UNIVERSITY OF GEORGIA

Project 3 Report

Performance Tuning of SQL Queries

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Query Values

Name	Attribute	Value
v1(Value1)	Student.id	482081
v2(Value2)	Student.id (Lower Bound)	205181
v3(Value3)	Student.id (Upper Bound)	205000
v4(Value4)	Course.crsCode	166690
v5(Value5)	Professor.name	name996317
v6(Value6)	Department.id (Include)	80028
v7(Value7)	Department.id (Disclude)	971318
v8(Value8)	Department.id	25784

Before Optimization

Statement	Query

1. List the name of the student with id equal to v1.	SELECT SQL_NO_CACHE s.name
	FROM Student s
	WHERE (s.id = 482081);

2. List the names of students with id in the range of v2 to v3 inclusively.	SELECT SQL_NO_CACHE s.name
	FROM Student s
	WHERE (s.id <= 205181) AND (s.id >= 205000);

3. List the names of students who have taken course v4.	SELECT SQL_NO_CACHE s.name
	FROM Transcript t
	INNER JOIN Course c ON t.crsCode = c.crsCode
	INNER JOIN Student s ON t.studId = s.id
	WHERE c.crsCode = 166690;

4. List the names of students who have taken a course taught by professor v5.	SELECT SQL_NO_CACHE s.name
	FROM Transcript t
	INNER JOIN Teaching te ON t.crsCode = te.crsCode
	INNER JOIN Professor p ON te.profId = p.id
	INNER JOIN Student s ON t.studId = s.id
	WHERE p.name = 'name996317';

5. List the names of students who have taken a course from department v6, but not v7.

```
SELECT SQL_NO_CACHE s.name
FROM Transcript t
INNER JOIN Student s ON t.studId = s.id
INNER JOIN Course c ON t.crsCode = c.crsCode
WHERE (s.id IN
    (SELECT s.id
    FROM Transcript t
    INNER JOIN Student s ON t.studId = s.id
    INNER JOIN Course c ON t.crsCode = c.crsCode
    INNER JOIN Department d ON c.deptId = d.id
    WHERE d.id = 80028
    ))
    AND (s.id NOT IN
    (SELECT s.id
    FROM Transcript t
    INNER JOIN Student s ON t.studId = s.id
    INNER JOIN Course c ON t.crsCode = c.crsCode
    INNER JOIN Department d ON c.deptId = d.id
    WHERE d.id = 971318
    ))
GROUP BY s.id;
```

6. List the names of students who have taken all courses offered by department v8.

```
SELECT SQL_NO_CACHE s.name
FROM
    (SELECT ss.id, COUNT(*) AS courses
    FROM
        (SELECT s.id, c.crsCode, d.id AS did
        FROM Transcript t
        INNER JOIN Student s ON t.studId = s.id
        INNER JOIN Course c ON t.crsCode = c.crsCode
        INNER JOIN Department d ON c.deptId = d.id
        GROUP BY s.id, c.crsCode
        ) AS ss
    WHERE ss.did = 25784
    GROUP BY ss.id
    ) AS st
INNER JOIN Student s ON st.id = s.id
WHERE st.courses IN
    (SELECT COUNT(*)
    FROM Course c
    INNER JOIN Department d ON c.deptId = d.id
    WHERE d.id = 25784
    );
```

After Optimization

Statement	**Query**

1. List the name of the student with id equal to v1.	SELECT name
	FROM Student
	WHERE id = 482081;

2. List the names of students with id in the range of v2 to v3 inclusively.	SELECT name
	FROM Student
	WHERE id BETWEEN 205000 AND 205181;

3. List the names of students who have taken course v4.	SELECT s.name
	FROM Transcript t
	INNER JOIN Course c ON t.crsCode = c.crsCode
	INNER JOIN Student s ON t.studId = s.id
	WHERE c.crsCode = 166690;

4. List the names of students who have taken a course taught by professor v5.	SELECT s.name
	FROM Transcript t
	INNER JOIN Student s ON t.studId = s.id
	WHERE t.crsCode = 166690;

5. List the names of students who have taken a course from department v6, but not v7.	CREATE VIEW SinD AS SELECT s.id, d.id AS did
	    FROM Transcript t
	    INNER JOIN Student s ON t.studId = s.id
	    INNER JOIN Course c ON t.crsCode = c.crsCode;
	SELECT s.name
	FROM Student s
	WHERE s.id IN
	    (SELECT id
	    FROM SinD
	    WHERE did = 80028
	    )
	    AND s.id NOT IN
	    (SELECT id
	    FROM SinD
	    WHERE did = 971318
	    );

6. List the names of students who have taken all courses offered by department v8.

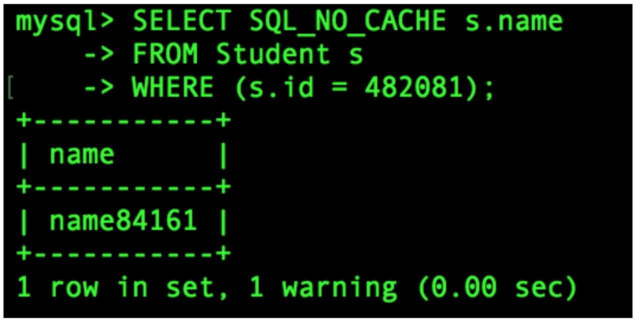
```
SELECT st.name
FROM
        (SELECT s.id, s.name, COUNT(DISTINCT c.crsCode)
AS courses
        FROM Transcript t
        INNER JOIN Student s ON t.studId = s.id
        INNER JOIN Course c ON t.crsCode = c.crsCode
        WHERE c.deptid = 25784
        GROUP BY s.id
        ) AS st
WHERE st.courses IN
        (SELECT COUNT(*)
        FROM Course c
        WHERE c.deptid = 25784
        );
```

Explaining the Optimizations

In order to optimize our queries we first removed most of the parenthesis that were there for clarification. We then removed costly unnecessary JOIN operations using variables from other tables to complete the task. When running the Explain path we saw that in query 5 the same execution of steps run multiple times. So we created a view to simplify the task into 1 execution. For query 6, we moved our where condition to eliminate tuples before grouping them opposed to after. We then also created the table in a way that indexes the table for a significant time deduction. Below you can see the output of each of the queries. Even with the recommended amount of tuples the time was still too small. However, you can see in the explinations the significantly less operations nessesary in the optimized queries.

