

Query Planning: Part 2 (Joins)

Overview

- ❖ Query usually divided in to SELECT query blocks for optimization (there are exceptions)
- ❖ For each block we consider:
 - ❖ each relation in FROM clause: all available access paths
 - ❖ [a hopefully good subset of] all join trees (considering all permutations and applicable join methods)

Enumeration of Alternative Plans

- ❖ Some strategy is needed to reduce the search space
- ❖ Exhaustive search possible for small number of relations
 - ❖ Heuristics are needed to reduce search space
- ❖ Estimate the cost of each plan
 - ❖ estimate cost of each operator
 - ❖ depends on input cardinalities, sorting
 - ❖ estimate the size of result

Join Plans - Heuristics

- ❖ System R (IBM) approach
 - ❖ Think of join plans as operator trees
 - ❖ Consider only “left-deep” plans
 - ❖ each join has at least one “base table”
 - ❖ joining one relation at a time in any order
- ❖ Avoid cross (cartesian) products

Example

- ❖ `SELECT *`
`FROM t0, t1, t2, t3`
`WHERE t0.pk = t1.fk AND t1.pk = t2.fk1 AND t2.fk2 = t3.pk`
`AND t0.c = 100 AND t3.e = 200;`
- ❖ t0 is 10K rows, t0.c = 100 has 1 / 100 selectivity => t0r is 100 rows
- ❖ t1 is 1M rows
- ❖ t2 is 10M rows
- ❖ t3 is 100K rows, t3.e = 200 has 1 / 200 selectivity => t3r is 500 rows

$$100000/200 = 500$$

Pass 1

- ❖ t_0 is 10K rows, $t_0.c = 100$ has $1/100$ selectivity $\Rightarrow t_{0r}$ is 100 rows.
 - ❖ form t_{0r} with best available access path
 - ❖ compare Index access (if available) to table Scan
- ❖ t_1 is 1M rows
- ❖ t_2 is 10M rows
- ❖ t_3 is 100K rows, $t_3.e = 200$ has $1/200$ selectivity $\Rightarrow t_{3r}$ is 500 rows
 - ❖ form t_{3r} with best available access path
 - ❖ compare Index access (if available) to table scan

Pass 2 - 2 table joins

- ❖ Six combinations - commit to the best way of joining pair
- ❖ t_0 join t_1 result size = 10000; cost = $t_{0r} + t_1 = 1,000,100$
- ❖ t_0 join t_2 result size = 10000000000; cost = $t_{0r} + t_2 = 10,000,100$
- ❖ t_0 join t_3 result size = 50000; cost = $t_{0r} + t_{3r} = 600$
- ❖ t_1 join t_2 result size = 100000000; cost = $t_1 + t_2 = 1,1000,000$
- ❖ t_1 join t_3 result size = 5000000000; cost = $t_1 + t_{3r} = 1,000,500$
- ❖ t_2 join t_3 result size = 50000; cost = $t_2 + t_{3r} = 10,000,500$

Pass 3 - 3 table joins

- ❖ $t_0 \text{ join } t_1 \text{ join } t_2$ result rows = 100000; cost = $t_0 \text{ join } t_1$ cost + read result + read t_2 cost = 11,010,100
 - ❖ $t_0 \text{ join } t_2 \text{ join } t_1$ result rows = 100000; cost 1011000100
 - ❖ $t_1 \text{ join } t_2 \text{ join } t_0$ result rows = 100000; cost 21000100
- ❖ $t_0 \text{ join } t_1 \text{ join } t_3$ result rows = 5000000; cost = $t_0 \text{ join } t_1$ cost + read result + read t_3 cost = 1,010,600
 - ❖ $t_0 \text{ join } t_3 \text{ join } t_1$ result rows = 5000000; cost 1050600
 - ❖ $t_1 \text{ join } t_3 \text{ join } t_0$ result rows = 5000000; cost 501000600
- ❖ $t_0 \text{ join } t_3 \text{ join } t_2$ result rows = 5000000; cost = $t_0 \text{ join } t_3$ cost + read result + read t_2 cost = 10,050,600
 - ❖ $t_2 \text{ join } t_3 \text{ join } t_0$ result rows = 5000000; cost 10050600
 - ❖ $t_0 \text{ join } t_2 \text{ join } t_3$ result rows = 5000000; cost 1010000600
- ❖ $t_2 \text{ join } t_3 \text{ join } t_1$ result rows = 50000; cost = $t_2 \text{ join } t_3$ cost + read result + read t_1 cost = 11,050,500
 - ❖ $t_1 \text{ join } t_2 \text{ join } t_3$ result rows = 50000; cost 21000500
 - ❖ $t_1 \text{ join } t_3 \text{ join } t_2$ result rows = 50000; cost 511000500

