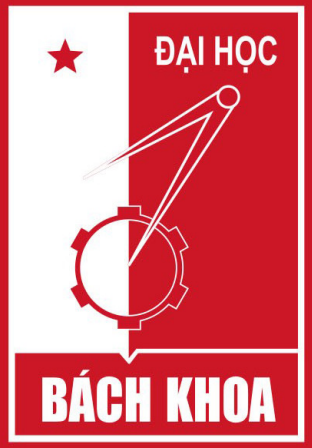



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# IT3090E - Databases

## Chapter 4: Structured Query Language
*part 3*

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# Contents

- Chapter 1: Introduction
- Chapter 2: Relational databases
- Chapter 3: Relational algebra
- **Chapter 4: Structured Query Language (SQL)**
- Chapter 5: Database Design
- Chapter 6: Indexing
- Chapter 7: Query processing and optimization
- Chapter 8: Constraints, rules and triggers
- Chapter 9: Security
- *(Optional) Chapter 10: Transactions: concurrency and recovery*

# Outline

1. Data Manipulation: SQL Data Manipulation Language for retrieving the data
2. Creating and managing views
3. Privileges and User Management in SQL

# Learning objective

- Write r**etrieval statement in SQL**: from simple queries to complex ones
- Create **views** and work correctly on predefined views
- Have experience with a DBMS: **manage user account and database access permissions**

# Global Outline of Chapter 4

- Chapter 4 - Part 1:
  - 1 - Introduction to SQL
  - 2 – Definition of a Relational Schema (DDL)
  - 3 – Data Manipulation: 3.1.-3.3. Insertion, deletion, updates
- Chapter 4 - Part 2:
  - 3.4. Data Manipulation Language for Querying (simple queries)
- Chapter 4 - Part 3:
  - **3.4. Data Manipulation Language for Querying (complex queries)**

# Keywords

| Keyword | Description |
|---|---|
| **Query** | A request (SQL statement) for information from a database |
| **Subquery** | A subquery (inner query, nested query) is a query within another (SQL) query. |
| **Privileges** | Database access permissions |
| **View** | A view is the result set of a stored query on the data, which the database users can query just as they would in a persistent database collection object. |

# Data Manipulation Language for querying: Advanced SQL Retrieval statement

a) Advanced joins operators
b) Subqueries (inside FROM clauses and inside WHERE clauses)
c) Aggregation operators (make calculations in SQL)
d) Grouping and aggregation in SQL,
e) HAVING clauses
f) Controlling outputs: eliminating duplicates, ordering results
g) Divisions

# 1. Example of a database schema

student(**student_id**, first_name, last_name, dob, gender, address, email, *program_id#*)
subject(**subject_id**, name, credit, percentage_final_exam)
lecturer(**lecturer_id**, first_name, last_name, dob, gender, address, email)
teaching(***subject_id#, lecturer_in_charge#***)
program(**program_id**, name, *lecturer_in_charge#*)
scores_per_subject(***student_id#, subject_id#, semester,*** midterm_score, final_score)

Client-applications
(in C#, Java, php, ...)

List of all female students ?

First name, last name and address of class monitors ?

**List of students (id and fullname) have enrolled subject 'Học máy' in semester 20172?**

List of students (id and fullname) having CPA >= 3.2?

DBMS

# 1. Example of a database schema

**student**

| student_id | first_name | last_name | dob | gender | … |
|---|---|---|---|---|---|
| 20160001 | Ngọc An | Bùi | 3/18/1987 | M | … |
| … | … | … | … | … | … |
| 20160003 | Thu Hồng | Trần | 6/6/1987 | F | … |
| 20160004 | Minh Anh | Nguyễn | 5/20/1987 | F | … |

**List of students (id and fullname) have enrolled subject 'Học máy' in semester 20172?**

**scores_per_subject**

| student_id | subject_id | semester | midterm_score | final_score |
|---|---|---|---|---|
| 20160001 | IT1110 | 20171 | 9 | 8.5 |
| … | … | … | … | … |
| 20160001 | IT4866 | 20172 | 7 | 9 |
| 20160002 | IT3080 | 20172 | 9 | |
| 20160003 | IT4866 | 20172 | 7 | 6 |

**subject**

| subject_id | name | credit | percentage_final_exam |
|---|---|---|---|
| IT1110 | Tin học đại cương | 4 | 60 |
| … | … | … | … |
| IT4866 | Học máy | 2 | 70 |

# 1. Data Manipulation: SELECT operation

```
SELECT[all|distinct]
    {*|{table_name.*|expr[alias]}|view_name.*}
        [,{table_name.*|expr[alias]}]...}
FROM table_name [alias][,table_name[alias]] ...
[WHERE condition]
[GROUP BY expr [,expr] ...]
[HAVING condition]
[{UNION|UNION ALL|INTERSECT|MINUS}
        SELECT ...]
[ORDER BY {expr|position} [ASC|DESC]
[,expr|position}[ASC|DESC]
```

# Data Manipulation: Advanced SELECT

1.1. Advanced joins operators

1.2. Subqueries (inside FROM clause and inside WHERE clause)

1.3. Aggregation operators (make calculations in SQL)

1.4. Grouping and aggregation in SQL

1.5. HAVING clauses

1.6. Controlling outputs: eliminating duplicates, ordering results

1.7. Division

# 1.1. Advanced join operators

- Syntax:

```
SELECT t1.c1, t1.c2, …, t2.c1, t2.c2
FROM t1, t2
WHERE condition_expression
```

