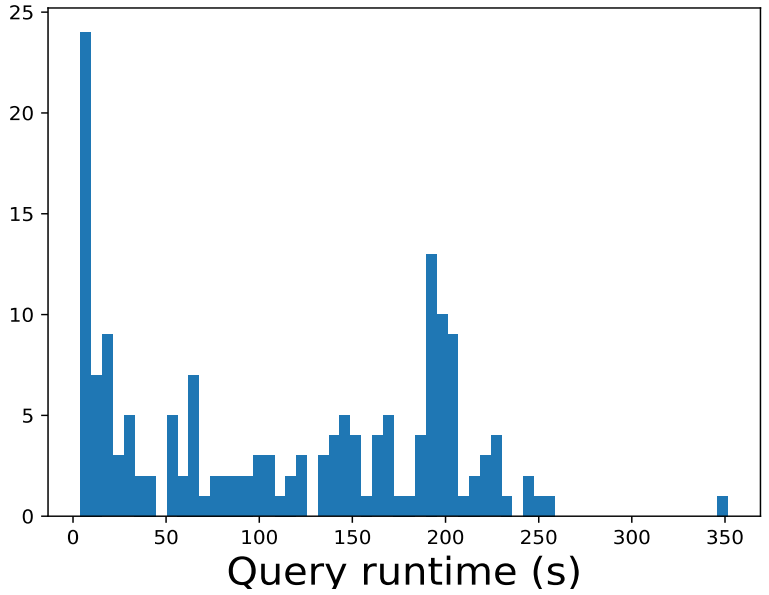
Improving DBMS Scheduling Decisions with Accurate Performance Prediction on Concurrent Queries

Ziniu Wu, **Markos Markakis**, Chunwei Liu, Peter Baile Chen, Balakrishnan Narayanaswamy, Tim Kraska, Samuel Madden

Concurrency impacts latency heavily

- Deciding when to execute a query can be crucial
- Bad scheduling decisions can have a significant impact on query latency.
- Microexperiment:
  - 4 clients issuing closed-loop queries against IMDB dataset on Postgres.
  - Look at runtime of the same query under different concurrent settings.
- Scheduling can have a large impact.



Can we build a reusable scheduler?

- We explore the design of a non-intrusive scheduler:
  - Coarser granularity (e.g. cannot schedule individual operators).
  - But can be applied to any underlying engine.

- Goal: improve query end-to-end time (queueing time + system runtime)

We need to capture resource contention

Q_0 (big join)

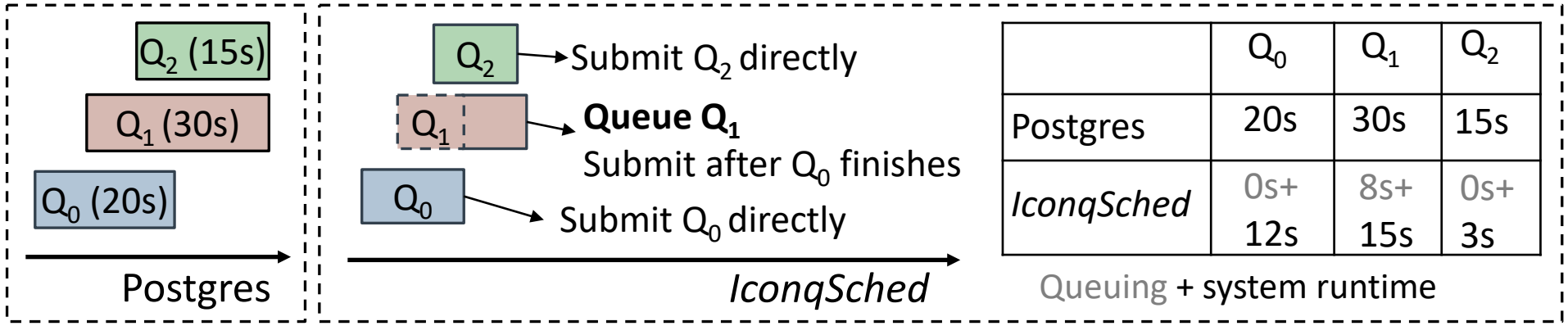
CPU: low
Memory: **high**
IO: **high**
Tables: T_1, T_2, T_3, T_4

Q_1 (big join)

CPU: low
Memory: **high**
IO: **high**
Tables: T_6, T_7

Q_2 (complex predicate)

