Berkeley Optimizer: Learning a Query Optimizer with Deep RL

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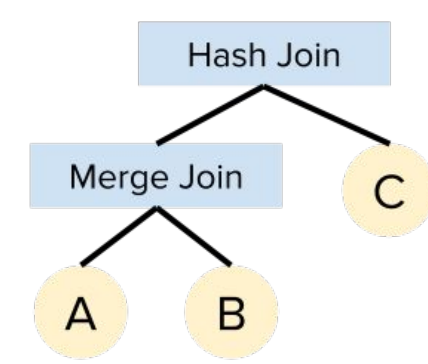
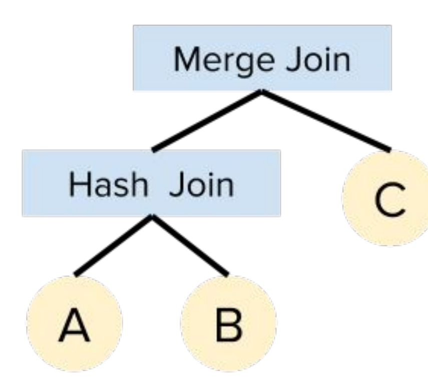
Query → Execution Plan

Query | *Plan*

```sql
SELECT MIN(chn.name), MIN(t.title)
FROM char_name AS chn, title AS t
WHERE t.production_year > 1990
  AND t.id = 4
  AND chn.id = 9;
```

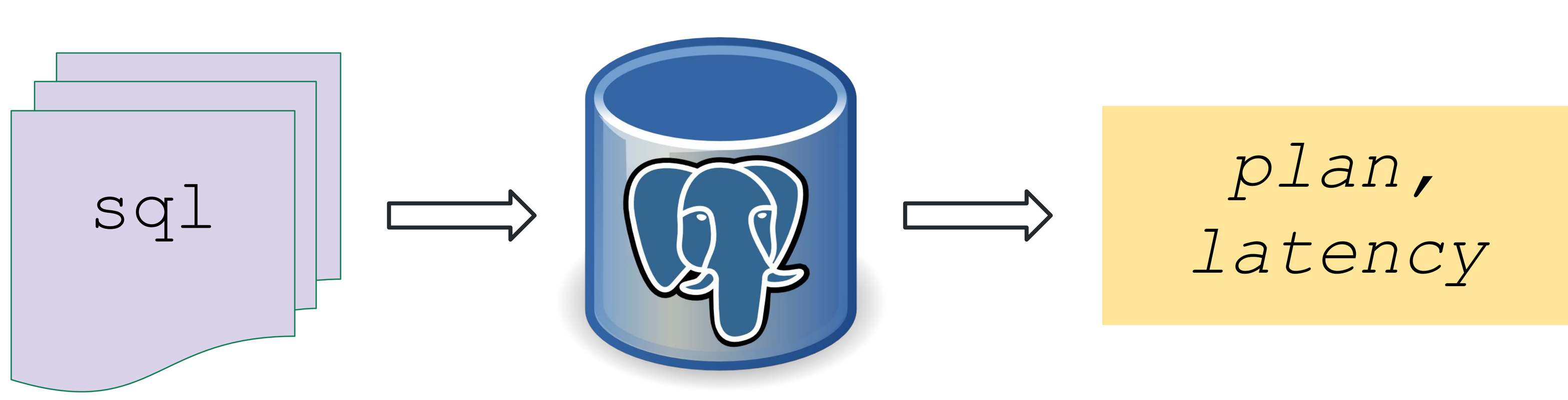



```sql
SELECT MAX(k.keyword), n.name
FROM keyword AS k, name AS n
WHERE k.keyword IN ('superhero',
                    'sequel')
  AND n.name LIKE '%Downey%Robert%'
```



Query execution plan space is exponentially large and often relies on human-engineered cost models to generate the best plan.

