7, 9, 10, 13, and 14 have not placed an order

Outer Joins (cont.)

The SQL Query

Query2

```
SELECT Customer_T.customer_id, customer_name, order_id
FROM Customer_T, Order_T
WHERE Customer_T.customer_id = Order_T.customer_id;
```

Result set

Query2

Customer_ID	Customer_Name	order_id
1	Contemporary Casuals	1001
1	Contemporary Casuals	1010
2	Value Furniture	1006
3	Home Furnishings	1005
4	Eastern Furniture	1009
5	Impressions	1004
8	Calfornia Classics	1002
11	American Euro Lifestyles	1007
12	Battle Creek Furniture	1008
15	Mountain Scenes	1003

Note that customer #'s 6, 7, 9, 10, 13, and 14 are not in the result set using a natural join

Outer Joins (cont.)

The SQL Query

Query1

```
SELECT Customer_T.customer_id, customer_name, order_id
FROM Customer_T LEFT OUTER JOIN Order_T
ON Customer_T.customer_id = Order_T.customer_id;
```

Result set

Query1

Customer_ID	Customer_Name	order_id
1	Contemporary Casuals	1001
1	Contemporary Casuals	1010
2	Value Furniture	1006
3	Home Furnishings	1005
4	Eastern Furniture	1009
5	Impressions	1004
6	Furniture Gallery	
7	Period Furniture	
8	Calfornia Classics	1002
9	M and H Casual Furniture	
10	Seminole Interiors	
11	American Euro Lifestyles	1007
12	Battle Creek Furniture	1008
13	Heritage Furnishings	
14	Kaneohe Homes	
15	Mountain Scenes	1003

Note that customer #'s 6, 7, 9, 10, 13, and 14 are in the result set using a left outer join

Summary of SQL JOIN Operations

Join Classification	Join Type	SQL Syntax Example	Description
Cross	CROSS JOIN	SELECT * FROM T1, T2;	Old style. Returns the Cartesian product of T1 and T2
		SELECT * FROM T1 CROSS JOIN T2;	New style. Returns the Cartesian product of T1 and T2.
Inner	Old Style JOIN	SELECT * FROM T1, T2 WHERE T1.C1 = T2.C1	Returns only the rows that meet the join condition in the WHERE clause – old style. Only rows with matching values are selected.
	NATURAL JOIN	SELECT * FROM T1 NATURAL JOIN T2	Returns only the rows with matching values in the matching columns. The matching columns must have the same names and similar data types.
	JOIN USING	SELECT * FROM T1 JOIN T2 USING (C1)	Returns only the rows with matching values in the columns indicated in the USING clause.
	JOIN ON	SELECT * FROM T1 JOIN T2 ON T1.C1 = T2.C1	Returns only the rows that meet the join condition indicated in the ON clause.

Summary of SQL JOIN Operations (cont.)

Join Classification	Join Type	SQL Syntax Example	Description
Outer	LEFT JOIN	SELECT * FROM T1 LEFT OUTER JOIN T2 ON T1.C1= T2.C1	Returns rows with matching values and includes all rows from the left table (T1) with unmatched values.
	RIGHT JOIN	SELECT * FROM T1 RIGHT OUTER JOIN T2 ON T1.C1= T2.C1	Returns rows with matching values and includes all rows from the right table (T2) with unmatched values.
	FULL JOIN	SELECT * FROM T1 FULL OUTER JOIN T2 ON T1.C1= T2.C1	Returns rows with matching values and includes all rows from both tables (T1 and T2) with unmatched values.

Subqueries and Correlated Queries

- The use of joins allows a RDBMS go get information from two or more tables. The data from the tables is processed simultaneously.
- It is often necessary to process data based on other processed data. Suppose, for example, that you want to generate a list of vendors who provide products. (Recall that not all vendors in the VENDOR table have provided products – some of them are only potential vendors.)
- The following query will accomplish our task:

```
SELECT  V_CODE, V_NAME
    FROM VENDOR
    WHERE V_CODE NOT IN (SELECT V_CODE    FROM PRODUCT);
```


Subqueries and Correlated Queries (cont.)

- A subquery is a query (SELECT statement) inside a query.
- A subquery is normally expressed inside parentheses.
- The first query in the SQL statement is known as the outer query.
- The second query in the SQL statement is known as the inner query.
- The inner query is executed first.
- The output of the inner query is used as the input for the outer query.
- The entire SQL statement is sometimes referred to as a nested query.

