BT5110 Data Management and Warehousing

Tutorial 3: Aggregate and Nested Queries

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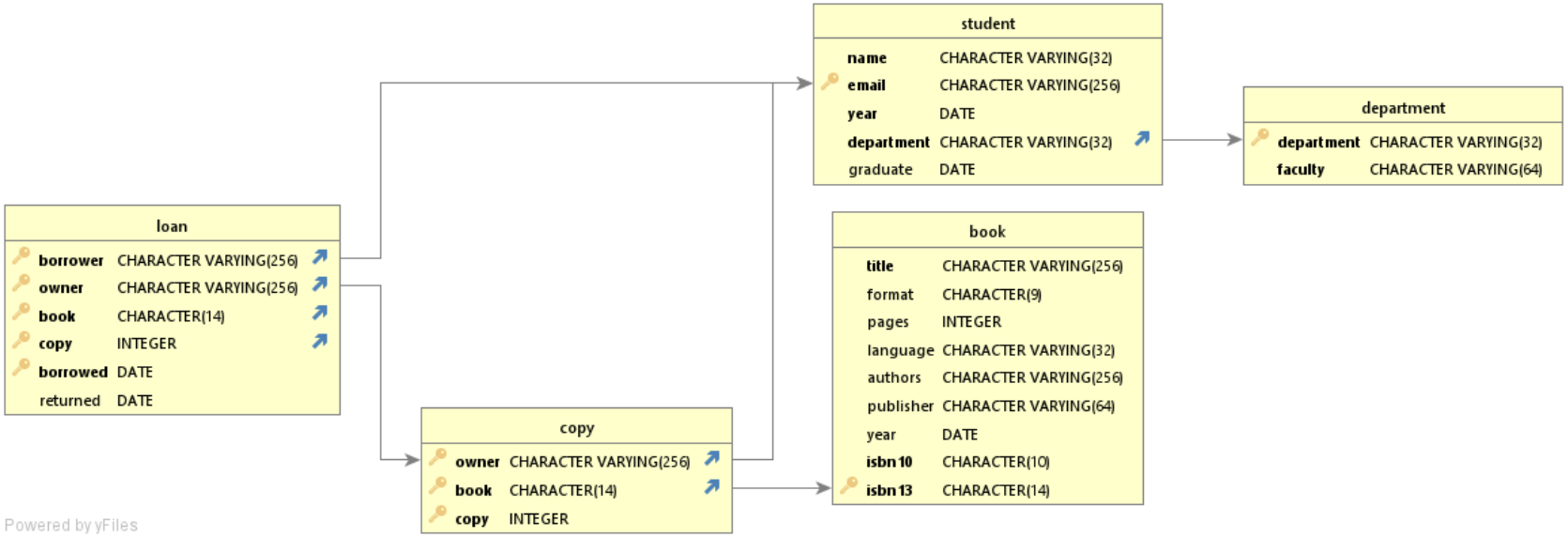
Quick Recap: End of Last Tutorial

What we have done in the last week:

(1) Write simple queries with arithmetic, comparison & logical operators;
(2) Write table joining queries (CROSS JOIN and INNER JOIN);
(4) Write simple queries with the set operators.

Summary of our database (# of rows):

book	student	copy	loan	department
311	105	1244	4976	13



(plotted by DbVisualizer)

Question 1 Aggregate Queries (a)

How many loans involve an owner and a borrower from the same department?

Solution:

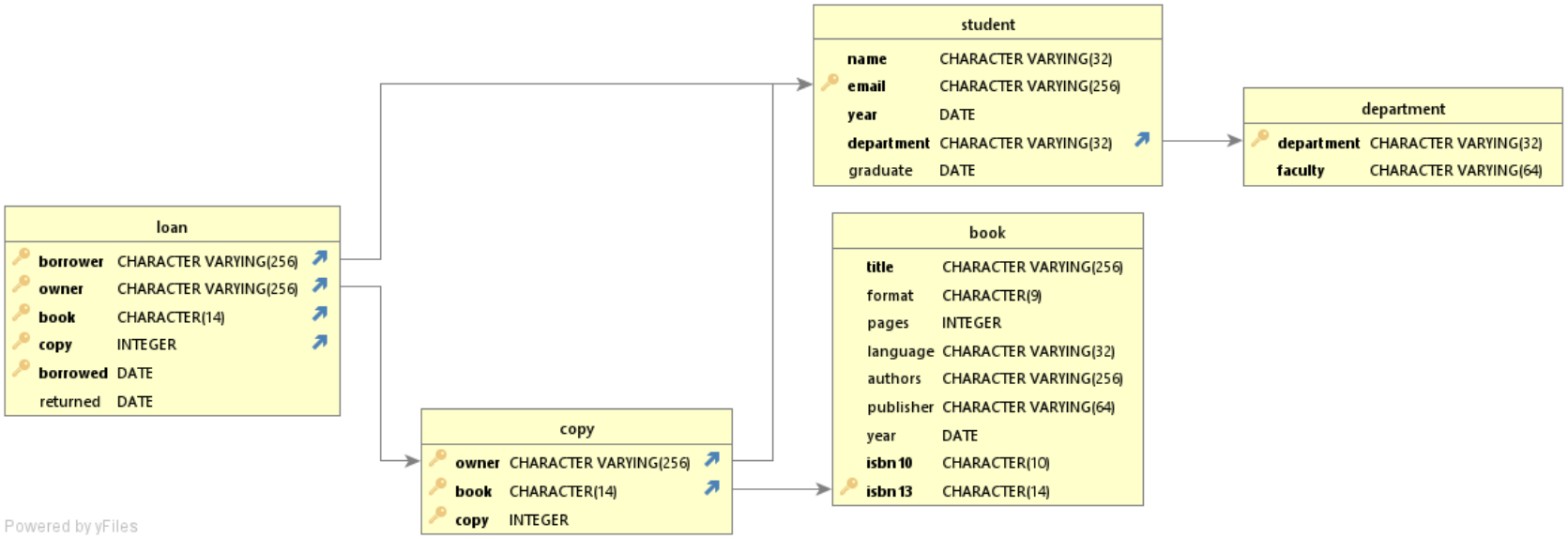
```
SELECT COUNT(*)
FROM loan l, student s1, student s2
WHERE l.owner = s1.email
AND l.borrower = s2.email
AND s1.department = s2.department;
```

You should have **502** observed in the output.

Question 1 (b)

For each faculty, print the number of loans that involve an owner and a borrower from this faculty?

Which tables are involved in this query?



(plotted by DbVisualizer)

Question 1 (b) Cont.

For each faculty, print the number of loans that involve an owner and a borrower from this faculty?

Solution:

```sql
SELECT d1.faculty, COUNT(*)
FROM loan l, student s1, student s2, department d1, department d2
WHERE l.owner = s1.email
  AND l.borrower = s2.email
  AND s1.department = d1.department
  AND s2.department = d2.department
  AND d1.faculty = d2.faculty
GROUP by d1.faculty;
```

Question 1 (b) Cont.

The output should be like as follows (for your reference).

```
             faculty                | count
------------------------------------+-------
Faculty of Arts and Social Science |   379
Faculty of Engineering             |    82
Faculty of Science                 |   239
School of Computing                |   529
(4 rows)
```

Question 1 (c)

What are the average and the standard deviation of the duration of a loan? (assume today is 2010-12-31)

Recap: Q1 (d) of Tutorial 2: print the duration of each loan:

```
SELECT l.book, ((CASE WHEN l.returned ISNULL
  THEN '2010-12-31'
  ELSE l.returned END) - l.borrowed + 1) AS duration
FROM loan l
ORDER BY l.book ASC, l.duration ASC;
```

How can we reuse this code?

Question 1 (c) Cont.

Solution:

```sql
SELECT AVG((CASE WHEN l.returned ISNULL
    THEN '2010-12-31'
    ELSE l.returned END) - borrowed + 1),
  STDDEV_POP((CASE WHEN l.returned ISNULL
    THEN '2010-12-31'
    ELSE l.returned END) - borrowed + 1)
FROM loan l;
```

The output should be as follows.

```
        avg         |     stddev_pop
--------------------+--------------------
 41.4963826366559486 | 38.4206806387009364
(1 row)
```

Attention

STDDEV_SAMP and STDDEV are equivalent, which calculate Sample Covariance. While STDDEV_POP calculate Population Covariance. Here we need to use the latter.

Extra: Can we use nested query to simplify it?

Question 1 (c) Cont.