- Example (with a variation of the current database):

student(**student_id**, first_name,last_name, dob, gender, address, note, *course_id*)

course(**course_id**, name, *lecturer_id#*, *TA_id#*)

- Question: what does the below query do?

```
SELECT course.course_id, last_name, first_name
FROM course, student
WHERE student_id = TA_id;
```

# 1.1. Advanced join operators: Operational semantics

**course**

| course_id | lecturer_id | TA_id |
|---|---|---|
| 20181101 | 02001 | 20150003 |
| 20162102 | | |
| 20172201 | 02002 | 20160001 |
| 20172202 | | |

**student**

| student_id | first_name | last_name | … | course_id |
|---|---|---|---|---|
| 20150001 | Ngọc An | Bùi | | |
| 20150002 | Anh | Hoàng | | 20152101 |
| 20150003 | Thu Hồng | Trần | | 20152101 |
| 20150004 | Minh Anh | Nguyễn | | 20152101 |
| 20160001 | Nhật Ánh | Nguyễn | | 20162201 |

**List of classes with TA names (firstname, lastname):**

```
SELECT course.course_id, name,
     student.last_name,          3
     student.first name
FROM course, student             1
WHERE student_id = TA_id         2
```

**result**

| course_id | last_name | first_name |
|---|---|---|
| 20182101 | Trần | Thu Hồng |
| 20172201 | Nguyễn | Nhật Ánh |



Tuple-variables loop over all tuples of each relation in FROM clause

# 1.1. Advanced join operators: AS keyword in FROM clause

- Used for naming variables:

```
SELECT …
FROM  <table_name> [AS] <variable_name>, …
[WHERE …]
```

  - AS: optional,
  - <variable_name>: used in the whole SQL statement

- Example:

```
SELECT c.course_id, name, s.last_name, s.first_name
FROM course AS c, student s
WHERE s.student_id = c.TA_id
```

# 1.1. Advanced join operators: Self-join

subject(**subject_id**, name, credit, percentage_final_exam)

Example: Find all pairs of subjects id having the *same name* but the cr edit of the first subject is less than the credit of the second one

```
SELECT sj1.subject_id, sj2. subject_id
FROM subject sj1, subject sj2
WHERE sj1.name = sj2.name
      AND sj1.credit < sj2.credit
```

# 1.1. Advanced join operators: Example

student(**student_id**, first_name,last_name, dob, gender,address,*program_id#*)

subject(**subject_id**, name, credit, percentage_final_exam)

scores_per_subject(***student_id#, subject_id#, semester***, midterm_score, final_score)

Example: List of students having enrolled in subjects in semester 20172: student full name, subject name, subject credit:

```
SELECT last_name ||' ' ||first_name as fullname,
     sj.name as subjectname, credit
FROM student s, scores_per_subject ss, subject sj
WHERE s.student_id = ss.student_id
     AND sj.subject_id = ss.subject_id
     AND semester = '20172'
```

# 1.1. Advanced join operators: Join types

- **Cartesian product:**
  - R CROSS JOIN S
- Theta join: (INNER JOIN)
  - R [INNER] JOIN S ON <condition>
- Natural join: (Be careful!) -> my personal recommendation is to avoid using it!!!
  - R NATURAL JOIN S
- Outer join:
  - R [LEFT|RIGHT|FULL] [OUTER] JOIN S ON <condition>
  - R NATURAL [LEFT|RIGHT|FULL] [OUTER] JOIN S

# 1.1. Advanced join operators: Join types

- Cartesian product:
  - S CROSS JOIN R
    - Equivalent to SELECT * from S, R;

PRODUCERS

| producer_id | name | address |
|---|---|---|
| 1369 | denecker sarl | Lyon |
| 1370 | chen'alpe diffussion | Lyon |
| 1502 | rodenas francois | Toulouse |
| 1623 | adidas | Dettwiller |

PRODUCTS

| reference | designation | unit_price | producer_id |
|---|---|---|---|
| 139 | Lamp rhapsody | 30.00 | 1623 |
| 248 | Female shoes camargue | 75.00 | 1623 |
| 258 | Male shoes camargue | 87.00 | 1623 |
| 416 | Backpack dolpo | 100.00 | 1369 |
| 426 | Backpack nepal | 155.00 | 1371 |
| 765 | tent | 300.00 | 1502 |

# 1.1. Advanced join operators: Join types

- Cartesian product:
  - PRODUCERS

    CROSS JOIN PRODUCTS

| producer_id | name | address | reference | designation | unit_price | Producer_id |
|---|---|---|---|---|---|---|
| 1369 | denecker sarl | Lyon | 139 | Lamp rhapsody | 30.00 | 1623 |
| 1369 | denecker sarl | Lyon | 248 | Female shoes camargue | 75.00 | 1623 |
| 1369 | denecker sarl | Lyon | 258 | Male shoes camargue | 87.00 | 1623 |
| 1369 | denecker sarl | Lyon | 416 | Backpack dolpo | 100.00 | 1369 |
| 1369 | denecker sarl | Lyon | 426 | Backpack nepal | 155.00 | 1371 |
| 1369 | denecker sarl | Lyon | 765 | tent | 300.00 | 1502 |
| 1370 | chen'alpe diffussion | Lyon | 139 | Lamp rhapsody | 30.00 | 1623 |
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# 1.1. Advanced join operators: Join types