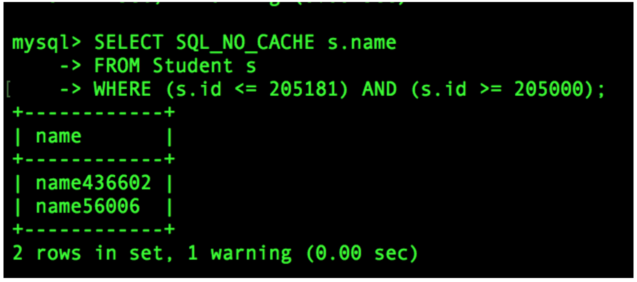
Appendices

Appendix A: Un-Optimized Queries



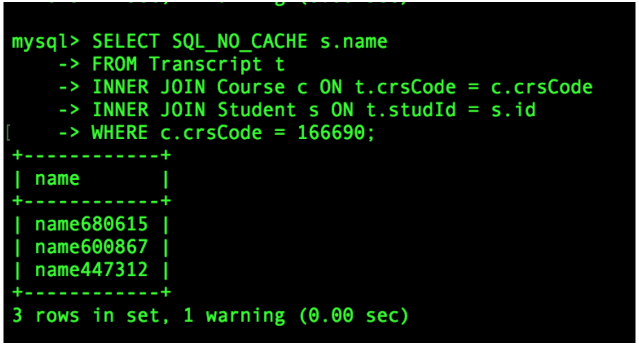
```
mysql> SELECT SQL_NO_CACHE s.name
    -> FROM Student s
[    -> WHERE (s.id = 482081);
+-----------+
| name      |
+-----------+
| name84161 |
+-----------+
1 row in set, 1 warning (0.00 sec)
```

Figure 1.1: Query 1



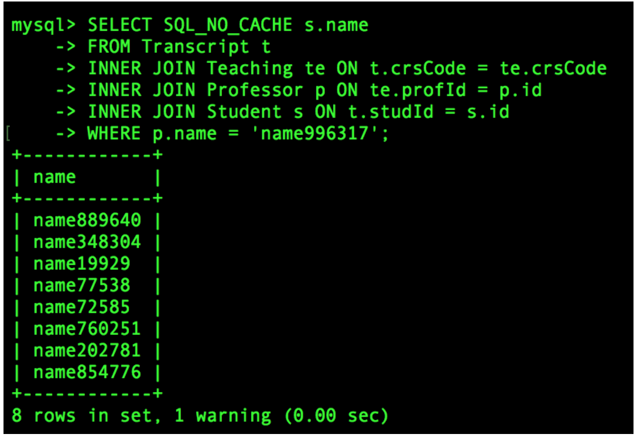
```
mysql> SELECT SQL_NO_CACHE s.name
    -> FROM Student s
[    -> WHERE (s.id <= 205181) AND (s.id >= 205000);
+------------+
| name       |
+------------+
| name436602 |
| name56006  |
+------------+
2 rows in set, 1 warning (0.00 sec)
```

Figure 1.2: Query 2



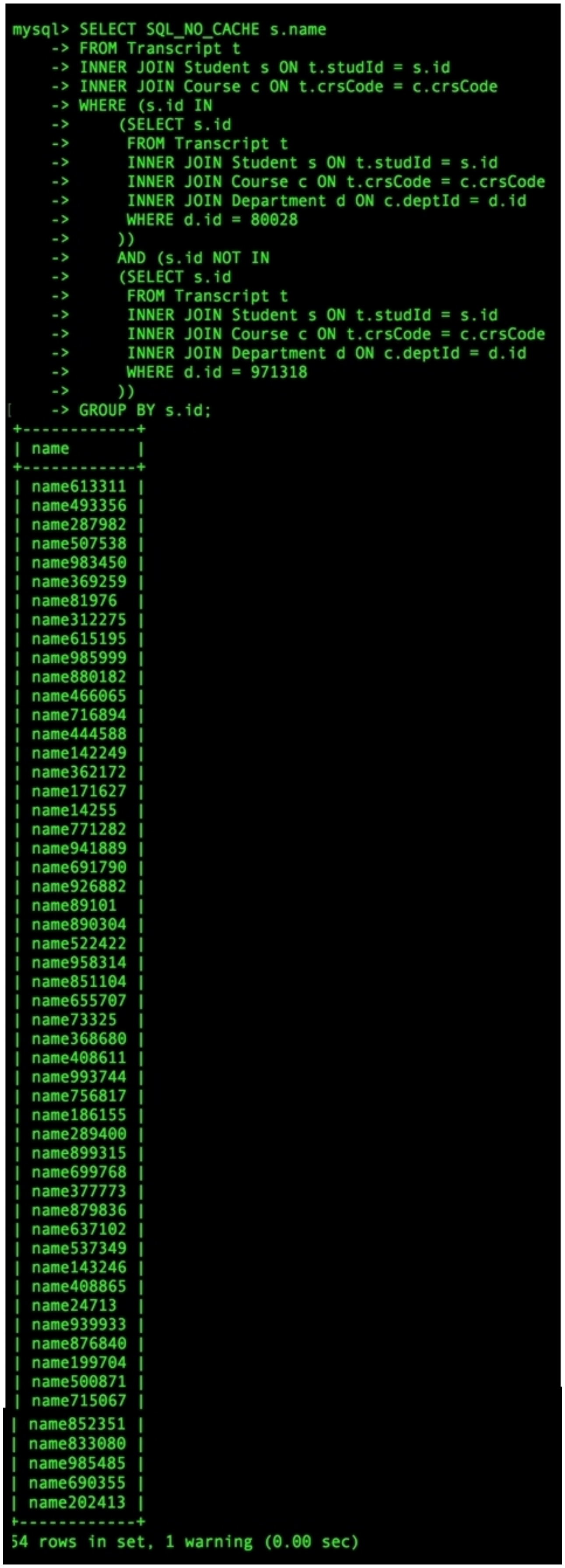
```
mysql> SELECT SQL_NO_CACHE s.name
    -> FROM Transcript t
    -> INNER JOIN Course c ON t.crsCode = c.crsCode
    -> INNER JOIN Student s ON t.studId = s.id
[    -> WHERE c.crsCode = 166690;
+------------+
| name       |
+------------+
| name680615 |
| name600867 |
| name447312 |
+------------+
3 rows in set, 1 warning (0.00 sec)
```

Figure 1.3: Query 3



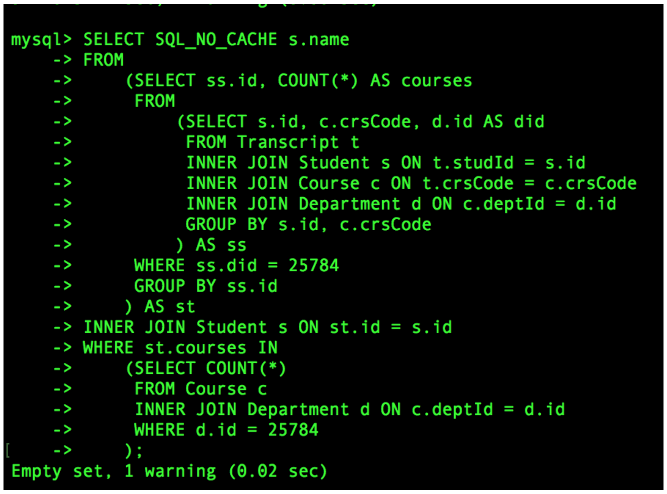
```
mysql> SELECT SQL_NO_CACHE s.name
    -> FROM Transcript t
    -> INNER JOIN Teaching te ON t.crsCode = te.crsCode
    -> INNER JOIN Professor p ON te.profId = p.id
    -> INNER JOIN Student s ON t.studId = s.id
[    -> WHERE p.name = 'name996317';
+------------+
| name       |
+------------+
| name889640 |
| name348304 |
| name19929  |
| name77538  |
| name72585  |
| name760251 |
| name202781 |
| name854776 |
+------------+
8 rows in set, 1 warning (0.00 sec)
```