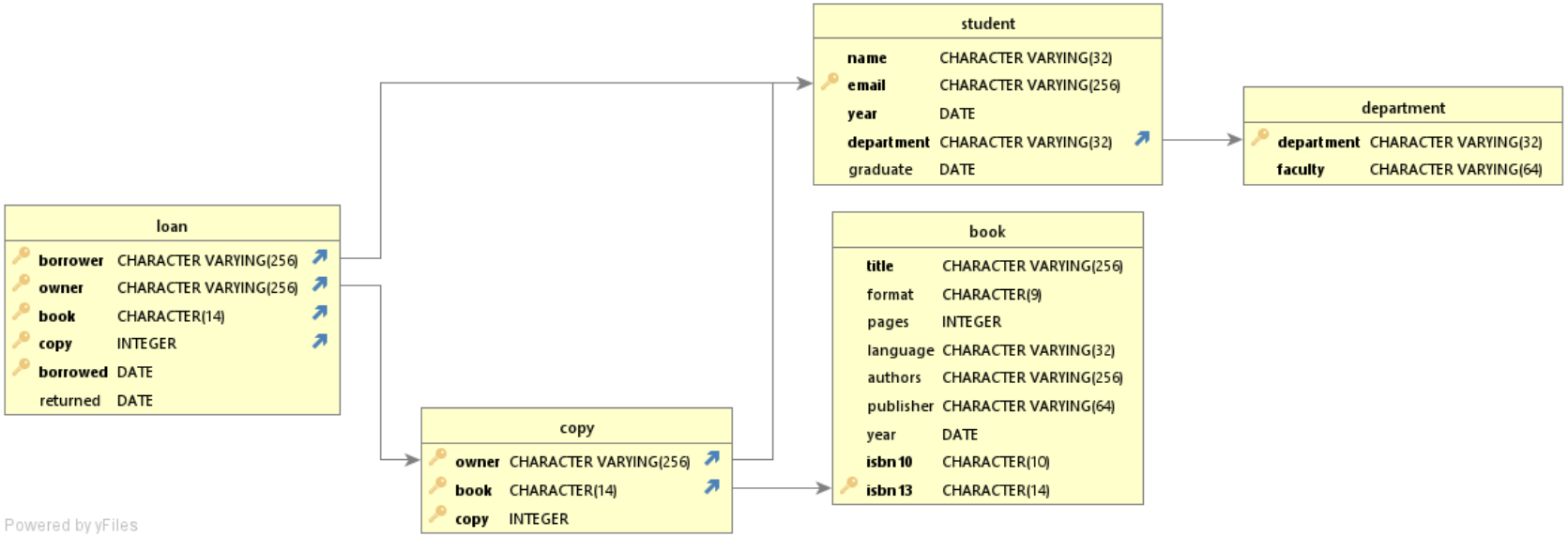
Solution (nested version):

```
SELECT AVG(temp.duration), STDDEV_POP(temp.duration)
FROM (SELECT ((CASE
    WHEN l.returned ISNULL
    THEN '2010-12-31'
    ELSE l.returned END) - l.borrowed + 1) AS duration
  FROM loan l) AS temp;
```

Question 2 Nested Queries (a)

Print the titles of different books that have never been borrowed. Use a nested query.

Which tables are involved in this nested query?



(plotted by DbVisualizer)

Question 2 (a) Cont.

Solution:

```
SELECT b.title
FROM book b
WHERE b.ISBN13 NOT IN (
  SELECT  l.book
  FROM loan l);
```

...or, equivalently,

```
SELECT b.title
FROM book b
WHERE b.ISBN13 <> ALL (
  SELECT l.book
  FROM loan l);
```

You should observe **no** record given in the output.

Question 2 (a) Cont.

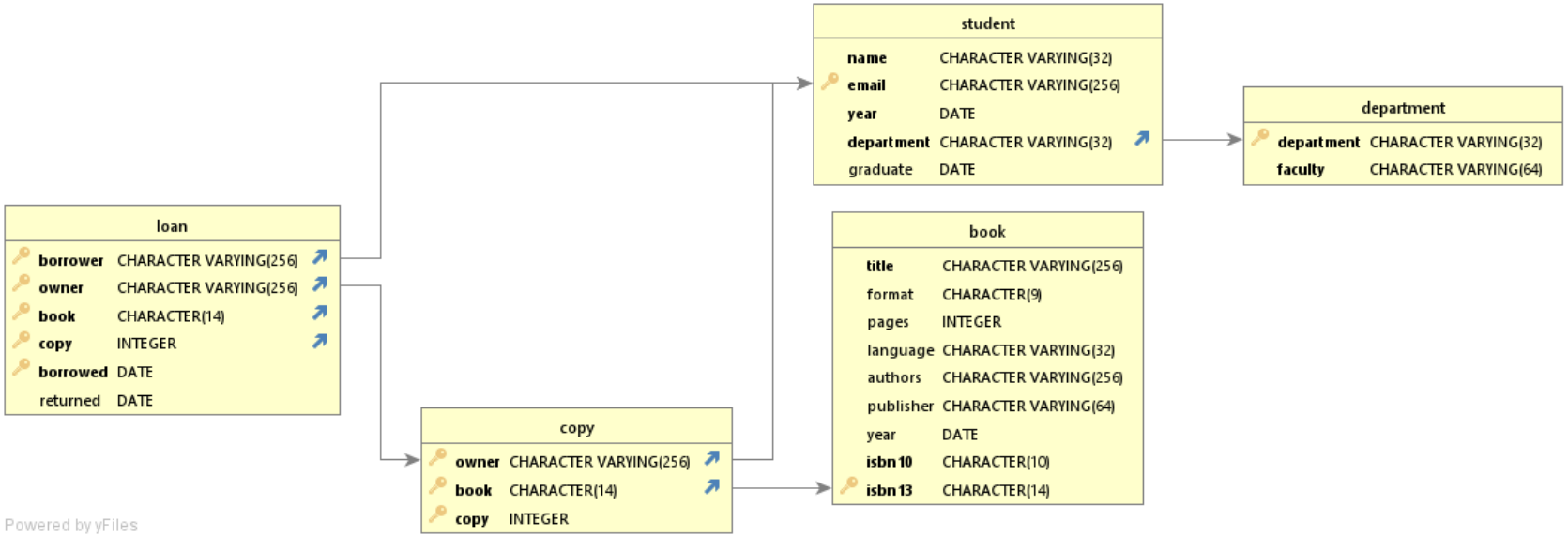
Extra: How many different queries you can write for this question (if nested query is not required)?