- Cartesian product:
  - R CROSS JOIN S
- **Theta join: (INNER JOIN)**
  - R [INNER] JOIN S ON <condition>
- Natural join: (Be careful!) -> my personal recommendation is to avoid using it!!!
  - R NATURAL JOIN S
- Outer join:
  - R [LEFT|RIGHT|FULL] [OUTER] JOIN S ON <condition>
  - R NATURAL [LEFT|RIGHT|FULL] [OUTER] JOIN S

# 1.1. Advanced join operators: Join types

- INNER JOIN
  - R [INNER] JOIN S ON <condition>
    - Equivalent to SELECT * from S, R where <condition>;
    - Example: select * from PRODUCERS S, PRODUCTS P

      where R.producer_id=S.producer_id

PRODUCERS

| producer_id | name | address |
|---|---|---|
| 1369 | denecker sarl | Lyon |
| 1370 | chen'alpe diffussion | Lyon |
| 1502 | rodenas francois | Toulouse |
| 1623 | adidas | Dettwiller |

PRODUCTS

| reference | designation | unit_price | producer_id |
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    - Example: select * from PRODUCERS S, PRODUCTS P

      where R.producer_id=S.producer_id

| producer_id | name | address | reference | designation | unit_price | Producer_id |
|---|---|---|---|---|---|---|
| 1369 | denecker sarl | Lyon | 416 | backpack dolpo | 100.00 | 1369 |
| 1502 | rodenas francois | Toulouse | 765 | tent | 300.00 | 1502 |
| 1623 | adidas | Dettwiller | 139 | lamp rhapsody | 30.00 | 1623 |
| 1623 | adidas | Dettwiller | 248 | Female shoes camargue | 75.00 | 1623 |
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  - R [INNER] JOIN S ON <condition>
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PRODUCERS

| producer_id | name | address |
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PRODUCTS

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| 413 | Backpack dolpo | 100.00 | 1369 |
| 426 | Backpack nepal | 155.00 | 1371 |
| 765 | tent | 300.00 | 1502 |

Not in the INNER JOIN's result

# 1.1. Advanced join operators: Join types

- Cartesian product:
  - R CROSS JOIN S
- Theta join: (INNER JOIN)
  - R [INNER] JOIN S ON <condition>
- **Natural join**: (Be careful!) -> my personal recommendation is to avoid using it!!!
  - R NATURAL JOIN S
- Outer join:
  - R [LEFT|RIGHT|FULL] [OUTER] JOIN S ON <condition>
  - R NATURAL [LEFT|RIGHT|FULL] [OUTER] JOIN S

# 1.1. Advanced join operators: Join types

- R NATURAL JOIN S
  - Finds automatically the “natural” attribute to make the join
  - Usually, the first attribute with the same name in the two tables!
    - Here, the result is the same as with an inner join
    - But, in general, VERY uncertain! -> I recommend you not to use it
      - » Example: what if “designation” was called “name”?

PRODUCERS

| producer_id | name | address |
|---|---|---|
| 1369 | denecker sarl | Lyon |
| 1370 | chen'alpe diffussion | Lyon |
| 1502 | rodenas francois | Toulouse |
| 1623 | adidas | Dettwiller |

PRODUCTS

| reference | designation | unit_price | producer_id |
|---|---|---|---|
| 139 | Lamp rhapsody | 30.00 | 1623 |
| 248 | Female shoes camargue | 75.00 | 1623 |
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# 1.1. Advanced join operators: Join types

- Cartesian product:
  - R CROSS JOIN S
- Theta join: (INNER JOIN)
  - R [INNER] JOIN S ON <condition>
- Natural join: (Be careful!) -> my personal recommendation is to avoid using it!!!
  - R NATURAL JOIN S
- **Outer join:**
  - R [LEFT|RIGHT|FULL] [OUTER] JOIN S ON <condition>
  - R NATURAL [LEFT|RIGHT|FULL] [OUTER] JOIN S

# 1.1. Advanced join operators: Join types

- Outer join:
  - R [LEFT|RIGHT|FULL] [OUTER] JOIN S ON <condition>
  - R NATURAL [LEFT|RIGHT|FULL] [OUTER] JOIN S
- Example:
  - SELECT * from S LEFT OUTER JOIN P
    ON S.producer_id=P.producer_id;

PRODUCERS

| producer_id | name | address |
|---|---|---|
| 1369 | denecker sarl | Lyon |
| 1370 | chen'alpe diffussion | Lyon |
| 1502 | rodenas francois | Toulouse |
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PRODUCTS

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# 1.1. Advanced join operators: Join types

- Example:
  - SELECT * from S LEFT OUTER JOIN P ON S.producer_id=P.producer_id;

| producer_id | name | address |
|---|---|---|
| 1369 | denecker sarl | Lyon |
| 1370 | chen'alpe diffussion | Lyon |
| 1502 | rodenas francois | Toulouse |
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| reference | designation | unit_price | producer_id |
|---|---|---|---|
| 139 | Lamp rhapsody | 30.00 | 1623 |
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| 426 | Backpack nepal | 155.00 | 1371 |
| 765 | tent | 300.00 | 1502 |

| producer_id | name | address | reference | designation | unit_price | Producer_id |
|---|---|---|---|---|---|---|
| 1369 | denecker sarl | Lyon | 416 | backpack dolpo | 100.00 | 1369 |
| 1502 | rodenas francois | Toulouse | 765 | tent | 300.00 | 1502 |
| 1623 | adidas | Dettwiller | 139 | lamp rhapsody | 30.00 | 1623 |
| 1623 | adidas | Dettwiller | 248 | Female shoes camargue | 75.00 | 1623 |
| 1623 | adidas | Dettwiller | 258 | Male shoes camargue | 87.00 | 1623 |
| 1370 | Chen'alpe diffusion | Lyon | NULL | NULL | NULL | NULL |