Figure 1.4: Query 4



```
mysql> SELECT SQL_NO_CACHE s.name
    -> FROM Transcript t
    -> INNER JOIN Student s ON t.studId = s.id
    -> INNER JOIN Course c ON t.crsCode = c.crsCode
    -> WHERE (s.id IN
    ->      (SELECT s.id
    ->       FROM Transcript t
    ->       INNER JOIN Student s ON t.studId = s.id
    ->       INNER JOIN Course c ON t.crsCode = c.crsCode
    ->       INNER JOIN Department d ON c.deptId = d.id
    ->       WHERE d.id = 80028
    ->      ))
    ->      AND (s.id NOT IN
    ->      (SELECT s.id
    ->       FROM Transcript t
    ->       INNER JOIN Student s ON t.studId = s.id
    ->       INNER JOIN Course c ON t.crsCode = c.crsCode
    ->       INNER JOIN Department d ON c.deptId = d.id
    ->       WHERE d.id = 971318
    ->      ))
[   -> GROUP BY s.id;
+------------+
| name       |
+------------+
| name613311 |
| name493356 |
| name287982 |
| name507538 |
| name983450 |
| name369259 |
| name81976  |
| name312275 |
| name615195 |
| name985999 |
| name880182 |
| name466065 |
| name716894 |
| name444588 |
| name142249 |
| name362172 |
| name171627 |
| name14255  |
| name771282 |
| name941889 |
| name691790 |
| name926882 |
| name89101  |
| name890304 |
| name522422 |
| name958314 |
| name851104 |
| name655707 |
| name73325  |
| name368680 |
| name408611 |
| name993744 |
| name756817 |
| name186155 |
| name289400 |
| name899315 |
| name699768 |
| name377773 |
| name879836 |
| name637102 |
| name537349 |
| name143246 |
| name408865 |
| name24713  |
| name939933 |
| name876840 |
| name199704 |
| name500871 |
| name715067 |
| name852351 |
| name833080 |
| name985485 |
| name690355 |
| name202413 |
+------------+
54 rows in set, 1 warning (0.00 sec)
```

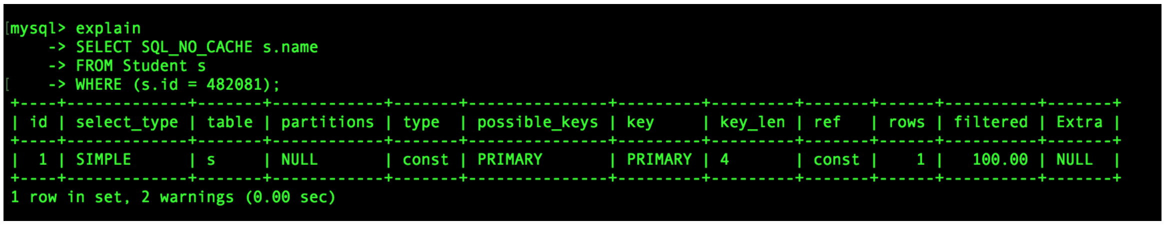
Figure 1.5: Query 5



```
mysql> SELECT SQL_NO_CACHE s.name
    -> FROM
    ->     (SELECT ss.id, COUNT(*) AS courses
    ->      FROM
    ->          (SELECT s.id, c.crsCode, d.id AS did
    ->           FROM Transcript t
    ->           INNER JOIN Student s ON t.studId = s.id
    ->           INNER JOIN Course c ON t.crsCode = c.crsCode
    ->           INNER JOIN Department d ON c.deptId = d.id
    ->           GROUP BY s.id, c.crsCode
    ->          ) AS ss
    ->      WHERE ss.did = 25784
    ->      GROUP BY ss.id
    ->     ) AS st
    -> INNER JOIN Student s ON st.id = s.id
    -> WHERE st.courses IN
    ->     (SELECT COUNT(*)
    ->      FROM Course c
    ->      INNER JOIN Department d ON c.deptId = d.id
    ->      WHERE d.id = 25784
[   ->     );
Empty set, 1 warning (0.02 sec)
```

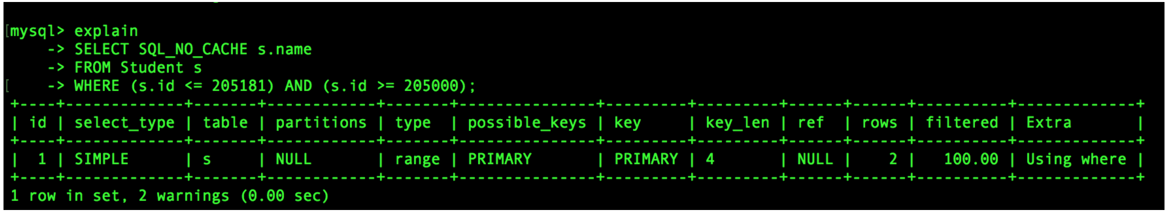
Figure 1.6: Query 6

Appendix B: Un-Optimized Queries w/ Explination



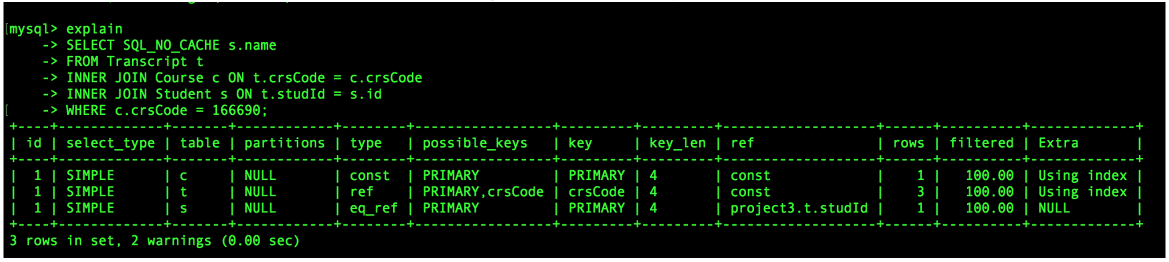
```
[mysql> explain
    -> SELECT SQL_NO_CACHE s.name
    -> FROM Student s
[   -> WHERE (s.id = 482081);
+----+-------------+-------+------------+-------+---------------+---------+---------+-------+------+----------+-------+
| id | select_type | table | partitions | type  | possible_keys | key     | key_len | ref   | rows | filtered | Extra |
+----+-------------+-------+------------+-------+---------------+---------+---------+-------+------+----------+-------+
|  1 | SIMPLE      | s     | NULL       | const | PRIMARY       | PRIMARY | 4       | const |    1 |   100.00 | NULL  |
+----+-------------+-------+------------+-------+---------------+---------+---------+-------+------+----------+-------+
1 row in set, 2 warnings (0.00 sec)
```

