AutoSteer: Learned Query Optimization for Any SQL Database

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TUM Uhrenturm

Background – Steering Query Optimizers

Many Database Management Systems expose tunable optimizer knobs.

- Usually belong to *rewrite rules* of the rule-based optimizer
- Can be used to *steer* query optimization

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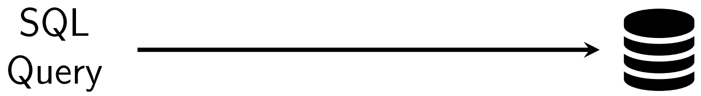

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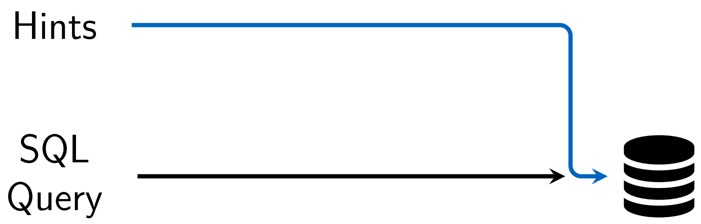

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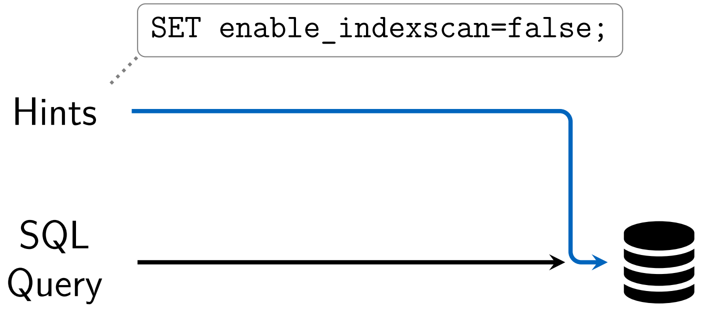

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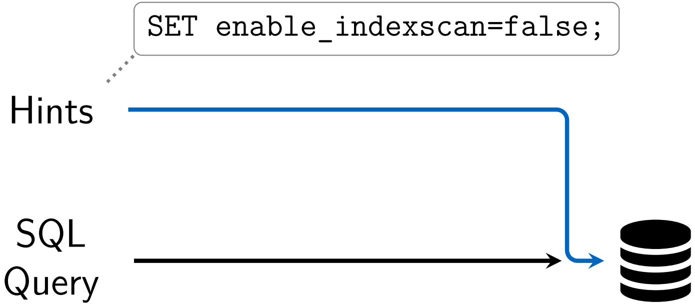

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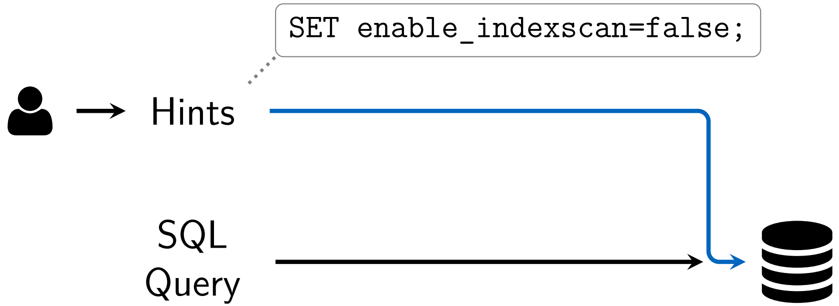

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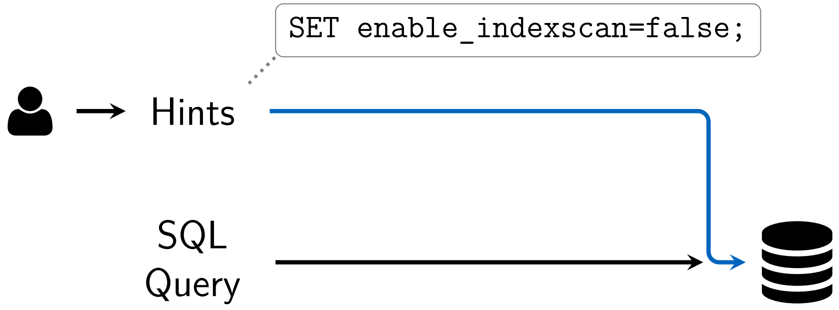

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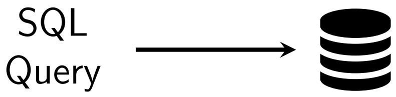

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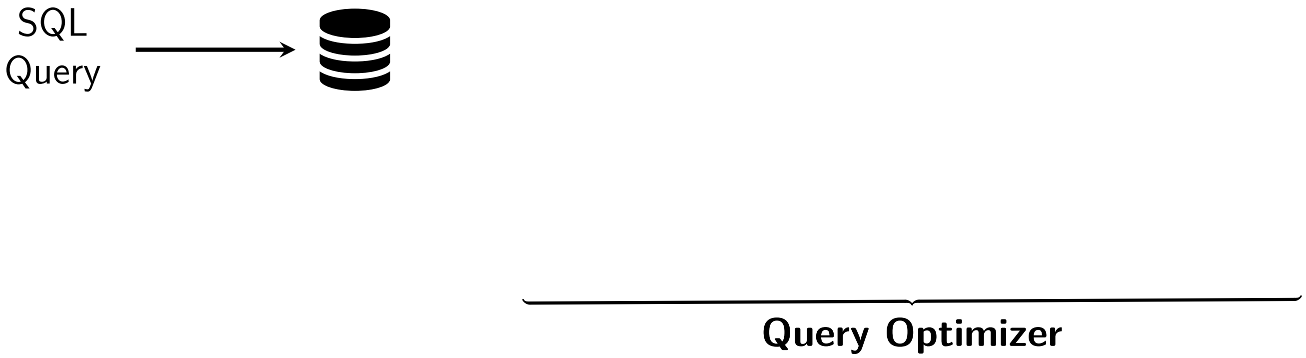

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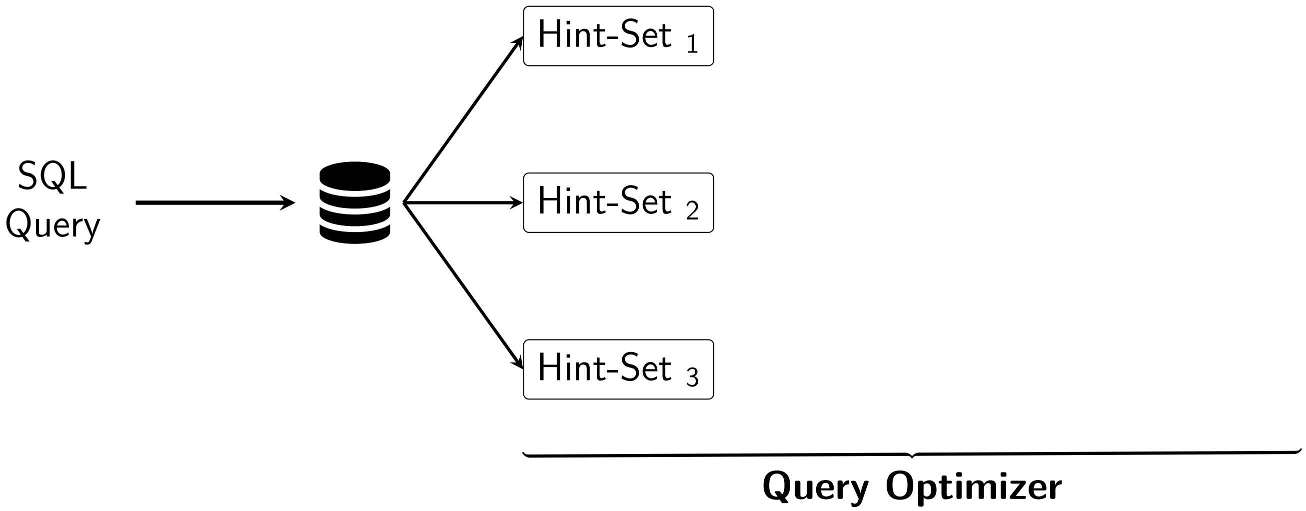

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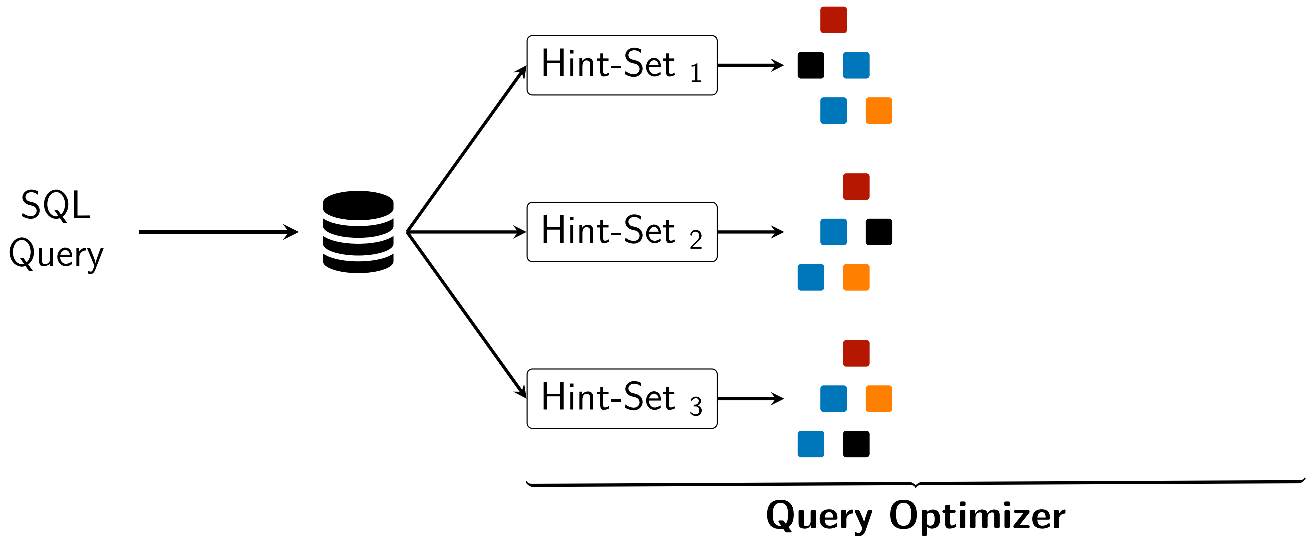