Was not in the INNER JOIN result

# 1.1. Advanced join operators: Join types

- Example:
  - SELECT * from S RIGHT OUTER JOIN P ON S.producer_id=P.producer_id;

| producer_id | name | address |
|---|---|---|
| 1369 | denecker sarl | Lyon |
| 1370 | chen'alpe diffussion | Lyon |
| 1502 | rodenas francois | Toulouse |
| 1623 | adidas | Dettwiller |

| reference | designation | unit_price | producer_id |
|---|---|---|---|
| 139 | Lamp rhapsody | 30.00 | 1623 |
| 248 | Female shoes camargue | 75.00 | 1623 |
| 258 | Male shoes camargue | 87.00 | 1623 |
| 416 | Backpack dolpo | 100.00 | 1369 |
| 426 | Backpack nepal | 155.00 | 1371 |
| 765 | tent | 300.00 | 1502 |

| producer_id | name | address | reference | designation | unit_price | Producer_id |
|---|---|---|---|---|---|---|
| 1369 | denecker sarl | Lyon | 416 | backpack dolpo | 100.00 | 1369 |
| 1502 | rodenas francois | Toulouse | 765 | tent | 300.00 | 1502 |
| 1623 | adidas | Dettwiller | 139 | lamp rhapsody | 30.00 | 1623 |
| 1623 | adidas | Dettwiller | 248 | Female shoes camargue | 75.00 | 1623 |
| 1623 | adidas | Dettwiller | 258 | Male shoes camargue | 87.00 | 1623 |
| NULL | NULL | NULL | 426 | Backpack nepal | 155.00 | 1371 |

Was not in the INNER JOIN result

# 1.1. Advanced join operators: Join types

- Example:
  - SELECT * from S FULL OUTER JOIN P ON S.producer_id=P.producer_id;

| producer_id | name | address |
|---|---|---|
| 1369 | denecker sarl | Lyon |
| 1370 | chen'alpe diffussion | Lyon |
| 1502 | rodenas francois | Toulouse |
| 1623 | adidas | Dettwiller |

| reference | designation | unit_price | producer_id |
|---|---|---|---|
| 139 | Lamp rhapsody | 30.00 | 1623 |
| 248 | Female shoes camargue | 75.00 | 1623 |
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| 416 | Backpack dolpo | 100.00 | 1369 |
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| 765 | tent | 300.00 | 1502 |

| producer_id | name | address | reference | designation | unit_price | Producer_id |
|---|---|---|---|---|---|---|
| 1369 | denecker sarl | Lyon | 416 | backpack dolpo | 100.00 | 1369 |
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| 1623 | adidas | Dettwiller | 248 | Female shoes camargue | 75.00 | 1623 |
| 1623 | adidas | Dettwiller | 258 | Male shoes camargue | 87.00 | 1623 |
| NULL | NULL | NULL | 426 | Backpack nepal | 155.00 | 1371 |
| 1370 | Chen'alpe diffussion | Lyon | NULL | NULL | NULL | NULL |

Were not in the INNER JOIN result

# 1.1. Advanced join operators: Join types

- NATURAL LEFT JOIN, NATURAL RIGHT JOIN
  - In this case, same result as OUTER LEFT JOIN, OUTER RIGHT JOIN
  - But more risk to make errors, I would not recommend it!

# 1.2. Sub-queries (nested queries)

- A SELECT-FROM-WHERE statement can be used within a clause of another outer query. It can be
  - within a WHERE clause
  - within a FROM clause
- Creates an intermediate result
- No limit to the number of levels of nesting
- Objectives:
  - Check if an element is in a set (IN, NOT IN)
  - Set comparison >ALL, >=ALL, <ALL,<=ALL,=ALL, ANY (SOME)
  - Check if a relation is empty or not (EXISTS, NOT EXISTS)

# 1.2. Sub-queries: Subquery returning a scalar value

- A sub-query provide a single value ➔ we can use it as if it were a constant

```
SELECT *
FROM student
WHERE program_id = (SELECT program_id
                    FROM program
                    WHERE name = 'CNTT1.01-K61');
```

# 1.2. Sub-queries: IN operators

- Syntax: <tuple> [**NOT** ] **IN** <subquery>
  - Can be used as INNER JOIN!!!
- Example: First name, last name and address of TAs? (variation of our DB)

student(**student_id**, first_name,last_name, dob, gender, address, note, *course_id*)

course(**course_id**, name, *lecturer_id#*, *TA_id#*)

```
SELECT first_name, last_name, address
FROM student
WHERE student_id IN (SELECT TA_id FROM course);
```

# 1.2. Sub-queries: EXISTS

- Syntax:

  [NOT] EXISTS (<subquery>)

  EXISTS (<subquery>): TRUE iff <subquery> result is **not empty**

- Question: what does this query return?

