华东师范大学软件工程学院实验报告

实验课程：数据库实践	姓名：黄凯勋	学号：10235101576
实验名称：SQL-Homework-Lab03	实验日期：2025.4.16	指导老师：姚俊杰

实验目标

1.学习mysql explain语句
2.学会解释计划查询
3.学会画查询计划树

实验要求

1.按照实验内容，依次完成每个实验步骤；
2.操作实验步骤时，需要理解该操作步骤的目的，预判操作的结果；当操作结果与预判不符时，及时向任课教师和助教咨询；
3.在实验报告中依次记录主要操作步骤的内容和结果（返回的消息或截图）；
4.对实验中遇到的问题、解决方案及收获进行总结；
5.确保实验报告整洁、美观（注意字体、字号、对齐、截图大小和分页等；）

实验过程记录

步骤1

连接数据库 college

```
Enter password: *********
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 10
Server version: 9.2.0 MySQL Community Server - GPL

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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> use college
Database changed
mysql>
```

步骤2

执行计划查询和解释

1.执行一下语句，获取并解释该查询的执行计划：

```
EXPLAIN SELECT title FROM course ORDER BY title, credits;
```

```
mysql> EXPLAIN SELECT title FROM course ORDER BY title, credits;
+----+-------------+--------+------------+------+---------------+------+---------+------+------+----------+----------------+
| id | select_type | table  | partitions | type | possible_keys | key  | key_len | ref  | rows | filtered | Extra          |
+----+-------------+--------+------------+------+---------------+------+---------+------+------+----------+----------------+
|  1 | SIMPLE      | course | NULL       | ALL  | NULL          | NULL | NULL    | NULL |  200 |   100.00 | Using filesort |
+----+-------------+--------+------------+------+---------------+------+---------+------+------+----------+----------------+
1 row in set, 1 warning (0.00 sec)
```

```
EXPLAIN FORMAT=TREE SELECT title FROM course ORDER BY title, credits;
```

```
mysql> EXPLAIN FORMAT=TREE SELECT title FROM course ORDER BY title, credits;
+-----------------------------------------------------------------------------------------------------------------------------------+
| EXPLAIN                                                                                                                           |
+-----------------------------------------------------------------------------------------------------------------------------------+
| -> Sort: course.title, course.credits  (cost=21 rows=200)
    -> Table scan on course  (cost=21 rows=200)
 |
+-----------------------------------------------------------------------------------------------------------------------------------+
1 row in set (0.05 sec)
```

图片表示1.首先查询的动作会是对course表进行全表扫描，其中成本cost=21，行数rows=200行。

```
EXPLAIN analyze SELECT title FROM course ORDER BY title, credits;
```

```
EXPLAIN analyze SELECT title FROM course ORDER BY title, credits;
```

```
mysql> explain analyze SELECT title FROM course ORDER BY title, credits;
+----------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------+
| EXPLAIN
                                                                    |
+----------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------+
| -> Sort: course.title, course.credits  (cost=21 rows=200) (actual time=8.5..8.5 rows=200 loops=1)
    -> Table scan on course  (cost=21 rows=200) (actual time=7.22..7.26 rows=200 loops=1)
 |
+----------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------+
1 row in set (0.01 sec)

mysql> explain analyze SELECT title FROM course ORDER BY title, credits;
+----------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------+
| EXPLAIN
                                                                                     |
+----------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------+
| -> Sort: course.title, course.credits  (cost=20.2 rows=200) (actual time=0.126..0.132 rows=200 loops=1)
    -> Table scan on course  (cost=20.2 rows=200) (actual time=0.0225..0.0605 rows=200 loops=1)
 |
+----------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------+
1 row in set (0.00 sec)
```