(1) (Native) Cross Joining
(2) Inner Joining
(3) Out Joining (refer to Tutorial 2 Q2 (e))
(4) Set Operation (refer to Tutorial 2 Q2 (e))
(5) Nested Queries (logical equivalence, "NOT IN" and "<> ALL")

Question 2 (b)

Print the name of the different students who own a copy of a book that they have never lent to anybody.

Which tables are involved in this nested query?



(plotted by DbVisualizer)

Question 2 (b) Cont.

Solution:

```
SELECT s.name
FROM student s
WHERE s.email IN
  (SELECT c.owner
  FROM copy c
  WHERE NOT EXISTS (
    SELECT *
    FROM loan l
    WHERE l.owner = c.owner
      AND l.book = c.book
      AND l.copy = c.copy));
```

Question 2 (b) Cont.

...or, equivalently,

```sql
SELECT s.name
FROM student s
WHERE s.email = ANY (
  SELECT c.owner
  FROM copy c
  WHERE NOT EXISTS (
    SELECT *
    FROM loan l
    WHERE l.owner = c.owner
      AND l.book = c.book
      AND l.copy = c.copy));
```

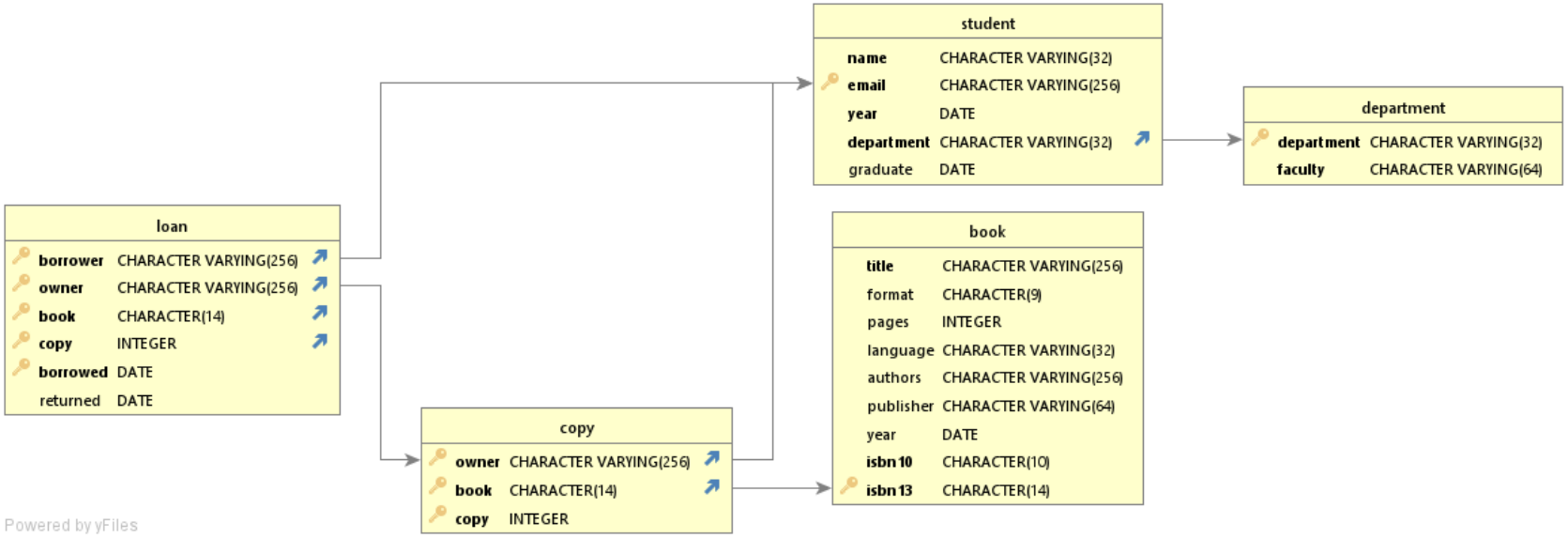
You should observe **no** record given in the output.