  -> subjects having no lecturer

  teaching(***subject_id#, lecturer_id#***)

  subject(**subject_id**, name, credit, percentage_final_exam)

```
SELECT * FROM subject s
WHERE not exists (SELECT *
        FROM teaching
        WHERE subject_id = s.subject_id)
```

# 1.2. Sub-queries: EXISTS

- Can also be used to express INNER JOIN!
- Ex: First name, last name and address of TAs? (variation of our DB)

student(**student_id**, first_name,last_name, dob, gender, address, note, *course_id*)

course(**course_id**, name, *lecturer_id#*, *TA_id#*)

```
SELECT first_name, last_name, address
FROM student
WHERE student_id IN (SELECT TA_id FROM course);
```

- Question: write the same query, but using the EXISTS operator

```
SELECT first_name, last_name, address
FROM student
WHERE EXISTS (SELECT TA_id FROM course WHERE TA_id = student_id);
```

# 1.2. Sub-queries: ALL, ANY

- Syntax: **<expression> <*comparison_operator*> ALL|ANY <subquery>**
  - *<comparison_operator>:* **>, <, <=, >=, =, <>**
  - X **>=ALL**<subquery>: TRUE if there is **no tuple larger than X** in <subquery> result
    - Can be used to express maximum, minimum
  - X **= ANY**<subquery>: TRUE if **x equals at least one tuple** in <subquery> result
  - X **>ANY**<subquery>: TRUE if **x is not the smallest tuple** produced by <subquery>
- Example: what does this query return?

-> subjects having the maximum number of credits

```
SELECT *
FROM subject
WHERE credit >= ALL (SELECT credit FROM subject);
```

# 1.2. Sub-queries: Example

**subject**

| subject_id | name | credit | perc… |
|---|---|---|---|
| IT1110 | Tin học đại cương | 4 | 60 |
| IT3080 | Mạng máy tính | 3 | 70 |
| IT3090 | Cơ sở dữ liệu | 3 | 70 |
| IT4857 | Thị giác máy tính | 3 | 60 |
| IT4866 | Học máy | 2 | 70 |

```
SELECT *
FROM subject
WHERE credit > ANY(SELECT credit
                   FROM subject);
```

**result**

| subject_id | name | credit | perc… |
|---|---|---|---|
| IT1110 | Tin học đại cương | 4 | 60 |
| IT3080 | Mạng máy tính | 3 | 70 |
| IT3090 | Cơ sở dữ liệu | 3 | 70 |
| IT4857 | Thị giác máy tính | 3 | 60 |

```
SELECT *
FROM subject
WHERE credit >= ALL(SELECT credit FROM subject);
```

**result**

| subject_id | name | credit | perc… |
|---|---|---|---|
| IT1110 | Tin học đại cương | 4 | 60 |

# 1.2. Sub-queries: Subquery in FROM Clause

- So far, we talked about using subqueries in WHERE clauses
- But, subquery can also be used as a relation in a FROM clause
- **Must** give it a tuple-variable alias
- Eg.: List of lecturers teaching subject whose id is 'IT3090'

```
SELECT l.*
FROM lecturer l,
    (SELECT lecturer_id
    FROM teaching
    WHERE subject_id = 'IT3090') lid
WHERE l.lecturer_id = lid.lecturer_id
```

# 1.3. Aggregation Operators

- SUM, AVG, COUNT, MIN, MAX: applied to a column in a SELECT clause
- COUNT(*) counts the number of tuples

```
SELECT AVG(credit), MAX(credit)
FROM subject
WHERE subject_id LIKE 'IT%';
```

**result**

| AVG | MAX |
|---|---|
| 3.0 | 4 |

**subject**

| subject_id | name | credit | perc… |
|---|---|---|---|
| IT1110 | Tin học đại cương | 4 | 60 |
| IT3080 | Mạng máy tính | 3 | 70 |
| IT3090 | Cơ sở dữ liệu | 3 | 70 |
| IT4857 | Thị giác máy tính | 3 | 60 |
| IT4866 | Học máy | 2 | 70 |
| LI0001 | life's happy song | 5 | |
| LI0002 | %life's happy song 2 | 5 | |

# 1.3. Aggregation Operators: Functions

- **Aggregate functions**: MAX, MIN, SUM, AVG, COUNT
- Functions applying on **individual tuples**:
  - Mathematic functions: ABS, SQRT, LOG, EXP, SIGN, ROUND, ..
  - String functions: LEN, LEFT, RIGHT, MID, **UPPER**...
  - Date/Time functions: DATE, DAY, MONTH, YEAR, HOUR, MINUTE, ...
  - ...
  - Remark:
    - In general, common functions are similar between different DBMSs,
    - Some functions have different formats or names,... especially for date, time and string data types ➔ See documentations for each DBMS

# 1.3. Aggregation Operators: Functions

- Example

```
SELECT ssid, name, MIN(score), MAX(score), AVG(score), stddev_pop(score)
FROM  (SELECT student_id sid, ss.subject_id ssid, name,
            (midterm_score*(1-1.0*percentage_final_exam/100)+
        final_score*1.0*percentage_final_exam/100) score
        FROM scores_per_subject ss, subject sj
        WHERE sj.subject_id = ss.subject_id) AS t
WHERE upper(ssid) LIKE 'IT%'
GROUP BY ssid, name;
```

**result**

| ssid | name | min | max | avg | stddev |
|---|---|---|---|---|---|
| IT1110 | Tin học đại cương | 5.4 | 8.7 | 7.05 | 1.254 |
| IT3080 | Mạng máy tính | | | | |
| IT3090 | Cơ sở dữ liệu | 8.1 | 8.1 | 8.1 | 0 |
| IT4857 | Thị giác máy tính | 8.25 | 8.25 | 8.25 | 0 |
| IT4866 | Học máy | 8.4 | 8.4 | 8.4 | 0 |

# 1.3. N.B. NULL is ignored in Aggregation

- NULL: no contribution
- no non-NULL values in a column ➔ the result: NULL
  - Exception: COUNT of an empty set is 0

```
SELECT AVG(percentage_final_exam)
FROM subject;
```
➔ 66=(60x2+70x3)/5

```
SELECT AVG(percentage_final_exam),
     count(percentage_final_exam)
FROM subject
WHERE subject_id NOT LIKE 'IT%';
```