4th Pass - 500 result rows

- ❖ $t_0 \text{ join } t_1 \text{ join } t_2 (100K) \text{ join } t_3$
 - ❖ $\text{cost} = 11,010,100 + \text{read result } 100K + \text{read } t_3 (500) = 11,110,600$
- ❖ $t_0 \text{ join } t_1 \text{ join } t_3 (5M) \text{ join } t_2$
 - ❖ $\text{cost} = 1,010,600 + \text{read result } 5M + \text{read } t_2 (10M) = 16,010,600$
- ❖ $t_0 \text{ join } t_3 \text{ join } t_2 (5M) \text{ join } t_1$
 - ❖ $\text{cost} = 10,050,600 + \text{read result } 5M + \text{read } t_1 (1M) = 16,050,600$
- ❖ $t_2 \text{ join } t_3 \text{ join } t_1 (50K) \text{ join } t_0$
 - ❖ $\text{cost} = 11,050,500 + \text{read result } 50K + \text{read } t_0 (100) = 11,100,600$

System R – left deep plans

- ❖ Enumerated using N passes (if N relations joined):
 - ❖ Pass 1: Find best 1-relation plan for each relation.
 - ❖ Pass 2: Find best way to join result of each 1-relation plan to another relation. (All 2-relation plans.)
 - ❖ Pass N : Find best way to join result of a $(N-1)$ -relation plan to the N 'th relation. (All N -relation plans.)
- ❖ For each subset of relations, retain only:
 - ❖ Cheapest plan overall, plus
 - ❖ Cheapest plan for each *interesting order* of the tuples.
 - ❖ sort-order information is useful for group-by, order-by and even joins
- ❖ Cartesian (cross) products considered at the end

Another Approach

- ❖ Evaluate (exhaustively) all N-way joins for the least costly join
 - ❖ If there are M tables: $\binom{M}{N}$ such combinations
 - ❖ Choose the least expensive of them
- ❖ Commit the least-costly join of the least costly N-way join.
- ❖ Replace the two source relations used in the join with their resulting joined relation.
- ❖ Loop through the process until only one relation remains.

all 3 way joins

- ❖ $t_0 \text{ join } t_1 \text{ join } t_2 \text{ result rows} = 100000$; cost = $t_0 \text{ join } t_1 \text{ cost} + \text{read result} + \text{read } t_2 \text{ cost} = 11,010,100$
 - ❖ $t_0 \text{ join } t_2 \text{ join } t_1 \text{ result rows} = 100000$; cost 1011000100
 - ❖ $t_1 \text{ join } t_2 \text{ join } t_0 \text{ result rows} = 100000$; cost 21000100
- ❖ $t_0 \text{ join } t_1 \text{ join } t_3 \text{ result rows} = 5000000$; cost = $t_0 \text{ join } t_1 \text{ cost} + \text{read result} + \text{read } t_3 \text{ cost} = 1,010,600$
 - ❖ $t_0 \text{ join } t_3 \text{ join } t_1 \text{ result rows} = 5000000$; cost 1050600
 - ❖ $t_1 \text{ join } t_3 \text{ join } t_0 \text{ result rows} = 5000000$; cost 501000600
- ❖ $t_0 \text{ join } t_3 \text{ join } t_2 \text{ result rows} = 5000000$; cost = $t_0 \text{ join } t_3 \text{ cost} + \text{read result} + \text{read } t_2 \text{ cost} = 10,050,600$
 - ❖ $t_2 \text{ join } t_3 \text{ join } t_0 \text{ result rows} = 5000000$; cost 10050600
 - ❖ $t_0 \text{ join } t_2 \text{ join } t_3 \text{ result rows} = 5000000$; cost 1010000600
- ❖ $t_2 \text{ join } t_3 \text{ join } t_1 \text{ result rows} = 50000$; cost = $t_2 \text{ join } t_3 \text{ cost} + \text{read result} + \text{read } t_1 \text{ cost} = 11,050,500$
 - ❖ $t_1 \text{ join } t_2 \text{ join } t_3 \text{ result rows} = 50000$; cost 21000500
 - ❖ $t_1 \text{ join } t_3 \text{ join } t_2 \text{ result rows} = 50000$; cost 511000500

Next Iter: (t0 join t1) join t2 join t3

- ❖ ((t0 join t1) join t2) join t3
 - ❖ cost 11,110,600
- ❖ (t0 join t1) join (t2 join t3)
 - ❖ cost 11,060,600
- ❖ ((t0 join t1) join t3) join t2
 - ❖ cost 16,010,600