Figure 2.1: Query 1



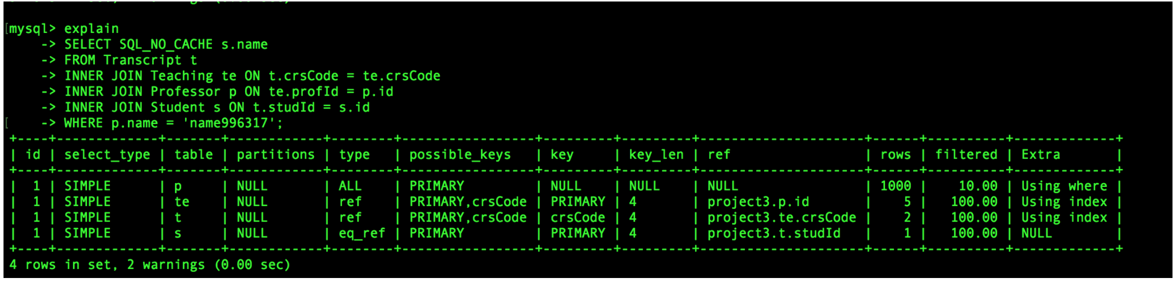
```
[mysql> explain
    -> SELECT SQL_NO_CACHE s.name
    -> FROM Student s
[   -> WHERE (s.id <= 205181) AND (s.id >= 205000);
+----+-------------+-------+------------+-------+---------------+---------+---------+------+------+----------+-------------+
| id | select_type | table | partitions | type  | possible_keys | key     | key_len | ref  | rows | filtered | Extra       |
+----+-------------+-------+------------+-------+---------------+---------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | s     | NULL       | range | PRIMARY       | PRIMARY | 4       | NULL |    2 |   100.00 | Using where |
+----+-------------+-------+------------+-------+---------------+---------+---------+------+------+----------+-------------+
1 row in set, 2 warnings (0.00 sec)
```

Figure 2.2: Query 2



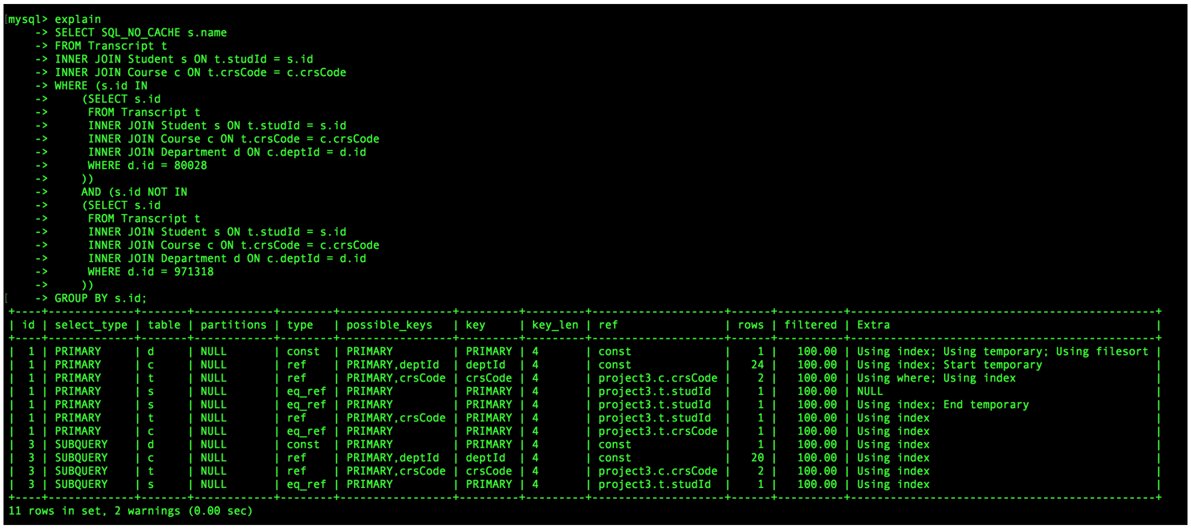
```
[mysql> explain
    -> SELECT SQL_NO_CACHE s.name
    -> FROM Transcript t
    -> INNER JOIN Course c ON t.crsCode = c.crsCode
    -> INNER JOIN Student s ON t.studId = s.id
[   -> WHERE c.crsCode = 166690;
+----+-------------+-------+------------+--------+-----------------+---------+---------+--------------------+------+----------+-------------+
| id | select_type | table | partitions | type   | possible_keys   | key     | key_len | ref                | rows | filtered | Extra       |
+----+-------------+-------+------------+--------+-----------------+---------+---------+--------------------+------+----------+-------------+
|  1 | SIMPLE      | c     | NULL       | const  | PRIMARY         | PRIMARY | 4       | const              |    1 |   100.00 | Using index |
|  1 | SIMPLE      | t     | NULL       | ref    | PRIMARY,crsCode | crsCode | 4       | const              |    3 |   100.00 | Using index |
|  1 | SIMPLE      | s     | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | NULL        |
+----+-------------+-------+------------+--------+-----------------+---------+---------+--------------------+------+----------+-------------+
3 rows in set, 2 warnings (0.00 sec)
```

Figure 2.3: Query 3



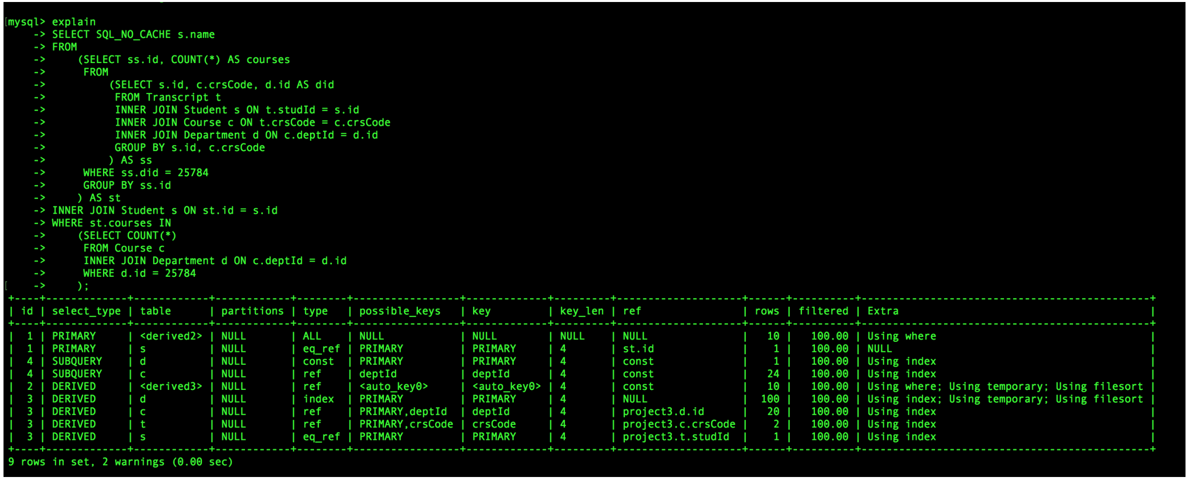
```
[mysql> explain
    -> SELECT SQL_NO_CACHE s.name
    -> FROM Transcript t
    -> INNER JOIN Teaching te ON t.crsCode = te.crsCode
    -> INNER JOIN Professor p ON te.profId = p.id
    -> INNER JOIN Student s ON t.studId = s.id
[   -> WHERE p.name = 'name996317';
+----+-------------+-------+------------+--------+-----------------+---------+---------+---------------------+------+----------+-------------+
| id | select_type | table | partitions | type   | possible_keys   | key     | key_len | ref                 | rows | filtered | Extra       |
+----+-------------+-------+------------+--------+-----------------+---------+---------+---------------------+------+----------+-------------+
|  1 | SIMPLE      | p     | NULL       | ALL    | PRIMARY         | NULL    | NULL    | NULL                | 1000 |    10.00 | Using where |
|  1 | SIMPLE      | te    | NULL       | ref    | PRIMARY,crsCode | PRIMARY | 4       | project3.p.id       |    5 |   100.00 | Using index |
|  1 | SIMPLE      | t     | NULL       | ref    | PRIMARY,crsCode | crsCode | 4       | project3.te.crsCode |    2 |   100.00 | Using index |
|  1 | SIMPLE      | s     | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId   |    1 |   100.00 | NULL        |
+----+-------------+-------+------------+--------+-----------------+---------+---------+---------------------+------+----------+-------------+
4 rows in set, 2 warnings (0.00 sec)
```