Subqueries and Correlated Queries (cont.)

- A subquery can return:

1. One single value (one column and one row). This subquery can be used anywhere a single value is expected. For example, in the right side of a comparison expression.

2. A list of values (one column and multiple rows). This type of subquery can be used anywhere a list of values is expected. For example, when using the IN clause.

3. A virtual table (multi-column, multi-row set of values). This type of subquery can be used anywhere a table is expected. For example, in the FROM clause.

4. No value at all, i.e., NULL. In such cases, the output of the outer query may result in an error or null empty set, depending on where the subquery is used (in a comparison, an expression, or a table set).

Correlated Queries

- A correlated query (really a subquery) is a subquery that contains a reference to a table that also appears in the outer query.
- A correlated query has the following basic form:

```
SELECT * FROM table1 WHERE col1 = ANY
    (SELECT col1 FROM table2
        WHERE  table2.col2 = table1.col1);
```

- Notice that the subquery contains a reference to a column of `table1`, even though the subquery's FROM clause doesn't mention `table1`. Thus, query execution requires a look outside the subquery, and finds the table reference in the outer query.

WHERE Subqueries

- The most common type of subquery uses an inner SELECT subquery on the right hand side of a WHERE comparison expression.
- For example, to find all products with a price greater than or equal to the average product price, the following query would be needed:

```
SELECT P_CODE, P_PRICE
  FROM PRODUCT
  WHERE P_PRICE >= (SELECT AVG(P_PRICE)
                    FROM PRODUCT);
```


WHERE Subqueries (cont.)

- Subqueries can also be used in combination with joins.
- The query below lists all the customers that ordered the product "Claw hammer".

```
SELECT DISTINCT CUS_CODE, CUS_LNAME, CUYS_FNAME
   FROM CUSTOMER JOIN INVOICE USING (CUS_CODE)
                 JOIN LINE USING (INV_NUMBER)
                 JOIN PRODUCT USING (P_CODE)
    WHERE P_CODE = (SELECT P_CODE
                    FROM PRODUCT
                     WHERE P_DESCRIPT = "Claw hammer");
```


WHERE Subqueries (cont.)

- Notice that the previous query could have been written as:

```
SELECT DISTINCT CUS_CODE, CUS_LNAME, CUYS_FNAME
   FROM CUSTOMER JOIN INVOICE USING (CUS_CODE)
                 JOIN LINE USING (INV_NUMBER)
                 JOIN PRODUCT USING (P_CODE)
    WHERE  P_DESCRIPT = 'Claw hammer');
```

- However, what would happen if two or more product descriptions contain the string "Claw hammer"?
  - You would get an error message because only a single value is expected on the right hand side of this expression.

IN Subqueries

- To handle the problem we just saw, the IN operand must be used.
- The query below lists all the customers that ordered any kind of hammer or saw.

```
SELECT DISTINCT CUS_CODE, CUS_LNAME, CUYS_FNAME
   FROM CUSTOMER JOIN INVOICE USING (CUS_CODE)
                 JOIN LINE USING (INV_NUMBER)
                 JOIN PRODUCT USING (P_CODE)
    WHERE P_CODE IN (SELECT P_CODE
                     FROM PRODUCT
                      WHERE P_DESCRIPT LIKE '%hammer%'
                        OR P_DESCRIPT LIKE '%saw%');
```


HAVING Subqueries

- It is also possible to use subqueries with a HAVING clause.
- Recall that the HAVING clause is used to restrict the output of a GROUP BY query by applying a conditional criteria to the grouped rows.
- For example, the following query will list all products with the total quantity sold greater than the average quantity sold.

```
SELECT DISTINCT P_CODE, SUM(LINE_UNITS)
   FROM LINE
    GROUP BY P_CODE
     HAVING SUM(LINE_UNITS) > (SELECT AVG(LINE_UNITS)
                               FROM LINE);
```

Multi-row Subquery Operators: ANY and ALL

- The IN subquery uses an equality operator; that is, it only selects those rows that match at least one of the values in the list. What happens if you need to do an inequality comparison of one value to a list of values?