CPU: **high**
Memory: low
IO: low
Tables: T_2, T_3, T_5



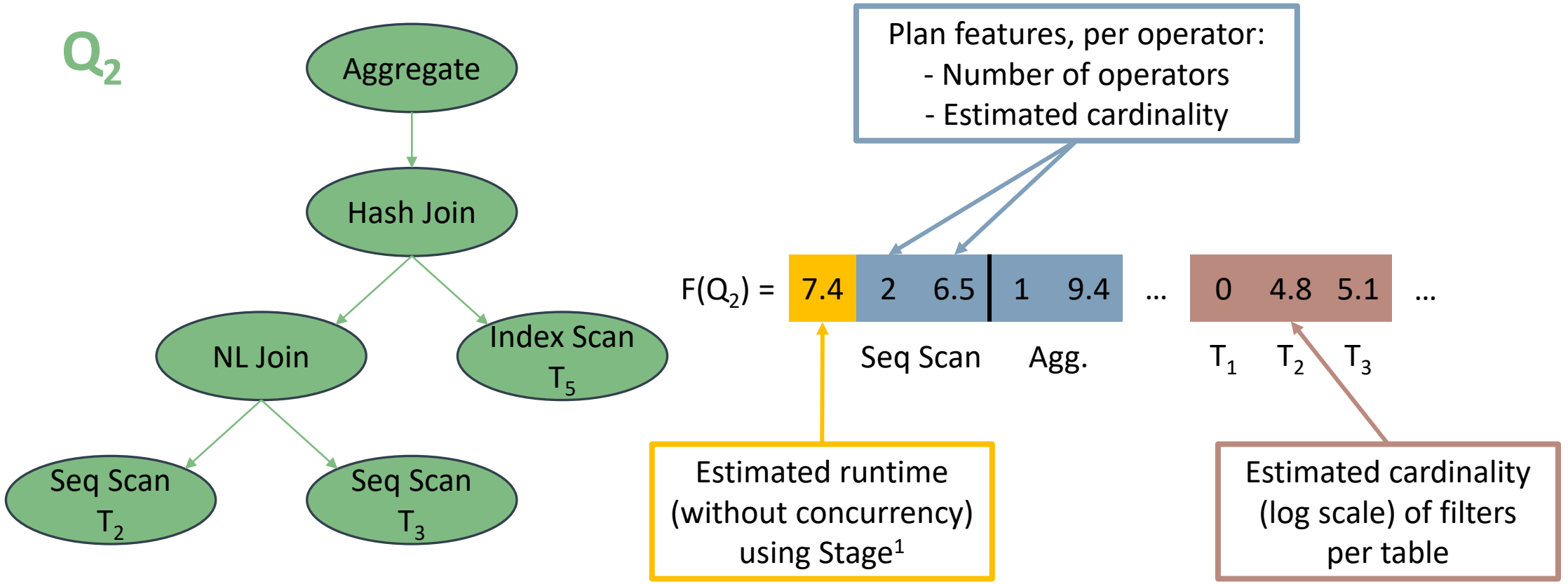
	Q_0	Q_1	Q_2
Postgres	20s	30s	15s
IconqSched	0s+ 12s	8s+ 15s	0s+ 3s

Queuing + system runtime

Key challenge: splitting past and future

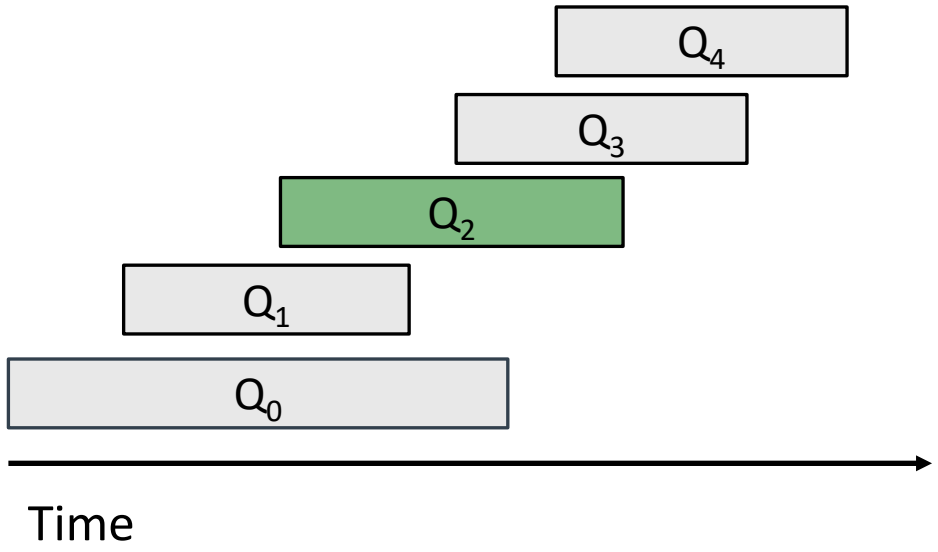
- The latency of each query is affected by both:
  - Queries that were submitted before it and are still running.
  - Queries that are submitted while it is still executing.
- The latter are not available at scheduling time.
- How can we update estimates for running queries as new ones arrive?
- Solution preview: Bidirectional LSTM

We first featurize a query using its plan



[1] Ziniu Wu, Ryan Marcus, Zhengchun Liu, Parimarjan Negi, Vikram Nathan, Pascal Pfeil, Gaurav Saxena, Mohammad Rahman, Balakrishnan Narayanaswamy, and Tim Kraska. 2024. Stage: Query Execution Time Prediction in Amazon Redshift.