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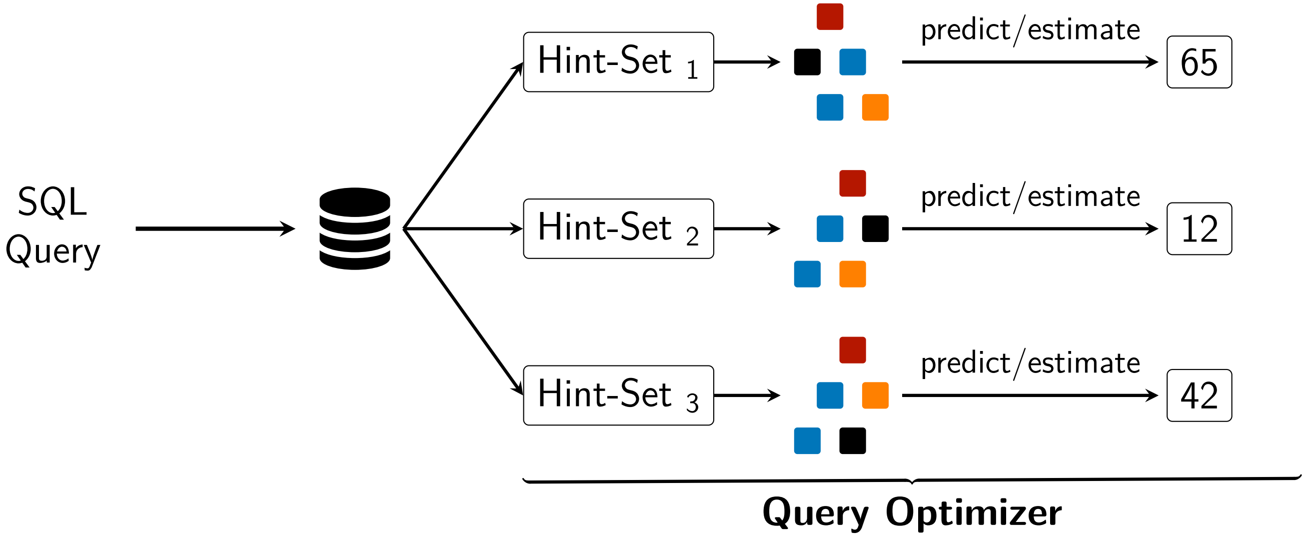

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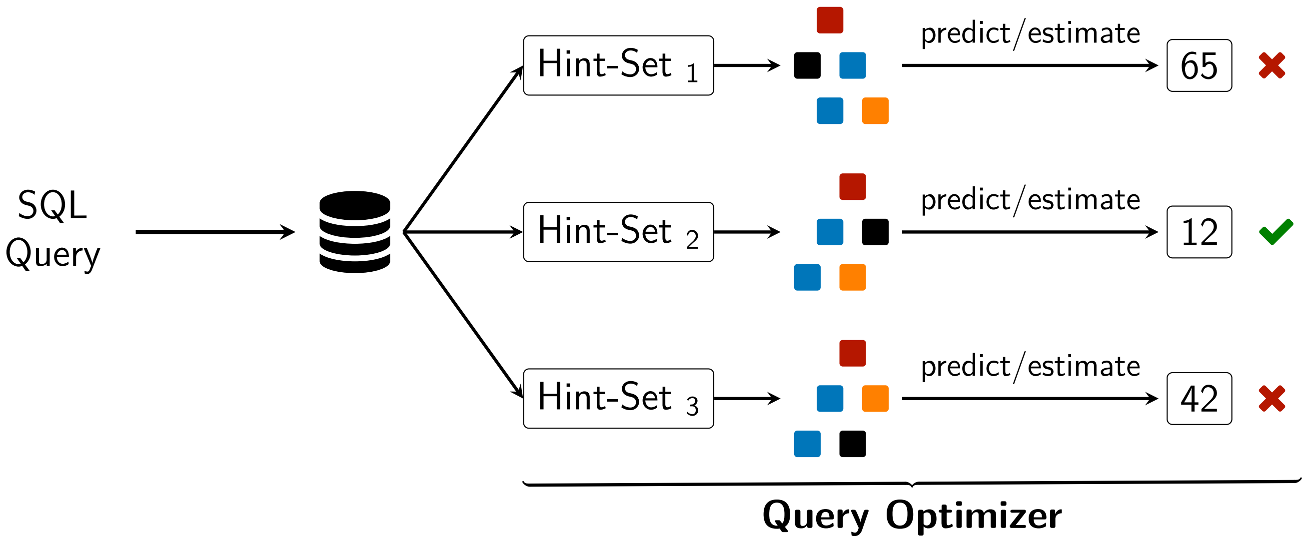

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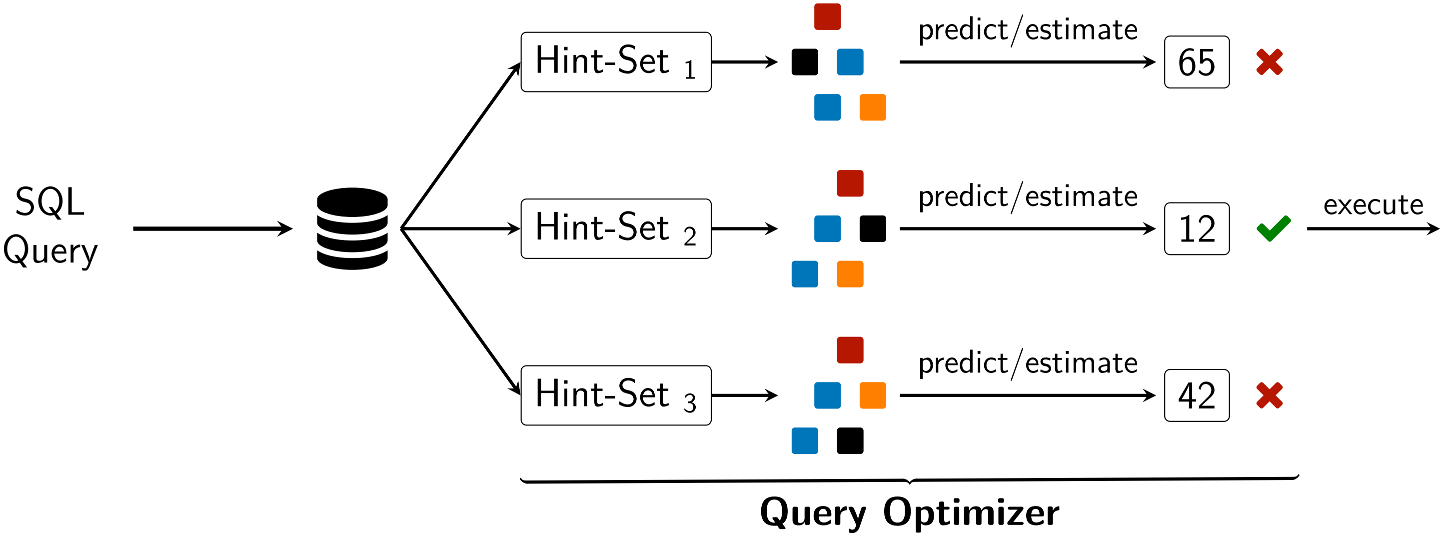

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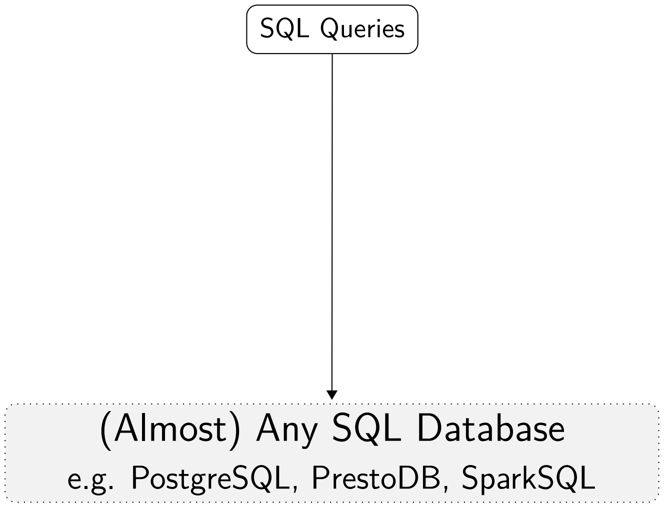

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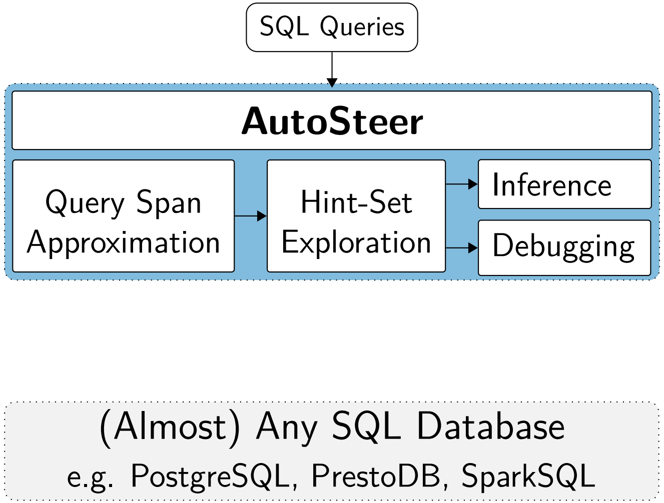

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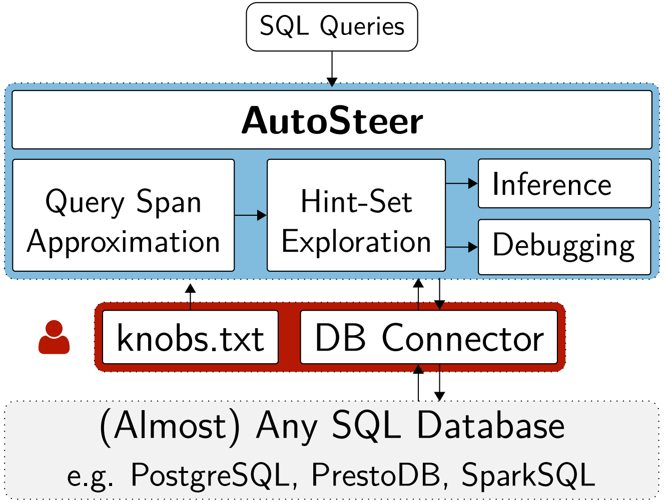

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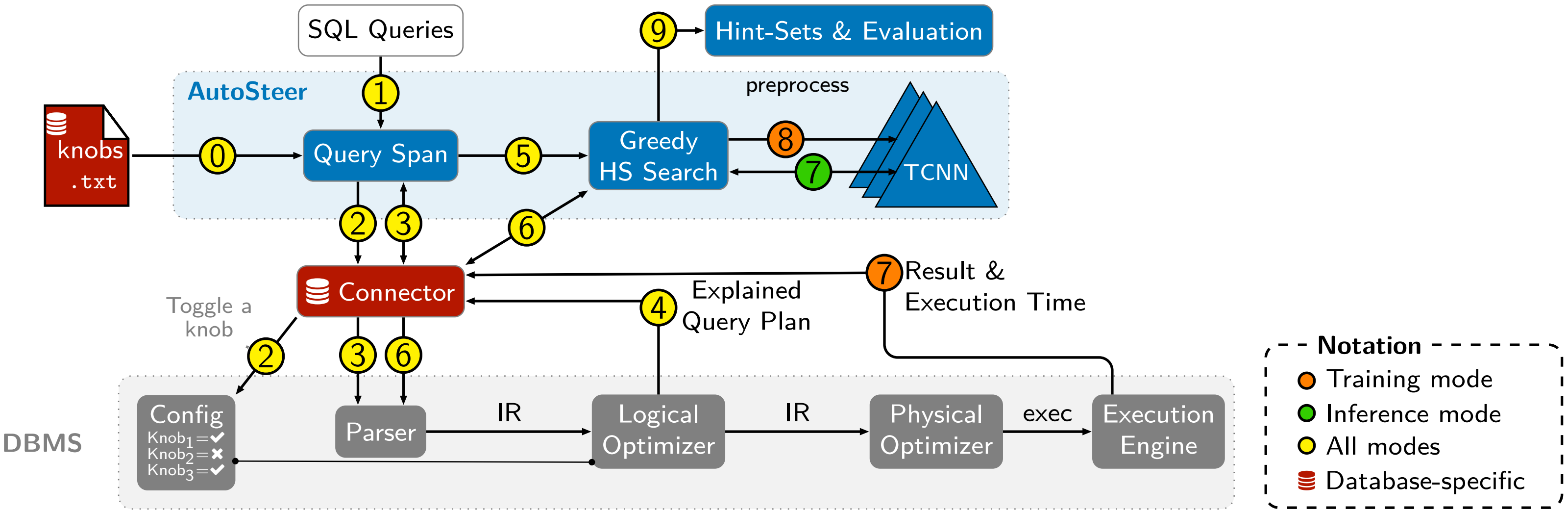
AutoSteer at a Glance