Notice

We can always use "`<> ALL`" as an equivalence of "`NOT IN`". Similarly, we can use "`= ANY`" as an equivalence of "`IN`"

Question 2 (c)

For each department, print the names of the students who lent the <u>most</u>.



(plotted by DbVisualizer)

Question 2 (c) Cont.

Solution:

```
SELECT  s.department, s.name, count(*)
FROM student s, loan l
WHERE l.owner = s.email
GROUP BY s.department, s.name
HAVING count(*) >= ALL
  (SELECT  count(*)
  FROM student s1, loan l1
  WHERE l1.owner = s1.email
  AND s.department = s1.department
  GROUP BY s1.name);
```

It is better to add "ORDER BY s.department" at the end for better output display, although it is not required by the question.

Question 2 (c) Cont.

You should observe the output as follows.

```
department |     name      | count
-----------+---------------+-------
Geography  | SEAH TECK KEE |    64
Geography  | ZHANG YUZHAO  |    64
EE         | WANG NA       |    60
CE         | TAY YONG MING |    68
Math       | HUANG WENXIN  |    76
CS         | LIU ZHENCAI   |    76
Geography  | DAVID HALL    |    64
ME         | GE DUO        |    64
Language   | NEELAM DEOL   |    68
Biology    | PENG JIAYUAN  |    80
IS         | ZHANG HONG    |    88
History    | ZENG YIHUI    |    60
Economics  | LI YUZHAO     |    60
Physics    | NI HANRAN     |    60
Chemistry  | XIE XIN       |    56
(15 rows)
```

(without ORDER BY)

```
   department    |     name      | count
-----------------+---------------+-------
Biology          | PENG JIAYUAN  |    80
CE               | TAY YONG MING |    68
Chemistry        | XIE XIN       |    56
Computer Science | LIU ZHENCAI   |    76
EE               | WANG NA       |    60
Economics        | LI YUZHAO     |    60
Geography        | SEAH TECK KEE |    64
Geography        | ZHANG YUZHAO  |    64
Geography        | DAVID HALL    |    64
History          | ZENG YIHUI    |    60
IS               | ZHANG HONG    |    88
Language         | NEELAM DEOL   |    68
ME               | GE DUO        |    64
Math             | HUANG WENXIN  |    76
Physics          | NI HANRAN     |    60
(15 rows)
```

(with ORDER BY s.department)

Warning

Notice that there are three such students in the department of **Geography** (that is why one should almost never use TOP N queries).

Question 2 (c) Cont. - *Extra(1)*

Extra(1): What if I insert the query below before we execute the solution?

```sql
INSERT INTO department VALUES('Business Analytics', 'School of Computing');
INSERT INTO student VALUES('MARK MENG', 'mark@biz.edu', '2010-01-01', 'Business
    Analytics', '2014-01-01');
```

We observe the output as:

```
department         |     name      | count
-------------------+---------------+-------
Geography          | SEAH TECK KEE |    64
Geography          | ZHANG YUZHAO  |    64
EE                 | WANG NA       |    60
CE                 | TAY YONG MING |    68
Math               | HUANG WENXIN  |    76
CS                 | LIU ZHENCAI   |    76
Geography          | DAVID HALL    |    64
ME                 | GE DUO        |    64
Language           | NEELAM DEOL   |    68
Biology            | PENG JIAYUAN  |    80
IS                 | ZHANG HONG    |    88
History            | ZENG YIHUI    |    60
Economics          | LI YUZHAO     |    60
Physics            | NI HANRAN     |    60
Chemistry          | XIE XIN       |    56
(15 rows)
```

We expect the output to be like:

```
department         |     name      | count
-------------------+---------------+-------
Geography          | SEAH TECK KEE |    64
Geography          | ZHANG YUZHAO  |    64
EE                 | WANG NA       |    60
CE                 | TAY YONG MING |    68
Math               | HUANG WENXIN  |    76
CS                 | LIU ZHENCAI   |    76
Geography          | DAVID HALL    |    64
ME                 | GE DUO        |    64
Language           | NEELAM DEOL   |    68
Biology            | PENG JIAYUAN  |    80
IS                 | ZHANG HONG    |    88
History            | ZENG YIHUI    |    60
Economics          | LI YUZHAO     |    60
Physics            | NI HANRAN     |    60
Chemistry          | XIE XIN       |    56
Business Analytics | MARK MENG     |    0
(16 rows)
```

