(ADVANCED) DATABASE SYSTEMS (DATABASE MANAGEMENTS)

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(6TH WEEK)

4. OUTLINE

4. Implementation

- 4.1 Introduction to SQL
- 4.2 Advanced SQL
- 4.3 Database Application Development
- 4.4 Data Warehousing

4.1 INTRODUCTİON TO SQL

OBJECTİVES

- Define terms
- Interpret history and role of SQL
- Define a database using SQL data definition language
- Write single table queries using SQL
- Establish referential integrity using SQL
- Discuss SQL:1999 and SQL:2011 standards

SQL OVERVIEW

- Structured Query Language – often pronounced "Sequel"
- The standard for relational database management systems (RDBMS)
- RDBMS: A database management system that manages data as a collection of tables in which all relationships are represented by common values in related tables

HISTORY OF SQL

- 1970–E. F. Codd develops relational database concept
- 1974-1979–System R with Sequel (later SQL) created at IBM Research Lab
- 1979–Oracle markets first relational DB with SQL
- 1981 – SQL/DS first available RDBMS system on DOS/VSE
- Others followed: INGRES (1981), IDM (1982), DG/SGL (1984), Sybase (1986)
- 1986–ANSI SQL standard released
- 1989, 1992, 1999, 2003, 2006, 2008, 2011–Major ANSI standard updates
- Current–SQL is supported by most major database vendors

PURPOSE OF SQL STANDARD

- Specify syntax/semantics for data definition and manipulation
- Define data structures and basic operations
- Enable portability of database definition and application modules
- Specify minimal (level 1) and complete (level 2) standards
- Allow for later growth/enhancement to standard (referential integrity, transaction management, user-defined functions, extended join operations, national character sets)