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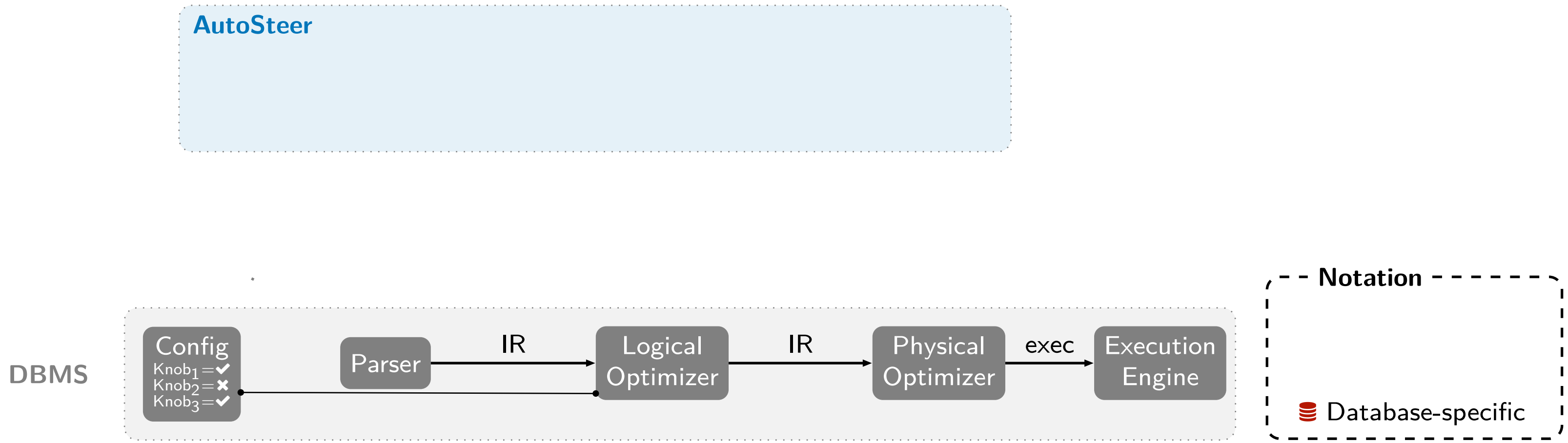

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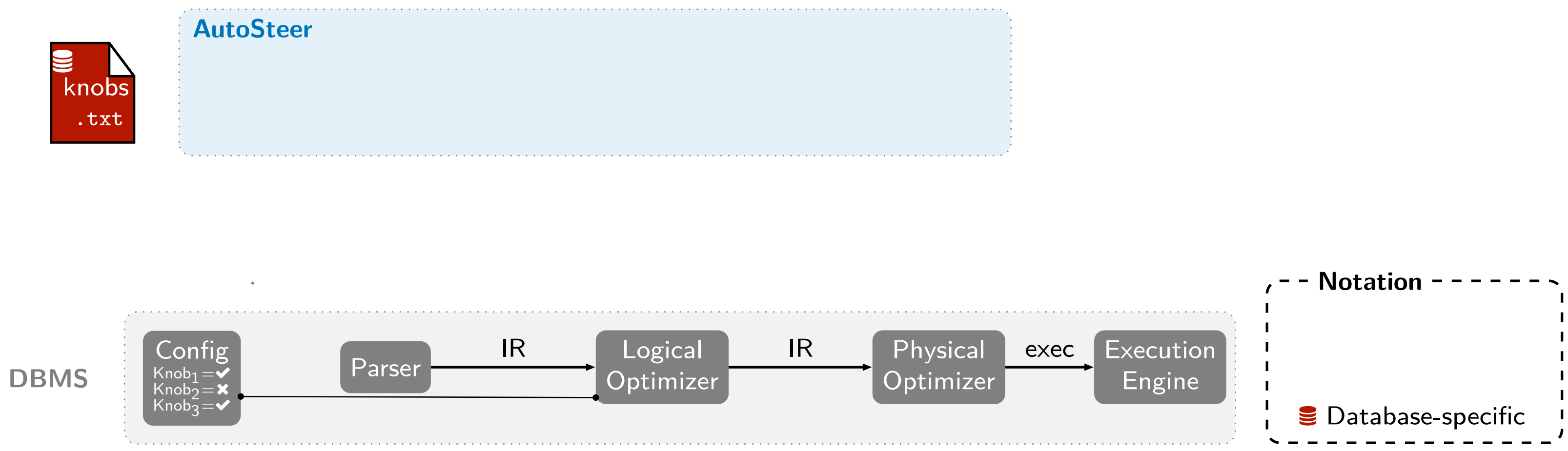

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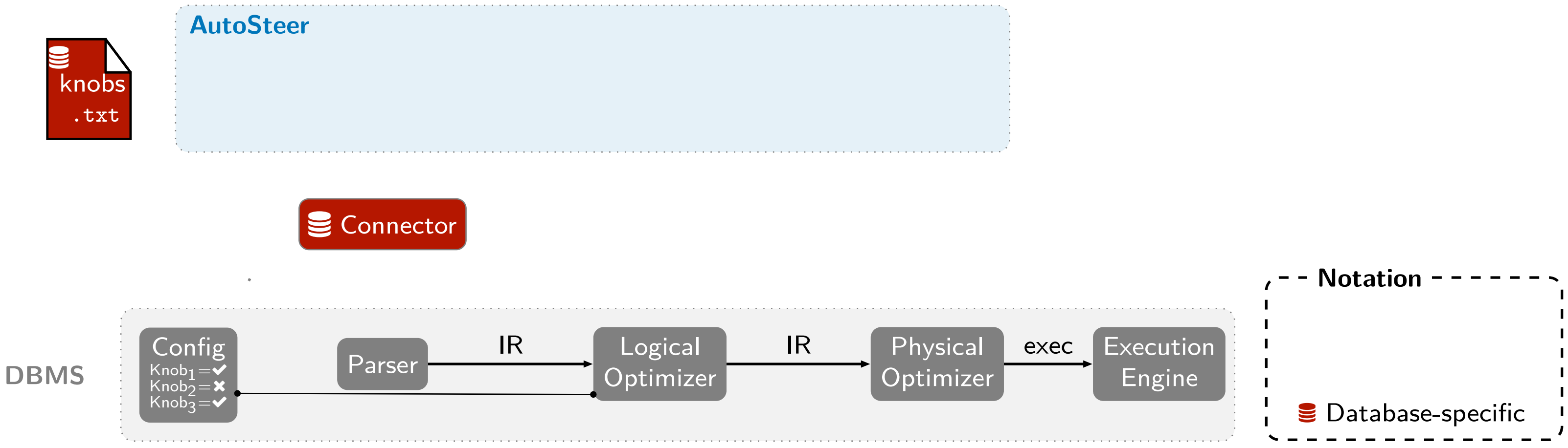

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Required Functionality:

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- Toggle optimizer knobs
- Explain and analyze SQL queries
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```python
class DBConnector:
  def set_knob(knob: str, enable: bool) -> None:
    """Disable the provided list of knobs"""
    raise NotImplementedError()

  def get_knob(self, knob: str) -> bool:
    """Get current status of a knob"""
    raise NotImplementedError()

  def explain(self, query: str) -> str:
    """Explain a query and return its plan"""
    raise NotImplementedError()

  def execute(self, query: str) -> TimedResult:
    """Execute query and measure time"""
    raise NotImplementedError()
```

AutoSteer - PostgreSQL Connector

```python
class PostgreSQLConnector(DBConnector):
  def __init__(url: str):
    self.conn = ... # setup PostgreSQL connection

  def set_knob(knob: str, enable: bool) -> None:
    self.conn.exec(f"SET {knob} TO {'ON' if enable else 'OFF'}")

  def execute(query: str) -> dict:
    return self.conn.exec(query)

  def explain(query: str) -> dict:
    return self.execute(f'EXPLAIN (FORMAT JSON) {query}')
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⇒ **DB Connectors mainly differ in the syntax to toggle knobs and to explain plans!**

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ℹ AutoSteer also supports **integrated database connectors (AutoSteer-C).**

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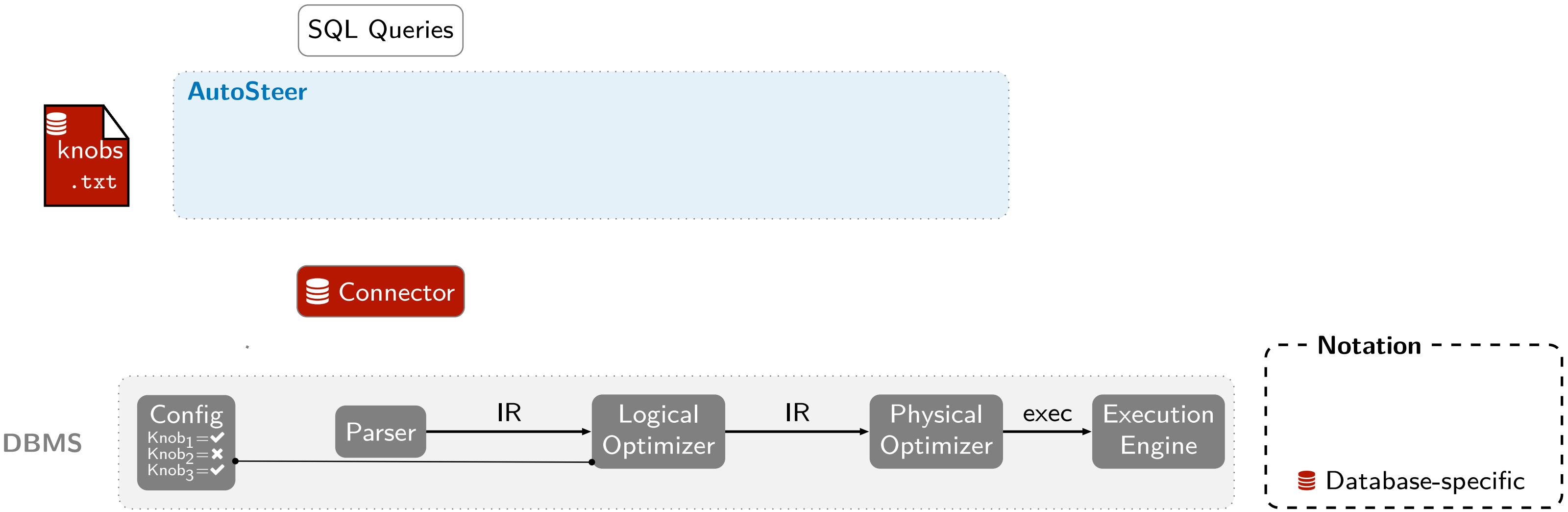