Figure 2.4: Query 4



```
mysql> explain
    -> SELECT SQL_NO_CACHE s.name
    -> FROM Transcript t
    -> INNER JOIN Student s ON t.studId = s.id
    -> INNER JOIN Course c ON t.crsCode = c.crsCode
    -> WHERE (s.id IN
    ->     (SELECT s.id
    ->      FROM Transcript t
    ->      INNER JOIN Student s ON t.studId = s.id
    ->      INNER JOIN Course c ON t.crsCode = c.crsCode
    ->      INNER JOIN Department d ON c.deptId = d.id
    ->      WHERE d.id = 80028
    ->     ))
    ->     AND (s.id NOT IN
    ->     (SELECT s.id
    ->      FROM Transcript t
    ->      INNER JOIN Student s ON t.studId = s.id
    ->      INNER JOIN Course c ON t.crsCode = c.crsCode
    ->      INNER JOIN Department d ON c.deptId = d.id
    ->      WHERE d.id = 971318
    ->     ))
    -> GROUP BY s.id;
+----+-------------+-------+------------+--------+------------------+---------+---------+--------------------+------+----------+----------------------------------------------+
| id | select_type | table | partitions | type   | possible_keys    | key     | key_len | ref                | rows | filtered | Extra                                        |
+----+-------------+-------+------------+--------+------------------+---------+---------+--------------------+------+----------+----------------------------------------------+
|  1 | PRIMARY     | d     | NULL       | const  | PRIMARY          | PRIMARY | 4       | const              |    1 |   100.00 | Using index; Using temporary; Using filesort |
|  1 | PRIMARY     | c     | NULL       | ref    | PRIMARY,deptId   | deptId  | 4       | const              |   24 |   100.00 | Using index; Start temporary                 |
|  1 | PRIMARY     | t     | NULL       | ref    | PRIMARY,crsCode  | crsCode | 4       | project3.c.crsCode |    2 |   100.00 | Using where; Using index                     |
|  1 | PRIMARY     | s     | NULL       | eq_ref | PRIMARY          | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | NULL                                         |
|  1 | PRIMARY     | s     | NULL       | eq_ref | PRIMARY          | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | Using index; End temporary                   |
|  1 | PRIMARY     | t     | NULL       | ref    | PRIMARY,crsCode  | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | Using index                                  |
|  1 | PRIMARY     | c     | NULL       | eq_ref | PRIMARY          | PRIMARY | 4       | project3.t.crsCode |    1 |   100.00 | Using index                                  |
|  3 | SUBQUERY    | d     | NULL       | const  | PRIMARY          | PRIMARY | 4       | const              |    1 |   100.00 | Using index                                  |
|  3 | SUBQUERY    | c     | NULL       | ref    | PRIMARY,deptId   | deptId  | 4       | const              |   20 |   100.00 | Using index                                  |
|  3 | SUBQUERY    | t     | NULL       | ref    | PRIMARY,crsCode  | crsCode | 4       | project3.c.crsCode |    2 |   100.00 | Using index                                  |
|  3 | SUBQUERY    | s     | NULL       | eq_ref | PRIMARY          | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | Using index                                  |
+----+-------------+-------+------------+--------+------------------+---------+---------+--------------------+------+----------+----------------------------------------------+
11 rows in set, 2 warnings (0.00 sec)
```

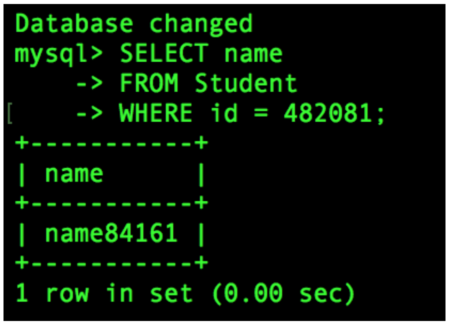
Figure 2.5: Query 5



```
mysql> explain
    -> SELECT SQL_NO_CACHE s.name
    -> FROM
    ->     (SELECT ss.id, COUNT(*) AS courses
    ->      FROM
    ->          (SELECT s.id, c.crsCode, d.id AS did
    ->           FROM Transcript t
    ->           INNER JOIN Student s ON t.studId = s.id
    ->           INNER JOIN Course c ON t.crsCode = c.crsCode
    ->           INNER JOIN Department d ON c.deptId = d.id
    ->           GROUP BY s.id, c.crsCode
    ->          ) AS ss
    ->      WHERE ss.did = 25784
    ->      GROUP BY ss.id
    ->     ) AS st
    -> INNER JOIN Student s ON st.id = s.id
    -> WHERE st.courses IN
    ->     (SELECT COUNT(*)
    ->      FROM Course c
    ->      INNER JOIN Department d ON c.deptId = d.id
    ->      WHERE d.id = 25784
    ->     );
+----+-------------+------------+------------+--------+-----------------+-------------+---------+--------------------+------+----------+----------------------------------------------+
| id | select_type | table      | partitions | type   | possible_keys   | key         | key_len | ref                | rows | filtered | Extra                                        |
+----+-------------+------------+------------+--------+-----------------+-------------+---------+--------------------+------+----------+----------------------------------------------+
|  1 | PRIMARY     | <derived2> | NULL       | ALL    | NULL            | NULL        | NULL    | NULL               |   10 |   100.00 | Using where                                  |
|  1 | PRIMARY     | s          | NULL       | eq_ref | PRIMARY         | PRIMARY     | 4       | st.id              |    1 |   100.00 | NULL                                         |
|  4 | SUBQUERY    | d          | NULL       | const  | PRIMARY         | PRIMARY     | 4       | const              |    1 |   100.00 | Using index                                  |
|  4 | SUBQUERY    | c          | NULL       | ref    | deptId          | deptId      | 4       | const              |   24 |   100.00 | Using index                                  |
|  2 | DERIVED     | <derived3> | NULL       | ref    | <auto_key0>     | <auto_key0> | 4       | const              |   10 |   100.00 | Using where; Using temporary; Using filesort |
|  3 | DERIVED     | d          | NULL       | index  | PRIMARY         | PRIMARY     | 4       | NULL               |  100 |   100.00 | Using index; Using temporary; Using filesort |
|  3 | DERIVED     | c          | NULL       | ref    | PRIMARY,deptId  | deptId      | 4       | project3.d.id      |   20 |   100.00 | Using index                                  |
|  3 | DERIVED     | t          | NULL       | ref    | PRIMARY,crsCode | crsCode     | 4       | project3.c.crsCode |    2 |   100.00 | Using index                                  |
|  3 | DERIVED     | s          | NULL       | eq_ref | PRIMARY         | PRIMARY     | 4       | project3.t.studId  |    1 |   100.00 | Using index                                  |
+----+-------------+------------+------------+--------+-----------------+-------------+---------+--------------------+------+----------+----------------------------------------------+
9 rows in set, 2 warnings (0.00 sec)
```