根据结果，先进行全表查询，然后对结果排序。
第一次全表扫描耗时actual time=10.4，读取行数rows=200，循环loops=1

第二次全表扫描耗时actual time=0.0284，读取行数rows=200，循环loops=1

第一次排序耗时actual time=11.6，读取行数rows=200，循环loops=1

第二次排序耗时actual time=0.208，读取行数rows=200，循环loops=1

说明：两次查询的开销从21到20.2，开销变小，第一次执行后某些数据被缓存在内存中，那么第二次执行时可能会更快地访问这些数据

2.执行一下语句，获取并解释该查询的执行计划：

```sql
explain SELECT T1.name FROM student  T1
JOIN advisor  T2 ON T1.id = T2.s_id
GROUP BY T2.s_id HAVING count(*) > 1;
```

```
mysql> explain SELECT T1.name FROM student  T1
    -> JOIN advisor  T2 ON T1.id = T2.s_id
    -> GROUP BY T2.s_id HAVING count(*) > 1;
+----+-------------+-------+------------+--------+---------------+---------+---------+-----------------+------+----------+--
-----------+
| id | select_type | table | partitions | type   | possible_keys | key     | key_len | ref             | rows | filtered | E
xtra       |
+----+-------------+-------+------------+--------+---------------+---------+---------+-----------------+------+----------+--
-----------+
|  1 | SIMPLE      | T2    | NULL       | index  | PRIMARY,i_ID  | PRIMARY | 22      | NULL            | 1997 |   100.00 | U
sing index |
|  1 | SIMPLE      | T1    | NULL       | eq_ref | PRIMARY       | PRIMARY | 22      | college.T2.s_ID |    1 |   100.00 | N
ULL        |
+----+-------------+-------+------------+--------+---------------+---------+---------+-----------------+------+----------+--
-----------+
2 rows in set, 1 warning (0.01 sec)
```

第一行 (id=1) 是对 T2 表的查询，使用 index 类型，表示使用了索引进行扫描。可能的索引是 PRIMARY 和 _ID，实际使用的索引是 PRIMARY。预计需要检查 2000 行，过滤率为 100%

第二行 (id=1) 是对 T1 表的查询，同样使用 index 类型，可能的索引是 eq_ref，实际使用的索引是 PRIMARY。预计需要检查 1 行，过滤率为 100%

Id相同，查询顺序从T2到T1

```
explain analyze SELECT T1.name FROM student  T1
JOIN advisor  T2 ON T1.id = T2.s_id
GROUP BY T2.s_id HAVING count(*) > 1;
```

```
explain analyze SELECT T1.name FROM student  T1
JOIN advisor  T2 ON T1.id = T2.s_id
GROUP BY T2.s_id HAVING count(*) > 1;
```

```
-> Filter: (count(0) > 1)  (cost=2863 rows=1997) (actual time=20.5..20.5 rows=0 loops=1)
    -> Group aggregate: count(0)  (cost=2863 rows=1997) (actual time=15.2..20.3 rows=1997 loops=1)
        -> Nested loop inner join  (cost=2402 rows=1997) (actual time=15..19.8 rows=1997 loops=1)
            -> Covering index scan on T2 using PRIMARY  (cost=206 rows=1997) (actual time=7.51..8.2 rows=1997 loops=1)
            -> Single-row index lookup on T1 using PRIMARY (ID = t2.s_ID)  (cost=1 rows=1) (actual time=0.00565..0.00567 rows=1 loops=1997)
 |
1 row in set (0.02 sec)

mysql> explain analyze SELECT T1.name FROM student  T1
    -> JOIN advisor  T2 ON T1.id = T2.s_id
    -> GROUP BY T2.s_id HAVING count(*) > 1;
| EXPLAIN
                                                    |
-> Filter: (count(0) > 1)  (cost=1360 rows=1997) (actual time=4..4 rows=0 loops=1)
    -> Group aggregate: count(0)  (cost=1360 rows=1997) (actual time=0.073..3.91 rows=1997 loops=1)
        -> Nested loop inner join  (cost=900 rows=1997) (actual time=0.0655..3.53 rows=1997 loops=1)
            -> Covering index scan on T2 using PRIMARY  (cost=201 rows=1997) (actual time=0.0494..0.304 rows=1997 loops=1)
            -> Single-row index lookup on T1 using PRIMARY (ID = t2.s_ID)  (cost=0.25 rows=1) (actual time=0.00148..0.0015 rows=1 loops=1997)
 |
```