**result**

| AVG | COUNT |
|---|---|
| NULL | 0 |

**subject**

| subject_id | name | credit | percentage_final_exam |
|---|---|---|---|
| IT1110 | Tin học đại cương | 4 | 60 |
| IT3080 | Mạng máy tính | 3 | 70 |
| IT3090 | Cơ sở dữ liệu | 3 | 70 |
| IT4857 | Thị giác máy tính | 3 | 60 |
| IT4866 | Học máy | 2 | 70 |
| LI0001 | life's happy song | 5 | |
| LI0002 | %life's happy song 2 | 5 | |

# 1.4. Grouping results

- Syntax:

```
SELECT ...
FROM ...
[WHERE condition]
GROUP BY expr [,expr]...
```

**student**

| student_id | first_name | last_name | ... | gender | ... | program_id |
|---|---|---|---|---|---|---|
| 20160001 | Ngọc An | Bùi | ... | M | ... | |
| 20160002 | Anh | Hoàng | ... | M | ... | 20162101 |
| 20160003 | Thu Hồng | Trần | ... | F | ... | 20162101 |
| 20160004 | Minh Anh | Nguyễn | ... | F | ... | 20162101 |
| 20170001 | Nhật Ánh | Nguyễn | ... | F | ... | 20172201 |

- Example and Operational semantic:

```
SELECT program_id, count(student_id)    3
FROM student                            1
WHERE gender = 'F'
GROUP BY program_id;                    2
```

**result**

| program_id | count |
|---|---|
| 20162101 | 2 |
| 20172201 | 1 |

# 1.4. Grouping results

- Each element of the SELECT list must be either:
  - Aggregated, or
  - An attribute on the GROUP BY list
  - Example:

```
SELECT program_id, count(student_id), first_name
FROM student
WHERE gender = 'F'
GROUP BY program_id;
```

- **Question**: why???

# 1.5. Grouping results: HAVING

- The aggregate functions can be used in a SELECT…
  - … or in the HAVING clause of a SELECT statement that includes a GROUP BY clause
- The HAVING clause enables to express conditions on aggregate functions
  - Aggregate functions are not allowed in WHERE statements
- Example:

```
SELECT  Country
FROM Customers
GROUP BY Country
HAVING COUNT(CustomerID) > 5;
```

# 1.5. Grouping results: HAVING

- Aggregate functions in HAVING statement can be used with or without aggregate function in the select statement
- If there is an aggregate function in the SELECT statement and one in the HAVING clause, the two aggregate functions **do not** need to be the same
- Examples:

```
SELECT COUNT(city), Country
FROM Customers
GROUP BY Country
HAVING COUNT(CustomerID) > 5;
```

```
SELECT COUNT(CustomerID), Country
FROM Customers
GROUP BY Country
HAVING COUNT(CustomerID) > 5;
```

# 1.5. Grouping results: HAVING

- Syntax:

```
SELECT ...
FROM ...
[WHERE condition]
GROUP BY expr [,expr]...
HAVING <condition on group>
```

- Example:

```
SELECT program_id, count(student_id)4
FROM student                          1
WHERE gender = 'F'
GROUP BY program_id                   2
HAVING count(student_id) >= 2;        3
```

**result**

| program_id | count |
|---|---|
| 20162101 | 2 |

# 1.5. Grouping results: HAVING

- Question: which question does the following query answer to?

```
SELECT subject_id, semester, count(student_id)
FROM scores_per_subject
GROUP BY subject_id, semester
HAVING count(student_id) >= ALL
                (SELECT count(student_id)
                FROM scores_per_subject
                 GROUP BY subject_id, semester)
```

# 1.5. Grouping results: HAVING

- **Which subject in which semester had the most students?**

```
SELECT subject_id, semester, count(student_id)
FROM scores_per_subject
GROUP BY subject_id, semester
HAVING count(student_id) >= ALL
            (SELECT count(student_id)
            FROM scores_per_subject
             GROUP BY subject_id, semester);
```

result

| subject_id | semester | count |
|---|---|---|
| IT4857 | 20172 | 1 |
| IT3090 | 20172 | 1 |
| IT4866 | 20172 | 1 |
| IT3080 | 20172 | 2 |
| IT1110 | 20171 | 4 |

result

| subject_id | semester | count |
|---|---|---|
| IT1110 | 20171 | 4 |

# 1.5. Grouping results: HAVING

- HAVING clauses can also express a condition on the groups in the GROUP BY
  - HAVING clauses do **not** necessarily contain aggregation functions!
- Example:

```
SELECT year(birthdate), count(*)
FROM  Employees
group by year(Birthdate)
Having year(Birthdate)>1960 ;
```

- Question: Give a SQL statement which will give the same output, but with a where instead of a having.