We next add query interaction details



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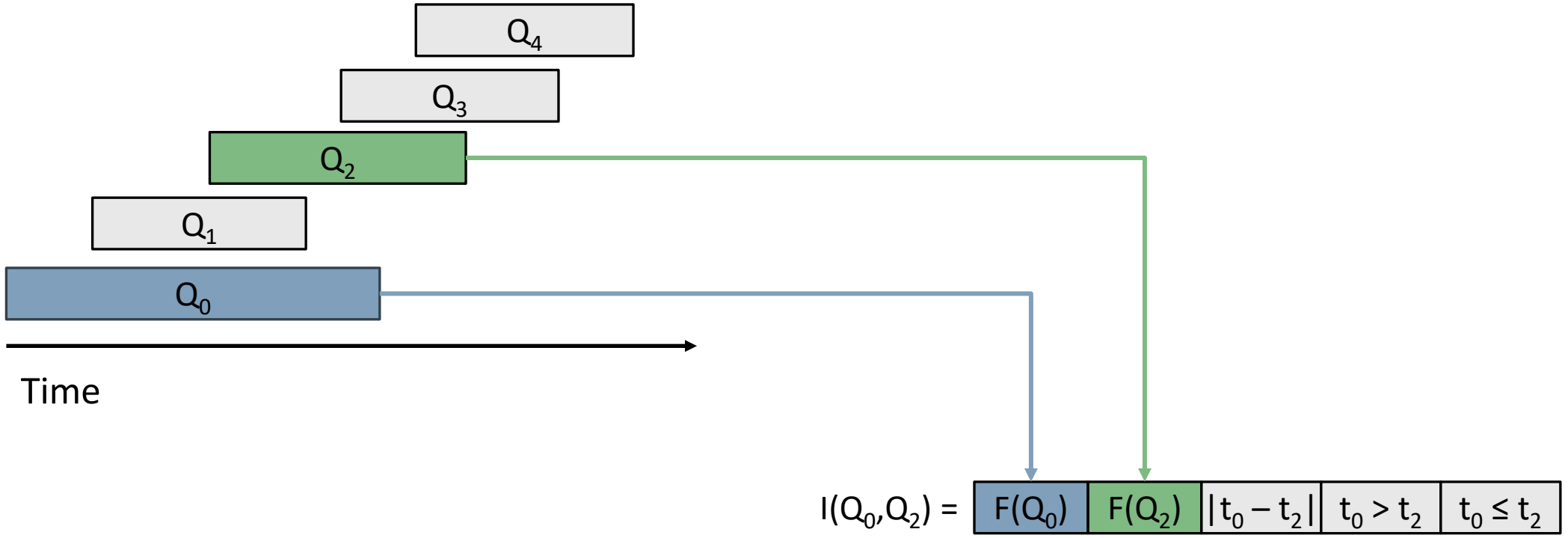

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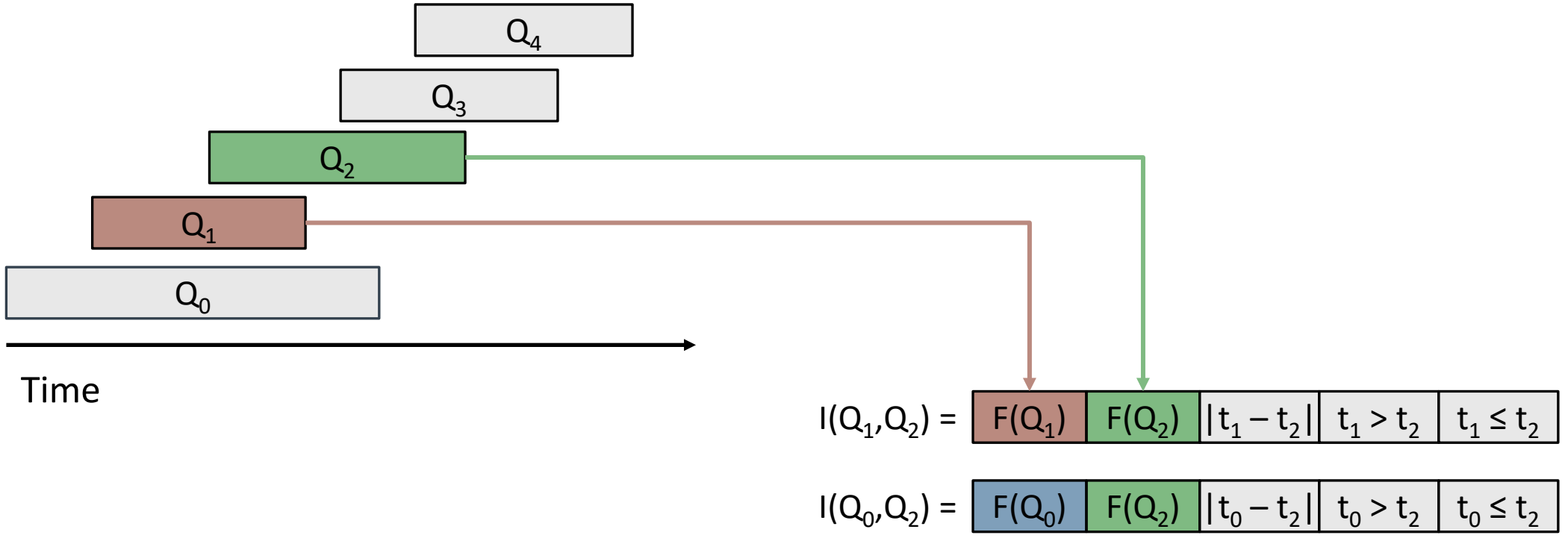