- For example, suppose you want to know what products have a product cost that is greater than all individual product costs for products provided by vendors from Florida.

```
SELECT P_CODE, P_ONHAND*P_PRICE
   FROM PRODUCT
    WHERE P_ONHAND*P_PRICE > ALL (SELECT P_ONHAND*P_PRICE
                                  FROM PRODUCT
                                  WHERE V_CODE IN (SELECT V_CODE
                                                   FROM VENDOR
                                                   WHERE V_STATE= 'FL'));
```

FROM Subqueries

- In all of the cases of subqueries we've seen so far, the subquery was part of a conditional expression and it always appeared on the right hand side of an expression. This is the case for WHERE, HAVING, and IN subqueries as well as for the ANY and ALL operators.
- Recall that the FROM clause specifies the table(s) from which the data will be drawn. Because the output of a SELECT statement is another table (or more precisely, a "virtual table"), you could use a SELECT subquery in the FROM clause.
- For example, suppose that you want to know all customers who have purchased products 13-Q2/P2 and 23109-HB. Since all product purchases are stored in the LINE table, it is easy to find out who purchased any given product just by searching the P_CODE attribute in the LINE table. However, in this case, you want to know all customers who purchased both, not just one.
- The query on the next page accomplishes this task.

FROM Subqueries (cont.)

```
SELECT DISTINCT CUSTOMER.CUS_CODE              , CUSTOMER.LNAME
  FROM CUSTOMER, (SELECT INVOICE.CUS_CODE
                    FROM INVOICE NATURAL JOIN LINE
                    WHERE P_CODE = '13-Q2/P2') CP1,
                 (SELECT INVOICE.CUS_CODE
                   FROM INVOICE NATURAL JOIN LINE
                   WHERE P_CODE = '23109-HB') CP2
          WHERE CUSTOMER.CUS_CODE = CP1.CUS_CODE
                AND CP1.CUS_CODE = CP2.CUS_CODE;
```


Conditional Expressions Using Case Syntax

This is available with newer versions of SQL, previously not part of the standard

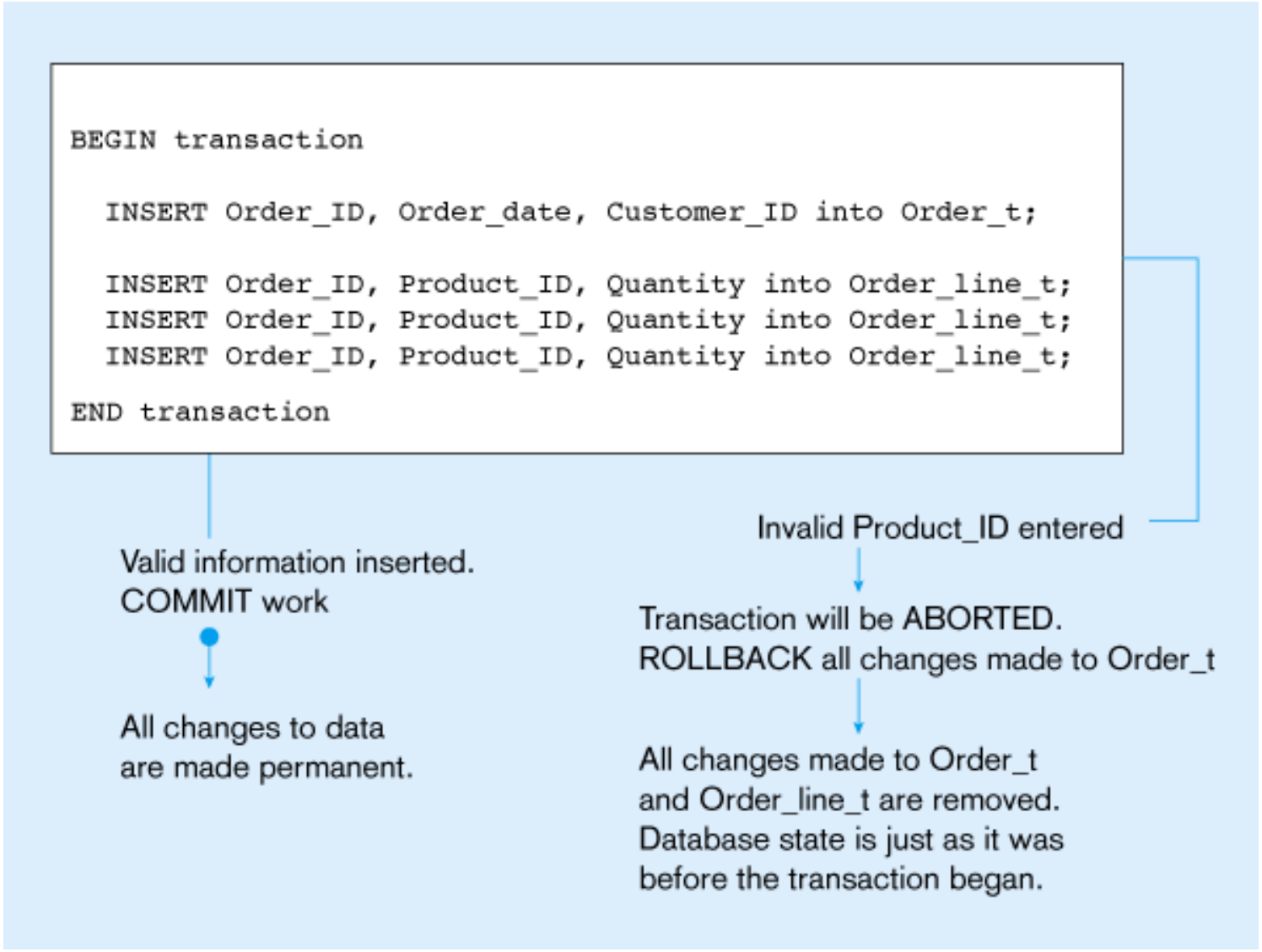
CASE conditional syntax

```
{CASE expression
{WHEN expression
THEN {expression | NULL}} . . .
| {WHEN predicate
THEN {expression | NULL}} . . .
[ELSE {expression  NULL}]
END }
| ( NULLIF (expression, expression) }
| ( COALESCE (expression . . .) }
```