# 1.6. Controlling the output: Eliminating Duplicates

- Remove duplicate tuples: DISTINCT

```
SELECT DISTINCT student_id FROM scores_per_subject;
```

- UNION | INTERSECT | EXCEPT: remove duplicate rows
- UNION | INTERSECT | EXCEPT **ALL**:
  - does not remove duplicate rows

# 1.6. Controlling the output: Eliminating Duplicates in an Aggregation

- Use **DISTINCT** inside aggregation

```
SELECT count(*) a,
    count(distinct percentage_final_exam) b,
    AVG(credit) c,
    AVG(distinct credit) d
FROM subject;
```

**result**

| a | b | c | d |
|---|---|---|---|
| 7 | 3 | 3.57 | 3.5 |

**subject**

| subject_id | name | credit | percentage_final_exam |
|---|---|---|---|
| IT1110 | Tin học đại cương | 4 | 60 |
| IT3080 | Mạng máy tính | 3 | 70 |
| IT3090 | Cơ sở dữ liệu | 3 | 70 |
| IT4857 | Thị giác máy tính | 3 | 60 |
| IT4866 | Học máy | 2 | 70 |
| LI0001 | life's happy song | 5 | |
| LI0002 | %life's happy song 2 | 5 | |

# 1.6. Controlling the output: Ordering results

- Syntax and operational semantic:

```
SELECT ...
FROM ...
[WHERE condition]
[GROUP BY expr [,expr]... ]
[HAVING …]
ORDER BY {expr|position} [ASC|DESC]
         [{,expr|position}[ASC|DESC]
```

1

# 1.6. Controlling the output: Ordering results

- Example:

```
SELECT subject_id, semester, count(student_id)
FROM scores_by_subject
GROUP BY subject_id, semester
ORDER BY semester,
     count(student_id) DESC, subject_id;
```

result

| subject_id | semester | count |
|---|---|---|
| IT4857 | 20172 | 1 |
| IT3090 | 20172 | 1 |
| IT4866 | 20172 | 1 |
| IT3080 | 20172 | 2 |
| IT1110 | 20171 | 4 |

result

| subject_id | semester | count |
|---|---|---|
| IT1110 | 20171 | 4 |
| IT3080 | 20172 | 2 |
| IT3090 | 20172 | 1 |
| IT4857 | 20172 | 1 |
| IT4866 | 20172 | 1 |

# 1.7. Division

- Example from the relational schema in Chapter 2

**SHOPS (no_shop, city, name_manager)**
**CUSTOMERS (no_customer, name, country, city, type)**
**ITEMS(no_item, name, weight, color, qty_stock, BuyingPrice, SellingPrice, no_supplier#)**
**DELIVERY (no_delivery, date_del, no_customer#, no_shop#)**
**ORDERS (no_order, date, no_customer#, no_shop#)**
**SUPPLIERS (no_supplier, supplier_name)**

**DELIVERY_DETAILS (no_delivery#, no_item#, qty, no_order#)**
**ORDER_DETAILS (no_order#, no_item#, qty, no_delivery#, total_amount)**

# 1.7. Division

• Introductive example (this is not a division yet):

*Items which do not appear in any order line*

$S=\{ a \in Items \mid \neg\, a \in Order\_Details \}$

$\Leftrightarrow S=\{ a \in Items \mid \forall\, c \in Order\_Details,$

$\neg\, Order\_Details(a,c) \}$

*How to express ∀?*

$\Rightarrow$ *Using its negation.*

$S=\{ a \in Items \mid \nexists\, c \in Order\_Details,$

$Order\_Details(a,c) \}$

# 1.7. Division

- Introductive example (this is not a division yet):

S={ a ∈ Items | ∄ c ∈ ORDER_Details,
ORDER_Details(a,c) }
May be translated in SQL by:

```
select * from ITEMS I
where not exists ( select *
                   from ORDER_Details OL
                   where OL.item_no = I.item_no);
```

# 1.7. Division

• Introductive example (this is a division): Which items have been ordered in every order?

*1) PROJECTION of all the order numbers => D*

*2) PROJECTION of all the items along with the order numbers where the item appear => N*

*3.4.1. Division: R= N / D*

# 1.7. Division

• Introductive example (this is a division): Which items have been ordered in every order?

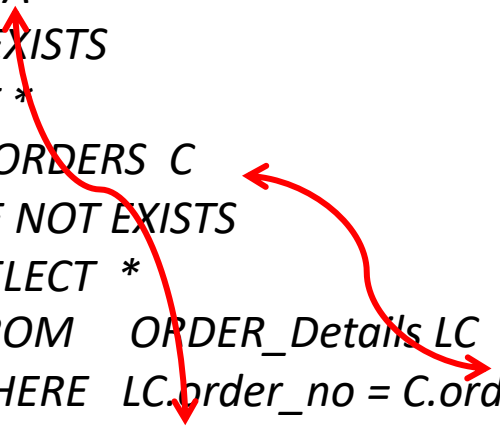
$S=\{ a \in Items \mid \forall c \in Orders, Order\_Details(a,c) \}$
$\Leftrightarrow S=\{a \in Items \mid \nexists c \in Orders, \neg Order\_Details(a,c) \}$
$\Leftrightarrow S=\{a \in Items \mid \nexists c \in Orders, \forall lc \in Order\_Details, \neg lc(a,c) \}$
$\Leftrightarrow S=\{a \in Items \mid \nexists c \in Orders, \nexists lc \in Order\_Details, lc(a,c) \}$

*List of all the items such that there is (exists) no order such that this item does not appear (exists) in at least one order line of this order*

# 1.7. Division

•Introductive example (this is a division): Which items have been ordered in every order?

```
SELECT *
FROM  ITEMS A
WHERE NOT EXISTS
        ( SELECT *
          FROM ORDERS  C
          WHERE NOT EXISTS
                ( SELECT  *
                  FROM     ORDER_Details LC
                  WHERE   LC.order_no = C.order_no
                  AND   A.item_no= LC.item_no )
        );
```



