NESTED QUERIES

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- A nested query is a query that has another query embedded within it; the embedded query is called a sub query.
- The embedded query can of course be a nested query itself; thus queries that have very deeply nested structures are possible.
- When writing a query, we sometimes need to express a condition that refers to a table that must itself be computed.

- The query used to compute this subsidiary table is a sub-query and appears as part of the main query.
- Conceptual evaluation strategy
- A sub-query typically appears within the WHERE clause of a query. Sub-queries can sometimes appear in the FROM clause or the HAVING clause

Find the names of sailors who have reserved boat 103.

```
SELECT S.sname
FROM Sailors S
WHERE S.sid IN
( SELECT R.sid
FROM Reserves R
WHERE R.bid = 103 )
```

Find the names of sailors who have reserved a red boat

```
SELECT S.sname
FROM Sailors S
WHERE S.sid IN
(SELECT R.sid
FROM Reserves R
WHERE R. bid IN
(SELECT B.bid
FROM Boats B
WHERE B.color = 'red‘))
```

Correlated Nested Queries

Find the names of sailors who have reserved boat number 103

```
SELECT S.sname
FROM Sailors S
WHERE EXISTS
( SELECT *
FROM Reserves R
WHERE R.bid = 103
AND R.sid = S.sid )
```

Complex Correlated Query

Product (pname, price, category, maker, year)

- Find products (and their manufacturers) that are more expensive than all products made by the same manufacturer before 1999

```
SELECT DISTINCT  pname, maker
FROM     Product AS x
WHERE  price > ALL  (SELECT  price
                     FROM    Product AS y
                     WHERE  x.maker = y.maker AND y.year < 1999);
```

Powerful, but much harder to optimize !

TRIGGERS AND ACTIVE DATABASES

- A trigger is a procedure that is automatically invoked by the DBMS in response to specified changes to the database, and is typically specified by the DBA.
- A database that has a set of associated triggers is called an active database.

- A trigger description contains three parts:
- Event: A change to the database that activates the trigger.
- Condition: A query or test that is run when the trigger is activated.
- Action: A procedure that is executed when the trigger is activated and its condition is true.

- A trigger can be thought of as a 'daemon' that monitors a databa.se, and is executed when the database is modified in a way that matches the *event specification.*
- An insert, delete, or update statement could activate a trigger, regardless of which user or application invoked the activating statement; users may not even be aware that a trigger was executed as a side effect of their program.

- A *condition in a trigger can be a true/false statement (e.g., all employee salaries* are less than $100,000) or a query. A query is interpreted as *true if the answer* set is nonempty and *false if the query ha.') no answers.*
- *If the condition part* evaluates to true, the action associated with the trigger is executed.
- A trigger *action can examine the answers to the query in the condition part* of the trigger, refer to old and new values of tuples modified by the statement activating the trigger, execute Hew queries, and make changes to the database.

```
CREATE TRIGGER iniLeount BEFORE INSERT ON Students      /* Event */
    DECLARE
        count INTEGER;
    BEGIN                                               /* Action */
        count := 0:
    END

CREATE TRIGGER incLcount AFTER INSERT ON Students       /* Event */
    WHEN (new.age < 18)  /* Condition; 'new' is just-inserted tuple */
    FOR EACH ROW
    BEGIN        /* Action; a procedure in Oracle's PL/SQL syntax */
        count := count + 1;
    END
```

Existential/Universal Conditions

Product (pname, price, company)
Company(cname, city)

Find all companies s.t. some of their products have price < 100

```
SELECT DISTINCT  Company.cname
FROM     Company, Product
WHERE  Company.cname = Product.company and Produc.price < 100
```

Existential: easy !

Existential/Universal Conditions

Product (pname, price, company)
Company(cname, city)

Find all companies s.t. all of their products have price < 100

Universal: hard !

Alternative English formulation:
Find all companies that make only products with price < 100

Existential/Universal Conditions

1. Find *the other* companies: i.e. s.t. some product ≥ 100

```
SELECT DISTINCT  Company.cname
FROM     Company
WHERE  Company.cname IN (SELECT Product.company
                         FROM Product
                         WHERE Produc.price >= 100
```

2. Find all companies s.t. all their products have price < 100

```
SELECT DISTINCT  Company.cname
FROM     Company
WHERE  Company.cname NOT IN (SELECT Product.company
                             FROM Product
                             WHERE Produc.price >= 100
```

Embedded SQL

- Embedded SQL
  - Standard SQL statements in host source, translated by preprocessor
- DBMS via an API (Application Programming interface)
  - Calls use host language conventions

SQL Programming: Embedded SQL

- Key idea: A preprocessor turns SQL statements into procedure calls that fit with the surrounding host-language code.
- All embedded SQL statements begin with EXEC SQL, so the preprocessor can find them easily.