两次查询顺序都是从下往上执行。

1. Single-row index lookup on T1 using PRIMARY (ID = t2.s_ID)
   在t1表上进行单行索引查询，显示预估成本和实际耗时以及查询的结果返回行数，循环次数
   第一次
   Single-row index lookup on T1 using PRIMARY (ID = t2.s_ID) (cost=1 rows=1) (actual time=0.00565..0.0567 rows=1 loops=1997)
   第二次
   Single-row index lookup on T1 using PRIMARY (ID = t2.s_ID) (cost=0.25 rows=1) (actual time=0.00148..0.0015 rows=1 loops=1997)
2. Covering index scan on T2 using PRIMARY (cost=207 rows=1997)
   在表T2上进行覆盖索引扫描，显示预估成本和实际耗时以及查询的结果返回行数，循环次数
   第一次
   Covering index scan on T2 using PRIMARY (cost=207 rows=1997) (actual time=7.51..8.2 rows=1997 loops=1)
   第二次
   Covering index scan on T2 using PRIMARY (cost=202 rows=1997) (actual time=0.0494..0.304 rows=1997 loops=1)
3. Nested loop inner join (cost=2407 rows=1997)
   执行嵌套循环内连接操作，将前两步的结果结合起来，显示预估成本和实际耗时以及查询的结果返回行数，循环次数
   第一次
   Nested loop inner join (cost=2402 rows=1997) (actual time=15..19.8 rows=1997 loops=1)
   第二次
   Nested loop inner join (cost=900 rows=1997) (actual time=0.0655..3.53 rows=1997 loops=1)
4. Filter: (count(0) > 1) (cost=2868 rows=1997)
   应用过滤条件，只返回满足条件的组，显示预估成本和实际耗时以及查询的结果返回行数，循环次数
   第一次
   Filter: (count(0) > 1) (cost=2863 rows=1997) (actual time=20.5..20.5 rows=0 loops=1)
   第二次
   Filter: (count(0) > 1) (cost=1360 rows=1997) (actual time=4..4 rows=0 loops=1)

3.执行一下语句，获取并解释该查询的执行计划：

```sql
explain SELECT title FROM course WHERE course_id IN
(SELECT T1.prereq_id FROM prereq AS T1
JOIN course AS T2 ON T1.course_id = T2.course_id
WHERE T2.title = 'Mobile Computing');
```

```
mysql> explain SELECT title FROM course WHERE course_id IN (SELECT T1.prereq_id FROM prereq AS T1 JOIN course AS T2 ON T1.course_id = T2.course_id WHERE T2.title = 'Mobile Computi
ng');
+----+-------------+--------+------------+--------+-------------------+---------+---------+----------------------+------+----------+-----------------------------+
| id | select_type | table  | partitions | type   | possible_keys     | key     | key_len | ref                  | rows | filtered | Extra                       |
+----+-------------+--------+------------+--------+-------------------+---------+---------+----------------------+------+----------+-----------------------------+
|  1 | SIMPLE      | T2     | NULL       | ALL    | PRIMARY           | NULL    | NULL    | NULL                 |  200 |    10.00 | Using where; Start temporary |
|  1 | SIMPLE      | T1     | NULL       | ref    | PRIMARY,prereq_id | PRIMARY | 34      | college.T2.course_id |    1 |   100.00 | Using index                 |
|  1 | SIMPLE      | course | NULL       | eq_ref | PRIMARY           | PRIMARY | 34      | college.T1.prereq_id |    1 |   100.00 | End temporary               |
+----+-------------+--------+------------+--------+-------------------+---------+---------+----------------------+------+----------+-----------------------------+
3 rows in set, 1 warning (0.01 sec)
```

