

COP 4710: Database Systems Spring 2008

Chapter 5 – Introduction To SQL – Part 2

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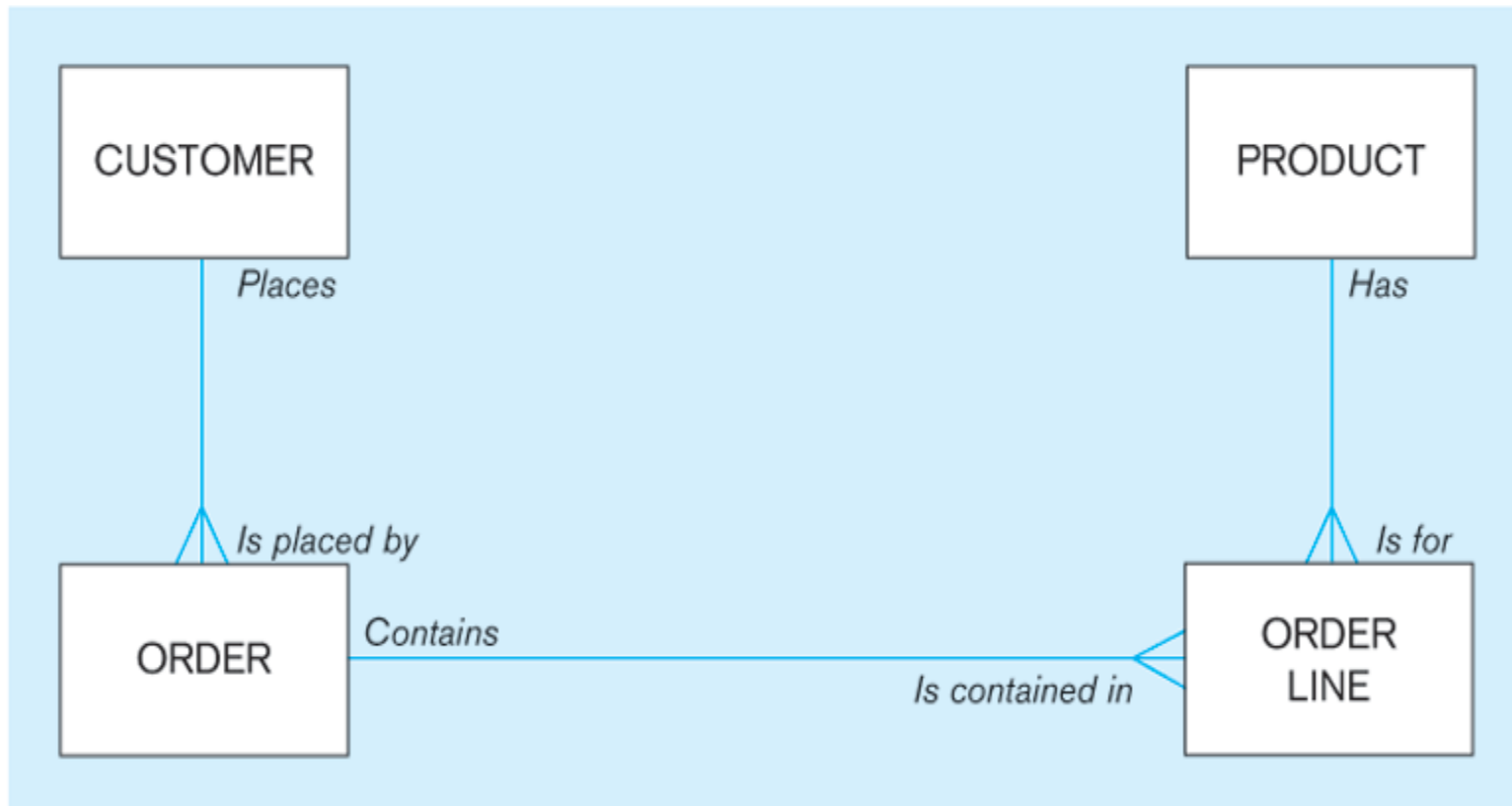
Processing Multiple Tables – Joins

- **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



The following slides create tables for this enterprise data model



Microsoft Access

File Edit View Insert Format Records Tools Window Help

Type a question for help

ORDER_t : Table

Order_ID	Order_Date	Customer_ID
1001	10/21/2004	1
1002	10/21/2004	8
1003	10/22/2004	15
1004	10/22/2004	5
1005	10/24/2004	3
1005	10/24/2004	2
1007	10/27/2004	11
1008	10/30/2004	12
1009	11/5/2004	4
1010	11/5/2004	1
*	0	0