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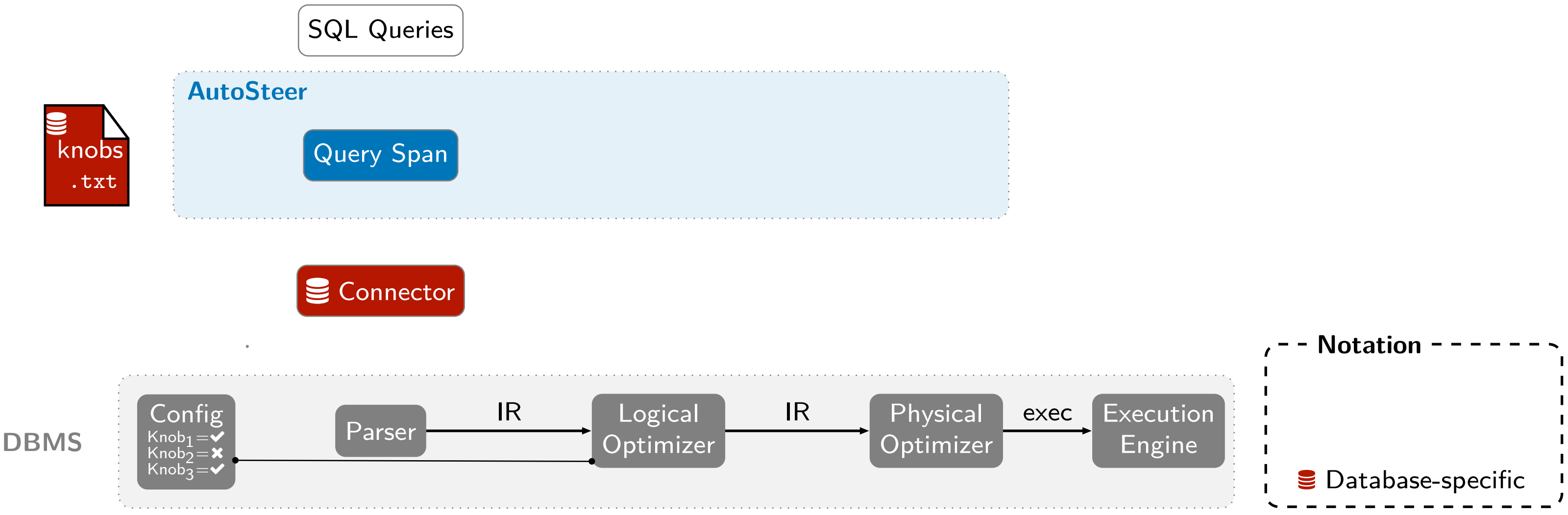

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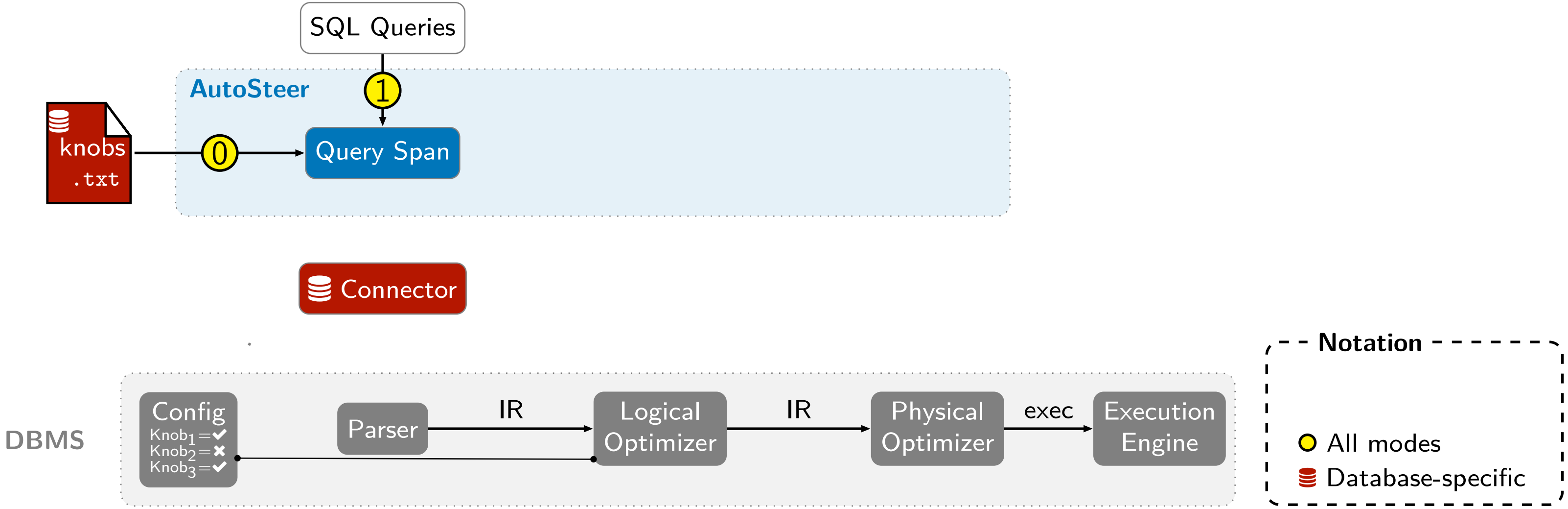

Query Span

A query span contains all the knobs that contribute to the query plan's optimization!

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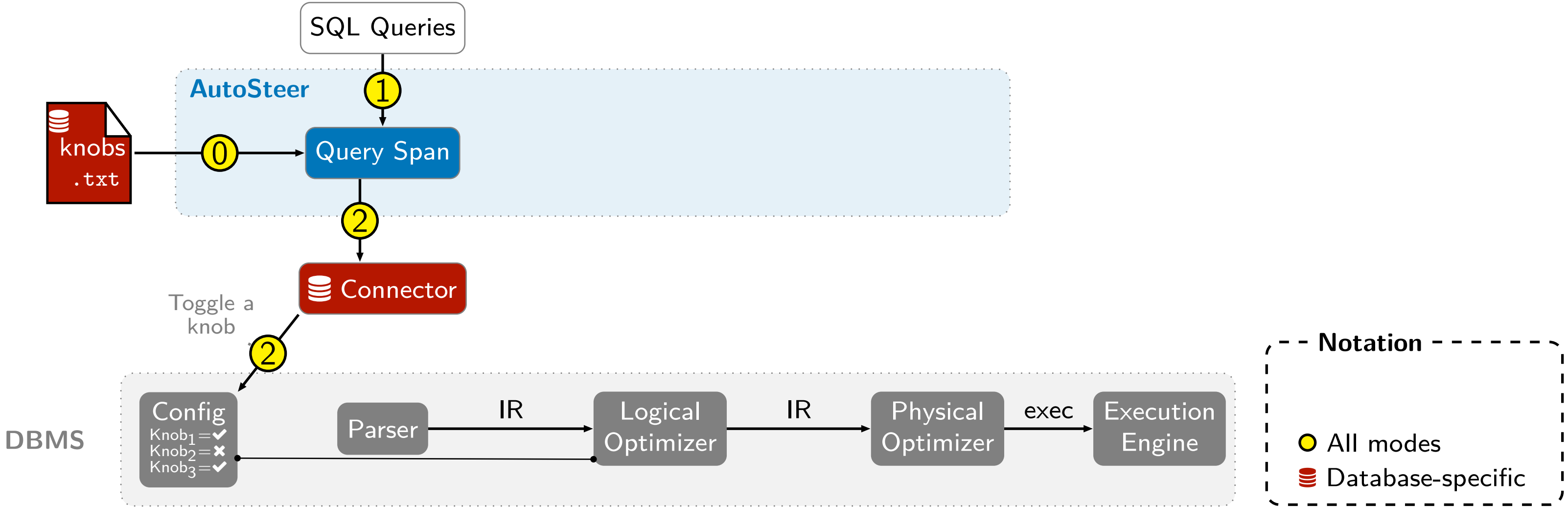

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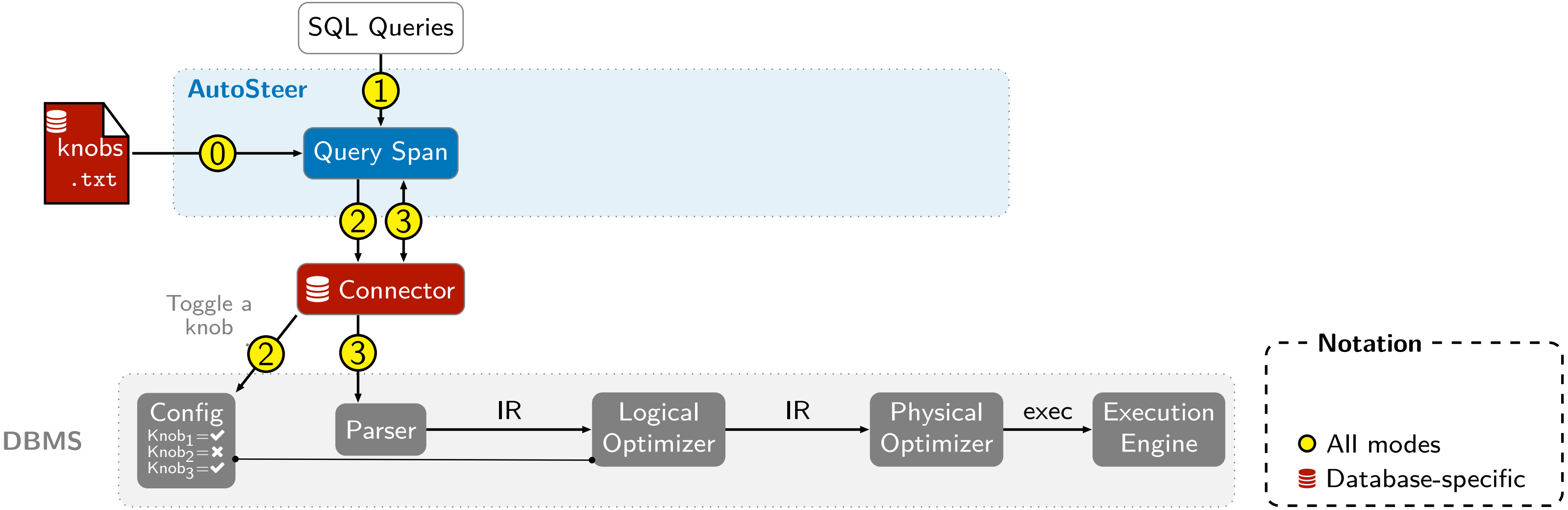