Id相同，按照顺序，先查询T2，用到了条件过滤，临时表，再查询T1,用到索引查询，最后查询course，用到临时表。

```sql
explain analyze SELECT title FROM course WHERE course_id IN
(SELECT T1.prereq_id FROM prereq AS T1
JOIN course AS T2 ON T1.course_id = T2.course_id
WHERE T2.title = 'Mobile Computing');
```

```sql
explain analyze SELECT title FROM course WHERE course_id IN
(SELECT T1.prereq_id FROM prereq AS T1
JOIN course AS T2 ON T1.course_id = T2.course_id
WHERE T2.title = 'Mobile Computing');
```

```
mysql> explain analyze SELECT title FROM course WHERE course_id IN (SELECT T1.prereq_id FROM prereq AS T1 JOIN course AS T2 ON T1.course_id = T2.course_id WHERE T2.title = 'Mobile
 Computing');
+----------------------------------------------------------------------------------------------------------+
| EXPLAIN                                                                                                  |
+----------------------------------------------------------------------------------------------------------+
| -> Remove duplicate course rows using temporary table (weedout)  (cost=51.7 rows=25.3) (actual time=12.9..13 rows=2 loops=1)
    -> Nested loop inner join  (cost=51.7 rows=25.3) (actual time=12.9..13 rows=2 loops=1)
        -> Nested loop inner join  (cost=42.9 rows=25.3) (actual time=12.9..12.9 rows=2 loops=1)
            -> Filter: (t2.title = 'Mobile Computing')  (cost=20.2 rows=20) (actual time=0.172..0.213 rows=2 loops=1)
                -> Table scan on T2  (cost=20.2 rows=200) (actual time=0.113..0.19 rows=200 loops=1)
            -> Covering index lookup on T1 using PRIMARY (course_id = t2.course_id)  (cost=1.01 rows=1.27) (actual time=6.36..6.36 rows=1 loops=2)
        -> Single-row index lookup on course using PRIMARY (course_id = t1.prereq_id)  (cost=0.254 rows=1) (actual time=0.0147..0.0149 rows=1 loops=2)
 |
+----------------------------------------------------------------------------------------------------------+
1 row in set (0.01 sec)
```

图片按照下面这个顺序执行的

1.-> Table scan on T2

2.-> Filter: (t2.title = 'Mobile Computing')

第一步扫描T2全表并立刻过滤筛出t2.title = 'Mobile Computing’

3.-> Covering index lookup on T1 using PRIMARY (course_id = t2.course_id)

使用PRIMARY索引在T1表中查找与T2.course_id匹配的行。这一步是嵌套循环的一部分

4.-> Nested loop inner join

将T2和T1通过嵌套循环连接

5.-> Single-row index lookup on course using PRIMARY (course_id = t1.prereq_id)

再次通过PRIMARY索引在course表中查找与T1.process_id匹配的行。这一步可能是关联子查询的最终结果

6.-> Nested loop inner join

再次执行嵌套循环连接，将上一步的结果与主查询关联。这里in使用嵌套内连接，因为外层表数据量小

7.-> Remove duplicate course rows using temporary table (weedout)