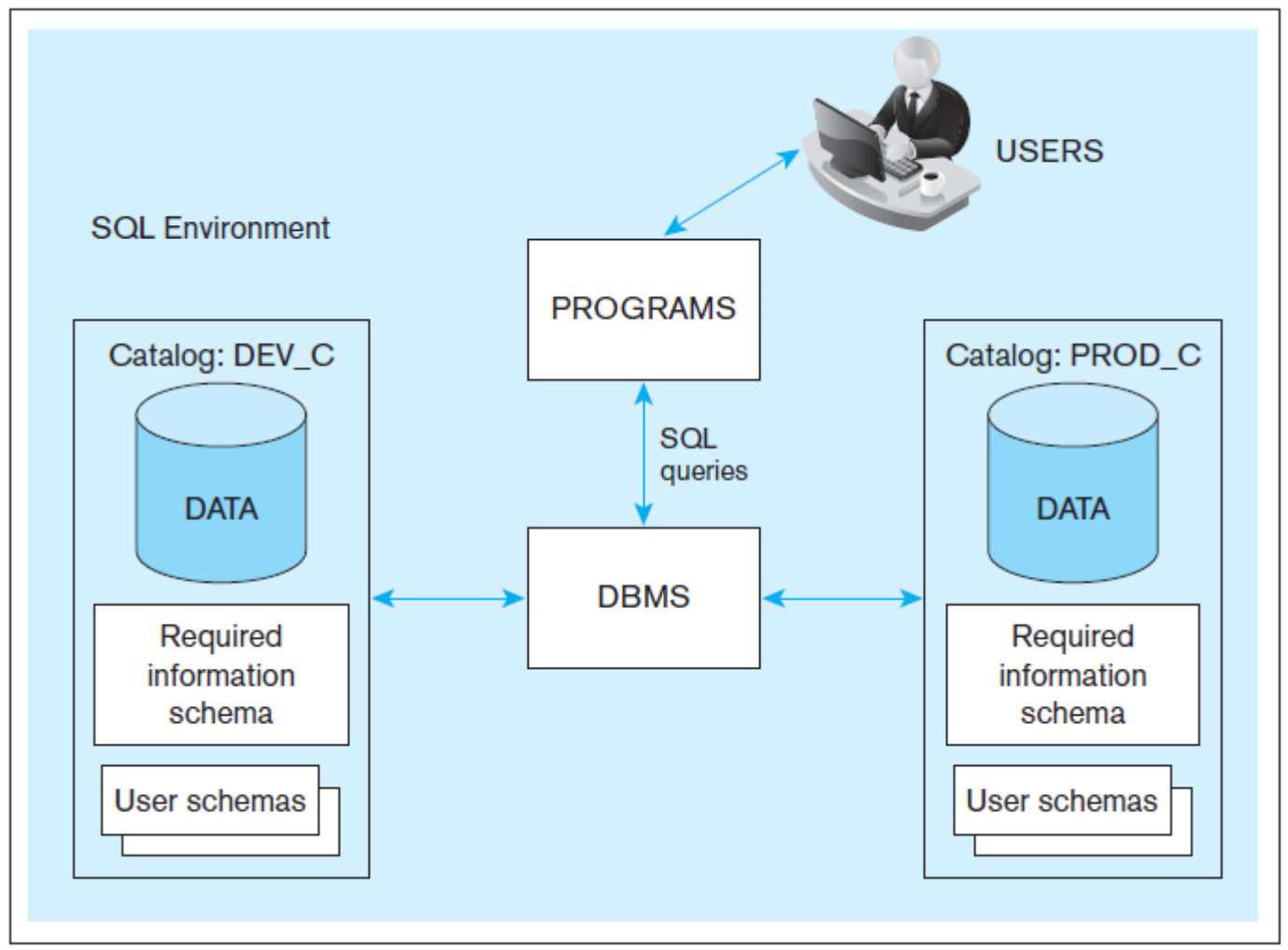
BENEFITS OF A STANDARDIZED RELATIONAL LANGUAGE

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

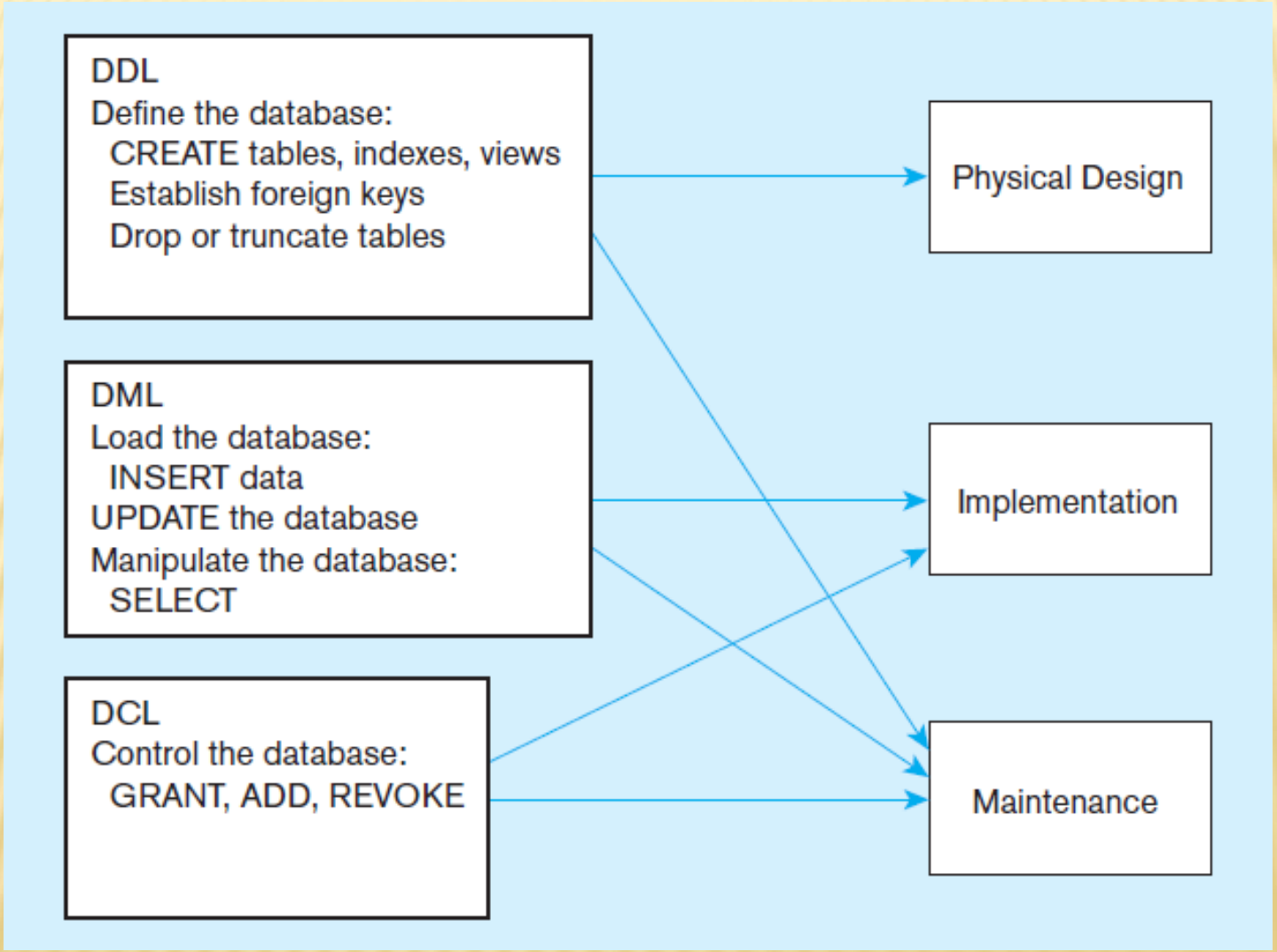
SQL ENVIRONMENT

- 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: 2011 standard



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 new table and its columns
  - CREATE VIEW–defines a logical table from one or more tables or views
- Other CREATE statements: CHARACTER SET, COLLATION, TRANSLATION, ASSERTION, DOMAIN

