Oracle Query Processing and Optimization

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Outline

• Some basic topics
  • Query transformations
  • Search space
  • Uncertainty

• Examples of “advanced” issues
  • Plan stability
  • Cost model
  • Optimization criteria
  • SQL Tune
Query Transformations

• Query transformations convert SQL statements into semantically equivalent statements that can result in more efficient access paths
  • Examples: subquery-to-join transformations, MV rewrite

• Query optimization is a mixture of techniques at different levels
  • Query transformations easier early
  • Access path selection easier later
  • But transformations should be cost based and access path selection is necessary to generate cost estimates

• Oracle includes query transformations as part of the cost-based search space
  • Mainly software-engineering challenges
Search Space

- Large space of possible access paths, join methods, and orderings for large queries
- Global effects of local decisions
  - Choice of join method in the middle of the join order may affect whether you can eliminate an ORDER BY sort
  - Hence, just picking the locally least expensive join method may not give the lowest global cost
- Bushy join trees
  - Bushy trees are sometimes optimal, but considering them increases the search space and complexity of the optimizer
- Substantial research results in this area
Search Space in Oracle

- Left-deep trees unless query is inherently bushy or plan has hash joins
- Exhaustive search of join orderings for small joins
- Initial ordering heuristics and cut-off based on best plan so far
  - Does a very good job of keeping search space problems in check
- Avoid considering Cartesian products for large joins
- Separate passes for global effects like row ordering for ORDER BY
- Includes query transformations and MV rewrites
Uncertainty about Cardinalities

- Can lead to bad join orders, bad join methods, and bad access paths
- Problem of computing accurate estimates for intermediate result sets
- Information about tables based on statistics
  - Correlation between columns unknown
    WHERE TITLE = 'MANAGER' AND SAL < 40000
  - Hard to know properties of join results for multiple joins
  - Difficult predicates WHERE ENAME LIKE '%SMITH%'
  - Bind variables WHERE SAL < :1
  - Missing statistics
Relevant Oracle Features

• Dynamic sampling for correlation, difficult predicates, and missing statistics
• Multicolumn statistics for correlation
• Bind peeking for bind variables
• SQL Tune (more later)
• Automatic gathering of statistics
  • Detection of stale statistics
  • Definition of stale is tricky
  • Efficient techniques for actual gathering including synopses
## Motivating Example: Oracle E-Business Suite

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Count:</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIALIZED VIEW</td>
<td>402</td>
</tr>
<tr>
<td>TYPE</td>
<td>584</td>
</tr>
<tr>
<td>JAVA CLASS</td>
<td>891</td>
</tr>
<tr>
<td>TABLE</td>
<td>21,980</td>
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<tr>
<td>INDEX</td>
<td>40,078</td>
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<td>TRIGGER</td>
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<td>VIEW</td>
<td>28,281</td>
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<tr>
<td>PACKAGE BODY</td>
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<tr>
<td>PACKAGE</td>
<td>41,939</td>
</tr>
<tr>
<td><strong>Queries</strong></td>
<td><strong>515,000</strong></td>
</tr>
</tbody>
</table>

Table references per query: AVG = 4  MAX = 232
Plan Stability

• Problem of improving the optimizer without risking that some queries deteriorate
• Customers don’t want something that works to be broken in a new release
• One query that deteriorates may outweigh improvements in all other queries
• Solutions to make database upgrades less risky:
  • Store plans – SQL Plan Management in Oracle
  • Versioning of optimizer behavior
Cost Model

- Affected by evolution of computer architecture
  - Originally focused on disk I/O
  - Large memory sizes makes for more in-memory processing
  - L-2 cache hit misses important for performance
  - Emergence of chips with large numbers of cores
  - Solid-state drives
  - Exadata – moving computation to storage

- Hardware evolution affects the adequacy of basic query processing algorithms

- Affects the optimizer’s cost model for both existing and new query processing algorithms
  - Painful to change model due to plan stability issues
Optimization Criteria

- What are we optimizing for?
  - Throughput on the system – use plans with the least resource consumption
  - Response time – use parallelism as much as possible
  - First batch of rows – avoid blocking operations
  - Avoiding catastrophic optimizer decisions – favor plans that avoid bad worst-case scenarios (No specific mode in Oracle but several optimizer heuristics)
- Determining the right degree of parallelism is difficult
  - Adaptive degree of parallelism vs. queuing
  - Also, adaptive memory management
- Not just an optimizer issue – need a model for queries with different response time priorities
  - Resource Management in Oracle
SQL Tune

- “Super-optimization” for “high-load” SQL
  - Go after statements that use up the most resources
- Intended for recurrent workloads and based on the notion of correcting optimizer cardinalities
- Spend time finding actual cardinalities using dynamic sampling and partial evaluation of queries
- Store correction factors for the optimizer to use when the query is optimized in the future
- Allows queries to be tuned without changing the query text
- Part of framework that includes advice about index creation, statistics gathering, query restructuring