Ensuring Transaction Integrity

- Transaction = A discrete unit of work that must be completely processed or not processed at all
  - May involve multiple updates
  - If any update fails, then all other updates must be cancelled
- SQL commands for transactions
- BEGIN TRANSACTION/END TRANSACTION
  - Marks boundaries of a transaction
  - COMMIT
    - Makes all updates permanent
  - ROLLBACK
    - Cancels updates since the last COMMIT

An SQL Transaction sequence (in pseudocode)



Data Dictionary Facilities

- System tables that store metadata
- Users usually can view some of these tables
- Users are restricted from updating them
- Examples in Oracle 11g
  - DBA_TABLES – descriptions of tables
  - DBA_CONSTRAINTS – description of constraints
  - DBA_USERS – information about the users of the system
- Examples in Microsoft SQL Server
  - SYSCOLUMNS – table and column definitions
  - SYSDEPENDS – object dependencies based on foreign keys
  - SYSPERMISSIONS – access permissions granted to users

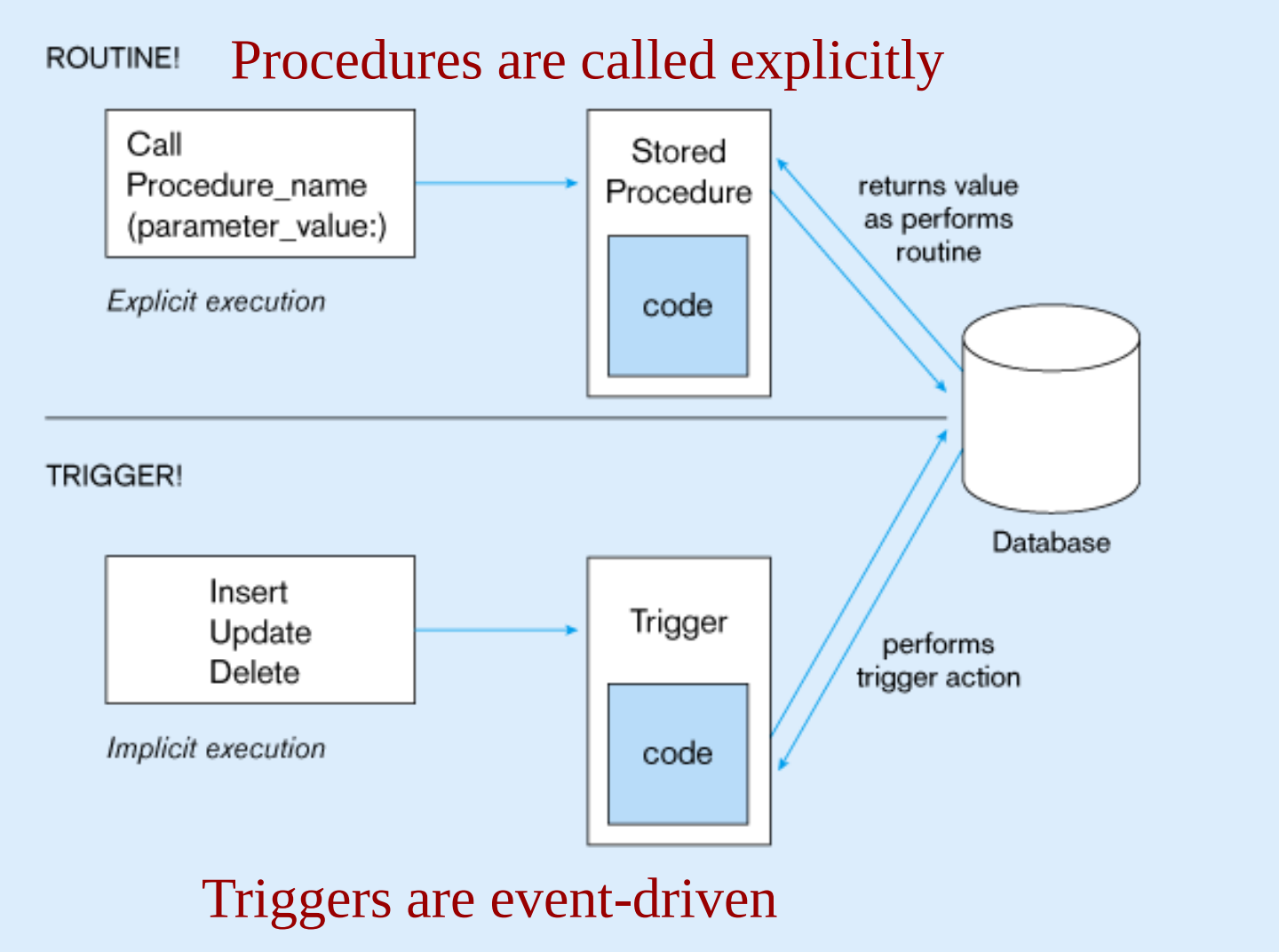
SQL:2007 Enhancements/Extensions

- User-defined data types (UDT)
  - Subclasses of standard types or an object type
- Analytical functions (for OLAP)
- Persistent Stored Modules (SQL/PSM)
  - Capability to create and drop code modules
  - New statements:
    - CASE, IF, LOOP, FOR, WHILE, etc.
    - Makes SQL into a procedural language
- Oracle has propriety version called PL/SQL, and Microsoft SQL Server has Transact/SQL