SQL DATA TYPES

TABLE 6-2 Sample SQL Data Types

String	CHARACTER (CHAR)	Stores string values containing any characters in a character set. CHAR is defined to be a fixed length.
	CHARACTER VARYING (VARCHAR or VARCHAR2)	Stores string values containing any characters in a character set but of definable variable length.
	BINARY LARGE OBJECT (BLOB)	Stores binary string values in hexadecimal format. BLOB is defined to be a variable length. (Oracle also has CLOB and NCLOB, as well as BFILE for storing unstructured data outside the database.)
Number	NUMERIC	Stores exact numbers with a defined precision and scale.
	INTEGER (INT)	Stores exact numbers with a predefined precision and scale of zero.
Temporal	TIMESTAMP TIMESTAMP WITH LOCAL TIME ZONE	Stores a moment an event occurs, using a definable fraction-of-a-second precision. Value adjusted to the user's session time zone (available in Oracle and MySQL).
Boolean	BOOLEAN	Stores truth values: TRUE, FALSE, or UNKNOWN.

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

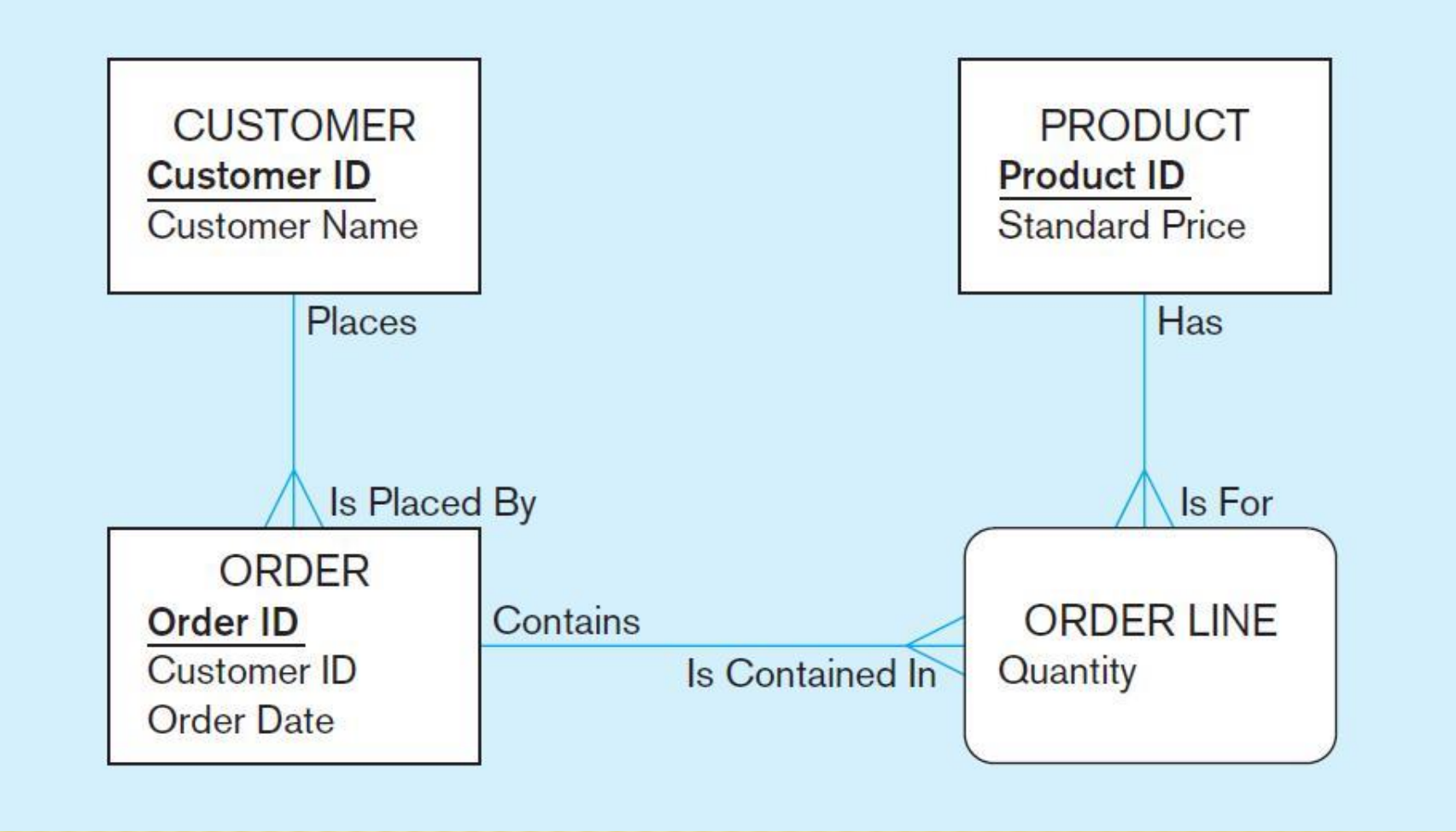
General syntax for CREATE TABLE statement used in data definition language

```
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]
```

