CS386D Problem Set #1

[1] Consider the following query:

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select * from A a, B b, C c, D d
where a.X=b.X and b.Y=c.Y and c.Z=d.Z and d.W=A.W
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(a) List *all* of the logical access plans are examined by the System R optimizer. Hint: *do not show the stream ordering and join predicate parameters in your expressions. Follow the analysis in the class notes (choose a sink and find all 1-relation queries, then prune, 2-relation queries, then prune, etc.)*

(b) What logical access plans are *not* examined by the System R optimizer? Why are they are not considered?

[2] Consider a linear query graph. What is the size of the search space that System R examines? (or how many plans does System R generate)? Pick one question — they have different answers.

[3] Consider the following attributes, their cardinalities, and index storage structures:

Attribute	**Cardinality**	**Storage Structure**
A	20	B+ trees
B	2000	B+ trees
C	2000	hash
D	20	Not Indexed

Now consider the following local predicates. For each predicate, what index would you use (if any) to most efficiently retrieve the tuples that satisfy this predicate:

(a) B=3 or B=4

(b) B= 66 and C=12

(c) B>3 and C>77

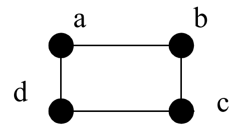
(d) B=22 and A = 15

(e) D=44 and B>34

[4] Suppose join predicates are of the form "A or B or C or ..." where A, B, C, ... are typical conjunctive join predicates. How would you generalize the System R algorithm to process such queries?

solution

[1a]



1 relation queries are a, b, c, d

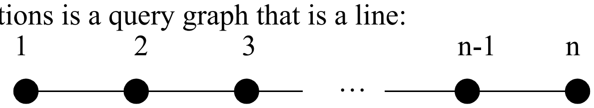
2 relation queries are a-b, a-d, b-a, b-c, c-b, c-d, d-a, d-c
pruning: ab = min(a-b,b-a), bc = min(b-c, c-b), cd = min(c-d, d-c), ad = min(a-d,d-a)

3 relation queries are: ab-c, ab-d, bc-a, bc-d, cd-a, cd-b, ad-b, ad-c
pruning: abc = min(ab-c, bc-a), abd = min(ab-d, ad-b), bcd = min(bc-d, cd-b), acd = min(cd-a, ad-c)

4 relation queries are: abc-d, adb-c, bcd-a, acd-b
pruning abcd = min(abc-d, adb-c, bcd-a, acd-b)

[1b] system r produces left-deep operator trees (meaning that the right operation is a retrieval, never a join). So a plan never considered is ((a,b),(c,d)) i.e., join(join(a,b), join(c,d))

[2] A *linear query* of n relations is a query graph that is a line:



How many distinct logical access plans (or equivalently, join orderings) could be produced by the System R algorithm for a linear query of *n* relations? You are to ignore stream orderings and simply consider the number of distinct orders in which relations can be joined. Define a (closed-form) formula for *S(n)*. You may find the following identity helpful:

$$2^k = \sum_{i=0}^{k} \binom{k}{i}$$

Let node *i* be the sink node. There are *i-1* nodes to the "left" of *i* and *n-i* nodes to the right. There are $\binom{n-1}{i-1}$ ways of forming a logical access plan, given node *i* as a sink. Reason: fixing *i*, nodes can be dragged down the sink in any order of listing from right to left. Summing over all positions for *i*, we have the total number of logical plans that can be created:

$$S(n) = \sum_{i=1}^{n} \binom{n-1}{i-1}$$

It follows that $S(n) = 2^{n-1}$.

Another way to interpret this question is how many plans are actually generated (i.e., taking into account pruning). The number of plans for 1 relation is *n*. The number of plans for 2 relations (before pruning) is approx n-1+n-1= 2*(n-1). Note: for a line of n nodes, only n-1 nodes can be joined with a node to the right, and only n-1 nodes can be joined to the left. The number of plans for 3 relations is n-2+n-2=2*(n-2). For i relations, there are 2*(n-i+1) plans. Summing, the complexity is $O(n^2)$.

[3] Consider the following attributes, their cardinalities, and index storage structures:

Attribute	Cardinality	Storage Structure
A	20	B+ trees
B	2000	B+ trees
C	2000	hash
D	20	Not Indexed

Now consider the following local predicates. For each predicate, what index would you use (if any) to most efficiently retrieve the tuples that satisfy this predicate:

(a) B=3 or B=4 -- either scan or use B index twice

(b) B= 66 and C=12 -- C would be fastest (if you use 1 index). You could use multiple indices and take the intersection of their pointers.

(c) B>3 and C>77 -- scan

(d) B=22 and A = 15 -- use B index (could intersect lists, but this is not clear that even creating an index for A is that useful).

(e) D=44 and B>34 -- scan

[4] There are a variety of answers that you could postulate. The “framework” of System-R is extraordinarily robust. Just as a join predicate (A.x = B.y and A.z=B.w) could be supplied as an argument to a join operation (e.g., JOIN(A,B, A.x=B.y and A.z=B.w)), there’s no reason why (A.x=B.y or A.z=B.w) could be provided as an argument to a join operation (e.g., JOIN(A,B, A.x=B.y or A.z=B.w)). The trick here is what algorithm could you use to process this join predicate. Nested loops would work just fine. As a possible future problem, is there a reasonable generalization of merge-join and/or hash-join to deal with such join predicates?

You could have other, more drastic solutions: you could allow cross-product edges with join predicate labels. They would be considered first, before pure or unrestricted cross products.

There is even a rather simple generalization of System-R algorithm to allow an additional operation that takes a stream S and predicate P (join predicate, relation predicate, mix of the two) and produces a stream where only records of S that satisfy P are output.

There is no end to the creativity of how this could be accomplished. If you don’t see such possibilities, as I list above, please (by all means) ask in class. If you do understand my points, you have a very good understanding of this material.