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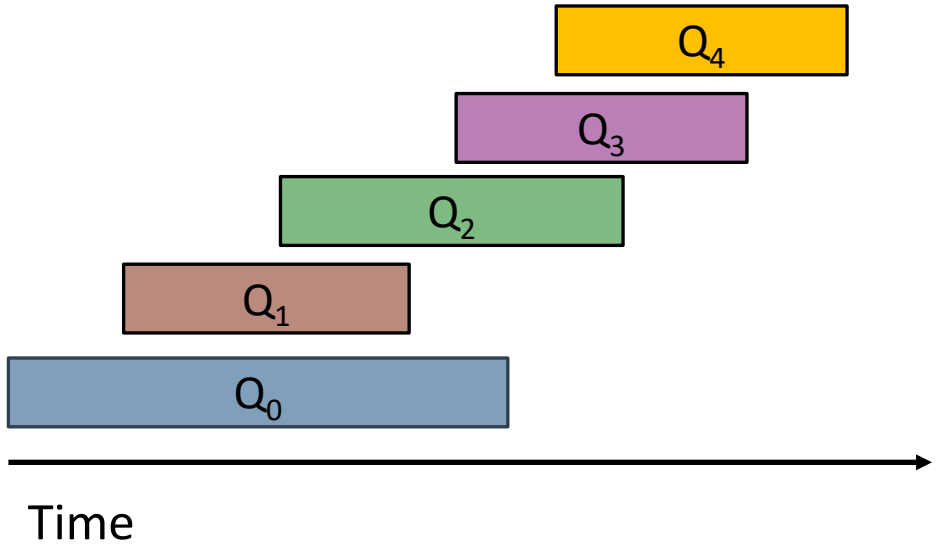