THE FOLLOWING SLIDES CREATE TABLES FOR THIS ENTERPRISE DATA MODEL



SQL database definition commands for PVF Company

(Oracle 12c)

```
CREATE TABLE Customer_T
                (CustomerID                 NUMBER(11,0)      NOT NULL,
                 CustomerName               VARCHAR2(25)      NOT NULL,
                 CustomerAddress            VARCHAR2(30),
                 CustomerCity               VARCHAR2(20),
                 CustomerState              CHAR(2),
                 CustomerPostalCode         VARCHAR2(9),
CONSTRAINT Customer_PK PRIMARY KEY (CustomerID));
```

```
CREATE TABLE Order_T
                (OrderID                    NUMBER(11,0)      NOT NULL,
                 OrderDate                  DATE DEFAULT SYSDATE,
                 CustomerID                 NUMBER(11,0),
CONSTRAINT Order_PK PRIMARY KEY (OrderID),
CONSTRAINT Order_FK FOREIGN KEY (CustomerID) REFERENCES Customer_T(CustomerID));
```

```
CREATE TABLE Product_T
                (ProductID                  NUMBER(11,0)      NOT NULL,
                 ProductDescription         VARCHAR2(50),
                 ProductFinish              VARCHAR2(20)
                        CHECK (ProductFinish IN ('Cherry', 'Natural Ash', 'White Ash',
                                                 'Red Oak', 'Natural Oak', 'Walnut')),
                 ProductStandardPrice       DECIMAL(6,2),
                 ProductLineID              INTEGER,
CONSTRAINT Product_PK PRIMARY KEY (ProductID));
```

```
CREATE TABLE OrderLine_T
                (OrderID                    NUMBER(11,0)      NOT NULL,
                 ProductID                  INTEGER           NOT NULL,
                 OrderedQuantity            NUMBER(11,0),
CONSTRAINT OrderLine_PK PRIMARY KEY (OrderID, ProductID),
CONSTRAINT OrderLine_FK1 FOREIGN KEY (OrderID) REFERENCES Order_T(OrderID),
CONSTRAINT OrderLine_FK2 FOREIGN KEY (ProductID) REFERENCES Product_T(ProductID));
```

Overall table definitions

Defining attributes and their data types

```
CREATE TABLE Product_T
        (ProductID                  NUMBER(11,0)      NOT NULL,
         ProductDescription         VARCHAR2(50),
         ProductFinish              VARCHAR2(20)
                CHECK (ProductFinish IN ('Cherry', 'Natural Ash', 'White Ash',
                       'Red Oak', 'Natural Oak', 'Walnut')),
         ProductStandardPrice       DECIMAL(6,2),
         ProductLineID              INTEGER,
CONSTRAINT Product_PK PRIMARY KEY (ProductID));
```

Non-nullable specification

```
CREATE TABLE Product_T
        (ProductID                  NUMBER(11,0)      NOT NULL,
         ProductDescription         VARCHAR2(50),
         ProductFinish              VARCHAR2(20)
                                    CHECK (ProductFinish IN ('Cherry', 'Natural Ash', 'White Ash',
                                           'Red Oak', 'Natural Oak', 'Walnut')),
         ProductStandardPrice       DECIMAL(6,2),
         ProductLineID              INTEGER,
CONSTRAINT Product_PK PRIMARY KEY (ProductID));
```

Primary keys can never have NULL values

Identifying primary key

Non-nullable specifications

```
CREATE TABLE OrderLine_T
        (OrderID                NUMBER(11,0)    NOT NULL,
         ProductID              INTEGER         NOT NULL,
         OrderedQuantity        NUMBER(11,0),
CONSTRAINT OrderLine_PK PRIMARY KEY (OrderID, ProductID),
CONSTRAINT OrderLine_FK1 FOREIGN KEY (OrderID) REFERENCES Order_T(OrderID),
CONSTRAINT OrderLine_FK2 FOREIGN KEY (ProductID) REFERENCES Product_T(ProductID));
```

Primary key

Some primary keys are composite–composed of multiple attributes

Controlling the values in attributes

```
CREATE TABLE Order_T
                (OrderID                    NUMBER(11,0)        NOT NULL,
                 OrderDate                  DATE DEFAULT SYSDATE,
                 CustomerID                 NUMBER(11,0),
CONSTRAINT Order_PK PRIMARY KEY (OrderID),
CONSTRAINT Order_FK FOREIGN KEY (CustomerID) REFERENCES Customer_T(CustomerID));

CREATE TABLE Product_T
                (ProductID                  NUMBER(11,0)        NOT NULL,
                 ProductDescription         VARCHAR2(50),
                 ProductFinish              VARCHAR2(20)
                    CHECK (ProductFinish IN ('Cherry', 'Natural Ash', 'White Ash',
                                             'Red Oak', 'Natural Oak', 'Walnut')),
                 ProductStandardPrice       DECIMAL(6,2),
                 ProductLineID              INTEGER,
CONSTRAINT Product_PK PRIMARY KEY (ProductID));
```