通过临时表去重，确保结果唯一

4.执行一下语句，获取并解释该查询的执行计划：

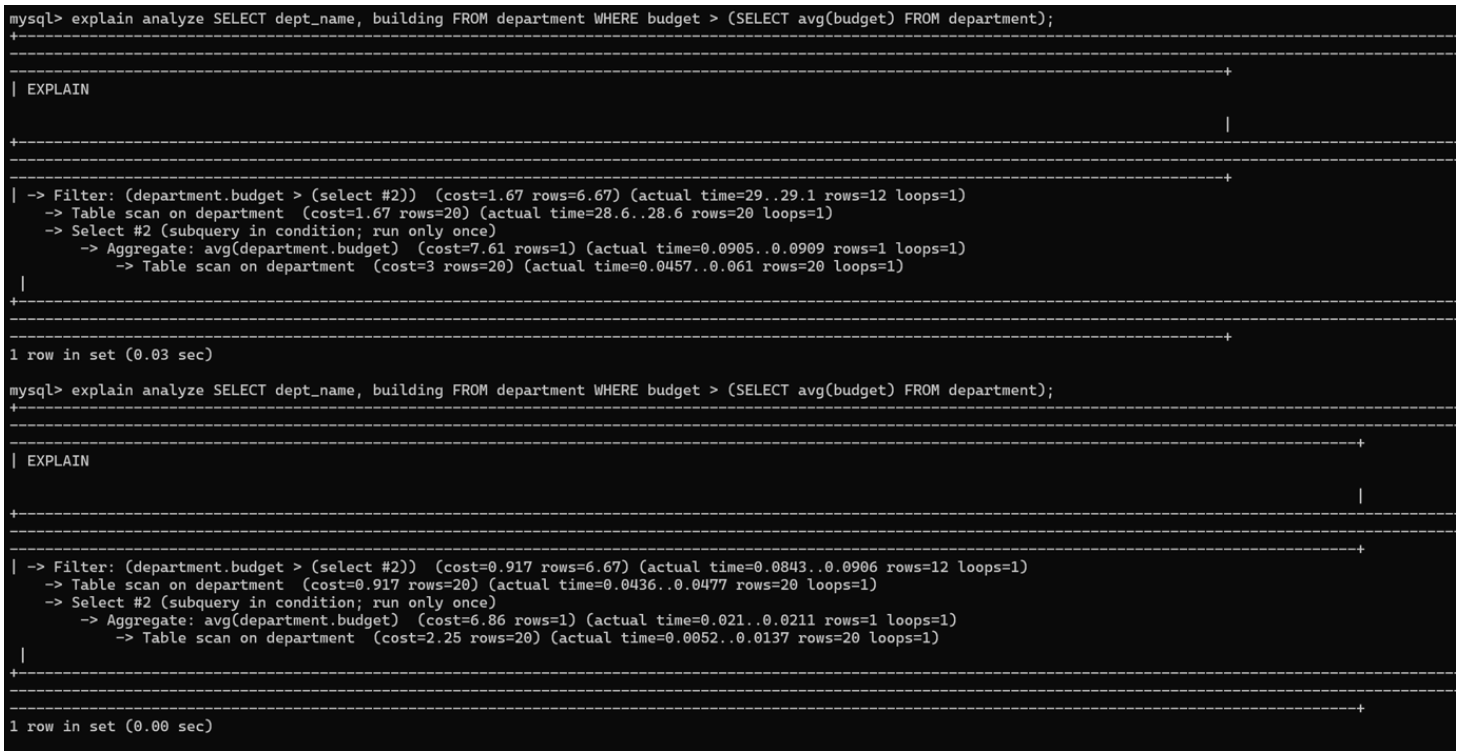
```
explain SELECT dept_name, building FROM department WHERE budget > (SELECT avg(budget) FROM depar
```

```
mysql> explain SELECT dept_name, building FROM department WHERE budget > (SELECT avg(budget) FROM department);
+----+-------------+------------+------------+------+---------------+------+---------+------+------+----------+---------
----+
| id | select_type | table      | partitions | type | possible_keys | key  | key_len | ref  | rows | filtered | Extra
   |
+----+-------------+------------+------------+------+---------------+------+---------+------+------+----------+---------
----+
|  1 | PRIMARY     | department | NULL       | ALL  | NULL          | NULL | NULL    | NULL |   20 |    33.33 | Using wh
ere |
|  2 | SUBQUERY    | department | NULL       | ALL  | NULL          | NULL | NULL    | NULL |   20 |   100.00 | NULL
   |
+----+-------------+------------+------------+------+---------------+------+---------+------+------+----------+---------
----+
2 rows in set, 1 warning (0.01 sec)
```

Id不同，从大到小执行，id=2进行子查询，未使用索引查询，id=1主查询，未使用索引查询，使用条件查询

```
explain analyze SELECT dept_name, building FROM department WHERE budget > (SELECT avg(budget) FR
```

```
explain analyze SELECT dept_name, building FROM department WHERE budget > (SELECT avg(budget) FR
```



