Rate-Based Query Optimization for Streaming Information Sources

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Query Optimization

Query Parser

Parsed query

Query Optimizer

Plan Generator

Plan Cost Estimator

Evaluation plan

Query Plan Evaluator

System Catalog
Cardinality Based vs. Rate Based
Cost Estimation
Let us consider two select operations A and B. Assume that the selectivity for A is 0.1 and B is 0.2 and that the input size is 500.

\[
\text{Cost (A} \rightarrow \text{B)} = 500 \times c_{\text{A}} + 500 \times 0.1 \times c_{\text{B}} \\
\text{Cost (B} \rightarrow \text{A)} = 500 \times c_{\text{B}} + 500 \times 0.2 \times c_{\text{A}}
\]
Assume that the selectivity of each of A and B is 0.1; input arrives at 500 tuples per second; A can process 50 inputs per second and B can process data as fast as it receives it.
Size of input is infinite

⇒ Cost of each plan is infinite
(a) Output rate = 0.5 outputs per second
(b) Output rate = 5 outputs per second
“What is the cost of this query plan?”

“What is the expected output rate of this query plan?”
Estimating Output Rates

Output rate = \frac{\text{Number of outputs transmitted}}{\text{Time needed to make the transmission}}

Table 1: Cost variables used in the estimation of output rates

<table>
<thead>
<tr>
<th>Cost Variable</th>
<th>Meaning</th>
<th>( r_0 )</th>
<th>( r_i )</th>
<th>( r_r )</th>
<th>( r_l )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{\pi} )</td>
<td>Cost of projecting parts of an input object</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( C_{\sigma} )</td>
<td>Cost of performing a selection on an input object</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( C_l )</td>
<td>Cost of handling an input coming from the left-hand side of a join</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( C_r )</td>
<td>Cost of handling an input coming from the right-hand side of a join</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( T )</td>
<td>Cost of making a single transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( r_0 \) Output Rate
\( r_i \) Input Rate
\( r_r \) Right Input Rate
\( r_l \) Left Input Rate
Estimating Output Rates

**Projections**
\[ r_o = r_i \]

**Selections**
\[ r_o = f \cdot r_i \]

**Joins**
\[ r_o = \frac{f \cdot r_l \cdot r_r \cdot t}{r_l \cdot C_l + r_r \cdot C_r} \]
Rate Based Optimization

Optimize for a specific time point in the execution process using local rate maximization

Optimize for output production size using local time minimization
Experimental Validation
Rate Based Cost Model
Experimental Validation

Does the cost model correctly estimate individual plan performance?

Is the framework capable of providing correct decisions regarding the best choice among a set of plans?
5 XML data sources
Wide range of selectivities

<table>
<thead>
<tr>
<th>Source</th>
<th>Number of tuples</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5,000</td>
<td>0.7 MB</td>
</tr>
<tr>
<td>B</td>
<td>10,000</td>
<td>1.5 MB</td>
</tr>
<tr>
<td>C</td>
<td>20,000</td>
<td>1.8 MB</td>
</tr>
<tr>
<td>D</td>
<td>50,000</td>
<td>5.9 MB</td>
</tr>
<tr>
<td>E</td>
<td>100,000</td>
<td>9.3 MB</td>
</tr>
</tbody>
</table>
5 Way Equi Join

(a) Left Deep

(b) Fast Leaves

(c) Evenly Spread
<table>
<thead>
<tr>
<th>Plan</th>
<th>Traditional Estimation</th>
<th>Rate-Based estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Deep</td>
<td>$10^4$</td>
<td>$1.3 \cdot 10^3$</td>
</tr>
<tr>
<td>Fast Leaves</td>
<td>$2 \cdot 10^3$</td>
<td>$9.7 \cdot 10^2$</td>
</tr>
<tr>
<td>Evenly Spread</td>
<td>$5 \cdot 10^3$</td>
<td>$8.8 \cdot 10^2$</td>
</tr>
</tbody>
</table>
Rate Based Estimation is the way to go!
Any questions?