

# Nested Queries

- In the atomic conditions of the **where** clause one can also use a **select** clause (which must appear in parentheses).

**Query 16.** Retrieve the name of each employee who has a dependent with the same first name and is the same sex as the employee.

**Q16:**      **SELECT**      E.Fname, E.Lname  
             **FROM**        EMPLOYEE **AS** E  
             **WHERE**      E.Ssn IN

```
( SELECT      D.Essn  
  FROM        DEPENDENT AS D  
  WHERE      E.Fname = D.Dependent_name  
             AND E.Sex = D.Sex );
```

# Nested Queries

In particular, in atomic conditions one can have:

- comparisons of an attribute (or several attributes) with the result of a subquery
- existential quantification **existential quantifier ( $\exists$ )**.

an existential quantifier = condition F is TRUE if there exists some tuple that makes F TRUE.

# Nested Queries (Example)

"Name and income of Frank's father"

```
select  f.name, f.income
from    person f, fatherChild fc
where   f.name = fc.father and fc.child = 'Frank'
```

```
select  f.name, f.income
from    person f
where   f.name = (select fc.father
                  from    fatherChild fc
                  where   fc.child = 'Frank')
```

An example of the first usage scenario:

the Where clause comparing f.name with the result of the nested SELECT

# Nested Queries: Operators

In the **where** clause, the result of a nested query can be related to other values by way of several **operators**:

- **equality and other comparisons such as >, < ...**  
(the result of the nested query must be unique)
- if it is not certain that the result of the nested query is unique, the nested query can be preceded by one of the keywords:
  - **any**: true, if the comparison is true for **at least one** of the result tuples of the nested query (e.g., > any, < any)
  - **all**: true, if the comparison is true for **all** the result tuples of the nested query (e.g., >all, <all)
- the operator **in**, which is equivalent to **=any**
- the operator **not in**, which is equivalent to **<>all**
- the operator **exists**

# Nested Queries: Example

"Name and income of the fathers of persons who earn more than 20k"

```
select distinct f.name, f.income
from   person f, fatherChild fc, person c
where  f.name = fc.father and
       fc.child = c.name and c.income > 20
```

```
select f.name, f.income
from   person f
where  f.name = any
       (select fc.father
        from   fatherChild fc, person c
        where  fc.child = c.name and
               c.income > 20)
```



fathers of persons  
who earn more  
than 20k

# Nested Queries: Example

"Name and income of the fathers of persons who earn more than 20k"

```
select f.name, f.income
from   person f
where  f.name = any
      (select fc.father
       from   fatherChild fc, person c
       where  fc.child = c.name and
              c.income > 20)
```

name	income
Greg	40
Frank	20
(2 rows)	

```
nuttdb=# select f.name, f.income from person f;
```

name	income
Andy	21
Rob	15
Mary	42
Anne	35
Phil	30
Greg	40
Frank	20
Kim	41
Mike	21
Lisa	87
(10 rows)	

```
nuttdb=# select fc.father from fatherchild fc, person c
nuttdb=# where fc.child = c.name and c.income > 20;
         father
```

```
-----
Greg
Greg
Frank
(3 rows)
```

# Nested Queries: Example

Name and income of the fathers of persons who earn more than 20k.

```
select f.name, f.income
from   person f
where  f.name in (select fc.father
                  from   fatherChild fc, person c
                  where  fc.child = c.name
                  and c.income > 20)
```

"in" equals to "= any"

```
select f.name, f.income
from   person f
where  f.name in (select fc.father
                  from   fatherChild fc
                  where  fc.child in (select c.name
                                     from   person c
                                     where c.income > 20)
                  )
```

fathers of  
persons who  
earn more than  
20k

persons who  
earn more  
than 20k

# Nested Queries: Comments

The **nested** formulation of a query is sometimes executed **less efficiently** than an equivalent unnested formulation (due to limitations of the query optimizer).

The nested formulation is sometimes more *readable*.