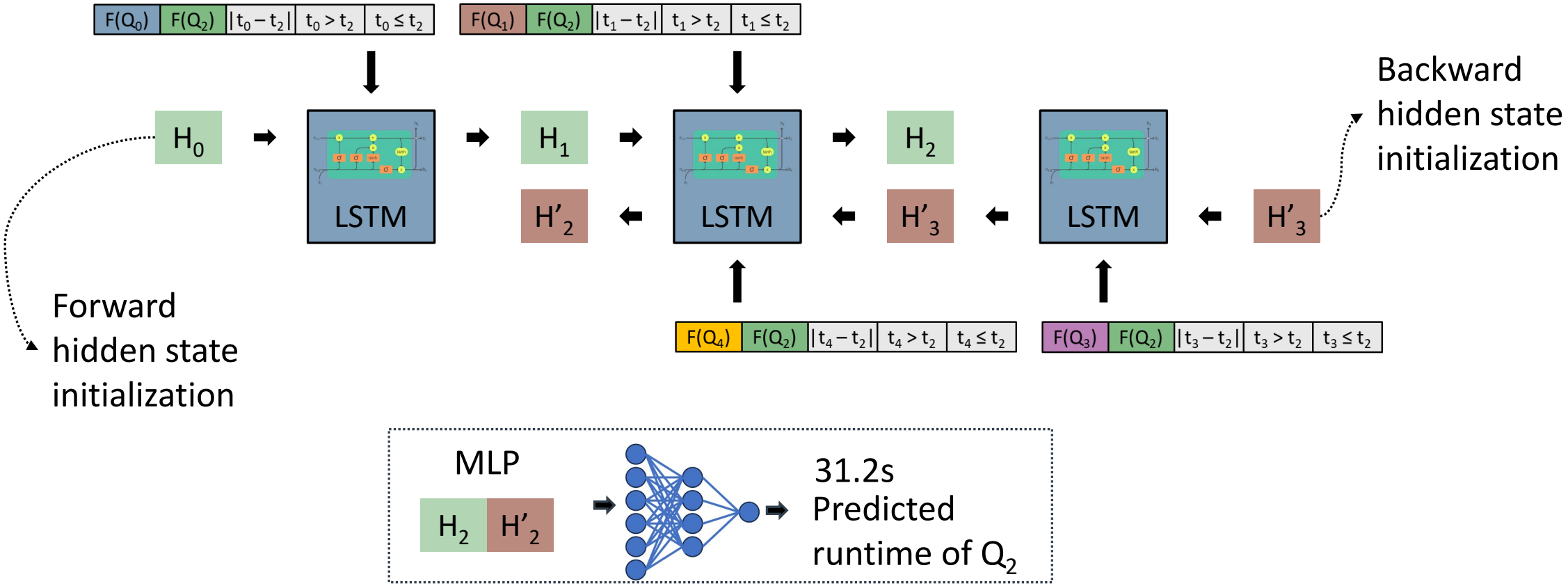
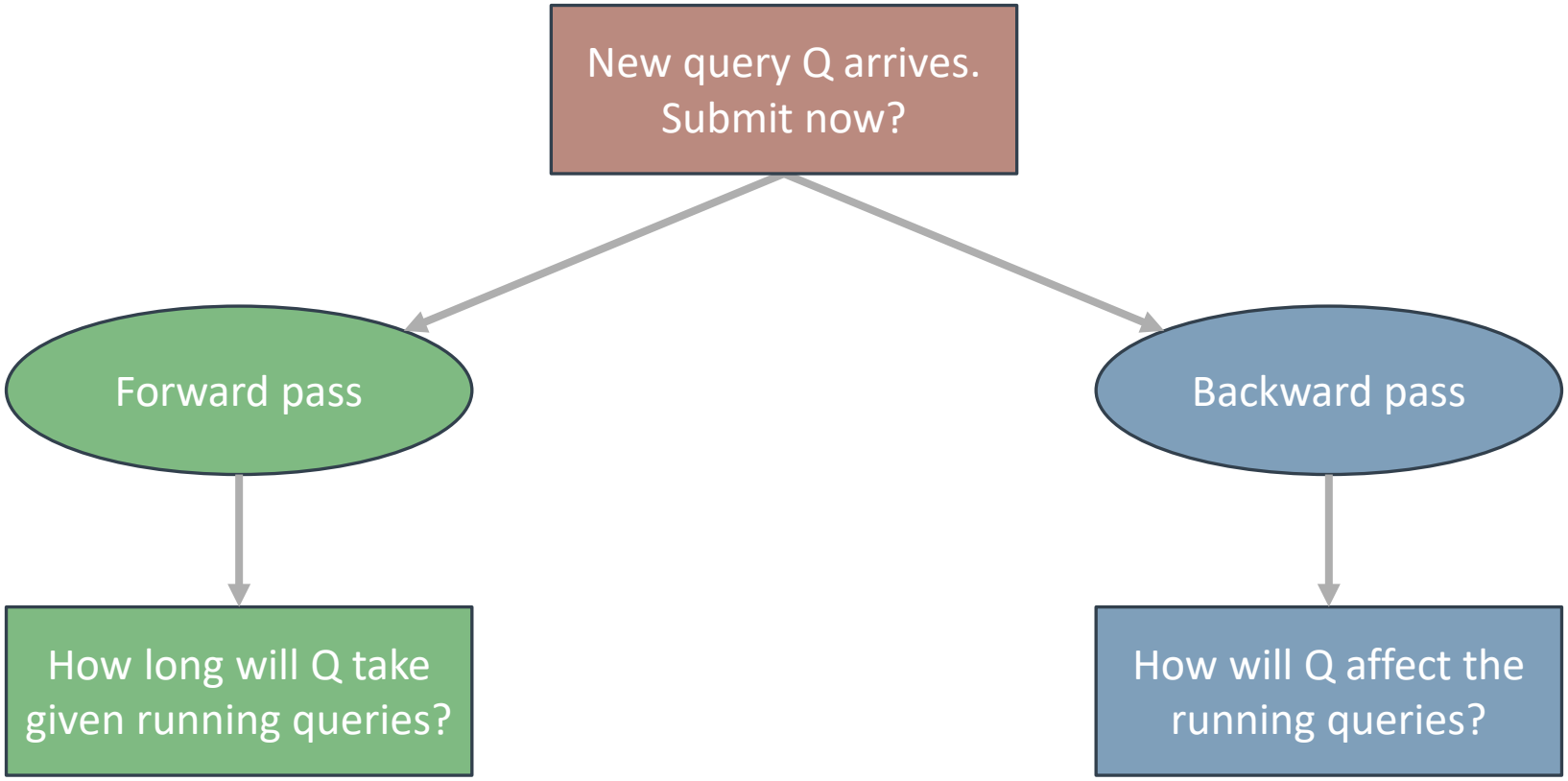


