Query Optimization

Exercise Session 5

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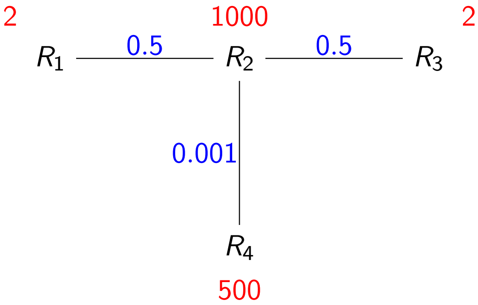
Example: Bushy with cross product



DPsub

- Iterate over subsets in the integer order
- Before a join tree for S is generated, all the relevant subsets of S must be available

DPsub

DPsub(R)
Input: a set of relations $R = \{R_1, \ldots, R_n\}$ to be joined
Output: an optimal bushy join tree
B = an empty DP table $2^R \rightarrow$ join tree
for each $R_i \in R$
  $B[\{R_i\}] = R_i$
for each $1 < i \leq 2^n - 1$ **ascending** {
  $S = \{R_j \in R | (\lfloor i/2^{j-1} \rfloor \mathit{mod}\, 2) = 1\}$
  for each $S_1 \subset S, S_2 = S \setminus S_1$ {
    if $\neg$cross products $\wedge \neg S_1$ connected to S_2 **continue**
    $p_1 = B[S_1], p_2 = B[S_2]$
    if $p_1 = \epsilon \vee p_2 = \epsilon$ **continue**
    P = CreateJoinTree(p_1, p_2);
    if $B[S] = \epsilon \vee C(B[S]) > C(P)$ $B[S] = P$
  }
}
return $B[\{R_1, \ldots, R_n\}]$

Implementation: DPsize

- dbTable - the vector of lists of Problems, each Problem is either a relation or a join of Problems
- lookup (hashtable) - mapping the set of the relations to the best solution and its cost
- initialize dpTable[0] with the list of R1, ..., Rn
- set the size of dpTable to n

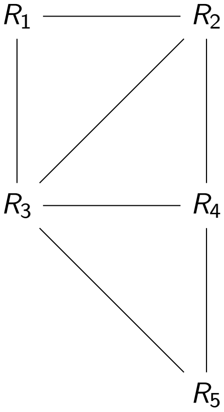
Implementation: DPsize

```
for (i = 1; i < dpTable.size(); i++)
    for (j=0; j < i; j++)
        for (leftRel in dpTable[j])
           for (rightRel in dpTable[i-j-1])
              can we join leftRel and rightRel?
              check lookup for solution and cost
              if the current is cheaper:
                 dpTable[i].add(leftRel join rightRel)
                 update lookup
```

DPccp

- Enumerate over all connected subgraphs
- For each subgraph enumerate all other connected subgraphs that are disjoint but connected to it

Connected Subgraph Enumeration



Connected Subgraph Enumeration

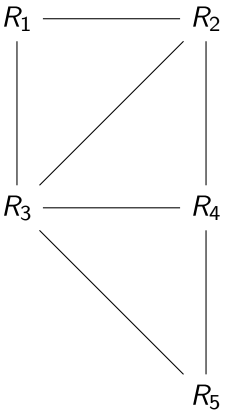
- Nodes in the query graph are ordered according to a BFS
- Start with the last node, all the nodes with smaller ID are forbidden
- At every step: compute neighborhood, get forbidden nodes, enumerate subsets of non-forbidden nodes N
- Recursive calls for subsets of N

Connected Subgraph Enumeration

EnumerateCsg(G)
for all $i \in [n-1, \ldots, 0]$ **descending** $\{$
  emit $\{v_i\}$;
  EnumerateCsgRec(G, $\{v_i\}$, $\mathcal{B}_i$);
$\}$

EnumerateCsgRec(G, S, X)
$N = \mathcal{N}(S) \setminus X$;
for all $S' \subseteq N$, $S' \neq \emptyset$, enumerate subsets first $\{$
  emit $(S \cup S')$;
$\}$
for all $S' \subseteq N$, $S' \neq \emptyset$, enumerate subsets first $\{$
  EnumerateCsgRec(G, $(S \cup S')$, $(X \cup N)$);
$\}$

Connected Subgraph Enumeration



Enumerating Complementary Subgraphs

EnumerateCmp(G,S_1)
$X = \mathcal{B}_{\min(S_1)} \cup S_1$;
$N = \mathcal{N}(S_1) \setminus X$;
for all ($v_i \in N$ by descending i) {
    emit $\{v_i\}$;
    EnumerateCsgRec(G, $\{v_i\}$, $X \cup (\mathcal{B}_i \cap N)$);
}

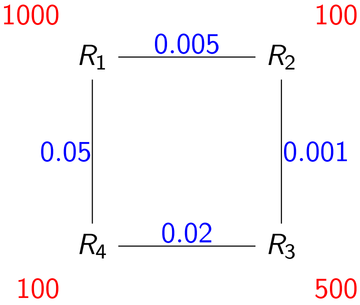
- EnumerateCsg+EnumerateCmp produce all ccp
- resulting algorithm DPccp considers exactly #ccp pairs
- which is the lower bound for all DP enumeration algorithms

Graph simplification

Sometimes the graph is too big, let's simplify it.

- GOO: choose the joins greedily (very hard, depends on all other joins)
- Simplification: choose the joins that must be avoided (we can start with 'obvious' decisions)

Graph simplification: Example



- $benefit(X \bowtie R_1, X \bowtie R_2) = \frac{C((X \bowtie R_1) \bowtie R_2)}{C((X \bowtie R_2) \bowtie R_1)}$
- $R_3 \bowtie R_2$ before $R_3 \bowtie R_4$. Remove $R_4 - R_3$
- $R_4 \bowtie (R_2 \bowtie R_3)$ before $R_4 \bowtie R_1$. Remove $R_1 - R_4$
- no more choices

$|R_1 \bowtie R_4| = 5000$, $|R_1 \bowtie R_2| = 500$, $|R_2 \bowtie R_3| = 50$, $|R_3 \bowtie R_4| = 1000$

More insights

- Guido Moerkotte, Thomas Neumann. Analysis of Two Existing and One New Dynamic Programming Algorithm. In VLDB'06
- Guido Moerkotte, Thomas Neumann. Dynamic Programming Strikes Back. In *SIGMOD'08*
- Thomas Neumann. Query Simplification: Graceful Degradation for Join-Order Optimization. In *SIGMOD'09*

Homework: Task 1 (10 points)

Create the DP table (manually) for the relations A, B, C with cardinalities $|A| = 10$, $|B| = 20$, $|C| = 100$ and selectivities $f_{AB} = 0.5$, $f_{BC} = 0.1$ (cost function C_{out}). Mark the final table entries. Enumerate subsets in the integer order. Consider cross products.

Homework: Task 2 & 3 (20 points)

- Using the program from the last exercise as basis, implement Greedy Operator Ordering. Print the partial steps together with their costs (e.g., $P = R_1 \bowtie R_2 200, Q = P \bowtie R_3 400$), as well as the final join tree.
- Load the TPC H data set. (You can use our snapshot of the data set, the loadtpch-* script loads the data). Then, execute the following SQL query using the program implemented above:
- ```
  select *
    from lineitem l, orders o, customers c
    where l.l_orderkey=o.o_orderkey
      and o.o_custkey=c.c_custkey
      and c.c_name='Customer#000014993'.
  ```
  ```

Info

- Exercises due: 9 AM, December 12, 2016