# 1.7. Division

```
SELECT names
FROM  ITEMS A
WHERE NOT EXISTS
        ( SELECT *
          FROM SHOPS M
          WHERE NOT EXISTS
                ( SELECT  *
                  FROM ORDERS CD,
                          ORDER_Details LCD
                 WHERE  CD.order_no = LCD.order_no
                 WHERE   LCD.item_no = A.item_no
                 AND   CD.shop_no = M.shop_no )
          );
```

```
/* Question: What does this
query return?*/
```

# 1.7. Division

```
SELECT name
FROM  ITEMS A
WHERE NOT EXISTS
        ( SELECT *
          FROM SHOPS M
          WHERE city= 'La Rochelle' and NOT EXISTS
                ( SELECT  *
                  FROM ORDERS CD,
                          ORDER_Details LCD
                 WHERE  CD.order_no = LCD.order_no
                 WHERE   LCD.item_no = A.item_no
                 AND   CD.shop_no = M.shop_no )
          );
```

/* Question: What does this query return?*/

# 1.7. Division

```
SELECT name
FROM  ITEMS A
WHERE color = 'green' and NOT EXISTS
        ( SELECT *
          FROM SHOPS M
          WHERE NOT EXISTS
                ( SELECT  *
                  FROM ORDERS CD,
                          ORDER_Details LCD
                 WHERE  CD.order_no = LCD.order_no
                 WHERE   LCD.item_no = A.item_no
                 AND   CD.shop_no = M.shop_no )
        );
```

/* Question: What does this query return?*/

# Views

1. View definition
2. Accessing views
3. Updatable views
4. Materialized views

# 2.1. View definition

- A view is a relation defined on the basis of stored tables (called base tables) and/or other views
- Two kinds:
  - Virtual (by default) = not stored in the database; just some kind of pre-defined query
    - There is a SQL standard of defining a view
  - Materialized = actually built and stored in the database
    - SQL does not provides any standard way of defining materialized view, however some database management system provides custom extensions to use materialized views.
- Declaring views:

  CREATE [MATERIALIZED] VIEW <name> AS <query>;

# 2.1. View definition

- A view can be queried exactly like a  table (select * from <view_name> - see later)
- The main difference between a view and a table is that the records in the views are computed on-the-fly every time the view is queried
  - The records in the view do not need to be updated every time the base tables are updated
- The views are often created to fit the specific needs of some end-user of the database, without modifiying the database itself

# 2.1. View definition: View Removal

- Dropping views: DROP VIEW <name>;

  DROP VIEW female_student;

- Consequences of dropping a view:
  - Deleting the definition of views: the female_student view no longer exists
  - **No record** of the base relation (student relation) is affected

# 2.2. Accessing views

- Declare:

```
CREATE VIEW TA AS
SELECT student_id, first_name, last_name, dob, program_id
FROM student s, class c
WHERE s.student_id = c.TA_id ;
```

- Query a view (we do that exactly as if it were a base table)

```
SELECT student_id, first_name, last_name, dob
FROM TA
WHERE class_id = '20172201' ;
```

# 2.3. Updatable views

- The SQL rules are complex for updating views
  - Because the views depend on the base tables!!!
  - So, an update in a view should trigger an update in the base table(s)
  - Therefore, the matching between the row in the view and the row in the base table must be exact
  - That's the main reasons why there are strict rules for updating views in SQL

# 2.3. Updatable views

- SQL rules for updating views
  - Updates are only possible on views that are defined by selecting (using SELECT, not SELECT DISTINCT) some attributes from one relation *R* (which may itself be an updatable view)
    - If the view contains joins between multiple tables, you can only insert and update records from one table in the view
  - The **WHERE** clause must not involve *R* in a subquery
  - The **FROM** clause can only consist of one occurrence of *R* and no other relation
  - There must be **no GROUP BY** clause
  - The **list of attributes** to update /insert must cover all NOT NULL attributes from R with no default value which value is not specified in the view
    - In particular, the view must include the PRIMARY KEY attribute of R
  - If the view you want to update is based upon another view, that view should be updatable

# 2.3. Updatable views: Example

- Base table: `student(student_id, first_name,last_name,dob,gender, address,note,program_id#)`
- Updatable view

```
CREATE VIEW female_student AS
    SELECT student_id, first_name, last_name FROM student
    WHERE gender = 'F';
```

- Insert into views:

```
INSERT INTO female_student VALUES('20160301', 'Hoai An', 'Tran');
```

Results in:

```
INSERT INTO student(student_id, first_name, last_name)
VALUES ('20160301', 'Hoai An', 'Tran');
```

# 2.3. Updatable views: Example

- Update views:

```
UPDATE female_student SET first_name = 'Hoài Ân'
WHERE first_name = 'Hoai An' ;
```

Results in

```
UPDATE student SET first_name = 'Hoài Ân'
WHERE first_name = 'Hoai An'  AND gender = 'F';
```

# 2.3. Delete from views: Views and INSTEAD OF trigger

- Generally, it is impossible to delete from a virtual view
- But an INSTEAD OF trigger (which we'll cover in next lectures) can help us control the effects of the delete on the base table

```
CREATE TRIGGER delete_view_trigger
    INSTEAD OF DELETE ON TA
    FOR EACH ROW
    BEGIN
        UPDATE class SET TA_id = NULL
        WHERE class_id = OLD.class_id;
    END;
```

# 2.4. Materialized Views

- A materialized view is the results of a query that is stored
- This enables much more efficient access
- Problems:
  - each time a base table changes, the materialized view may change
- Solutions:
  - Periodic reconstruction (REFRESH) of the materialized view
  - Triggers (next lesson)

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# Questions