$I(Q_1,Q_2) =$	$F(Q_4)$	$F(Q_2)$	$\lvert t_4 - t_2 \rvert$	$t_4 > t_2$	$t_4 \leq t_2$
$I(Q_3,Q_2) =$	$F(Q_3)$	$F(Q_2)$	$\lvert t_3 - t_2 \rvert$	$t_3 > t_2$	$t_3 \leq t_2$
$I(Q_1,Q_2) =$	$F(Q_1)$	$F(Q_2)$	$\lvert t_1 - t_2 \rvert$	$t_1 > t_2$	$t_1 \leq t_2$
$I(Q_0,Q_2) =$	$F(Q_0)$	$F(Q_2)$	$\lvert t_0 - t_2 \rvert$	$t_0 > t_2$	$t_0 \leq t_2$

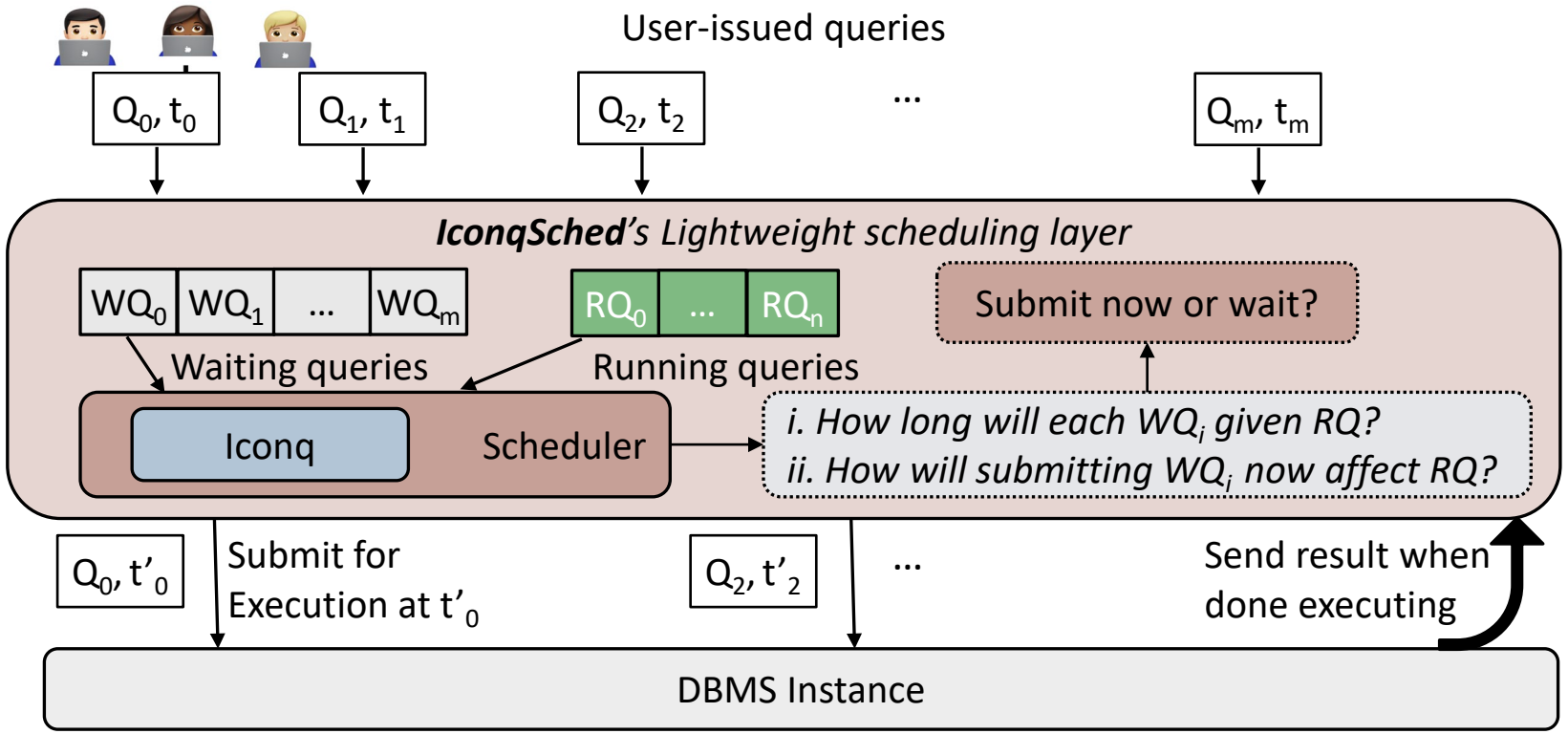
We then train Iconq: a bidirectional LSTM



At inference time, separate the passes



Iconq is at the center of our scheduler



*** For short queries (Stage[1] estimate < 5s), always submit, since Iconq requires around 100ms for inference**

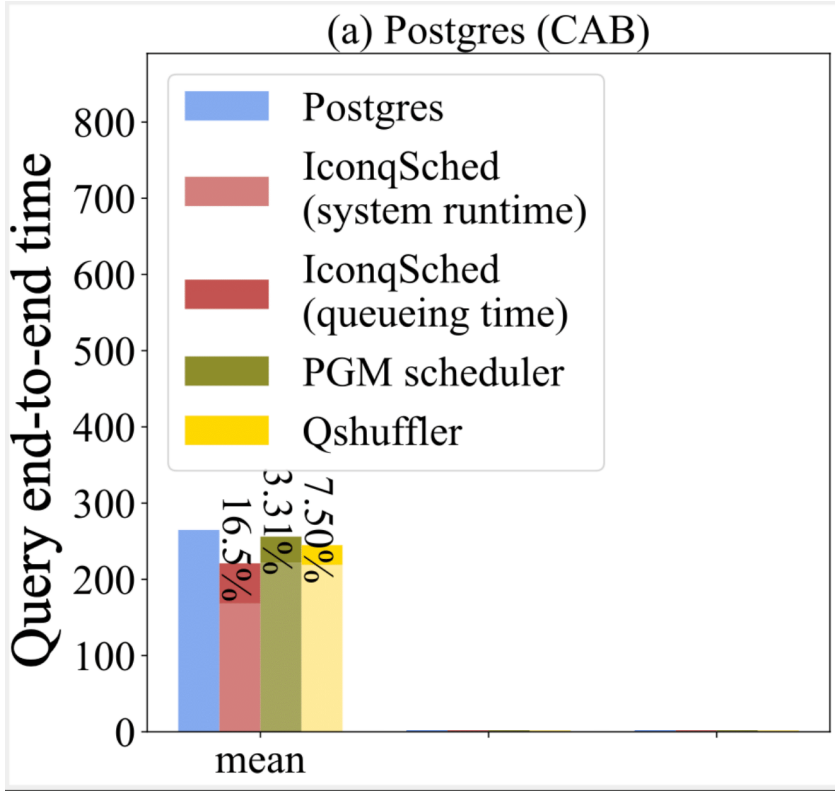
[1] Ziniu Wu, Ryan Marcus, Zhengchun Liu, Parimarjan Negi, Vikram Nathan, Pascal Pfeil, Gaurav Saxena, Mohammad Rahman, Balakrishnan Narayanaswamy, and Tim Kraska. 2024. Stage: Query Execution Time Prediction in Amazon Redshift.