Record: 1 of 10

CUSTOMER_1 : Table

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

Record: 1 of 15

Unique number to identify customer

These tables are used in queries that follow



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



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 (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



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, STATE, 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_T.CUSTOMER_ID   AND ORDER_T.ORDER_ID =  
       ORDER_LINE_T.ORDER_ID  
       AND ORDER_LINE_T.PRODUCT_ID =  
       PRODUCT_T.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	PRODUCT_NAME	STANDARD_PRICE	(QUANTITY* STANDARD_PRICE)
1006	24-OCT-04	1	Entertainment Center	650	650
1006	24-OCT-04	2	Writer's Desk	325	650
1006	24-OCT-04	2	Dining Table	800	1600

From ORDER_T table

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.

The IN operator will test to see if the CUSTOMER_ID value of a row is included in the list returned from the subquery

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

Subquery is embedded in parentheses. In this case it returns a list that will be used in the WHERE clause of the outer query



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

Order ID	Product ID	Order Quantity
1001	1	1
1001	2	1
1001	3	1
1001	4	1
1001	5	1
1001	6	1
1001	7	1
1001	8	1
1002	1	1
1002	2	1
1002	3	1
1002	4	1
1002	5	1
1002	6	1
1002	7	1
1002	8	1
1004	1	1
1004	2	1
1004	3	1
1004	4	1
1004	5	1
1004	6	1
1004	7	1
1004	8	1
1010	1	1
1010	2	1
1010	3	1
1010	4	1
1010	5	1
1010	6	1
1010	7	1
1010	8	1

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

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	

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.)

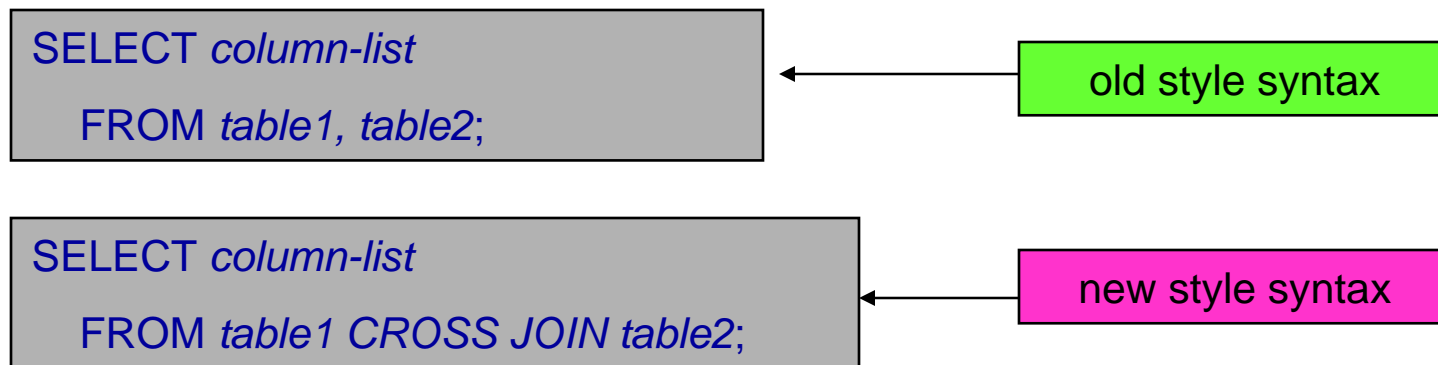
```
SELECT P_CODE, P_DESCRIPT, P_PRICE, V_NAME  
FROM PRODUCT, VENDOR  
WHERE PRODUCT.V_CODE = VENDOR.V_CODE;
```

- 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:



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;
```

old style syntax

- 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 9i 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 generate 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;
```



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_DESCRIPTOR = "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;
```



Subqueries in MySQL

- The ability to handle subqueries like we've just examined was not available in MySQL until version 4.1.
- If you are using a version of MySQL earlier than 4.1 you will need to download the latest version (5.0) before you begin to work on the next assignment which will involve the execution of subqueries.
- There are a number of other enhancements that became active with version 4.1 that are extremely useful and we will examine a number of these over the coming days.



Subqueries in MySQL (cont.)

- Subqueries are also useful in optimizing queries as they can be used to eliminate more costly join operations.
- Consider the following general query:

```
SELECT DISTINCT table1.col1  
FROM table1, table2  
WHERE table1.col1 = table2.col1;
```

- This query can be more efficiently expressed using subqueries as:

```
SELECT DISTINCT col1  
FROM table1  
WHERE table1.col1 IN (SELECT col1  
                      FROM table2);
```



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)