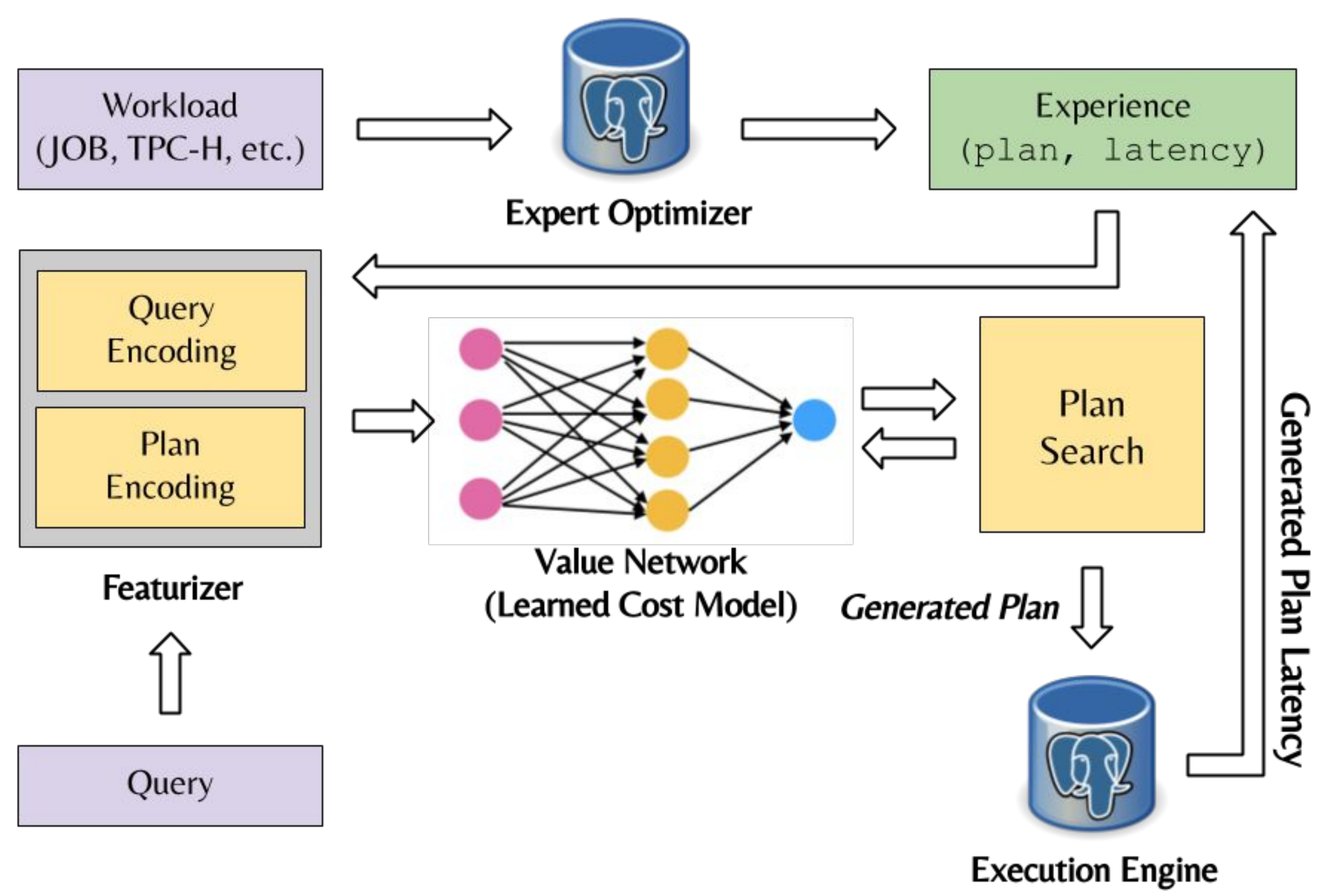
Expert Bootstrapping



Deep reinforcement learning agent learns an initial policy π_0 from a human-engineered (expert) model.