# Nested Queries: Example with a11

“Persons who have an income that is higher than the income of all persons younger than 30”

# Nested Queries: Example with all

“Persons who have an income that is higher than the income of all persons younger than 30”

```
select name
from person
where income >= all (select income
                     from person
                     where age < 30)
```

```
name
-----
Mary
Anne
Phil
Greg
Kim
Lisa
(6 rows)
```

```
[nuttdb=# select name, income, age from person;
```

```
 name | income | age
-----+-----+-----
Andy  |      21 |   27
Rob    |      15 |   25
Mary   |      42 |   55
Anne   |      35 |   50
Phil   |      30 |   26
Greg   |      40 |   50
Frank  |      20 |   60
Kim    |      41 |   30
Mike   |      21 |   85
Lisa   |      87 |   75
(10 rows)
```

```
[nuttdb=# select income from person where age < 30;
```

```
 income
-----
      21
      15
      30
(3 rows)
```

# Equivalent Formulation with max

“Persons who have an income that is higher than the income of all persons younger than 30”

```
select name
from   person
where  income >= (select max(income)
                  from   person
                  where  age < 30)
```

```
name
-----
Mary
Anne
Phil
Greg
Kim
Lisa
(6 rows)
```

```
[nuttdb=# select name, income, age from person;
```

name	income	age
Andy	21	27
Rob	15	25
Mary	42	55
Anne	35	50
Phil	30	26
Greg	40	50
Frank	20	60
Kim	41	30
Mike	21	85
Lisa	87	75

(10 rows)

```
[nuttdb=# select max(income)
[nuttdb=# from person
[nuttdb=# where age < 30
[nuttdb=# ;
max
-----
30
(1 row)
```

# Nested Queries: Example with exists

An expression with the operator **exists** is true if the result of the subquery is **not empty**.

**Example:** “Persons with at least one child”

```
select p.name, p.age, p.income
from   person p
where  exists (select *
               from   fatherChild fc
               where  fc.father = p.name)
       or
       exists (select *
               from   motherChild mc
               where  mc.mother = p.name)
```

*Note: the attribute **name** refers to the table in the outer **from** clause.*

# Nesting, Union, and “or”

The query for “persons with at least one child” can also be expressed as a **union**:

```
select p.name, p.age, p.income
from   person p, fatherChild fc
where  fc.father = p.name
union
select p.name, p.age, p.income
from   person p, motherChild mc
where  mc.mother = p.name
```

Does the following query with “**or**” return the same answers?

```
select distinct p.name, p.age, p.income
from   person p, fatherChild fc, motherChild mc
where  fc.father = p.name
       or mc.mother = p.name
```

# Nested Queries and Negation

All the queries with nesting in the previous examples are equivalent to some unnested query. So, what's the point of nesting?

**Example:** “Persons without a child”

```
select *  
from   person p  
where  not exists (select *  
                  from   fatherChild fc  
                  where  fc.father = p.name)  
  
      and  
      not exists (select *  
                  from   motherChild mc  
                  where  mc.mother = p.name)
```

This cannot be expressed equivalently as a “**select from where**” query ...  
(join? union?)

## Query 8 – nested queries

“Name and age of the mothers all of whose children are at least 18”

Approach 1: Subquery with **all**

Approach 2: Subquery with **min**

Approach 3: Subquery with **not exists**

## Query 8 – Solution with all

“Name and age of the mothers all of whose children are at least 18”

```
select m.name, m.age
from   person m join motherChild mc
        on m.name = mc.mother
where  18 <= all (select c0.age
                  from   motherChild mc0 join person c0
                        on mc0.child = c0.name
                  where  mc0.mother = mc.mother)
```



## Query 8: Solution with min

“Name and age of the mothers all of whose children are at least 18”

```
select m.name, m.age
from   person m join motherChild mc
        on m.name = mc.mother
where  18 <= (select min(c0.age)
              from   motherChild mc0 join person c0
                  on mc0.child = c0.name
              where  mc0.mother = mc.mother)
```

“Name and age of mothers where the minimal age of their children is greater or equal 18”

## Query 8: Solution with not exists

“Name and age of the mothers all of whose children are at least 18”

```
select m.name, m.age
from   person m join motherChild mc
        on m.name = mc.mother
where  not exists
        (select *
         from   motherChild mc0 join person c0
                on mc0.child = c0.name
         where  mc0.mother = mc.mother and
                c0.age < 18)
```

Name and age of mothers who don't have a child that is younger than 18.