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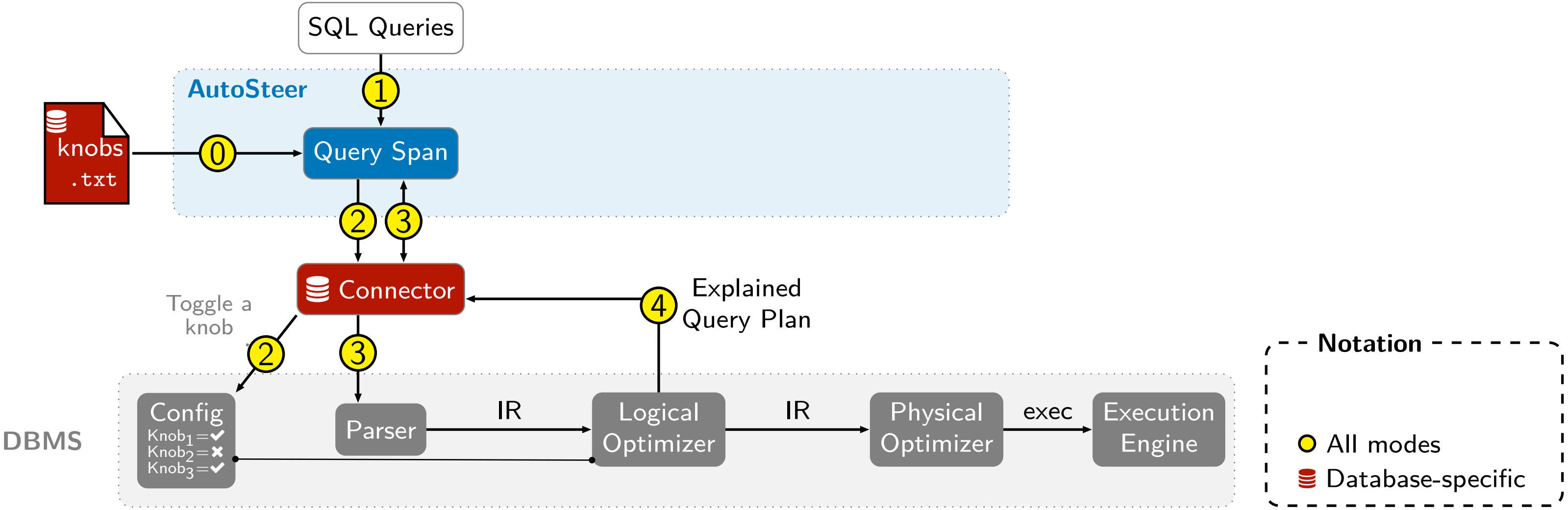

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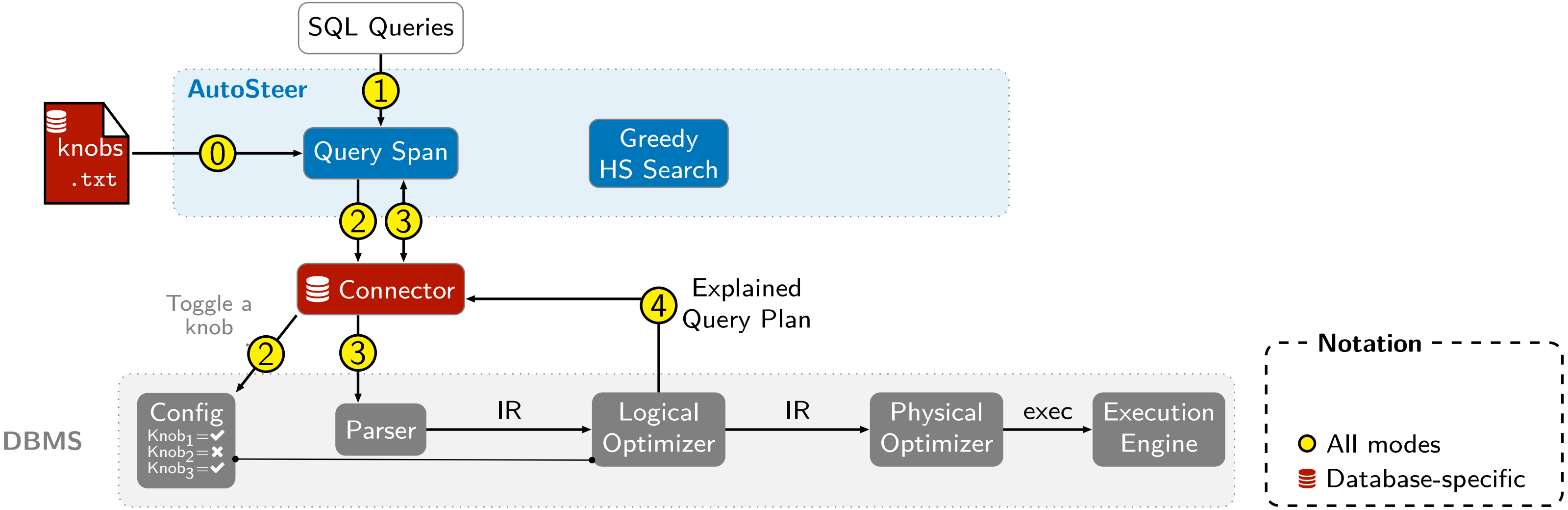

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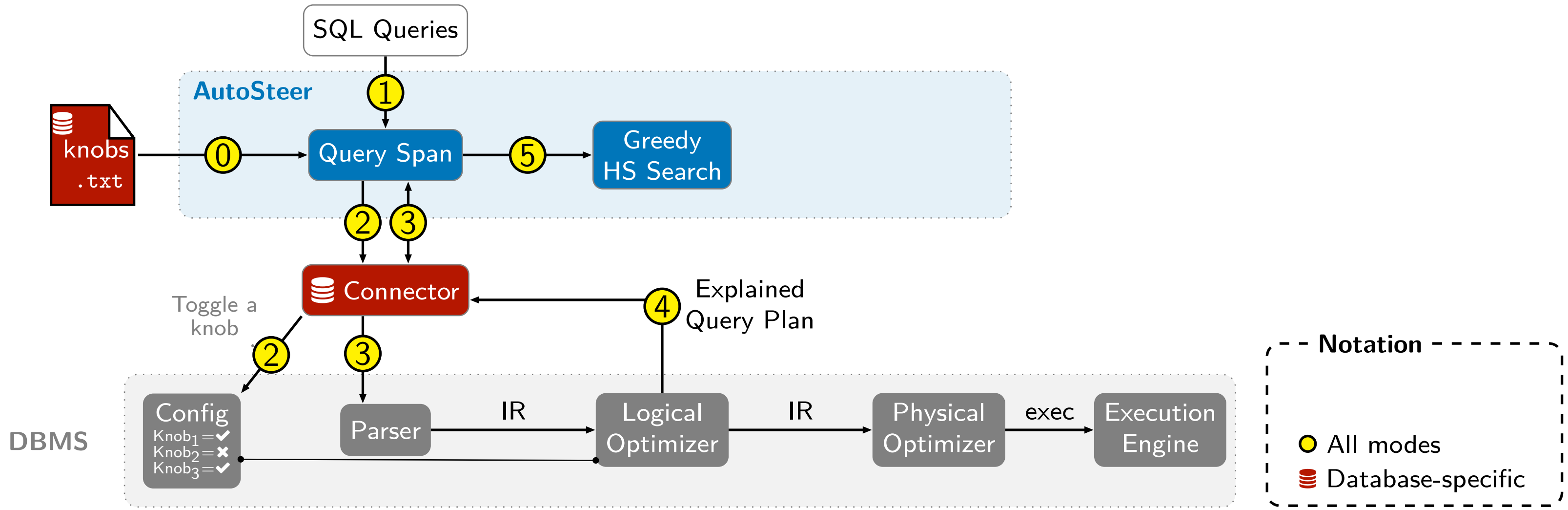

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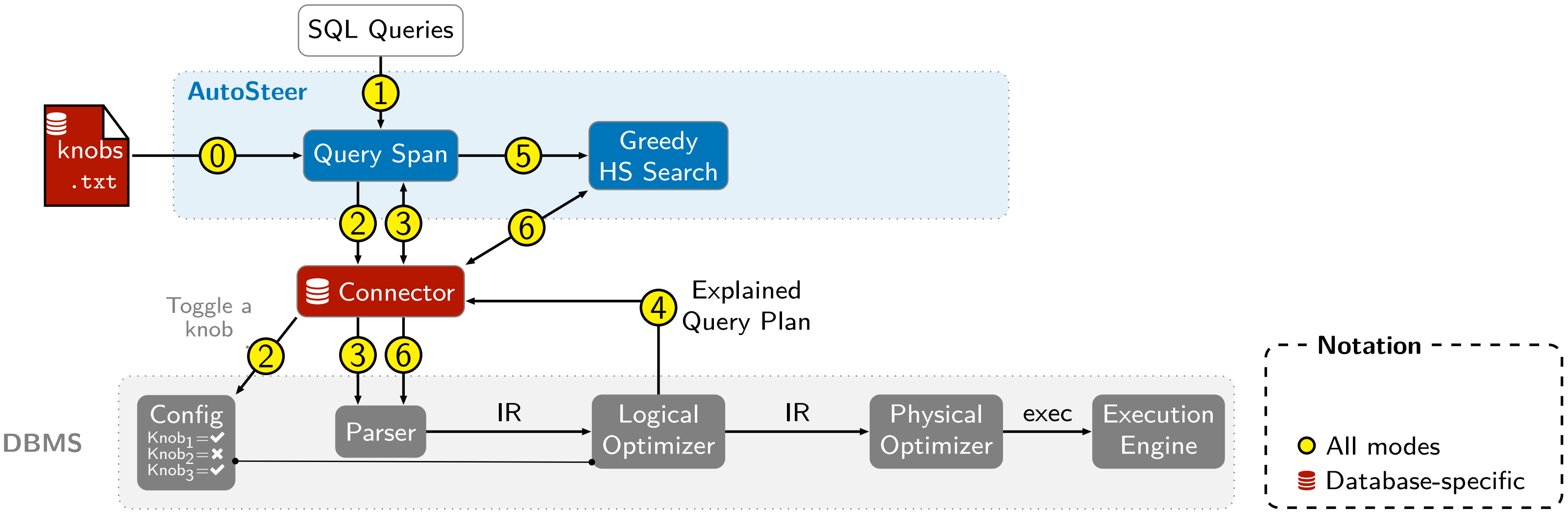