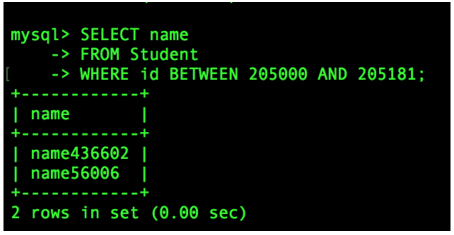
Figure 2.6: Query 6

Appendix C: Optimized Queries



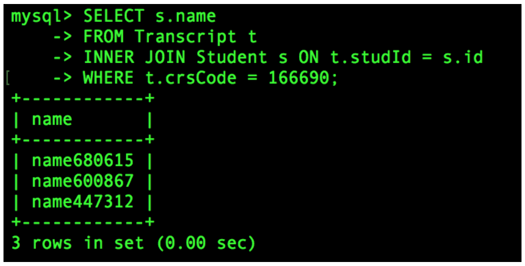
```
Database changed
mysql> SELECT name
    -> FROM Student
    -> WHERE id = 482081;
+-----------+
| name      |
+-----------+
| name84161 |
+-----------+
1 row in set (0.00 sec)
```

Figure 3.1: Query 1



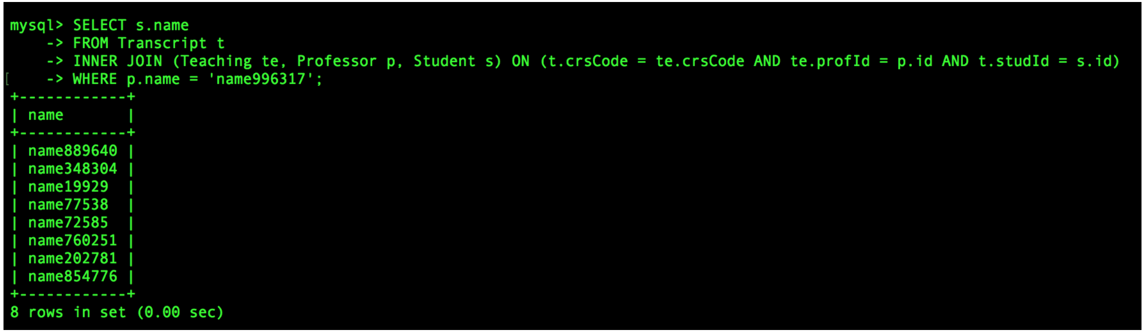
```
mysql> SELECT name
    -> FROM Student
    -> WHERE id BETWEEN 205000 AND 205181;
+------------+
| name       |
+------------+
| name436602 |
| name56006  |
+------------+
2 rows in set (0.00 sec)
```

Figure 3.2: Query 2



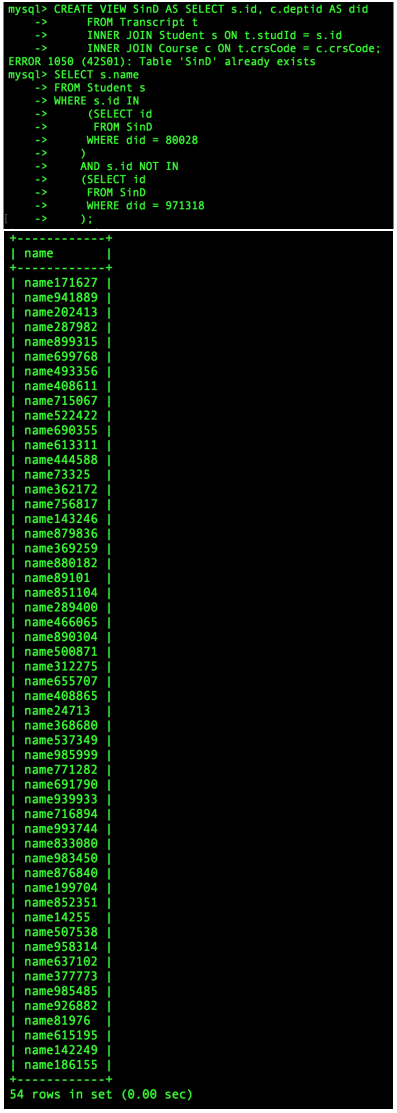
```
mysql> SELECT s.name
    -> FROM Transcript t
    -> INNER JOIN Student s ON t.studId = s.id
    -> WHERE t.crsCode = 166690;
+------------+
| name       |
+------------+
| name680615 |
| name600867 |
| name447312 |
+------------+
3 rows in set (0.00 sec)
```

Figure 3.3: Query 3



```
mysql> SELECT s.name
    -> FROM Transcript t
    -> INNER JOIN (Teaching te, Professor p, Student s) ON (t.crsCode = te.crsCode AND te.profId = p.id AND t.studId = s.id)
    -> WHERE p.name = 'name996317';
+------------+
| name       |
+------------+
| name889640 |
| name348304 |
| name19929  |
| name77538  |
| name72585  |
| name760251 |
| name202781 |
| name854776 |
+------------+
8 rows in set (0.00 sec)
```

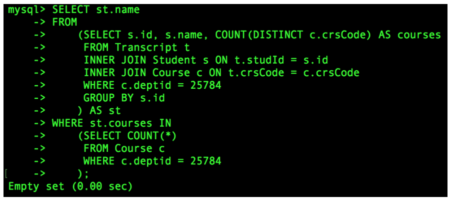
Figure 3.4: Query 4



```
mysql> CREATE VIEW SinD AS SELECT s.id, c.deptid AS did
    ->      FROM Transcript t
    ->      INNER JOIN Student s ON t.studId = s.id
    ->      INNER JOIN Course c ON t.crsCode = c.crsCode;
ERROR 1050 (42S01): Table 'SinD' already exists
mysql> SELECT s.name
    -> FROM Student s
    -> WHERE s.id IN
    ->      (SELECT id
    ->       FROM SinD
    ->      WHERE did = 80028
    ->     )
    ->     AND s.id NOT IN
    ->     (SELECT id
    ->      FROM SinD
    ->      WHERE did = 971318
    ->     );
```

```
+------------+
| name       |
+------------+
| name171627 |
| name941889 |
| name202413 |
| name287982 |
| name899315 |
| name699768 |
| name493356 |
| name408611 |
| name715067 |
| name522422 |
| name690355 |
| name613311 |
| name444588 |
| name73325  |
| name362172 |
| name756817 |
| name143246 |
| name879836 |
| name369259 |
| name880182 |
| name89101  |
| name851104 |
| name289400 |
| name466065 |
| name890304 |
| name500871 |
| name312275 |
| name655707 |
| name408865 |
| name24713  |
| name368680 |
| name537349 |
| name985999 |
| name771282 |
| name691790 |
| name939933 |
| name716894 |
| name993744 |
| name833080 |
| name983450 |
| name876840 |
| name199704 |
| name852351 |
| name14255  |
| name507538 |
| name958314 |
| name637102 |
| name377773 |
| name985485 |
| name926882 |
| name81976  |
| name615195 |
| name142249 |
| name186155 |
+------------+
54 rows in set (0.00 sec)
```