Setting up the evaluation

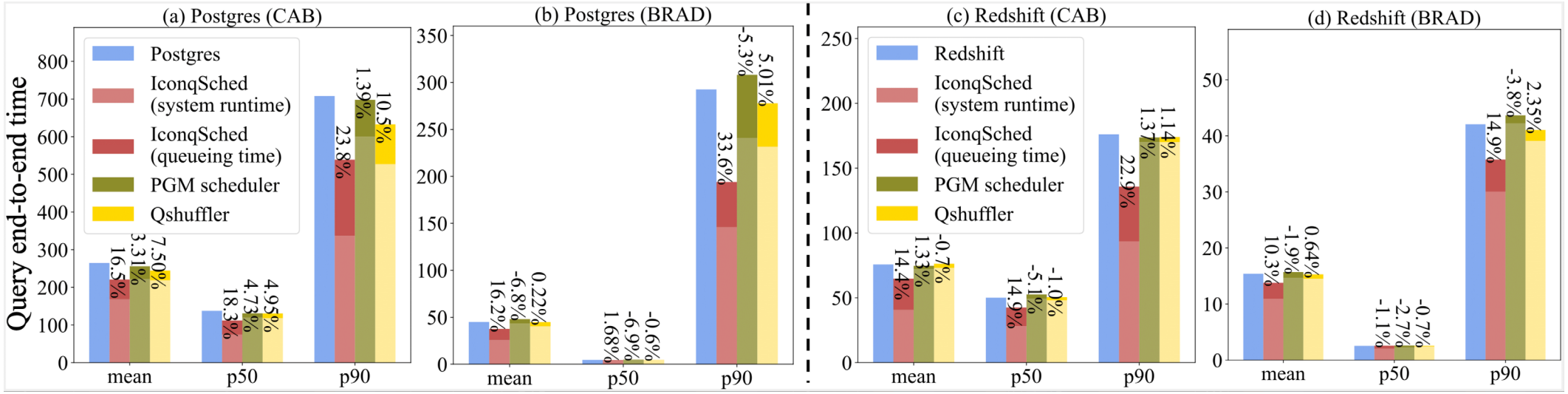
- Two different DBMS engines:
  - PostgreSQL
  - Amazon Redshift
- Two different open-source benchmarks:
  - CAB[1]: Cloud Analytics Benchmark
  - BRAD[2]: IMDB data + Snowset query arrival timestamps
- Two different state-of-the-art baselines:
  - PGM Scheduler[3]: Estimate memory and keep total bounded.
  - Qshuffler[4]: Represent system state as counts per query cluster.

[1] Alexander van Renen and Viktor Leis. 2023. Cloud Analytics Benchmark.
[2] Geoffrey X. Yu, Ziniu Wu, Ferdi Kossmann, Tianyu Li, Markos Markakis, Amadou Ngom, Samuel Madden, and Tim Kraska. 2024. Blueprinting the Cloud: Unifying and Automatically Optimizing Cloud Data Infrastructures with BRAD.
[3] Abhay Mehta, Chetan Gupta, and Umeshwar Dayal. 2008. BI batch manager: a system for managing batch workloads on enterprise data-warehouses.
[4] Mumtaz Ahmad, Ashraf Aboulnaga, Shivnath Babu, and Kamesh Munagala. 2011. Interaction-aware scheduling of report-generation workloads.