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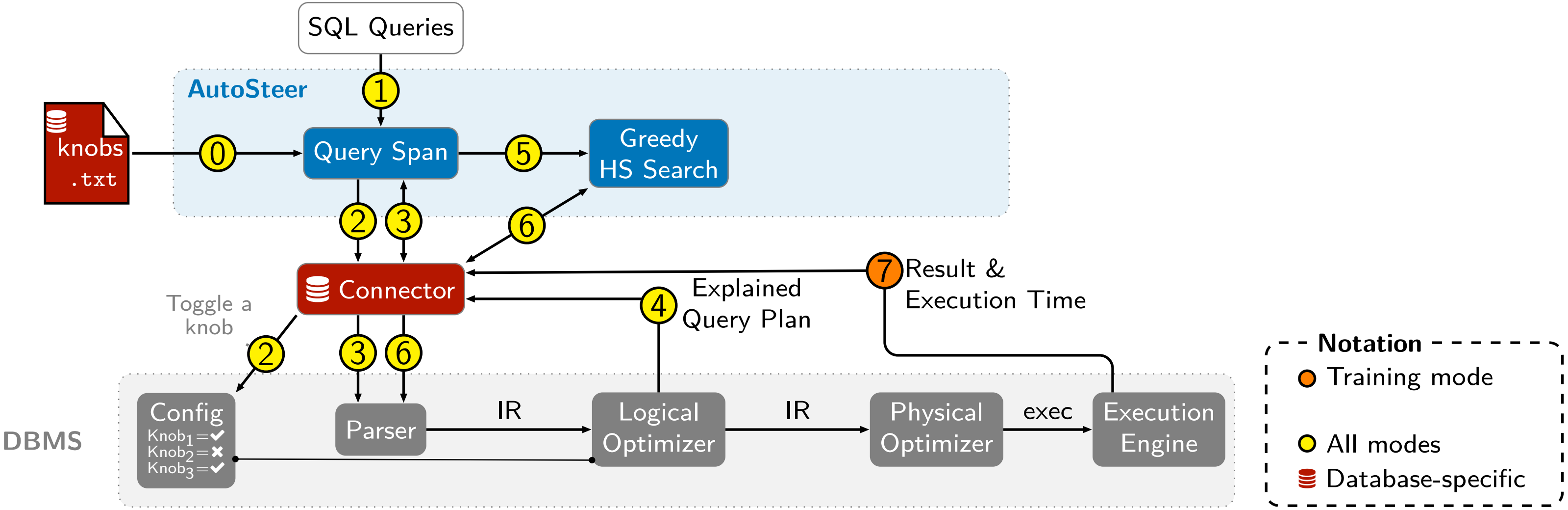

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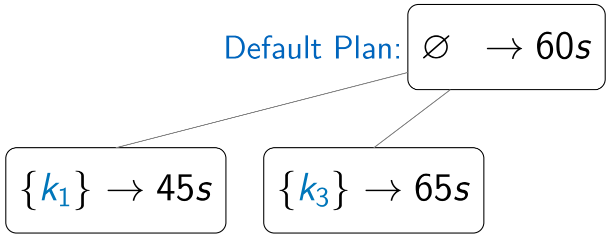

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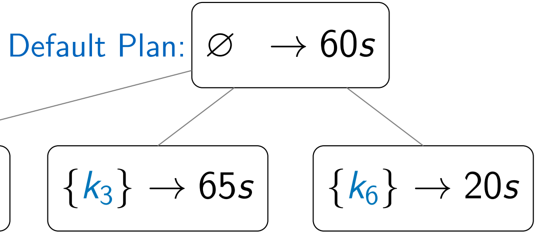

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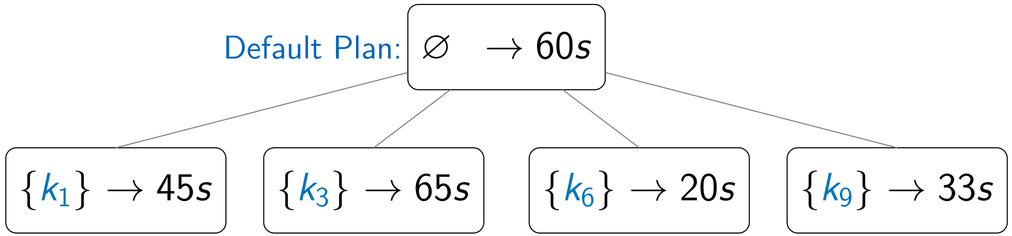

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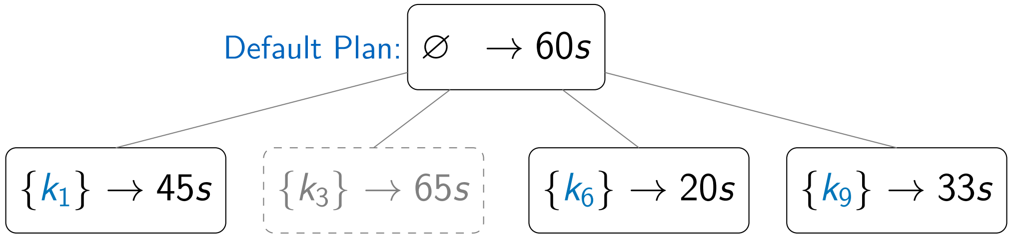

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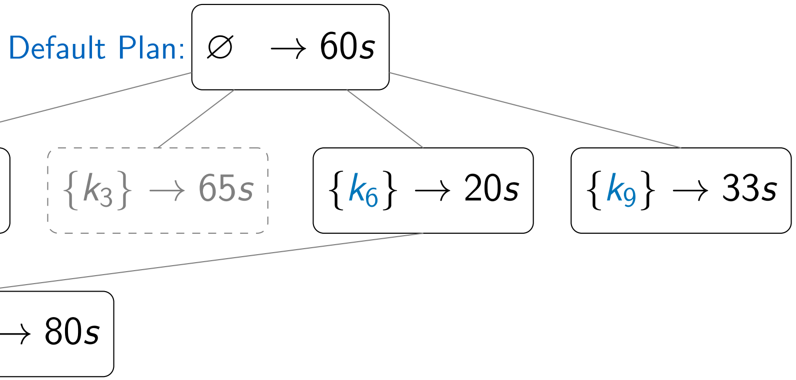

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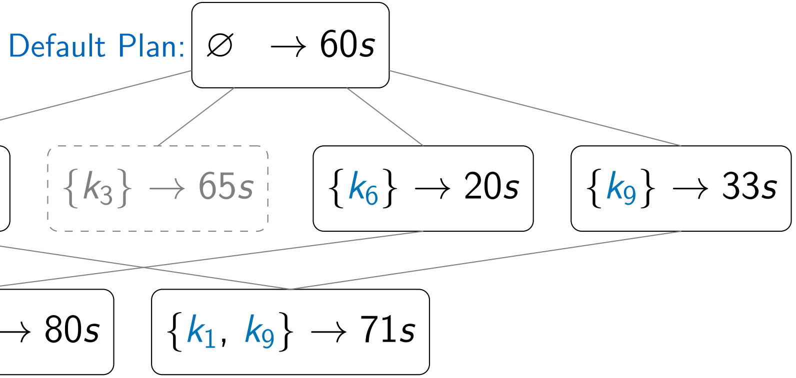

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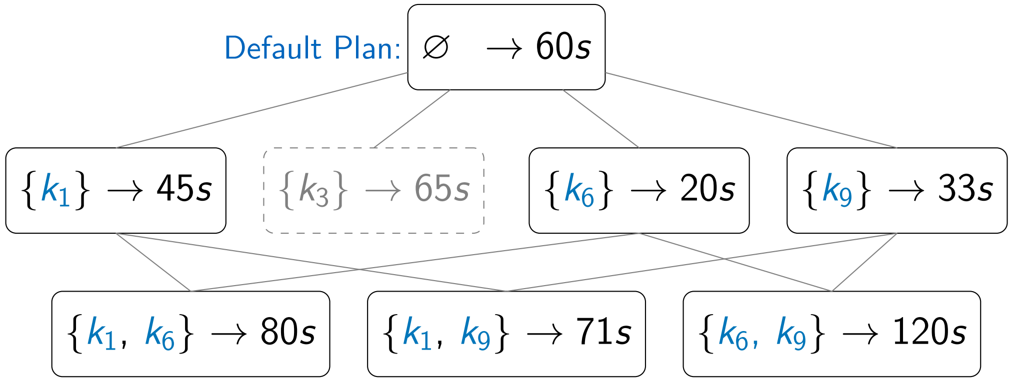
- There are $2^{|\text{Query Span}|}$ different hint-sets; However, most yield bad query plans.
- Greedy search generates promising hint-sets (HS) with reasonable overhead.
  - **Assumption**: Larger, beneficial HSs consist of smaller, beneficial HSs
    Not always, but in many cases true – experimentally tested ✔
- **Input**: SQL Query and Query Span (example: $[k_1, k_3, k_6, k_9]$)



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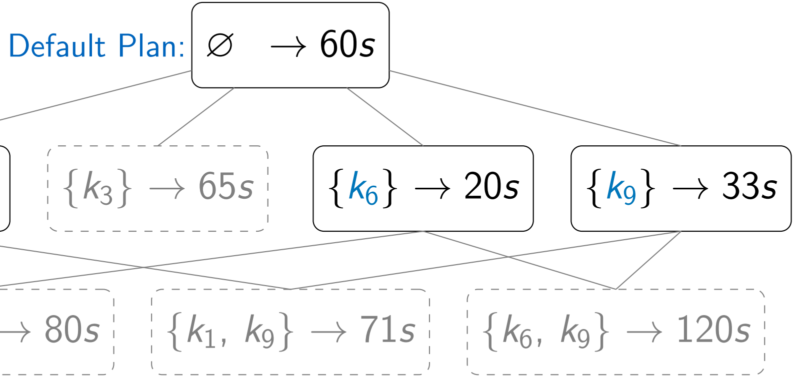
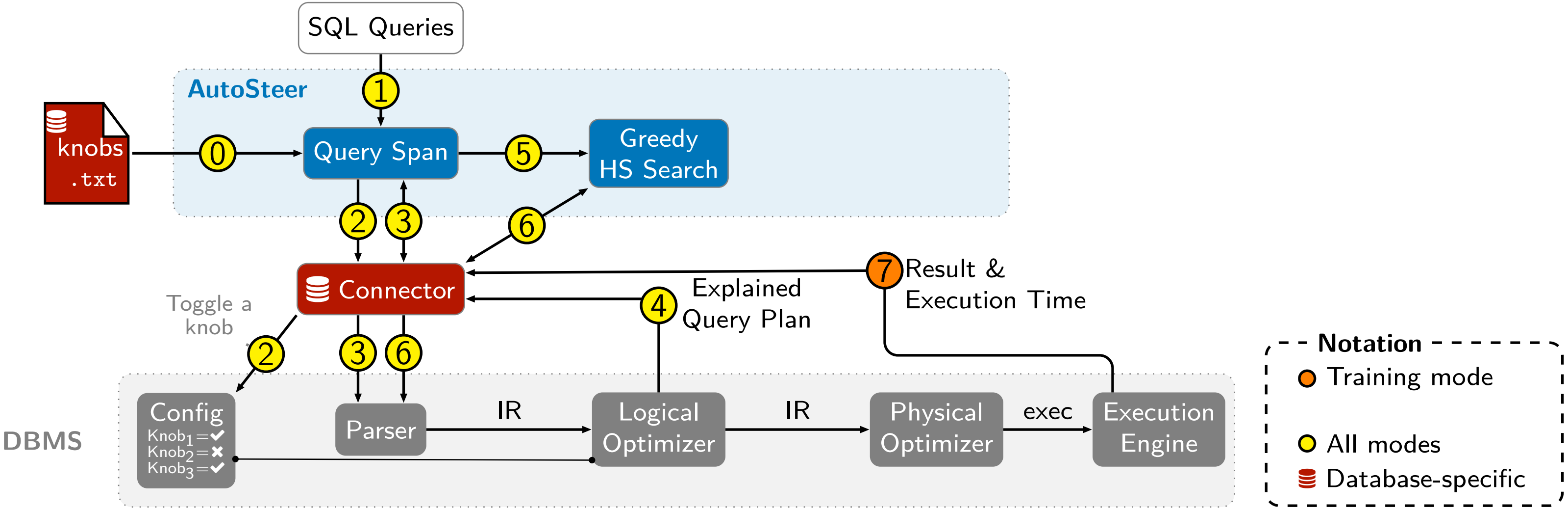