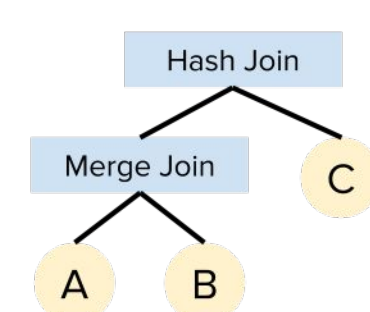
Why is this necessary?	Executing poorly planned queries can take hours to complete.
Value Iteration	Use π_0 to learn an optimal policy through retraining agent based on generated plans + latency.

System Architecture



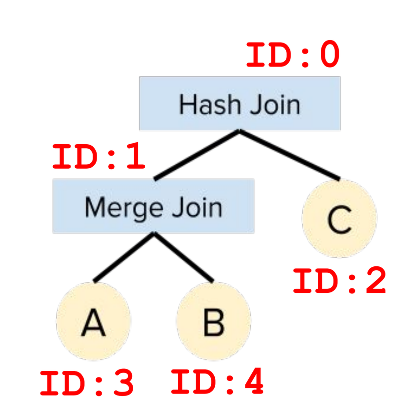
Encoding Plans as Sequences

Pre-order Seq. Encoding

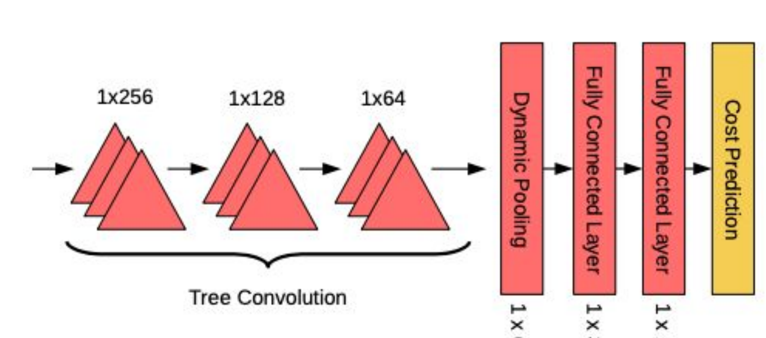


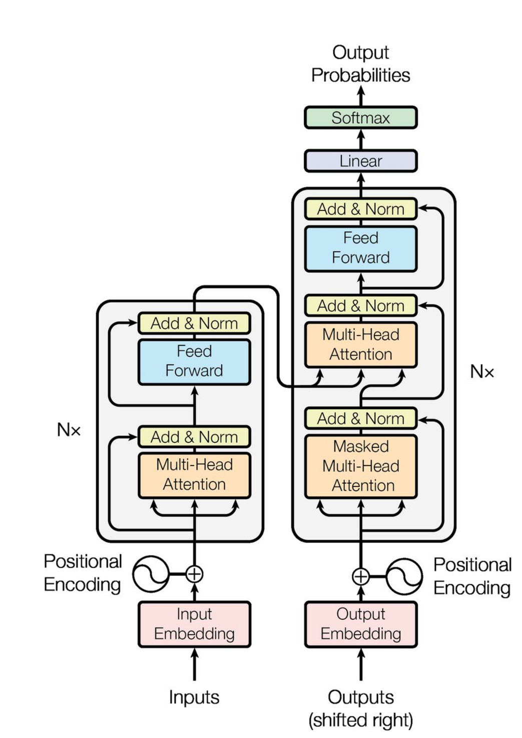
$[HJ, MJ, T_A, T_B, T_C]$

Parent Positional Embeddings (parent's ID)



[-1, 0, 1, 1, 0]