Default value

Domain constraint

Identifying foreign keys and establishing relationships

```
CREATE TABLE Customer_T
                (CustomerID              NUMBER(11,0)        NOT NULL,
                 CustomerName            VARCHAR2(25)        NOT NULL,
                 CustomerAddress         VARCHAR2(30),
                 CustomerCity            VARCHAR2(20),
                 CustomerState           CHAR(2),
                 CustomerPostalCode      VARCHAR2(9),
CONSTRAINT Customer_PK PRIMARY KEY (CustomerID));

CREATE TABLE Order_T
                (OrderID                 NUMBER(11,0)        NOT NULL,
                 OrderDate               DATE DEFAULT SYSDATE,
                 CustomerID              NUMBER(11,0),
CONSTRAINT Order_PK PRIMARY KEY (OrderID),
CONSTRAINT Order_FK FOREIGN KEY (CustomerID) REFERENCES Customer_T(CustomerID));
```

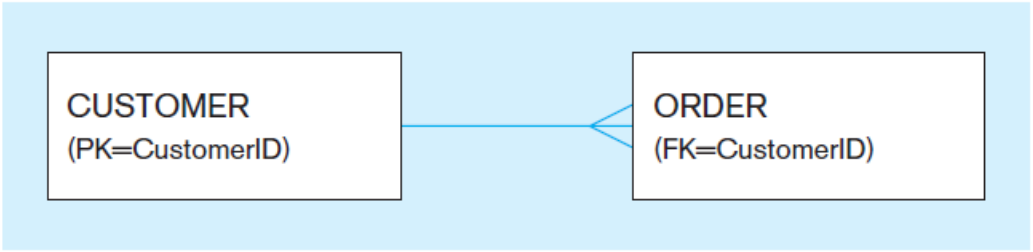
Primary key of parent table

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

Ensuring data integrity through updates



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

```
CREATE TABLE CustomerT
                (CustomerID          INTEGER DEFAULT '999'     NOT NULL,
                 CustomerName        VARCHAR(40)               NOT NULL,
                 . . .
CONSTRAINT Customer_PK PRIMARY KEY (CustomerID),
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 TABLES

- ALTER TABLE statement allows you to change column specifications:

```
ALTER TABLE table_name alter_table_action;
```

- Table Actions:

```
ADD [COLUMN] column_definition
ALTER [COLUMN] column_name SET DEFAULT default-value
ALTER [COLUMN] column_name DROP DEFAULT
DROP [COLUMN] column_name [RESTRICT] [CASCADE]
ADD table_constraint
```

- Example (adding a new column with a default value):

```
ALTER TABLE CUSTOMER_T
ADD COLUMN CustomerType VARCHAR2 (10) DEFAULT "Commercial";
```

REMOVING TABLES

- DROP TABLE statement allows you to remove tables from your schema:
  - DROP TABLE CUSTOMER_T

INSERT STATEMENT

- Adds one or more rows 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 (ProductID,
ProductDescription, ProductFinish, ProductStandardPrice)
    VALUES (1, 'End Table', 'Cherry', 175, 8);
```

- Inserting from another table

```
INSERT INTO CaCustomer_T
SELECT * FROM Customer_T
    WHERE CustomerState = 'CA';
```

CREATING TABLES WITH IDENTITY COLUMNS

```
CREATE TABLE Customer_T
(CustomerID INTEGER GENERATED ALWAYS AS IDENTITY
     (START WITH 1
     INCREMENT BY 1
     MINVALUE 1
     MAXVALUE 10000
     NO CYCLE),
CustomerName          VARCHAR2(25) NOT NULL,
CustomerAddress       VARCHAR2(30),
CustomerCity          VARCHAR2(20),
CustomerState         CHAR(2),
CustomerPostalCode    VARCHAR2(9),
CONSTRAINT Customer_PK PRIMARY KEY (CustomerID);
```

Introduced with SQL:2008

Inserting into a table does not require explicit customer ID entry or field list

```
INSERT INTO CUSTOMER_T VALUES ( 'Contemporary Casuals',
'1355 S. Himes Blvd.', 'Gainesville', 'FL', 32601);
```

DELETE STATEMENT

- Removes rows from a table
- Delete certain rows
  - DELETE FROM CUSTOMER_T WHERE CUSTOMERSTATE = 'HI';
- Delete all rows
  - DELETE FROM CUSTOMER_T;

