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CS486/586 Introduction to Databases
Fall 2021 Quarter

Assignment 6 – Query Optimization, Transactions, Recovery
Due: Monday, Nov 29th at 11:59PM.

Instructions & Notes:

- Do this assignment in groups of 2.
- Ensure that each group member's name is listed on the assignment, and in the notes field of Canvas to ensure credit.
- Submit your assignment in PDF format.
- Submit your completed assignment on Canvas, one submission per group.
- 100 points total.

Part I: Join Implementation – 15 points

Question 1 (15 points):

A. Write a SQL query using the spy schema for which you believe it would be efficient to use hash join. Include the query here.

```
SELECT s.skill, r.agent_id
FROM skill s JOIN skillrel r ON s.skill_id = r.skill_id;
```

B. Explain why you believe the hash join algorithm could or would be used.

The skillrel table is the second largest table in the spy schema with 9 pages and 1954 tuples while the skill table is one of the smallest table in the schema with 1 page and 66 tuples. Hash join is an efficient choice when one of the tables is much larger than the other table. Because all of the tables in the spy schema will fit in memory, we didn't consider whether or not a table would fit in memory when selecting tables to include in the query.

C. **Use EXPLAIN to see (and report) which join algorithm postgresql actually uses. (Note: It's fine if the join algorithm postgresql uses does not match the join algorithm named in the question.)**

Postgres uses hash join:

```
fall2021db96=> EXPLAIN
fall2021db96-> SELECT s.skill, r.agent_id
fall2021db96-> FROM skill s JOIN skillrel r ON s.skill_id = r.skill_id;
                            QUERY PLAN
------------------------------------------------------------------------
 Hash Join  (cost=2.49..36.49 rows=1954 width=19)
   Hash Cond: (r.skill_id = s.skill_id)
   ->  Seq Scan on skillrel r  (cost=0.00..28.54 rows=1954 width=8)
   ->  Hash  (cost=1.66..1.66 rows=66 width=19)
         ->  Seq Scan on skill s  (cost=0.00..1.66 rows=66 width=19)
(5 rows)
```

Part II: Statistics – 25 points

Question 2 (5 points): **Determine the min and max salary values in the agent table, and the number of rows in that table.**

Min Salary Value: 50,008
Max Salary Value: 366,962
Row Count in agent Table: 662

Queries:

- SELECT MIN(salary), MAX(salary)
  FROM agent;

- SELECT relname, reltuples
  FROM pg_class
  WHERE relname = 'agent';

Question 3 (5 points): **Give an estimate for the number of rows in agent with salary < 92000, assuming a uniform distribution of salaries between min and max salary. Explain how you derived your estimate.**

First we found the range (T) between the minimum salary and maximum salary:

T = max - min = 366,962 - 50,008 = 316,954

Given that we are assuming a uniform distribution, we can divide T by the number of rows in the table plus one to find out the range between each salary (S). We needed to add one to account for the fact that T is inclusive of both the min and the max:

S = T / total rows = 316,954 / (662 + 1) = 478

Then we found the range (R) between our target value of 92,000 and the minimum salary:

R = target value - min = 92,000 - 50,008 = 41,992

Finally, we divided R by S to find the number of rows with a salary lower than 92,000:

R / S = 41,992 / 478 = 87.85

Since we can only have whole values for rows, we ignored the decimal and estimated that there are 87 rows in the agent table with a salary < 92,000.

Question 4 (5 points): **Find the 25th, 50th and 75th percentile values for salaries in the agent table. (The 50th percentile value, for instance, is the smallest number such that 50% of the rows have salary value less than or equal to s.)**

25th Percentile: 54,802
50th Percentile: 58,430
75th Percentile: 89,643

Query:

```
SELECT
  PERCENTILE_DISC(.25) WITHIN GROUP (ORDER BY agent.salary),
  PERCENTILE_DISC(.5) WITHIN GROUP (ORDER BY agent.salary),
  PERCENTILE_DISC(.75) WITHIN GROUP (ORDER BY agent.salary)
FROM agent;
```

Question 5 (5 points): **Give an estimate of the number of rows in agent with salary < 92000, assuming in a uniform distribution in each quartile determined in Question 4. Explain how you derived your estimate. (Uniform distribution means values are evenly distributed between the min and max.)**

Using the quartiles from Question 4, we found that the 75th is at 89,643 which is very close to the target value of 92,000. Because of this, we can estimate that at least 75% of the rows in agent have a salary < 92,000:

total rows * .75 = 662 * .75 = 496.5

Since we can only have whole values for rows, we ignored the decimal and estimated that there are 496 rows in the agent table with a salary < 92,000.