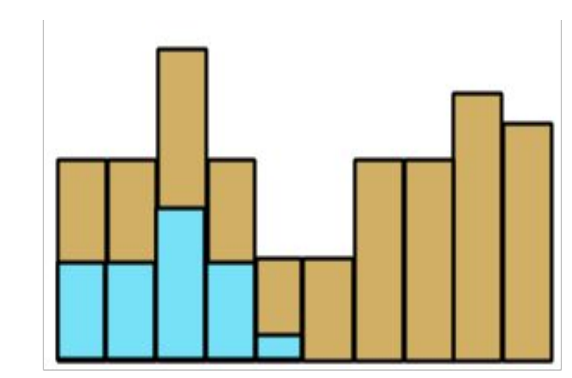


Plan encodings are processed by either a transformer[1] or tree convolution[2] cost model.

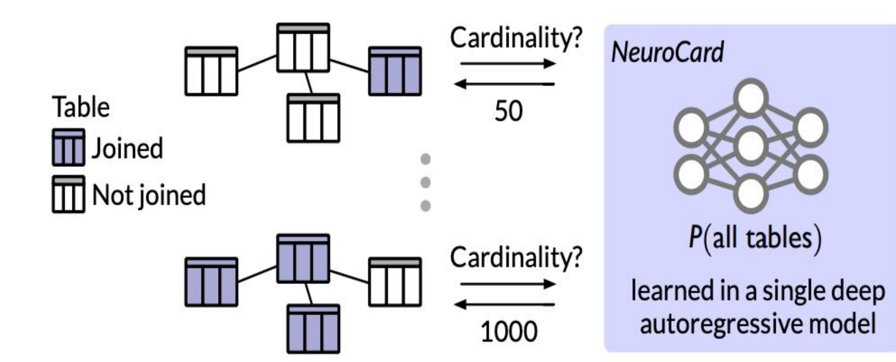
[1] Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N Gomez, Lukasz Kaiser, and Illia Polosukhin. 2017. Attention is all you need. In Advances in Neural Information Processing Systems, pages 6000–6010.
[2] L. Mou, G. Li, L. Zhang, T. Wang, and Z. Jin. Convolutional neural networks over tree structures for programming language processing. In Proceedings of the Thirtieth AAAI Conference on Artificial Intelligence (AAAI'16), 2016.

Query Encoding

Flexibility of system allows for novel improvements to featurization and cost model.



