Bao: Learning to Steer Query Optimizers

Ryan Marcus, Parimarjan Negi, Hongzi Mao, Nesime Tatbul, Mohammad Alizadeh, Tim Krask
Background: Query Optimization

- Query optimization in relational database systems
## Key Problem

<table>
<thead>
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<th>Query plan estimation</th>
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<td>Optimizing complicated joins</td>
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<tr>
<td>Handling dynamic workloads</td>
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<td>Improve tail performance</td>
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Solution: BAO

Bandit Optimizer using ML to give “hints” to query plan optimizer

Improves average-case performance

Improves tail performance
Previous Works/Novelty

• Improved cardinality estimation using neural networks [4]
• Neo: Neural Optimizer for entire query plan optimizer based on deep RL [5]
  • Performs poorly in tail performance
• Bao: “first learned query optimisation system that outperforms both open source and commercial systems in cost and latency, all while adapting to changes in workload, data, and schema” [2]
Approach

- Selects a set of hints within existing parameter space
- Predict execution time using tree convolutional neural networks
- Thompson sampling
Approach

Figure 4: Vectorized query plan tree (vector tree)
Approach

Figure 2: Bao system model
Results

- Improves average performance on open source and commercial systems
Results

• Avoids tail catastrophe problem

Figure 8: Percentile latency for queries, IMDb workload. Each column represents a VM type, from smallest to largest. The top row compares Bao against the PostgreSQL optimizer on the PostgreSQL engine. The bottom row compares Bao against a commercial database system on the commercial system’s engine. Measured across the entire (dynamic) IMDb workload.
Results

• Improvement over Neo
• Resiliency testing

(a) Stable query workload  (b) Dynamic query workloads
Summary

• Bao uses a hint optimization system
• Works within any existing optimization system
Pros

• Extensive testing
• Clear results
• Bao can easily adapt and generalize

Cons

• Restricted to traditional query plan
• Fixed number of hints
Impact and Future Work

• Impressive and novel system that makes significant optimization improvements
• 39 citations since 2020
• Learn to produce independent physical plans
  • Balsa [3]
Works Cited


Figure 5: Bao prediction model architecture