Question 6 (5 points): **How many rows in the agent table actually have salary < 92000?**

Rows with salary < 92000: 572

Query:

SELECT COUNT(*)
FROM agent
WHERE salary < 92000;

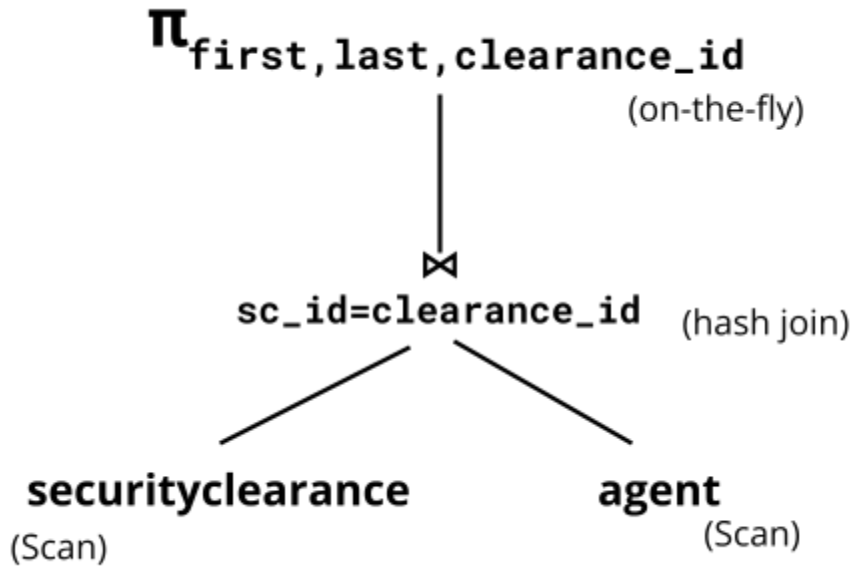
Part III: Query Plans, cont'd – 60 points

Following on the query plans work from HW 5 and using the same set of queries, please do the following. For each SQL statement below, draw the query plan PostgreSQL uses (you can find the query plan with the EXPLAIN command See Documentation: 14: EXPLAIN Also, see slide 19 in Slides 12 for and Activities for Slides 12 for information about Explain). For each plan, suggest a reason that the particular join algorithms were chosen.

Question 7 (20 points):
SELECT A.first, A.last, A.clearance_id
FROM agent A, securityclearance S
WHERE A.clearance_id = S.sc_id

```
fall2021db96=> EXPLAIN
fall2021db96-> SELECT A.first, A.last, A.clearance_id
fall2021db96-> FROM agent A, securityclearance S
fall2021db96-> WHERE A.clearance_id = S.sc_id;
                                QUERY PLAN
---------------------------------------------------------------------------
 Hash Join  (cost=1.16..18.57 rows=662 width=17)
   Hash Cond: (a.clearance_id = s.sc_id)
   ->  Seq Scan on agent a  (cost=0.00..14.62 rows=662 width=17)
   ->  Hash  (cost=1.07..1.07 rows=7 width=4)
         ->  Seq Scan on securityclearance s  (cost=0.00..1.07 rows=7 width=4)
(5 rows)
```

Query Plan:

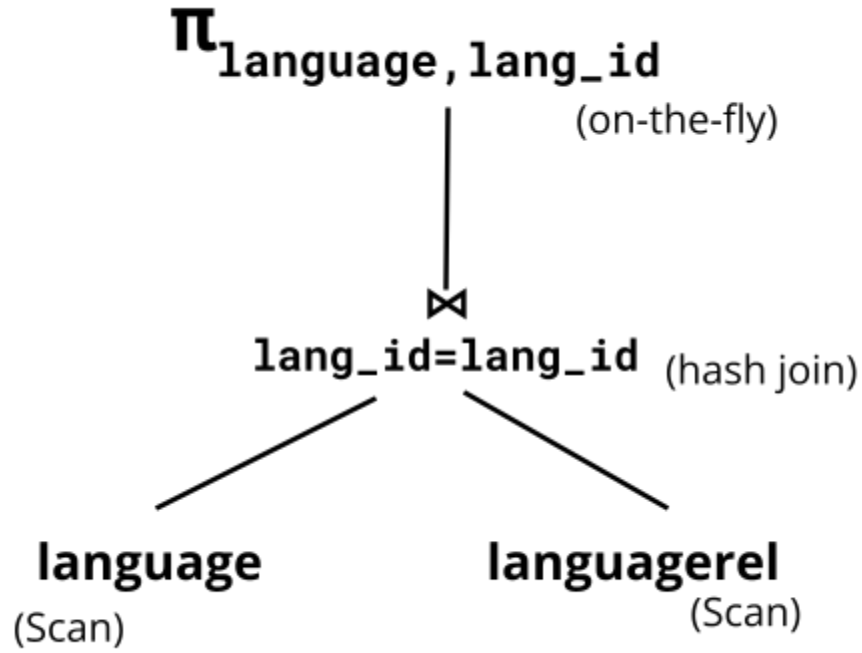


Reason to Choose Hash Join Algorithm:
securityclearance is a very small table (7 rows), and agents is one of the larger tables in the spy schema (662 rows). Hash join is a good choice for joining two relations when one of the relations is small and the other relation is large.