UPDATE STATEMENT

- Modifies data in existing rows

```
UPDATE Product_T
SET ProductStandardPrice = 775
    WHERE ProductID = 7;
```

MERGE STATEMENT

```
MERGE INTO Product_T AS PROD
USING
(SELECT ProductID, ProductDescription, ProductFinish,
ProductStandardPrice, ProductLineID FROM Purchases_T) AS PURCH
      ON (PROD.ProductID = PURCH.ProductID)
WHEN MATCHED THEN UPDATE
      PROD.ProductStandardPrice = PURCH.ProductStandardPrice
WHEN NOT MATCHED THEN INSERT
      (ProductID, ProductDescription, ProductFinish, ProductStandardPrice,
      ProductLineID)
      VALUES(PURCH.ProductID, PURCH.ProductDescription,
      PURCH.ProductFinish, PURCH.ProductStandardPrice,
         PURCH.ProductLineID);
```

Makes it easier to update a table…allows combination of Insert and Update in one statement

Useful for updating master tables with new data

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(CUSTOMERNAME)
    - This makes an index for the CUSTOMERNAME field of the CUSTOMER_T table

SELECT STATEMENT

- Used for queries on single or multiple tables
- Clauses of the SELECT statement:
  - **SELECT**
    - List the columns (and expressions) to 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

SELECT EXAMPLE

- Find products with standard price less than $275

```
SELECT ProductDescription, ProductStandardPrice
   FROM Product_T
        WHERE ProductStandardPrice < 275;
```

Comparison Operators in SQL

TABLE 6-3 Comparison Operators in SQL

Operator	Meaning
=	Equal to
>	Greater than
>=	Greater than or equal to
<	Less than
<=	Less than or equal to
<>	Not equal to
!=	Not equal to

SELECT EXAMPLE USING ALIAS

- Alias is an alternative column or table name

```
SELECT CUST.CUSTOMERNAME AS
  NAME,   CUST.CUSTOMERADDRESS
FROM CUSTOMER_V CUST
      WHERE NAME = 'Home Furnishings';
```

SELECT EXAMPLE USING A FUNCTION

- Using the COUNT *aggregate function* to find totals

```
SELECT COUNT(*) FROM ORDERLINE_T
    WHERE ORDERID = 1004;
```

Note: With aggregate functions you can't have single-valued columns included in the SELECT clause, unless they are included in the GROUP BY clause.