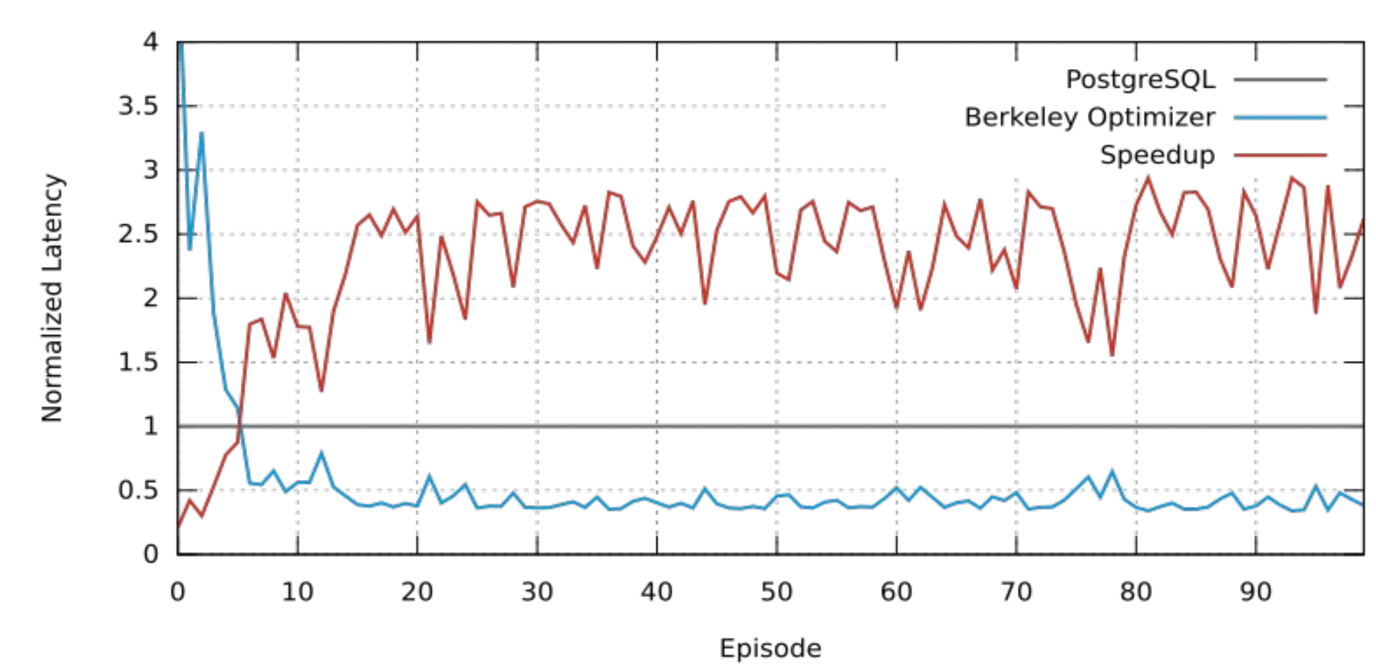
Histogram-based Selectivity Estimation



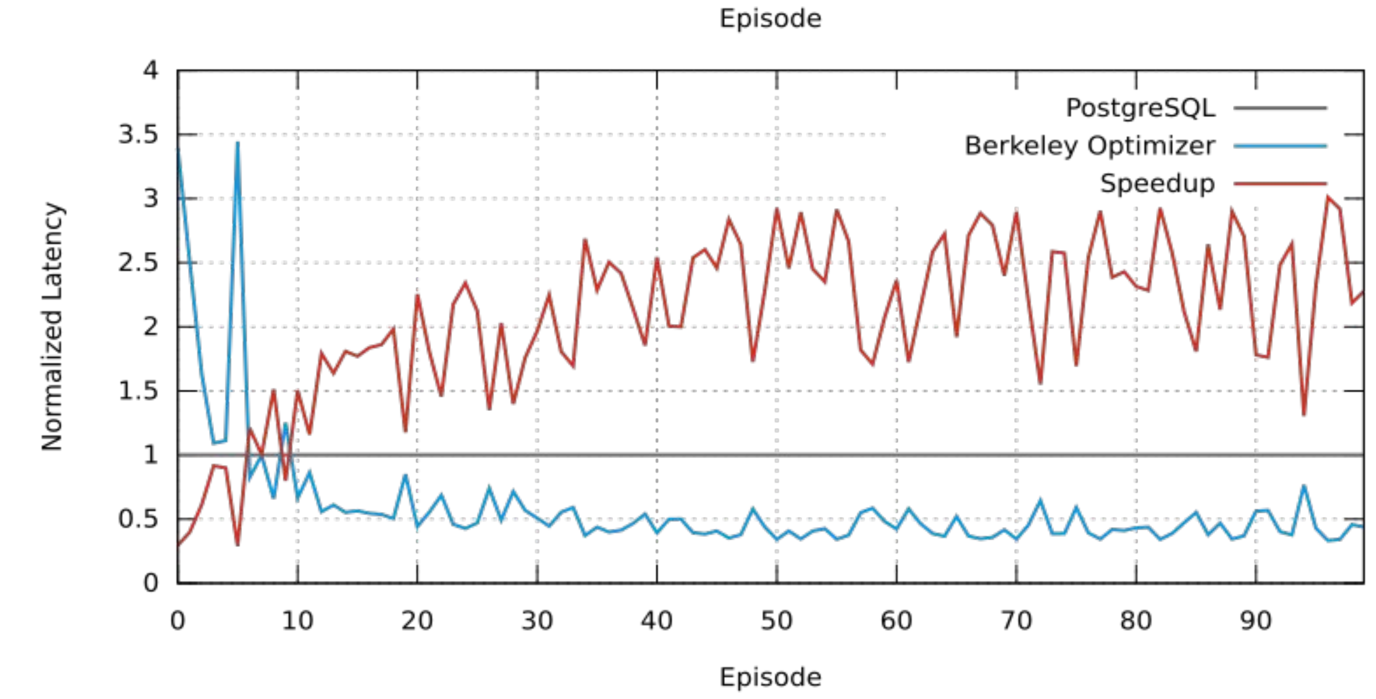
NeuroCard (Yang et al., 2020)