Question 8 (20 points):
SELECT L.language, L.lang_id
FROM language L, languagerel LR
WHERE L.lang_id = LR.lang_id;

```
fall2021db96=> EXPLAIN
fall2021db96-> SELECT L.language, L.lang_id
fall2021db96-> FROM language L, languagerel LR
fall2021db96-> WHERE L.lang_id = LR.lang_id;
                                QUERY PLAN
---------------------------------------------------------------------------
 Hash Join  (cost=1.45..36.70 rows=1991 width=62)
   Hash Cond: (lr.lang_id = l.lang_id)
   ->  Seq Scan on languagerel lr  (cost=0.00..28.91 rows=1991 width=4)
   ->  Hash  (cost=1.20..1.20 rows=20 width=62)
         ->  Seq Scan on language l  (cost=0.00..1.20 rows=20 width=62)
(5 rows)
```

Query Plan:

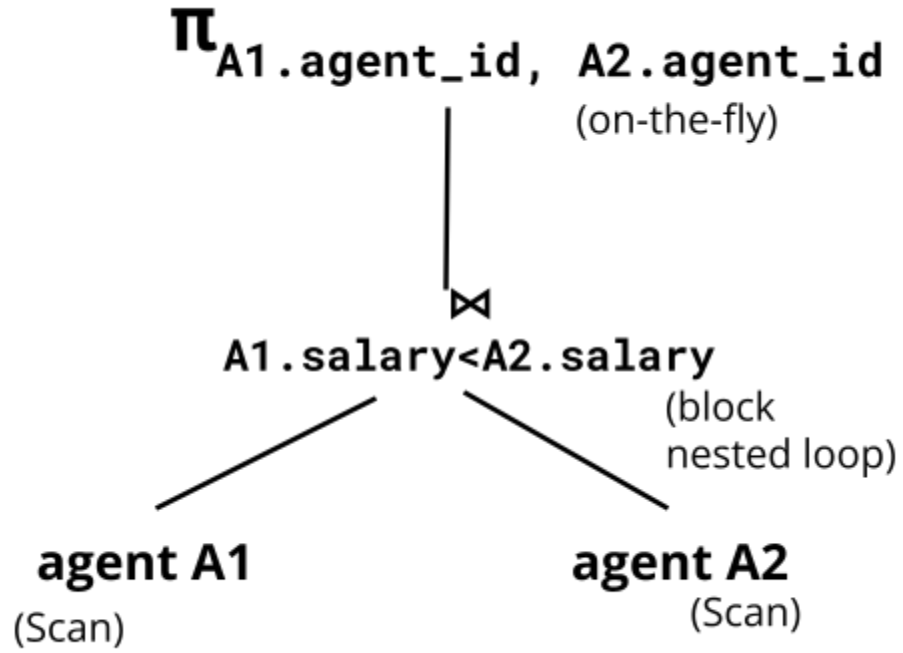


Reason to Choose Hash Join Algorithm:
language is a small table (20 rows), and *languagerel* is the largest table in the *spy* schema (1991 rows). Hash join is a good choice for joining two relations when one of the relations is small and the other relation is large.

Question 9 (20 points):
SELECT A1.agent_id, A2.agent_id
FROM agent A1, agent A2
WHERE A1.salary < A2.salary

```
fall2021db96=> EXPLAIN
fall2021db96-> SELECT A1.agent_id, A2.agent_id
fall2021db96-> FROM agent A1, agent A2
fall2021db96-> WHERE A1.salary < A2.salary;
                            QUERY PLAN
------------------------------------------------------------------------
 Nested Loop  (cost=0.00..6604.56 rows=146081 width=8)
   Join Filter: (a1.salary < a2.salary)
   ->  Seq Scan on agent a1  (cost=0.00..14.62 rows=662 width=8)
   ->  Materialize  (cost=0.00..17.93 rows=662 width=8)
         ->  Seq Scan on agent a2  (cost=0.00..14.62 rows=662 width=8)
(5 rows)
```

Query Plan:



Reason to Choose Block Nested Loop Join Algorithm:
This query does not use an equi-join, and block nested loop is the go-to choice for queries that have JOINs that are not equi-joins.