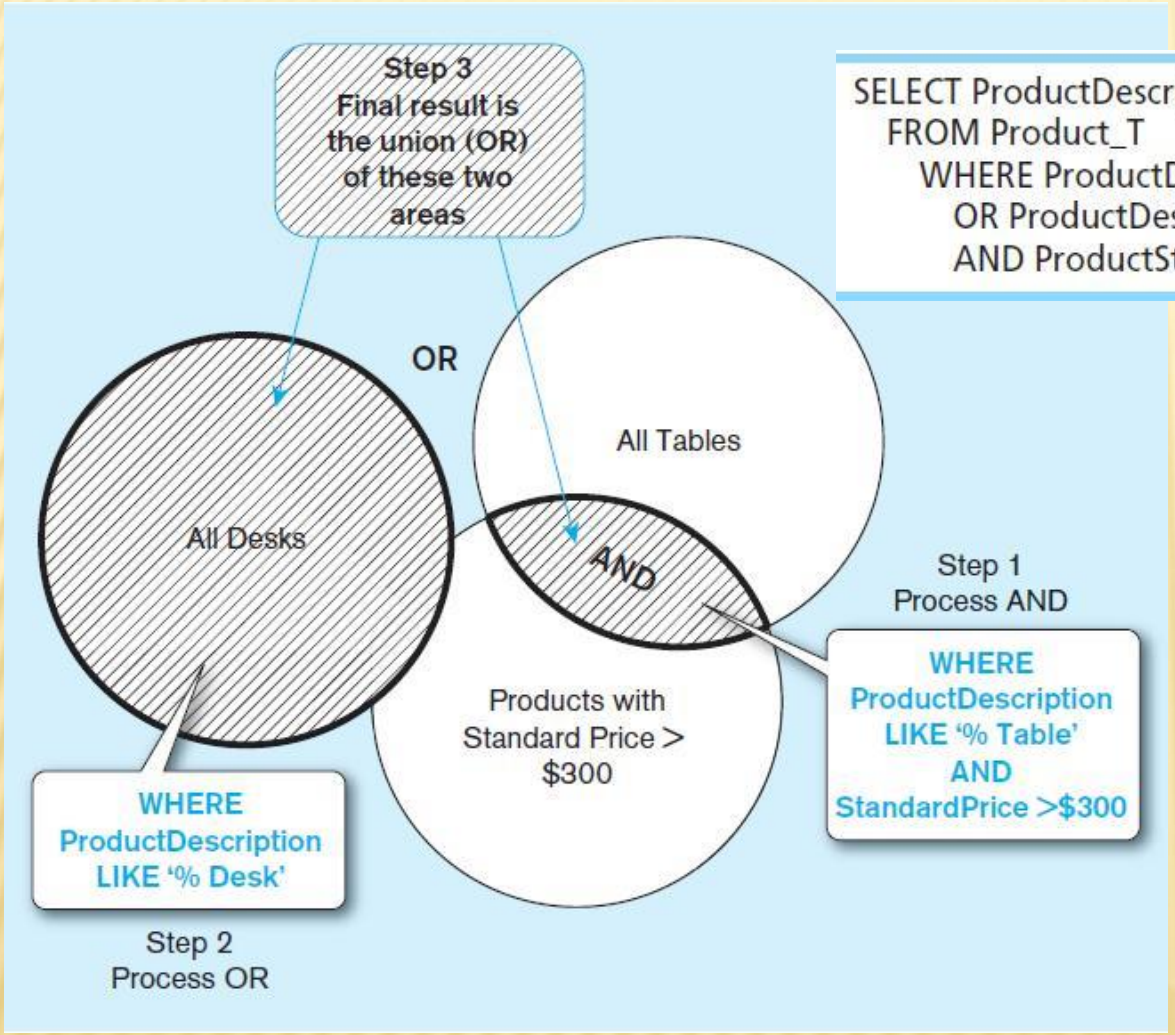
SELECT EXAMPLE–BOOLEAN OPERATORS

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

```
SELECT ProductDescription, ProductFinish, ProductStandardPrice
   FROM Product_T
      WHERE ProductDescription LIKE '%Desk'
         OR ProductDescription LIKE '%Table'
         AND ProductStandardPrice > 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.

Boolean query A without use of parentheses




```
SELECT ProductDescription, ProductFinish, ProductStandardPrice
  FROM Product_T
    WHERE ProductDescription LIKE '%Desk'
      OR ProductDescription LIKE '%Table'
      AND ProductStandardPrice > 300;
```

By default, processing order of Boolean operators is NOT, then AND, then OR

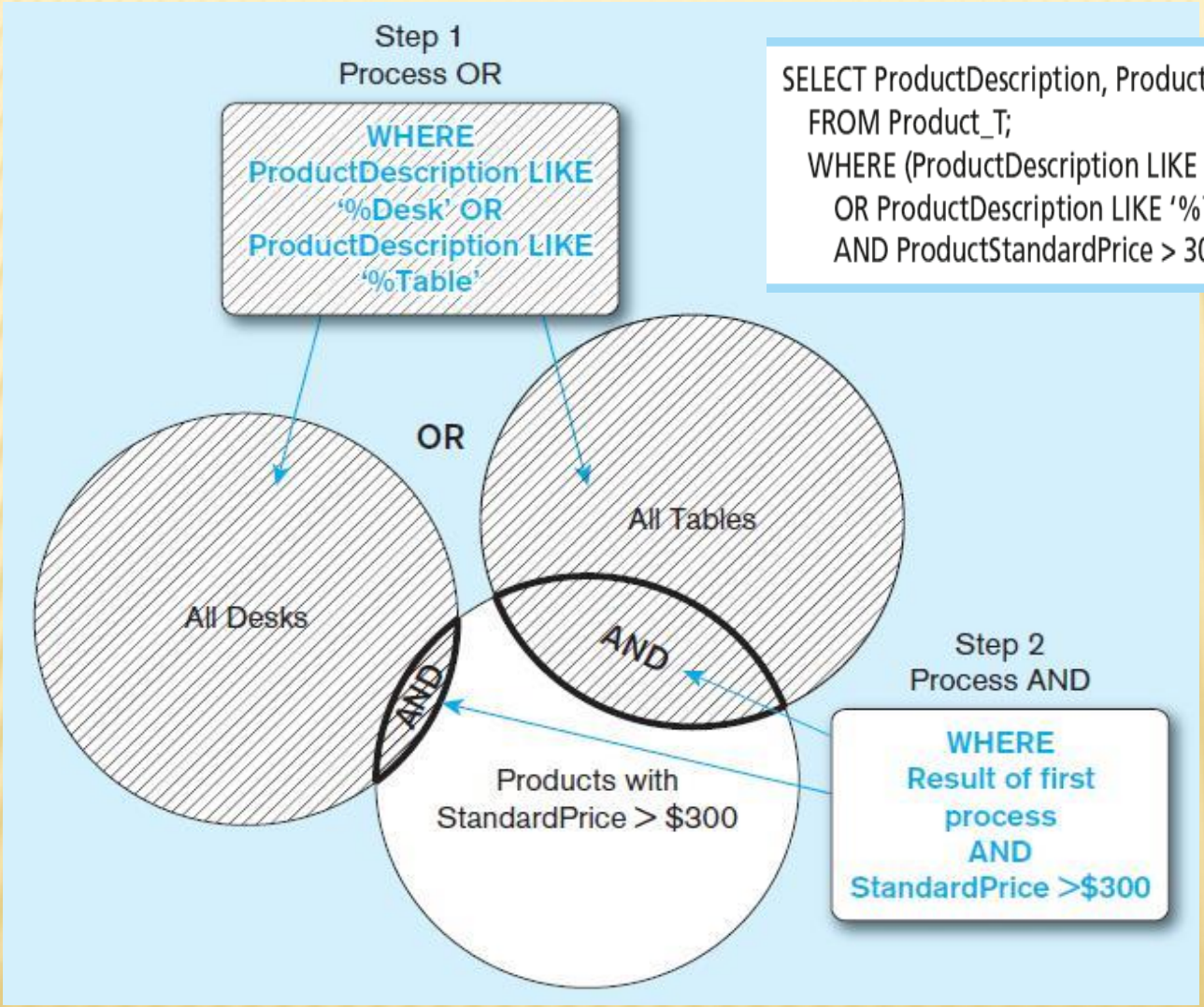
SELECT EXAMPLE–BOOLEAN OPERATORS

- **With parentheses…**these override the normal precedence of Boolean operators