```
BEGIN transaction

INSERT Order_ID, Order_date, Customer_ID into Order_t;

INSERT Order_ID, Product_ID, Quantity into Order_line_t;
INSERT Order_ID, Product_ID, Quantity into Order_line_t;
INSERT Order_ID, Product_ID, Quantity into Order_line_t;

END transaction
```

Valid information inserted.
COMMIT work

All changes to data
are made permanent.

Invalid Product_ID entered

Transaction will be ABORTED.
ROLLBACK all changes made to Order_t

All changes made to Order_t
and Order_line_t are removed.
Database state is just as it was
before the transaction began.



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 9i
 - 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:2003

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

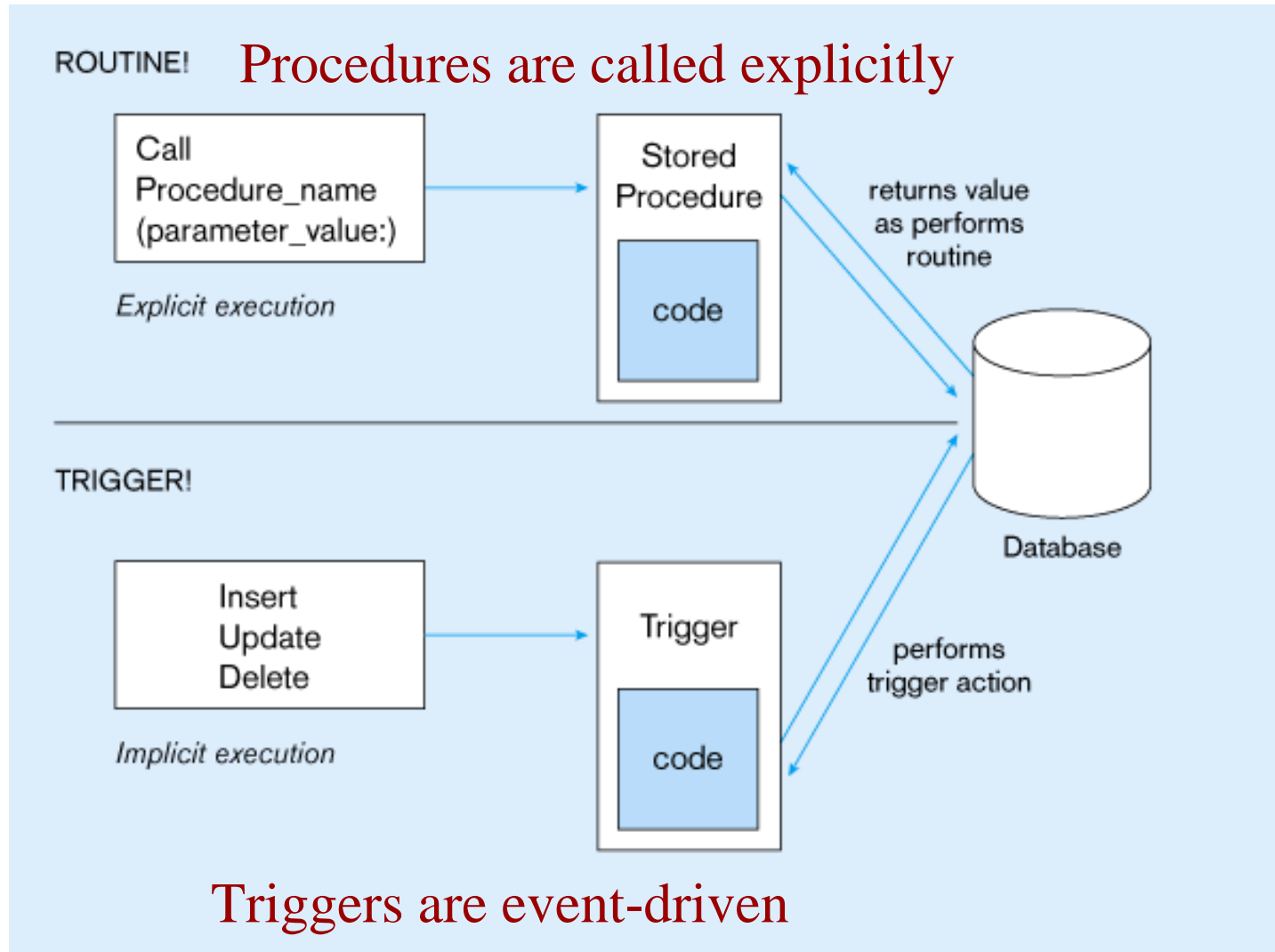


Routines and Triggers

- **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:2003 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