AutoSteer – Overview



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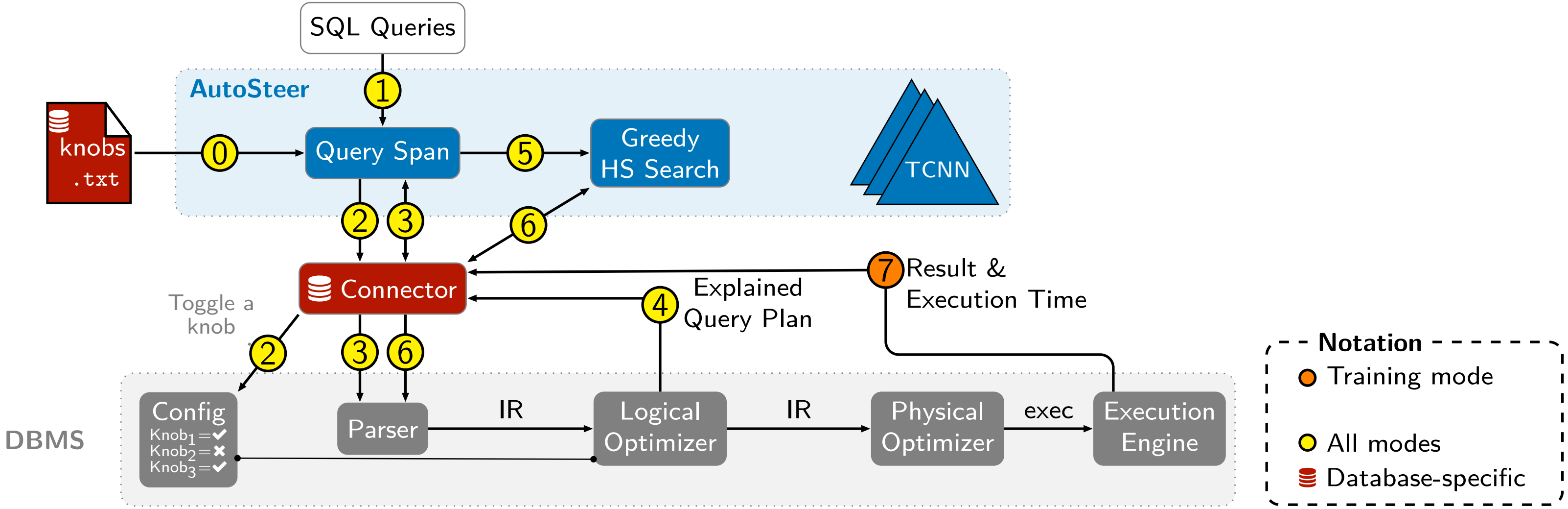

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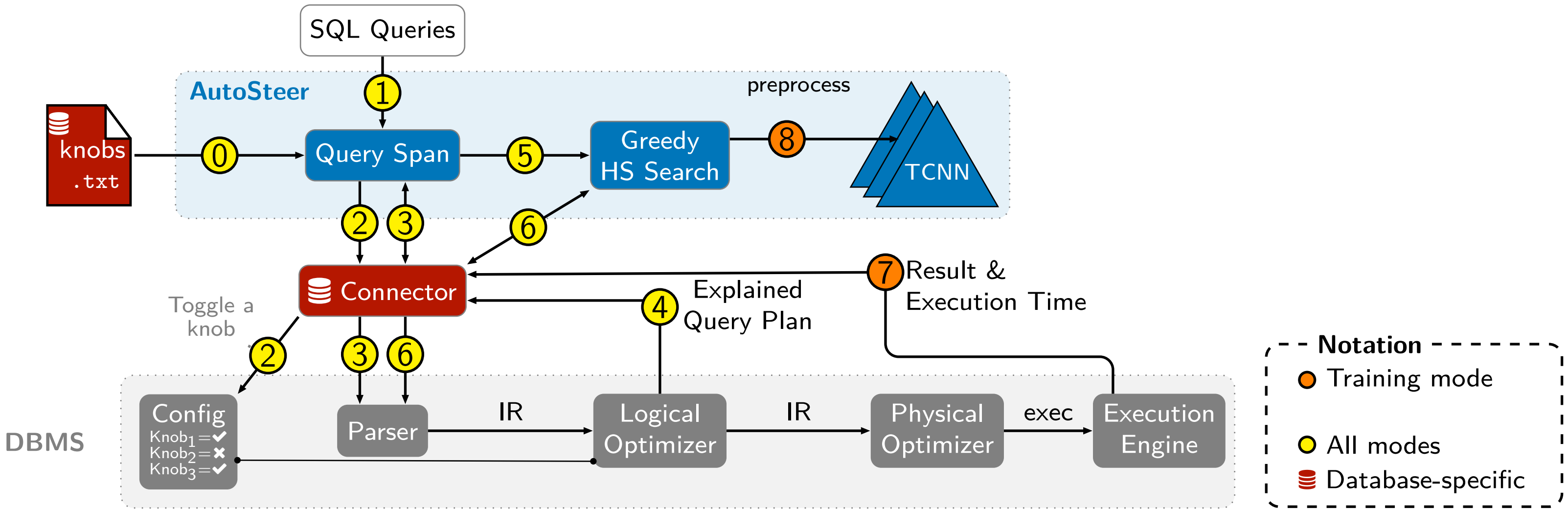

Training Mode

AutoSteer **generates training data** by exploring and **executing** alternative plans.

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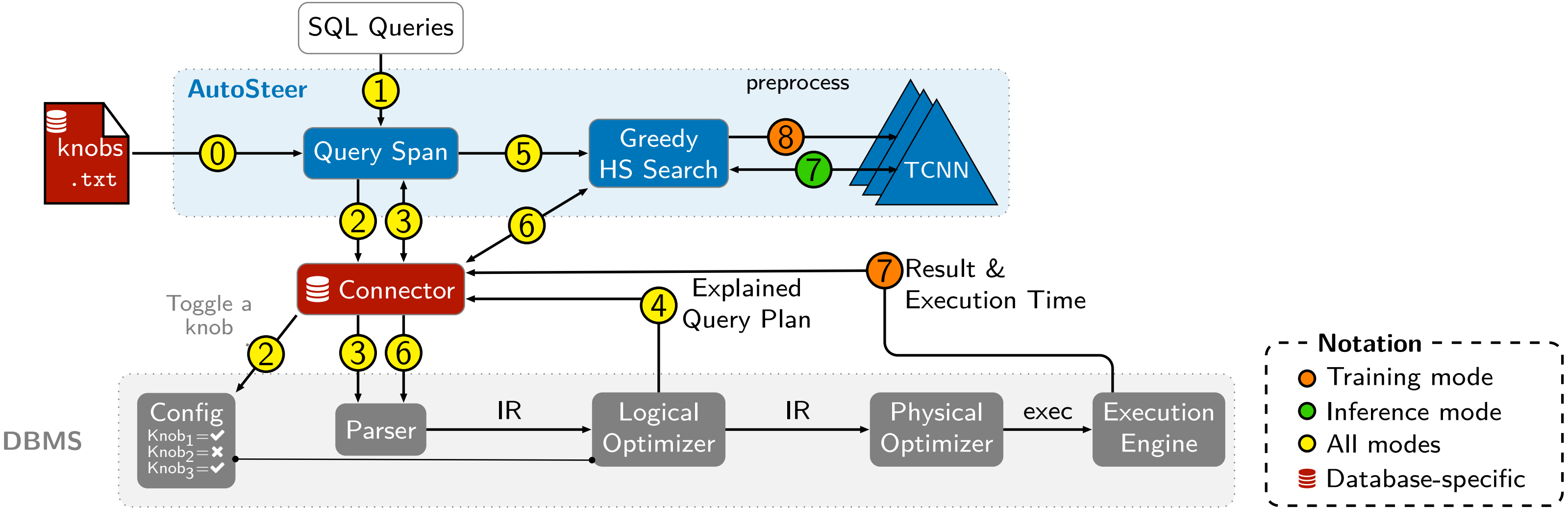


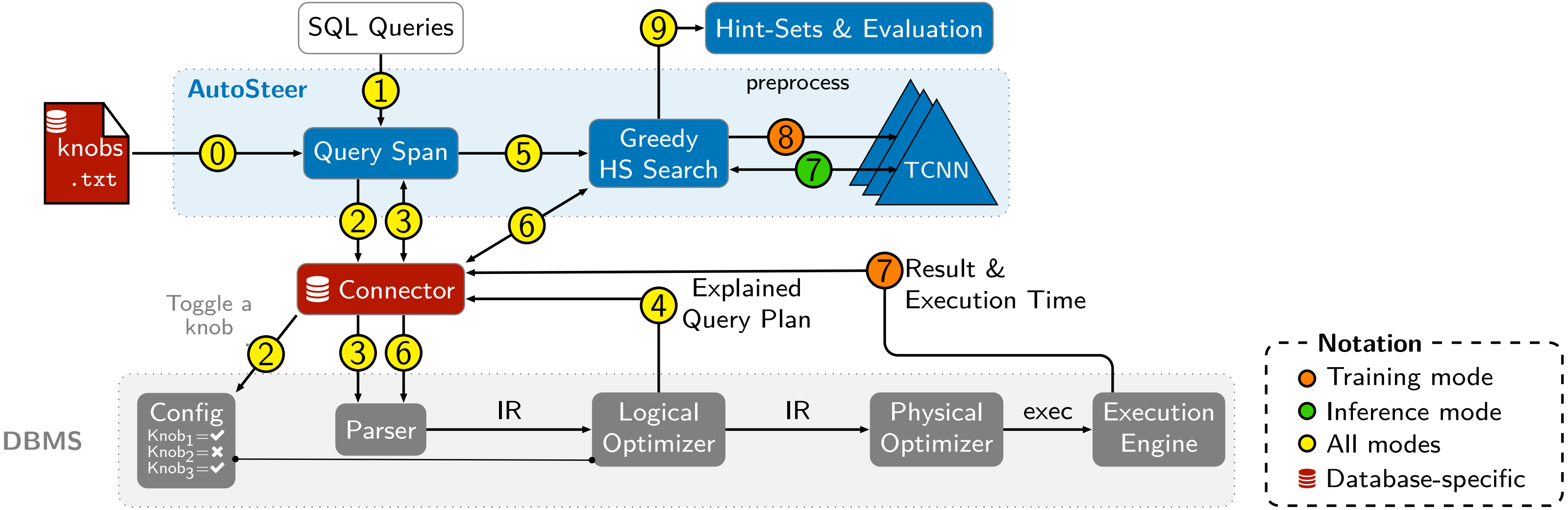
Training Mode

AutoSteer **generates training data** by exploring and **executing** alternative plans.