```
SELECT ProductDescription, ProductFinish, ProductStandardPrice
   FROM Product_T;
   WHERE (ProductDescription LIKE '%Desk'
      OR ProductDescription LIKE '%Table')
      AND ProductStandardPrice > 300;
```

With parentheses, you can override normal precedence rules. In this case parentheses make the OR take place before the AND.

Boolean query B with use of parentheses




```
SELECT ProductDescription, ProductFinish, ProductStandardPrice
  FROM Product_T;
  WHERE (ProductDescription LIKE '%Desk'
    OR ProductDescription LIKE '%Table')
    AND ProductStandardPrice > 300;
```

SORTING RESULTS WITH ORDER BY CLAUSE

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

```
SELECT CustomerName, CustomerCity, CustomerState
   FROM Customer_T
      WHERE CustomerState IN ('FL', 'TX', 'CA', 'HI')
         ORDER BY CustomerState, CustomerName;
```

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

CATEGORIZING RESULTS USING 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 CustomerState, COUNT (CustomerState)
   FROM Customer_T
      GROUP BY CustomerState;
```

You can use single-value fields with aggregate functions if they are included in the GROUP BY clause

QUALIFYING RESULTS BY CATEGORIES USING THE HAVING CLAUSE

- For use with GROUP BY

```
SELECT CustomerState, COUNT (CustomerState)
   FROM Customer_T
      GROUP BY CustomerState
      HAVING COUNT (CustomerState) > 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.

A QUERY WITH BOTH WHERE AND HAVING

```
SELECT ProductFinish, AVG (ProductStandardPrice)
   FROM Product_T
      WHERE ProductFinish IN ('Cherry', 'Natural Ash', 'Natural Maple',
      'White Ash')
         GROUP BY ProductFinish
            HAVING AVG (ProductStandardPrice) < 750
               ORDER BY ProductFinish;
```

ProductID	ProductDescription	ProductFinish	ProductStandardPrice	ProductLineID
1	End Table	Cherry	$175.00	1
2	Coffee Table	Natural Ash	$200.00	2
3	Computer Desk	Natural Ash	$375.00	2
4	Entertainment Cente	Natural Maple	$650.00	3
5	Writers Desk	Cherry	$325.00	1
6	8-Drawer Desk	White Ash	$750.00	2
7	Dining Table	Natural Ash	$800.00	2
8	Computer Desk	Walnut	$250.00	3

Result:

PRODUCTFINISH	AVG(PRODUCTSTANDARDPRICE)
Cherry	250
Natural Ash	458.333333
Natural Maple	650

USING AND DEFINING VIEWS

- Views provide users controlled access to tables
- Base Table–table containing the raw data
- Dynamic View
  - A “virtual table” created dynamically upon request by a user
  - No data actually stored; instead data from base table made available to user
  - Based on SQL SELECT statement on base tables or other views
- Materialized View
  - Copy or replication of data
  - Data actually stored
  - Must be refreshed periodically to match corresponding base tables

SAMPLE CREATE VIEW

```
CREATE VIEW ExpensiveStuff_V
  AS
    SELECT ProductID, ProductDescription, ProductStandardPrice
     FROM Product_T
       WHERE ProductStandardPrice > 300
       WITH CHECK OPTION;
```

- View has a name.
- View is based on a SELECT statement.
- CHECK_OPTION works only for updateable views and prevents updates that would create rows not included in the view.

ADVANTAGES OF VIEWS

- Simplify query commands
- Assist with data security (but don't rely on views for security, there are more important security measures)
- Enhance programming productivity
- Contain most current base table data
- Use little storage space
- Provide customized view for user
- Establish physical data independence

DISADVANTAGES OF VIEWS

- Use processing time each time view is referenced
- May or may not be directly updateable