图片给出执行所耗时间及返回行数和循环次数，并按照下面顺序执行：

1. Table scan on department
   对 department 表进行全表扫描，获取所有数据
2. Aggregate: avg(department.budget)
   计算department中budget的平均值
3. Select #2 (subquery in condition; run only once)
   表示子查询仅执行一次，结果入缓存重复使用，可以优化时间
4. Table scan on department
5. Filter: (department.budget > (select #2))
   扫描全表，并过滤筛出budget > (SELECT AVG(budget) FROM department)

步骤3

对实验2中的小项目作业中涉及的SQL查询语句，使用EXPLAN语句进行分析：

1. 画出查询计划树，说明每个节点的功能和执行时间信息
2. 说明该执行计划是否为最优的
3. 针对可能出现的性能问题，提出解决方案。（若为最优的，尝试做一个较差的执行方案并说明性能差距出现的原因

```
explain select * from student where name like ?
```

```
mysql> explain select * from student where name like 'Duan';
+----+-------------+---------+------------+------+---------------+------+---------+------+------+----------+-------------+
| id | select_type | table   | partitions | type | possible_keys | key  | key_len | ref  | rows | filtered | Extra       |
+----+-------------+---------+------------+------+---------------+------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | student | NULL       | ALL  | NULL          | NULL | NULL    | NULL | 2000 |    11.11 | Using where |
+----+-------------+---------+------------+------+---------------+------+---------+------+------+----------+-------------+
```

查询计划树为

-> Filter: (student. `name` like 'Duan') (cost=202 rows=222)

过滤筛选出student表中的name 为'Duan'

-> Table scan on student (cost=202 rows=2000)

扫描student表

不是最优，查询type为ALL，效率最低，应当为name列建立索引，这样可以避免全表扫描，直接通过索引定位name为'Duan'

```
explain select * from student where id = ?
```

```
mysql> explain select * from student where id = 1000
    -> ;
+----+-------------+---------+------------+------+---------------+------+---------+------+------+----------+-------------+
| id | select_type | table   | partitions | type | possible_keys | key  | key_len | ref  | rows | filtered | Extra       |
+----+-------------+---------+------------+------+---------------+------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | student | NULL       | ALL  | PRIMARY       | NULL | NULL    | NULL | 2000 |    10.00 | Using where |
+----+-------------+---------+------------+------+---------------+------+---------+------+------+----------+-------------+
1 row in set, 4 warnings (0.00 sec)
```

查询计划树为

-> Filter: (student.ID = 1000) (cost=202 rows=200)

过滤筛选出id为1000的一行

-> Table scan on student (cost=202 rows=2000)

扫描全表

不是最优的，可以为id建立索引，通过索引直接定位到id为1000的student信息，减少查询时间

```
explain  select t.course_id,t.year,t.semester,
c.title,c.dept_name,t.grade,c.credits
FROM takes t JOIN course c ON t.course_id =c.course_id WHERE t.id = ?
```

查询计划树为

-> Nested loop inner join (cost=4147 rows=3000)

循环内连接，将c与t相连

-> Filter: (t.ID = 1000) (cost=3097 rows=3000)

过滤筛选出表t中ID为1000的一行

-> Table scan on t (cost=3097 rows=30000)

扫描表t

-> Single-row index lookup on c using PRIMARY (course_id = t.course_id) (cost=0.25 rows=1)

通过主键关联（PRIMARY），确保每个 course_id 在表 c 中唯一匹配一行
在查询表t时候可以为id建索引，这样可以加快查询速率，要想降低速率，可以删除c 表中id的主键索引

存在的问题及解决方案

对实验2中的小项目作业中涉及的SQL查询语句，使用EXPLAN语句进行分析有些困难，因为涉及到多个表的关联查询，需要对每个表的索引进行分析，并且需要考虑到查询计划树的结构。

实验结论

通过查阅资料，我学会了mysql explain语句及其返回结果，并学会解释计划查询，还掌握了如何画查询计划树，实验过程有些困难，但最终都被解决。