Question 2 (c) Cont. *Extra(1)*

To simplify this question, let's create a VIEW first:

```sql
CREATE VIEW lender AS
SELECT  s.department, s.name, count(*) AS count
FROM student s, loan l
WHERE l.owner = s.email
GROUP BY s.department, s.email;
```

How to print those departments & students without any student lending a book?

```sql
SELECT s.department, s.name
FROM student s LEFT OUTER JOIN loan l
ON l.owner = s.email
WHERE l.borrower ISNULL;
```

The output will be like follows.

```
     department     |      name
--------------------+---------------
 Computer Science   | RIKKI TAVI
 Computer Science   | TIKKI TAVI
 Business Analytics | MARK MENG
 Computer Science   | ADELINE WONG
 IS                 | GERALDINE LEE
 IS                 | TANG CHEE YONG
```

Question 2 (c) Cont. *Extra(1)*

Let's create the view that includes those department without a lender?

```sql
DROP VIEW lender;
```

```sql
CREATE VIEW lender AS
(SELECT  s.department, s.name, count(*) AS count
  FROM student s, loan l
  WHERE l.owner = s.email
  GROUP BY s.department, s.email)
UNION
(SELECT s.department, s.name, 0 AS count
  FROM student s LEFT OUTER JOIN loan l
  ON l.owner = s.email
  WHERE l.borrower ISNULL);
```

Question 2 (c) Cont. *Extra(1)*

Now let's recap the solution of Q2(c) (on the **left**), and convert it to the code on the **right**.

```
SELECT  s.department, s.name, count(*)
FROM student s, loan l
WHERE l.owner = s.email
GROUP BY s.department, s.email
HAVING count(*) >= ALL
  (SELECT  count(*)
  FROM student s1, loan l1
  WHERE l1.owner = s1.email
  AND s.department = s1.department
  GROUP BY s1.email)
ORDER BY s.department;
```

```
SELECT  l.department, l.name, l.count
FROM lender l
GROUP BY l.department, l.name, l.count
HAVING l.count >= ALL
  (SELECT l2.count
  FROM lender l2
  WHERE l.department = l2.department)
ORDER BY l.department;
```

The output below is better, and is in fact the CORRECT one. (see next slide)

Question 2 (c) *Extra(1)*

The output:

```
    department     |     name      | count
-------------------+---------------+-------
Biology            | PENG JIAYUAN  |    80
Business Analytics | MARK MENG     |     0
CE                 | TAY YONG MING |    68
Chemistry          | XIE XIN       |    56
Computer Science   | LIU ZHENCAI   |    76
EE                 | WANG NA       |    60
Economics          | LI YUZHAO     |    60
Geography          | DAVID HALL    |    64
Geography          | SEAH TECK KEE |    64
Geography          | ZHANG YUZHAO  |    64
History            | ZENG YIHUI    |    60
IS                 | ZHANG HONG    |    88
Language           | NEELAM DEOL   |    68
ME                 | GE DUO        |    64
Math               | HUANG WENXIN  |    76
Physics            | NI HANRAN     |    60
(16 rows)
```

Notice

If you have run those code, don't forget to delete ME from student, as those record are not in the scope of our tutorials.
E.g., DELETE FROM student WHERE name='MARK MENG';
DELETE FROM department WHERE department='Business Analytics';

Question 2 (c) *Extra(2)*

Extra(2): What if the question asks to print the top **3** lenders in each department?

Suppose we have dropped the VIEW `lender` or Extra (1). And let's create the view again, as the code below:

```
CREATE VIEW lender AS
SELECT  s.department, s.name, count(*) AS count
FROM student s, loan l
WHERE l.owner = s.email
GROUP BY s.department, s.email;
```

Hint: This time we may seek help from the troublesome "LEFT OUTER JOIN".

Question 2 (c) *Extra(2)*

Solution of Extra(2):

```sql
SELECT loser.department, loser.name, loser.count
FROM lender loser LEFT OUTER JOIN lender winner
  ON winner.department=loser.department
  AND winner.name<>loser.name
  AND winner.count>loser.count
GROUP BY loser.department, loser.name, loser.count -- We only show
    these three columns, and discard the RHS (winner' details)
HAVING COUNT(loser.name) < 3 -- only those students have less than 3
    times lending less number of books within the same department are
    counted as ''top 3'' (in fact those losers are not real losers)
ORDER BY loser.department;
```

Question 2 (c) *Extra(2)*

The output will be as follows.