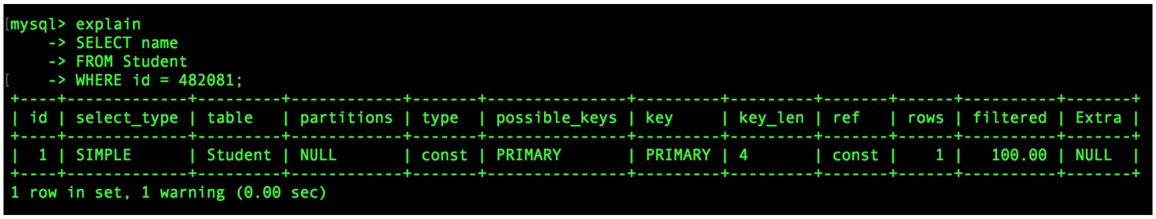
Figure 3.5: Query 5



```
mysql> SELECT st.name
    -> FROM
    ->     (SELECT s.id, s.name, COUNT(DISTINCT c.crsCode) AS courses
    ->      FROM Transcript t
    ->      INNER JOIN Student s ON t.studId = s.id
    ->      INNER JOIN Course c ON t.crsCode = c.crsCode
    ->      WHERE c.deptid = 25784
    ->      GROUP BY s.id
    ->     ) AS st
    -> WHERE st.courses IN
    ->     (SELECT COUNT(*)
    ->      FROM Course c
    ->      WHERE c.deptid = 25784
    ->     );
Empty set (0.00 sec)
```

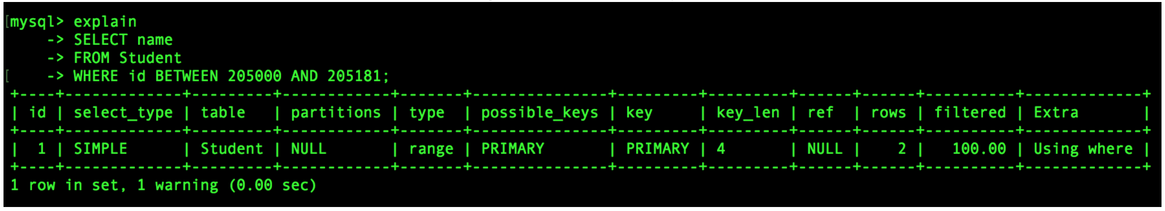
Figure 3.6: Query 6

Appendix D: Optimized Queries w/ Explination



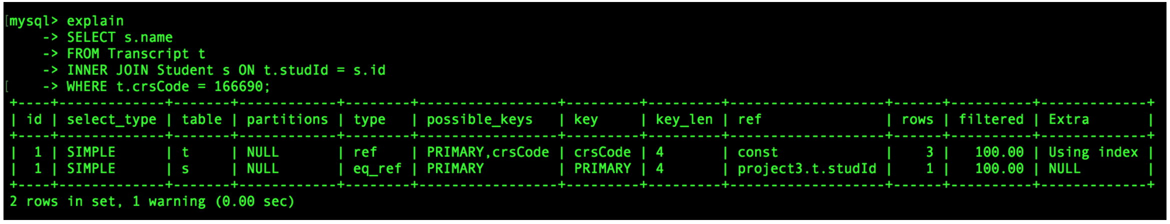
```
mysql> explain
    -> SELECT name
    -> FROM Student
    -> WHERE id = 482081;
+----+-------------+---------+------------+-------+---------------+---------+---------+-------+------+----------+-------+
| id | select_type | table   | partitions | type  | possible_keys | key     | key_len | ref   | rows | filtered | Extra |
+----+-------------+---------+------------+-------+---------------+---------+---------+-------+------+----------+-------+
|  1 | SIMPLE      | Student | NULL       | const | PRIMARY       | PRIMARY | 4       | const |    1 |   100.00 | NULL  |
+----+-------------+---------+------------+-------+---------------+---------+---------+-------+------+----------+-------+
1 row in set, 1 warning (0.00 sec)
```

Figure 4.1: Query 1



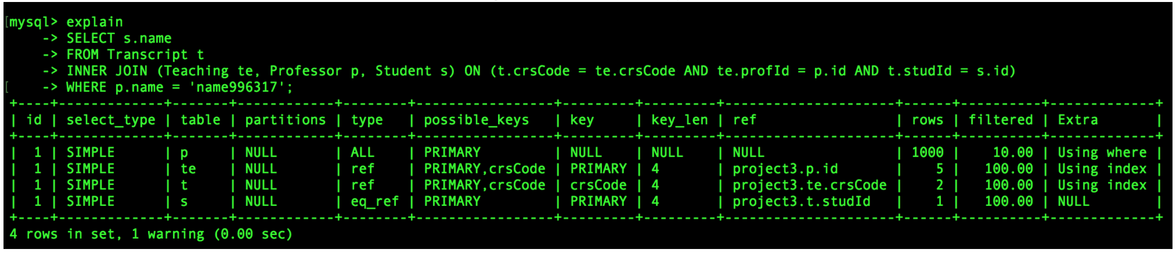
```
mysql> explain
    -> SELECT name
    -> FROM Student
    -> WHERE id BETWEEN 205000 AND 205181;
+----+-------------+---------+------------+-------+---------------+---------+---------+------+------+----------+-------------+
| id | select_type | table   | partitions | type  | possible_keys | key     | key_len | ref  | rows | filtered | Extra       |
+----+-------------+---------+------------+-------+---------------+---------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | Student | NULL       | range | PRIMARY       | PRIMARY | 4       | NULL |    2 |   100.00 | Using where |
+----+-------------+---------+------------+-------+---------------+---------+---------+------+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)
```

Figure 4.2: Query 2



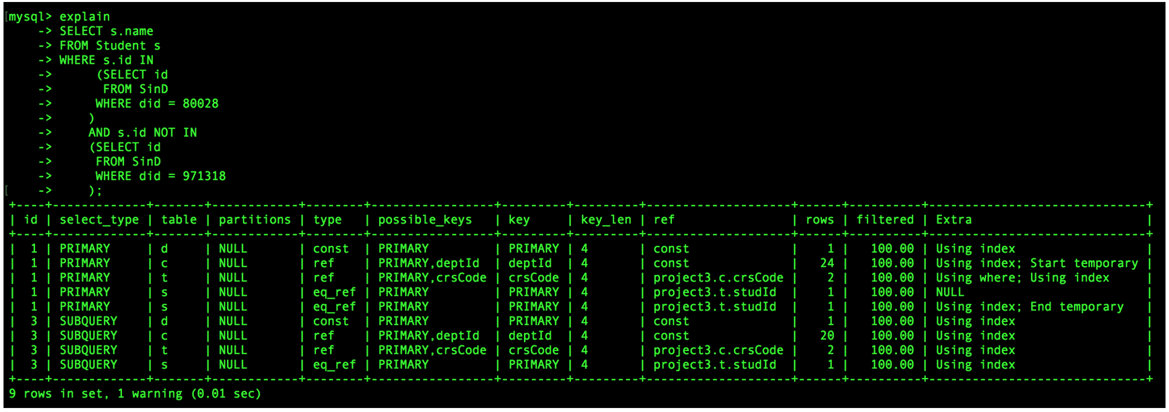
```
mysql> explain
    -> SELECT s.name
    -> FROM Transcript t
    -> INNER JOIN Student s ON t.studId = s.id
    -> WHERE t.crsCode = 166690;
+----+-------------+-------+------------+--------+-----------------+---------+---------+-------------------+------+----------+-------------+
| id | select_type | table | partitions | type   | possible_keys   | key     | key_len | ref               | rows | filtered | Extra       |
+----+-------------+-------+------------+--------+-----------------+---------+---------+-------------------+------+----------+-------------+
|  1 | SIMPLE      | t     | NULL       | ref    | PRIMARY,crsCode | crsCode | 4       | const             |    3 |   100.00 | Using index |
|  1 | SIMPLE      | s     | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId |    1 |   100.00 | NULL        |
+----+-------------+-------+------------+--------+-----------------+---------+---------+-------------------+------+----------+-------------+
2 rows in set, 1 warning (0.00 sec)
```