Inference Mode

AutoSteer **steers queries at runtime** and uses the TCNN to **infer execution times**.

AutoSteer – Overview



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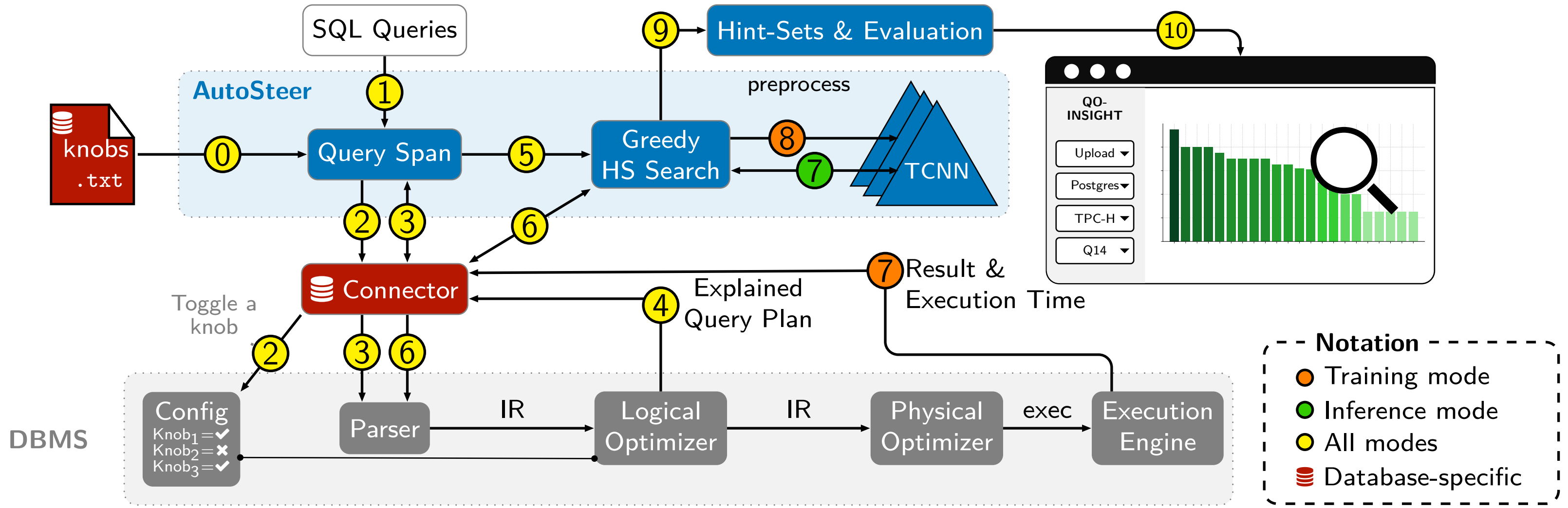


VLDB 2023: "QO-Insight: Inspecting Steered Query Optimizers" → Demo Group B

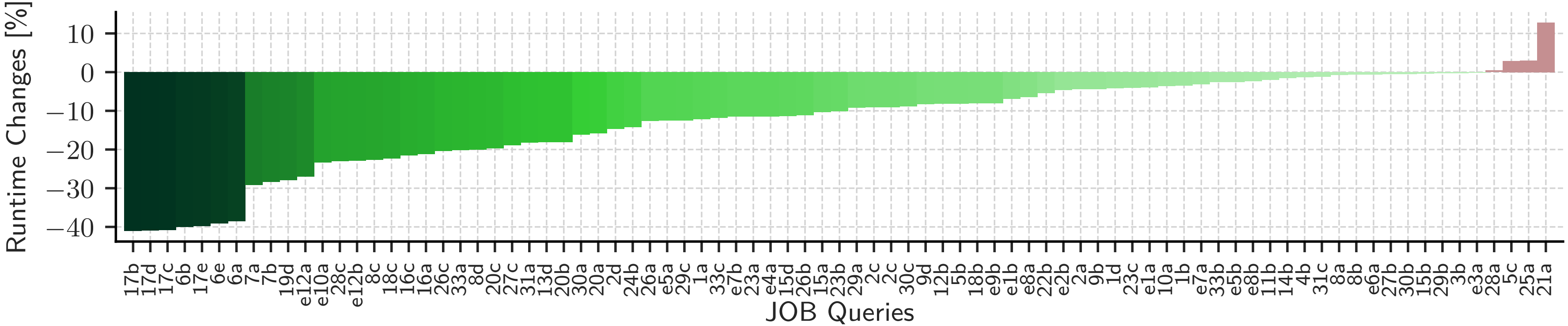
Evaluation

Evaluation of AutoSteer

- Tested AutoSteer with **PostgreSQL**, **DuckDB**, **PrestoDB**, **MySQL**, and **SparkSQL**
- Evaluation based on **public benchmarks** and **production workloads at Meta**
  - Join Order Benchmark (137 queries)
  - TPC-DS (100 queries)
  - Stackexchange (100 queries)
  - Dashboard application at Meta (>3000 queries, scanning PBs of data)
- Comparison to **previous steering approaches** (cf. to the paper for more details!)

Join Order Benchmark – PrestoDB

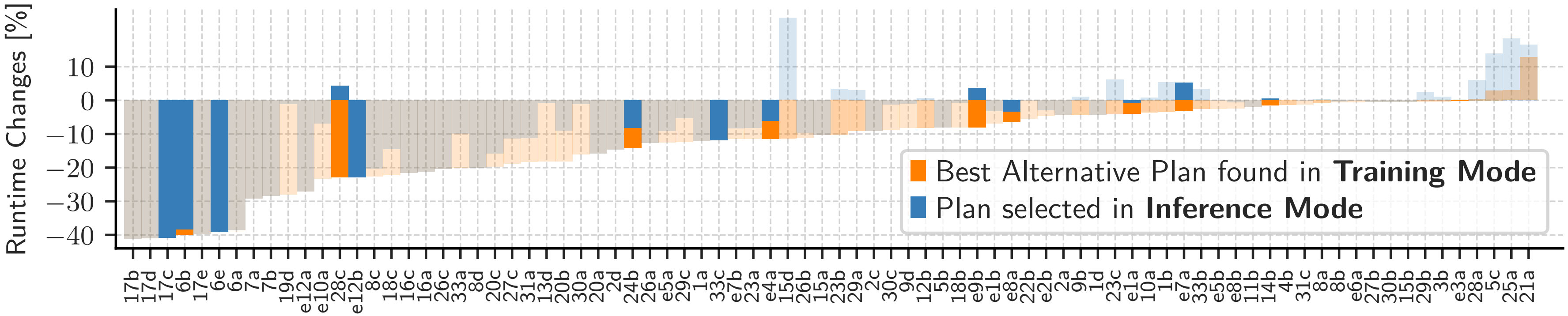
- For 137 queries, AutoSteer-C (w/ integrated connector) explored 1730 different hint-sets
- Evaluated between 8 and 34 different plans per query
- Achieved improvements of **up to 40%**



Relative performance changes of the best known alternative plan compared to the default plan.

Join Order Benchmark – PrestoDB

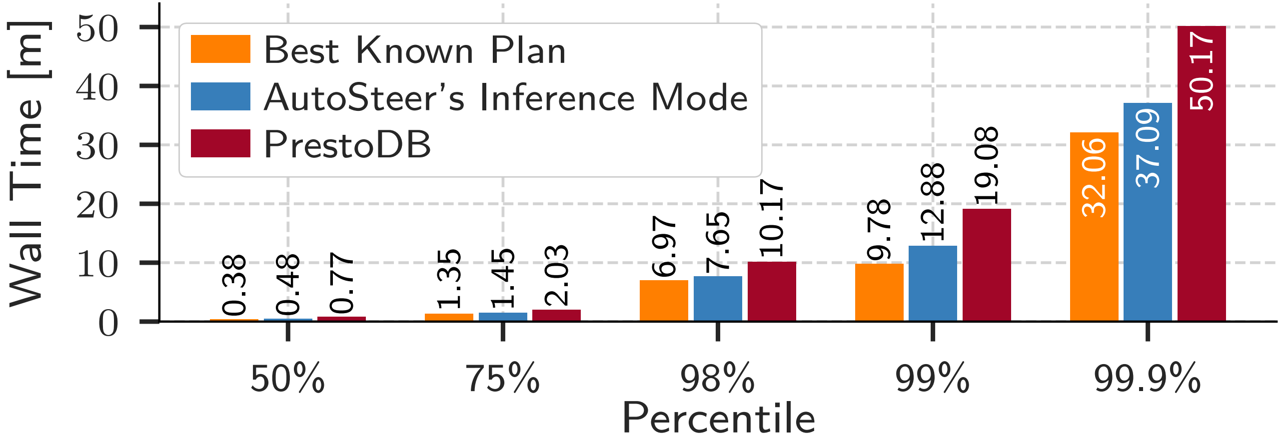
- AutoSteer-C (w/ integrated connector) using a tree convolutional neural network to infer execution times
- Reduces execution times of
  - unseen queries by 20.6% (opaque)
  - seen queries by 26.8% (transparent)



Relative performance changes of the optimal and the selected plan wrt. the default plan.

Dashboard Application at Meta – PrestoDB

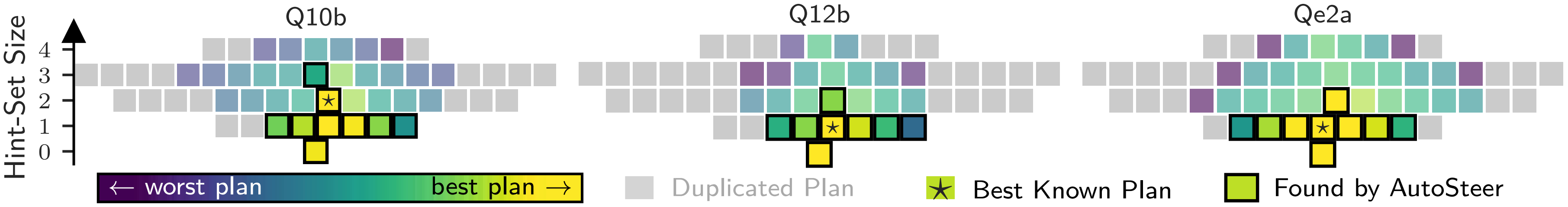
- Focus on **tail latencies**
- >3000 Queries, scanning PBs of data, hundreds of worker nodes
- Workload runs multiple times per day



AutoSteer significantly reduces tail latencies of production workloads at Meta

Greedy Exploration

- **Assumption**: Larger, beneficial HSs consist of smaller, beneficial HSs
- Greedy explores significantly fewer hint-sets than previous approaches (like Bao),
- but it meets or outperforms their performance improvements



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Thank you for your attention!