# Nested Queries: Comments

## **Visibility** rules:

- it is not possible to refer to a variable defined in a block below the current block
- if an attribute name is not qualified with a variable or table name, it is assumed that it refers to the “closest” variable or table with that attribute

In each block, one can refer to variables defined in the same block or in surrounding blocks

**Semantics:** the inner query is executed **for every tuple** of the outer query

# Nested Queries: Visibility

Persons having at least one child.

```
select *
from person
where exists (select *
              from fatherChild
              where father = name)
or
exists (select *
        from motherChild
        where mother = name)
```

name	age	income
-----	-----	-----

father	child
-----	-----

mother	child
-----	-----

The attribute **name** refers to the table **person** in the outer **from** clause.

# More on Visibility

Note: This query is incorrect:

```
select *  
from employee  
where dept in (select name  
               from department D1  
               where name = 'Production')  
or  
dept in (select name  
         from department D2  
         where D2.city = D1.city)
```

<b>employee</b>	<b>name</b>	<b>lastName</b>	<b>dept</b>
-----------------	-------------	-----------------	-------------

<b>department</b>	<b>name</b>	<b>address</b>	<b>city</b>
-------------------	-------------	----------------	-------------

# Visibility: Variables in Internal Blocks

Name and income of the fathers of persons who earn more than 20k, **showing also the income of the child.**

```
select distinct f.name, f.income, c.income
from   person f, fatherChild, person c
where  f.name = fc.father and fc.child = c.name
       and c.income > 20
```

In this case, the “intuitive” nested query is incorrect:

```
select name, income, c.income
from   person
where  name in (select father
                from fatherChild
                where child in (select name
                                from person c
                                where c.income > 20))
```

# Correlated Subqueries

It may be necessary to **use in inner blocks** variables that are **defined in outer blocks**. In this case one talks about **correlated** subqueries.

**Example:** The fathers all of whose children earn strictly more than 20k.

```
select distinct fc.father
from   fatherChild fc
where  not exists (select *
                   from   fatherChild fc0, person c
                   where  fc.father = fc0.father
                        and fc0.child = c.name
                        and c.income <= 20)
```

## Query 10. Correlated Subqueries

“Name and age of mothers who have a child whose age differs less than 20 years from their own age”

```
select m.name, m.age
from   person m, motherChild mc
where  m.name = mc.mother and
       mc.child in (select c.name
                    from   person c
                    where  m.age - c.age < 20)
```



## Question: Intersection

Can one express intersection by way of nesting?

```
select name from employee
```

```
intersection
```

```
select lastName as name from employee
```

**employee**

name	lastName	dept
------	----------	------

# Intersection by Way of Nesting

```
select name from employee
```

```
intersection
```

```
select lastName as name from employee
```

```
select name
```

```
from employee
```

```
where name in (select lastName  
               from employee)
```

```
select name
```

```
from employee e
```

```
where exists (select *  
              from employee  
              where lastName = e.name)
```

# Intersection Without Nesting

Is it possible to express intersection without nesting?

```
select name from employee
```

```
intersection
```

```
select lastName as name from employee
```

```
select en.name
```

```
from   employee en, employee eln
```

```
where  en.name = eln.lastName
```

# Query 11

Can one express set difference by way of nesting?

```
select name from employee
```

```
  except
```

```
select lastName as name from employee
```

# Query 11 (Solution 1)

Can one express set difference by way of nesting?

```
select name from employee
except
select lastName as name from employee
```

```
select name
from employee
where name not in (select lastName
                    from employee)
```

## Query 11 - (Solution 2)

Can one express set difference by way of nesting?

```
select name from employee
except
select lastName as name from employee
```

```
select name
from   employee e
where  not exists (select *
                  from   employee
                  where  lastName = e.name)
```

## Query 12: Nesting and Functions

“The person (or the persons) that *have the highest income*”

```
select *  
from person  
where income = (select max(income)  
                from person)
```

Or:

```
select *  
from person  
where income >= all (select income  
                    from person)
```

# Conditions on Several Attributes

The persons which have a unique combination of age and income

*(that is, persons for whom the pair (age, income) is different from the corresponding pairs of **all other persons**).*

```
select *  
from person p  
where (age, income) not in  
      (select age, income  
       from person  
       where name <> p.name)
```



