Bench-Ranking:
Towards prescriptive analysis of big graph processing: the case of SparkSQL

The 14th LDBC TUC Meeting

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RDF data is exploding...

The Linked Open Data Cloud: https://lod-cloud.net/
Do you think that's a Graph you are querying?
Native Vs. Non-native (Relational) RDF Proc.

Native Triple Stores
- Centralized
- E.g, Jena, RDF3X,..

Big Relational Systems
- Not tailored for RDF Processing.
- E.g, Apache Spark, Hive, Impala.

Exploiting emergent schemas to make RDF systems more efficient, Minh Duc Pham*, Peter Boncz, ISWC 2016
Let's take (Apache Spark-SQL) as example

01 Schema
- Single Statement Table (ST)
- Vertically Partitioned Tables (VT)
- Property Tables (PT)

02 Partitioning
- Horizontal Partitioning (HP)
- Subject-based Partitioning (SBP)
- Predicate-based Partitioning (PBP)

03 Storage Formats
- Row-oriented (Avro, CSV).
- Columnar-oriented (ORC, Parquet).
Experimental Solution Space

\[ a \rightarrow b \rightarrow c \rightarrow \text{iii} \rightarrow \text{SBP} \rightarrow \text{PBP} \rightarrow 1 \rightarrow \text{Avro} \]
\[ a \rightarrow b \rightarrow c \rightarrow \text{iii} \rightarrow \text{SBP} \rightarrow \text{PBP} \rightarrow 2 \rightarrow \text{CSV} \]
\[ a \rightarrow b \rightarrow c \rightarrow \text{iii} \rightarrow \text{SBP} \rightarrow \text{PBP} \rightarrow 3 \rightarrow \text{ORC} \]
\[ a \rightarrow b \rightarrow c \rightarrow \text{iii} \rightarrow \text{SBP} \rightarrow \text{PBP} \rightarrow 4 \rightarrow \text{Parquet} \]
\[ a \rightarrow b \rightarrow c \rightarrow \text{iii} \rightarrow \text{SBP} \rightarrow \text{PBP} \rightarrow 5 \rightarrow \text{HIVE} \]

\[ \text{a.i.1} \Rightarrow \text{ST.HP.Avro} \]
Which configuration combination the best to choose ?!
The 4 Levels of Analysis

01 Descriptive Analysis
- Describe results (Which dimension was better).
- By how much.

02 Diagnostic Analysis
- Try to describe why it happened using the Domain knowledge.

03 Predictive Analysis
- Predict what will happen?!
- Applying ML and other stat.

04 Prescriptive Analysis
- What should be done?
  - E.g. what is the best conf

The 4 levels of Data Analytics: https://koopingshung.com/blog/four-levels-of-analytics-data-science-descriptive-diagnostic/
Looking at the descriptive analysis is not enough!
- looking at a lot of performance data might be overwhelming.
- Sometimes, **Contradicting results**.

**Dimensions Trade-offs**
There are always clear trade-offs between these dimensions.

**Selecting Best Combination**
Selecting the best configuration combination out of this complex solution space is not an easy task.

**Bench-Ranking: Simple Yet Accurate**
Bench-ranking criteria provide an accurate yet simple way that supports the practitioners in this task even in the existence of dimensions’ trade-offs.

**Firsts Steps of BD Ranking: Saleem et.al**
Saleem et al. Proposed a ranking criteria for ranking 7 approaches for Partitioning RDF graphs.

Individual Ranking Criteria

- For each dimension, we rank how the alternatives of this dimension are ranked.
- Example of Rank Scores.

\[
R = \sum_{r=1}^{d} \frac{O_{\text{dim}}(r) \cdot (d-r)}{Q(d-1)}, \quad 0 < R \leq 1
\]

<table>
<thead>
<tr>
<th>HP/Avro</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>Rank(R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>0.23</td>
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<tr>
<td>VT</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>0.73</td>
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<tr>
<td>PT</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>0.55</td>
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<table>
<thead>
<tr>
<th>ST/Avro</th>
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<th>2nd</th>
<th>3rd</th>
<th>Rank(R)</th>
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<tbody>
<tr>
<td>HP</td>
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<td>6</td>
<td>3</td>
<td>0.45</td>
</tr>
<tr>
<td>SBP</td>
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<td>3</td>
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<td>0.86</td>
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<tr>
<td>PBP</td>
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<td>2</td>
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<td>0.18</td>
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</table>

<table>
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<tr>
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<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>Rank(R)</th>
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<td>3</td>
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<td>Hive</td>
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<td>2</td>
<td>4</td>
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<td>0</td>
<td>0.77</td>
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</table>

Ranking towards each dimension (Rf, Rp, Rs)
Individual ranking Limitations

Rank_Schema (Rs)  Rank_Format (Rf)  Rank_Partition. (Rp)
Ranking Criteria Goodness Metrics

Conformance
1. Conformance with the actual query rankings

Coherence
2. How coherent the ranking across different dataset scales.
A ranking criterion “good” if it does not suggest a low-performing configuration.
We are interested to be the best at any particular query as long as we are never the worst.
The ranking criterion is confident if it’s top ranked configurations are not actually performing bad.

\[
A(R^k) = 1 - \sum_{i=0}^{Q} \sum_{j=0}^{k} \frac{\bar{A}(i,j)}{Q \times k}, \quad \bar{A}(i,j) = \begin{cases} 
1 & R^k[j] \in Q^i_h \\
0 & \text{otherwise}
\end{cases}
\]

<table>
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<tr>
<th>Conf</th>
<th>500M</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
<th>Q11</th>
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<td>30</td>
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<td>40</td>
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<tr>
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<td>42</td>
<td>39</td>
<td>37</td>
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<td>28</td>
<td>31</td>
<td>2</td>
<td>31</td>
<td>43</td>
<td>43</td>
</tr>
</tbody>
</table>

**Confs. Query Ranking**
Goodness example

Ranking by Storage (Rf)
2- Ranking Coherence

- We opt for **Kendall index**, which counts the number of pairwise disagreements between two rank sets.
- The larger the distance, the more dissimilar the rank sets are.

\[
K(\mathcal{R}_1, \mathcal{R}_2) = \sum_{\{i,j\} \in P} \frac{\bar{K}_{i,j}(\mathcal{R}_1, \mathcal{R}_2)}{|P|}
\]

\[
\bar{K}_{i,j}(\mathcal{R}_1, \mathcal{R}_2) = \begin{cases} 
0 & \mathcal{R}_1[r_i^1] = \mathcal{R}_2[r_i^2] = i \land \mathcal{R}_1[r_j^1] = \mathcal{R}_2[r_j^2] = j \land \ \\
      & r_i^1 - r_i^1 = r_i^2 - r_j^2 \\
1 & \text{otherwise}
\end{cases}
\]

Experiments showed that Individual ranking criteria have:

- High coherence.
- Low conformance.
Bench-Ranking as a multi-Objective Optimiz. Problem

- We look at the Bench-ranking as a multi-objective problem.
- We aim to maximize the three dimensions altogether.
- We opt for the standard Pareto Front algorithm (NSGA2).

An item of configuration combination

e.g, a.i.4

Conclusions

BD Prescriptive Analysis
There is still gap in BD Prescriptive analysis.

Case study
We worked the case study of Processing RDF graphs in the realm of Relational world (Apache Spark).

Bench-Ranking
Simple Yet accurate, in the cases of Selecting the best configuration combination out of this complex solution.
“All the models rankings are wrong but some of them are useful!”  

George Box-Ragab