Figure 4.3: Query 3



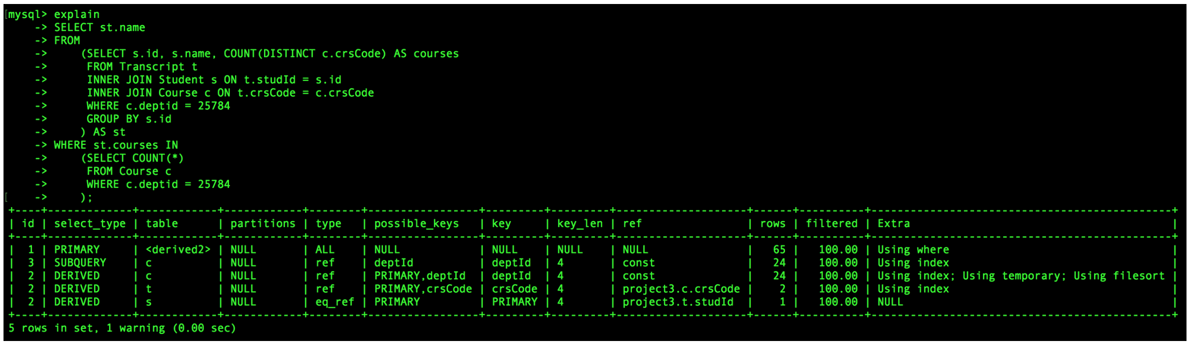
```
mysql> explain
    -> SELECT s.name
    -> FROM Transcript t
    -> INNER JOIN (Teaching te, Professor p, Student s) ON (t.crsCode = te.crsCode AND te.profId = p.id AND t.studId = s.id)
    -> WHERE p.name = 'name996317';
+----+-------------+-------+------------+--------+-----------------+---------+---------+---------------------+------+----------+-------------+
| id | select_type | table | partitions | type   | possible_keys   | key     | key_len | ref                 | rows | filtered | Extra       |
+----+-------------+-------+------------+--------+-----------------+---------+---------+---------------------+------+----------+-------------+
|  1 | SIMPLE      | p     | NULL       | ALL    | PRIMARY         | NULL    | NULL    | NULL                | 1000 |    10.00 | Using where |
|  1 | SIMPLE      | te    | NULL       | ref    | PRIMARY,crsCode | PRIMARY | 4       | project3.p.id       |    5 |   100.00 | Using index |
|  1 | SIMPLE      | t     | NULL       | ref    | PRIMARY,crsCode | crsCode | 4       | project3.te.crsCode |    2 |   100.00 | Using index |
|  1 | SIMPLE      | s     | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId   |    1 |   100.00 | NULL        |
+----+-------------+-------+------------+--------+-----------------+---------+---------+---------------------+------+----------+-------------+
4 rows in set, 1 warning (0.00 sec)
```

Figure 4.4: Query 4



```
mysql> explain
    -> SELECT s.name
    -> FROM Student s
    -> WHERE s.id IN
    ->      (SELECT id
    ->       FROM SinD
    ->      WHERE did = 80028
    ->     )
    ->     AND s.id NOT IN
    ->     (SELECT id
    ->      FROM SinD
    ->      WHERE did = 971318
    ->     );
+----+-------------+-------+------------+--------+-----------------+---------+---------+--------------------+------+----------+------------------------------+
| id | select_type | table | partitions | type   | possible_keys   | key     | key_len | ref                | rows | filtered | Extra                        |
+----+-------------+-------+------------+--------+-----------------+---------+---------+--------------------+------+----------+------------------------------+
|  1 | PRIMARY     | d     | NULL       | const  | PRIMARY         | PRIMARY | 4       | const              |    1 |   100.00 | Using index                  |
|  1 | PRIMARY     | c     | NULL       | ref    | PRIMARY,deptId  | deptId  | 4       | const              |   24 |   100.00 | Using index; Start temporary |
|  1 | PRIMARY     | t     | NULL       | ref    | PRIMARY,crsCode | crsCode | 4       | project3.c.crsCode |    2 |   100.00 | Using where; Using index     |
|  1 | PRIMARY     | s     | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | NULL                         |
|  1 | PRIMARY     | s     | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | Using index; End temporary   |
|  3 | SUBQUERY    | d     | NULL       | const  | PRIMARY         | PRIMARY | 4       | const              |    1 |   100.00 | Using index                  |
|  3 | SUBQUERY    | c     | NULL       | ref    | PRIMARY,deptId  | deptId  | 4       | const              |   20 |   100.00 | Using index                  |
|  3 | SUBQUERY    | t     | NULL       | ref    | PRIMARY,crsCode | crsCode | 4       | project3.c.crsCode |    2 |   100.00 | Using index                  |
|  3 | SUBQUERY    | s     | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | Using index                  |
+----+-------------+-------+------------+--------+-----------------+---------+---------+--------------------+------+----------+------------------------------+
9 rows in set, 1 warning (0.01 sec)
```

Figure 4.5: Query 5



```
[mysql> explain
    -> SELECT st.name
    -> FROM
    ->     (SELECT s.id, s.name, COUNT(DISTINCT c.crsCode) AS courses
    ->      FROM Transcript t
    ->      INNER JOIN Student s ON t.studId = s.id
    ->      INNER JOIN Course c ON t.crsCode = c.crsCode
    ->      WHERE c.deptid = 25784
    ->      GROUP BY s.id
    ->     ) AS st
    -> WHERE st.courses IN
    ->     (SELECT COUNT(*)
    ->      FROM Course c
    ->      WHERE c.deptid = 25784
[   ->     );
+----+-------------+------------+------------+--------+-----------------+---------+---------+--------------------+------+----------+----------------------------------------------+
| id | select_type | table      | partitions | type   | possible_keys   | key     | key_len | ref                | rows | filtered | Extra                                        |
+----+-------------+------------+------------+--------+-----------------+---------+---------+--------------------+------+----------+----------------------------------------------+
|  1 | PRIMARY     | <derived2> | NULL       | ALL    | NULL            | NULL    | NULL    | NULL               |   65 |   100.00 | Using where                                  |
|  3 | SUBQUERY    | c          | NULL       | ref    | deptId          | deptId  | 4       | const              |   24 |   100.00 | Using index                                  |
|  2 | DERIVED     | c          | NULL       | ref    | PRIMARY,deptId  | deptId  | 4       | const              |   24 |   100.00 | Using index; Using temporary; Using filesort |
|  2 | DERIVED     | t          | NULL       | ref    | PRIMARY,crsCode | crsCode | 4       | project3.c.crsCode |    2 |   100.00 | Using index                                  |
|  2 | DERIVED     | s          | NULL       | eq_ref | PRIMARY         | PRIMARY | 4       | project3.t.studId  |    1 |   100.00 | NULL                                         |
+----+-------------+------------+------------+--------+-----------------+---------+---------+--------------------+------+----------+----------------------------------------------+
5 rows in set, 1 warning (0.00 sec)
```

Figure 4.6: Query 6