# SQL Views

A view is a table whose instance is derived from other tables by a query.

```
create view ViewName [(AttributeList)] as SQLSelect
```

*Views are virtual tables: their instances (or parts of them) are only calculated when they are used (for instance in other queries).*

*Example:*

```
create view AdminEmp(empNo,firstName,lastName,sal) as
select EmpNo, firstName, lastName, salary
from   employee
where  dept = 'Administration' and
       salary > 10
```

# Maximizing Aggregates

“Which age group has the highest total income?”

One solution is to use nesting in the **having** clause:

```
select age
from   person
group by age
having sum(income) >= all (select sum(income)
                           from   person
                           group by age)
```

Another solution is to create a view.

# Solution with Views

**create view ageIncome(age, sumIncome) as**

```
select age, sum(income)
from person
group by age
```

```
[nuttdb=# create view ageIncome(age, sumIncome) as
[nuttdb=# select age, sum(income) from person
[nuttdb=# group by age;
CREATE VIEW
[nuttdb=# select * from ageIncome;
 age | sumincome
-----+-----
  60 |         20
  26 |         30
  85 |         21
  30 |         41
  50 |         75
  75 |         87
  25 |         15
  55 |         42
  27 |         21
(9 rows)
```

```
select age
from ageIncome
where sumIncome = (select max(sumIncome)
                   from ageIncome)
```

```
[nuttdb=# select age from ageIncome
[nuttdb=# where sumIncome = (select max(sumIncome) from ageIncome);
 age
-----
  75
(1 row)
```

## Query 13

Among all companies based in George Street that sell red parts, which is the one with the least average price for red parts?

On the supplier and parts DB:

```
Supplier(sid, sname, address)
Part(pid, pname, colour)
Catalog(sid, pid, cost)
```

## Query 13 (Solution)

Among all companies based in George Street that supply red parts, which is the one with the least average price for red parts?

```
create view RedPartCompGS (sid, name, avgCost) as  
  select sid, name, avg(cost)  
  from    supplier natural join catalog  
          natural join part  
  where   address LIKE '%George St%' AND  
          colour = 'red'  
  group by sid, name
```

## Query 13 (Solution, cntd)

Among all companies based in George Street that sell red parts, which is the one with *the least average price* for red parts?

```
select name
from   RedPartCompGS
where  avgCost = (select min(avgCost)
                  from   RedPartCompGS)
```

# Views can be used in subqueries

```
select *  
from   person  
where  name in (select father from fatherChild);
```

*With a view*

```
create view father(name) as  
select distinct father from fatherChild;  
  
select *  
from   person  
where  name in (select name from father);
```

# Inline Views: Views in the FROM Clause

An equivalent formulation ( ... showing a view appearing in JOIN)

```
select person.*  
from   person, father  
where  person.name = father.name;
```

*where father is the view we saw previously.*

If we need a view only once, we can define it in the FROM clause

```
select *  
from   person,  
       (select distinct father as name  
        from   fatherChild) father  
where  person.name = father.name;
```



# Inline Views (Cntd)

Inline views can also take part in joins

```
select person.*  
from    person  
        natural join  
        (select distinct father as name  
         from    fatherChild) father;
```

*Note: The inline view needs to be named, even if the name is never used.*

# Exercises ...

Consider a database about suppliers and parts with the following schema:

`Supplier(sid, sname, address)`

`Part(pid, pname, colour)`

`Catalog(sid, pid, cost)`

Formulate the following queries in SQL:

# Queries: Exercises (cntd)

1. Find the names of suppliers who supply some red part.
2. Find the IDs of suppliers who supply some red or green part
3. Find the IDs of suppliers who supply some red part and are based at 21 George Street
4. Find pairs of IDs such that for some part the supplier with the first ID charges more than the supplier with the second ID.
5. For each supplier, return the maximal and the average cost of the parts they offer.
6. List those red parts that on average cost no more than 30 Euro.
7. List the names of those red parts that are offered by at least three suppliers.
8. Suppliers that supply *only* red parts
9. Suppliers that supply *all* red parts