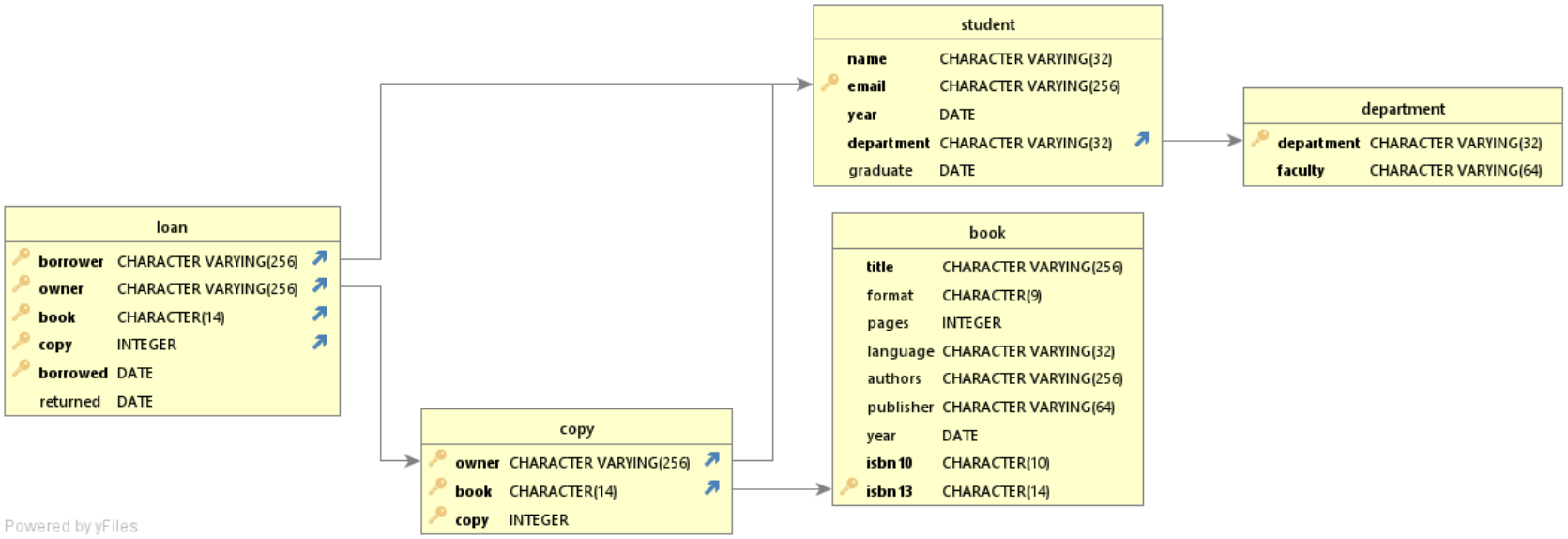
```
   department    |          name          | count
-----------------+------------------------+-------
Biology          | CHOY YI TING           |    56
Biology          | GOH HUI YING           |    72
Biology          | PENG JIAYUAN           |    80
CE               | ANUPAMA ANGHAN         |    64
CE               | DING KUAN CHONG        |    60
CE               | TAY YONG MING          |    68
Chemistry        | LISA SMITH             |    40
Chemistry        | LIU ZHANPENG           |    52
Chemistry        | XIE XIN                |    56
Computer Science | ANG JIA YI             |    64
Computer Science | LIU ZHENCAI            |    76
Computer Science | SIOW CAO KHOA          |    72
EE               | LIU JUN                |    48
EE               | WANG NA                |    60
EE               | ZHANG CONG             |    48
Economics        | JERRY BROWN            |    56
Economics        | LI YUZHAO              |    60
Economics        | LIU LINXI              |    44
Geography        | DAVID HALL             |    64
Geography        | SEAH TECK KEE          |    64
Geography        | ZHANG YUZHAO           |    64
```

```
(Continue)
Geography        | ZHANG YUZHAO           |    64
History          | DING YANG              |    56
History          | ZENG YIHUI             |    60
History          | ZHU CHANG              |    48
IS               | HUANG QI               |    60
IS               | SUBRAMANIAM GHANTASALA |    76
IS               | ZHANG HONG             |    88
Language         | ANNIE CHAPMAN          |    60
Language         | NEELAM DEOL            |    68
Language         | NEHAL KANWAT           |    64
ME               | DENNIS PALMER          |    32
ME               | GE DUO                 |    64
ME               | LIU DANNI              |    32
ME               | NG ANH QUANG           |    32
Math             | HUANG WENXIN           |    76
Math             | ZHANG ZHANPENG         |    72
Math             | ZHANG ZHUO             |    52
Physics          | GE YUWEI               |    52
Physics          | NI HANRAN              |    60
Physics          | TAN CHENG HAN          |    44
Physics          | TSO HUI LIN            |    44
(41 rows)
```

Question 2 (d)

Print the emails and the names of the different students who borrowed <u>all</u> the books authored by Adam Smith.