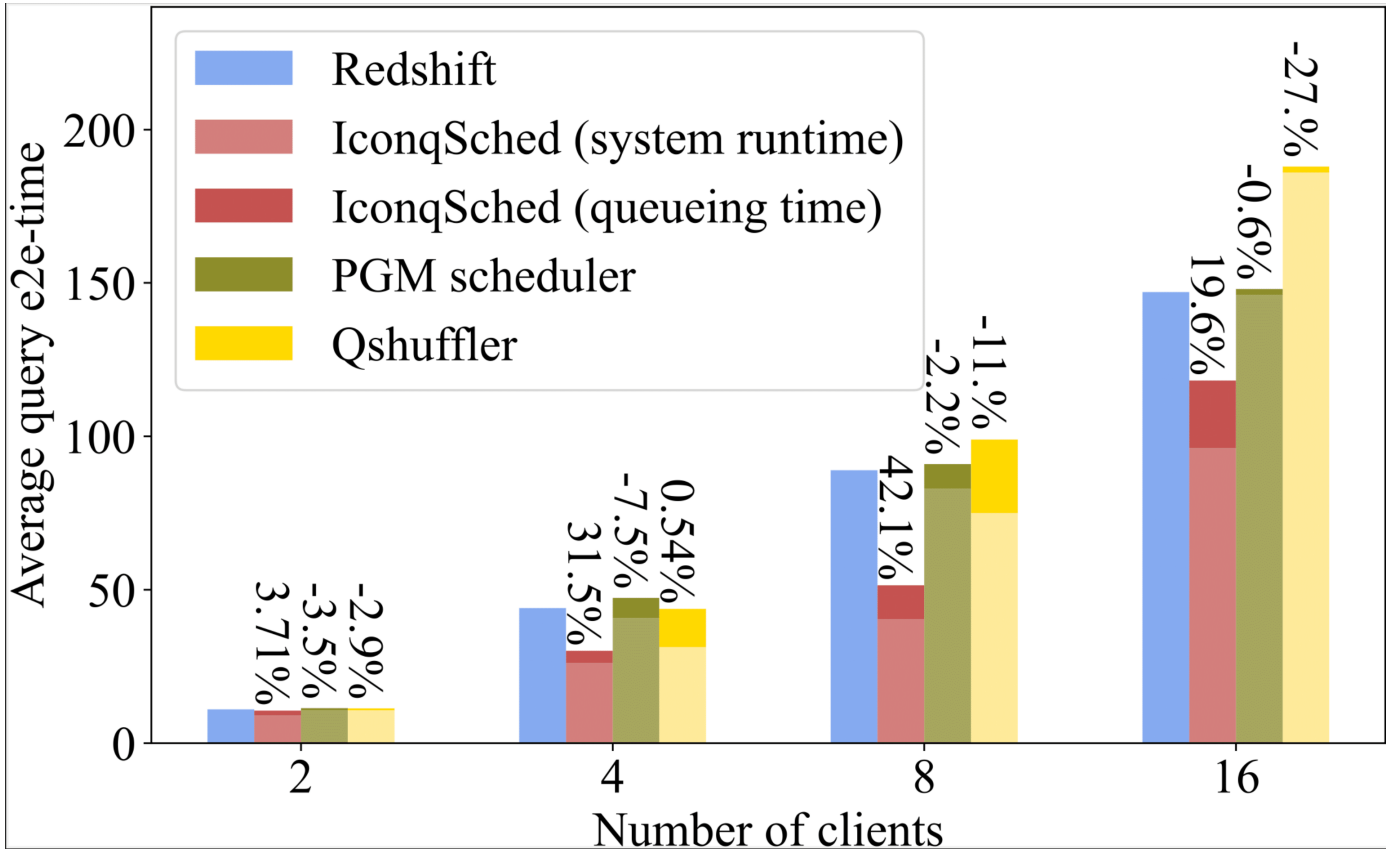
We improve query end-to-end time



We outperform baselines across settings



Iconq performs under high concurrency

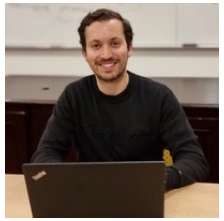
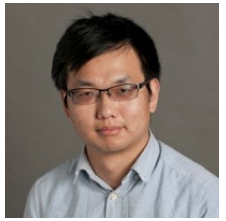


Key Takeaway

IconqSched reduces
query end-to-end time
without accessing DBMS internals

Data Systems Group @ MIT

Thank you!

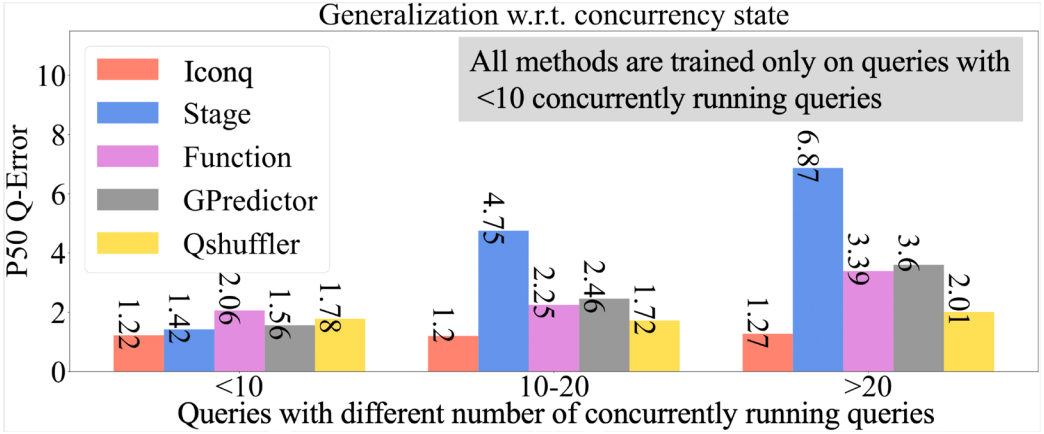




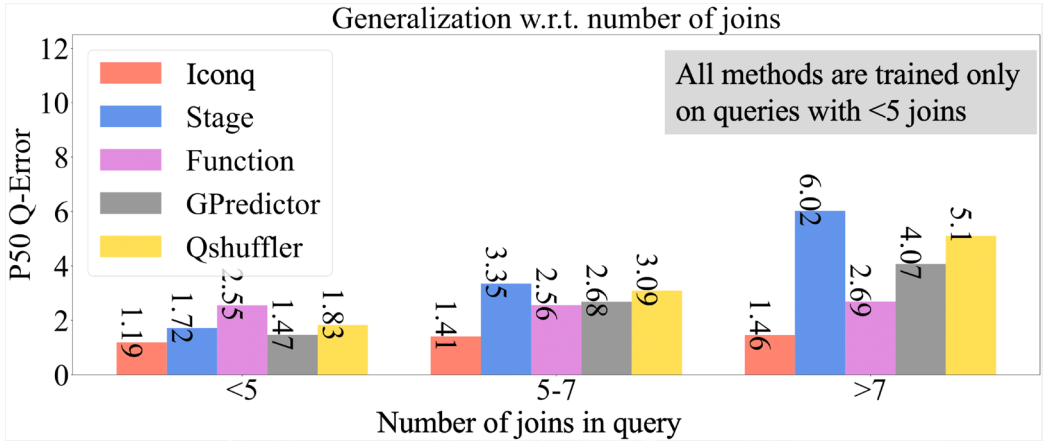


Paper: https://www.vldb.org/pvldb/vol18/p4185-wu.pdf

Questions? Reach out at ziniuw@mit.edu

Iconq generalizes well to harder contexts





$$Q_{\text{error}} = max\left(\frac{true}{pred}, \frac{pred}{true}\right)$$