Routines and Triggers

- **Routines**
  - Program modules that execute on demand
  - **Functions** – routines that return values and take input parameters
  - **Procedures** – routines that do not return values and can take input or output parameters
- **Triggers**
  - Routines that execute in response to a database event (INSERT, UPDATE, or DELETE)

Triggers contrasted with stored procedures



Oracle PL/SQL trigger syntax

```
CREATE [OR REPLACE] TRIGGER trigger_name
        {BEFORE AFTER} {INSERT | DELETE | UPDATE} ON table_name
        [FOR EACH ROW [WHEN (trigger_condition)]]
        trigger_body_here;
```

SQL:2007 Create routine syntax

```
{CREATE PROCEDURE | CREATE FUNCTION} routine_name
([parameter [{,parameter} . . .]])
[RETURNS data_type result_cast]    /* for functions only */
[LANGUAGE {ADA | C | COBOL | FORTRAN | MUMPS | PASCAL | PLI | SQL}]
[PARAMETER STYLE {SQL | GENERAL}]
[SPECIFIC specific_name]
[DETERMINISTIC | NOT DETERMINISTIC]
[NO SQL | CONTAINS SQL | READS SQL DATA | MODIFIES SQL DATA]
[RETURN NULL ON NULL INPUT | CALL ON NULL INPUT]
[DYNAMIC RESULT SETS unsigned_integer]      /* for procedures only */
[STATIC DISPATCH]                           /* for functions only */
routine_body
```


Embedded and Dynamic SQL

- Embedded SQL
  - Including hard-coded SQL statements in a program written in another language such as C or Java
- Dynamic SQL
  - Ability for an application program to generate SQL code on the fly, as the application is running