Can we make use of negation with nested query?



(plotted by DbVisualizer)

Question 2 (d) Cont.

Solution:

```sql
SELECT s.email, s.name
FROM student s
WHERE NOT EXISTS (
  SELECT *
  FROM book b
  WHERE authors = 'Adam Smith' AND NOT EXISTS (
    SELECT *
    FROM loan l
    WHERE l.book = b.isbn13 AND l.borrower = s.email));
```

```
          email          |    name
-------------------------+-------------
 yeojiahao1989@yahoo.com | YEO JIA HAO
 (1 row)
```

Question 2 (d) Cont.

Interpretation: We are going to print the emails and the names of students who have borrowed all Adam's book.

Our query must start with:
SELECT s.email, s.name FROM student s...

Then how to use DOUBLE NEGATION to describe this student?

```
SELECT s.email, s.name
FROM student s  -- if the student has not missed borrowing any book of Adam, that
      means the student has borrowed all Adam's books.
-- next, let's describe the student by using double negation
WHERE NOT EXISTS ( -- it means ''no such a book by Adam Smith ...''
  SELECT *
  FROM book b
  WHERE authors = 'Adam␣Smith'
  AND NOT EXISTS ( -- ''... has not been borrowed by the student''
    SELECT *
    FROM loan l
    WHERE l.book = b.isbn13 AND l.borrower = s.email));
```

Question 2 (d) - Extra

Extra: Can you spot the difference between the 2 queries below:

```sql
SELECT s.email, s.name
FROM student s
WHERE NOT EXISTS (
  SELECT *
  FROM book b
  WHERE authors = 'Adam␣Smith'
  AND NOT EXISTS (
    SELECT *
    FROM loan l
    WHERE l.book = b.isbn13
    AND l.borrower = s.email));
```

```sql
SELECT s.email, s.name
FROM student s
WHERE NOT EXISTS (
  SELECT *
  FROM loan l
  WHERE l.borrower = s.email
  AND NOT EXISTS (
    SELECT *
    FROM book b
    WHERE b.authors = 'Adam␣Smith'
    AND l.book = b.isbn13));
```

```
          email          |    name
-------------------------+-------------
 yeojiahao1989@yahoo.com | YEO JIA HAO
 (1 row)
```

```
          email          |      name
-------------------------+----------------
 glee@msn.com            | GERALDINE LEE
 tcy@hotmail.com         | TANG CHEE YONG
 awong007@msn.com        | ADELINE WONG
 tikki@gmail.com         | TIKKI TAVI
 rikki@gmail.com         | RIKKI TAVI
 (5 rows)
```

Question 2 (d) - Extra

```sql
SELECT s.email, s.name
FROM student s
WHERE NOT EXISTS (
  SELECT *
  FROM loan l
  WHERE l.borrower = s.email
  AND NOT EXISTS (
    SELECT *
    FROM book b
    WHERE b.authors = 'Adam Smith'
    AND l.book = b.isbn13));
```

Print the names and emails of students who have left NO borrowing record in the loan table, of any book NOT written by Adam Smith

Output 5 students who actually have never borrowed any book according to the loan table.

Question 2 (d) - Extra

How to interpret the LHS query and the RHS query?

```sql
SELECT s.email, s.name
FROM student s
WHERE NOT EXISTS (
  SELECT *
  FROM book b
  WHERE authors = 'Adam Smith'
  AND NOT EXISTS (
    SELECT *
    FROM loan l
    WHERE l.book = b.isbn13
    AND l.borrower = s.email));
```

There is NO SUCH a book written by Adam Smith ... NOT been borrowed by the student

```sql
SELECT s.email, s.name
FROM student s
WHERE NOT EXISTS (
  SELECT *
  FROM loan l
  WHERE l.borrower = s.email
  AND NOT EXISTS (
    SELECT *
    FROM book b
    WHERE b.authors = 'Adam Smith'
    AND l.book = b.isbn13));
```

There is NO SUCH a borrowing record in the loan table ... of any book NOT written by Adam Smith

Question 2 (d) - Extra (2)

There always exists alternative solution, either simpler or more complicated.

Can you guy come up with another solution (or idea) to solve this question rather then using DOUBLE NEGATION.

First of all, we may calculate how many books are written by Adam Smith -> 2 books

Then select distinct those students who has borrowed at least one book of Adam Smith (i.e., the email of student has ever appeared in loan table as the borrower of Adam Smith's books)

Wrap the first two queries into a bigger query, that using HAVING to enforce the aggregate condition to print students who has borrow (2) different books written by Adam Smith according to all records of the loan table

Please feel free to let me know (through email or Forum) your (own) solution!

For any further question, please feel free to email me:

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