Evaluation

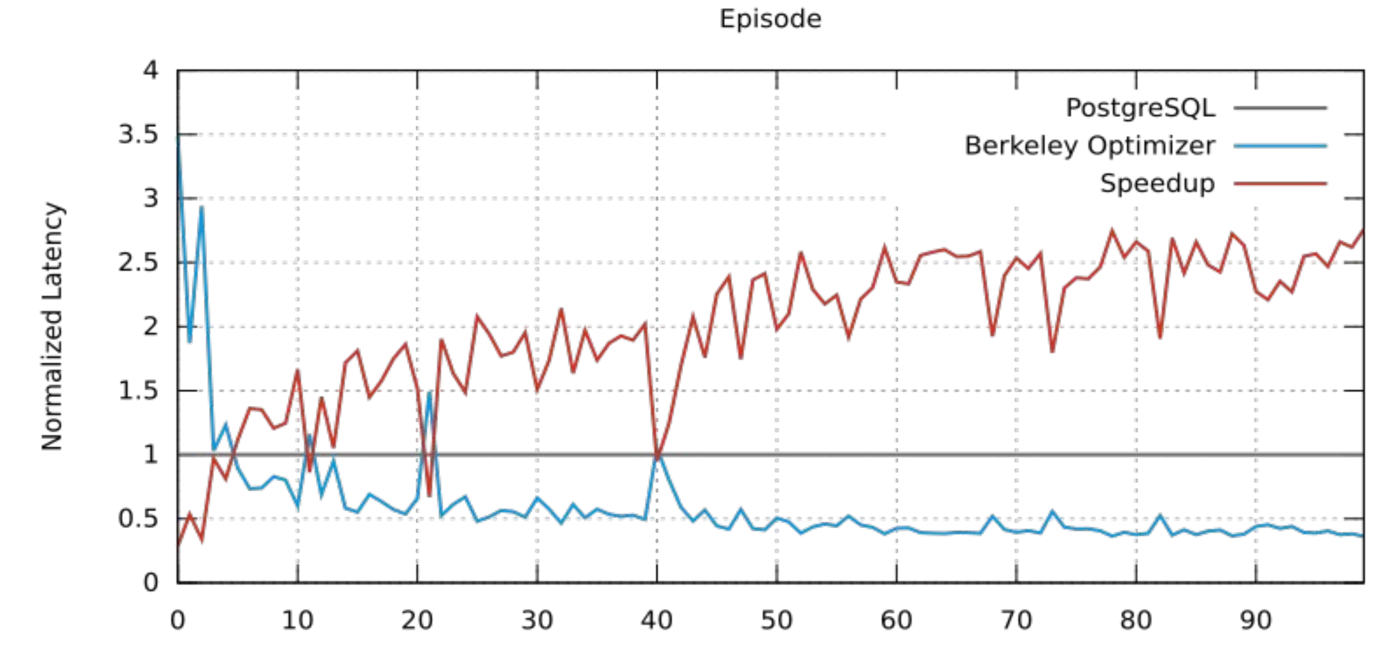
All experiments use the JOB (113 queries) benchmark.



Transformer with expert bootstrapping



Tree convolution with expert bootstrapping



Transformer without expert bootstrapping