Concordia

Multi-Horizon Forecasting of Network Metrics Using Machine Learning

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COMP 6321: Machine Learning - Fall 2025 - Project Presentation

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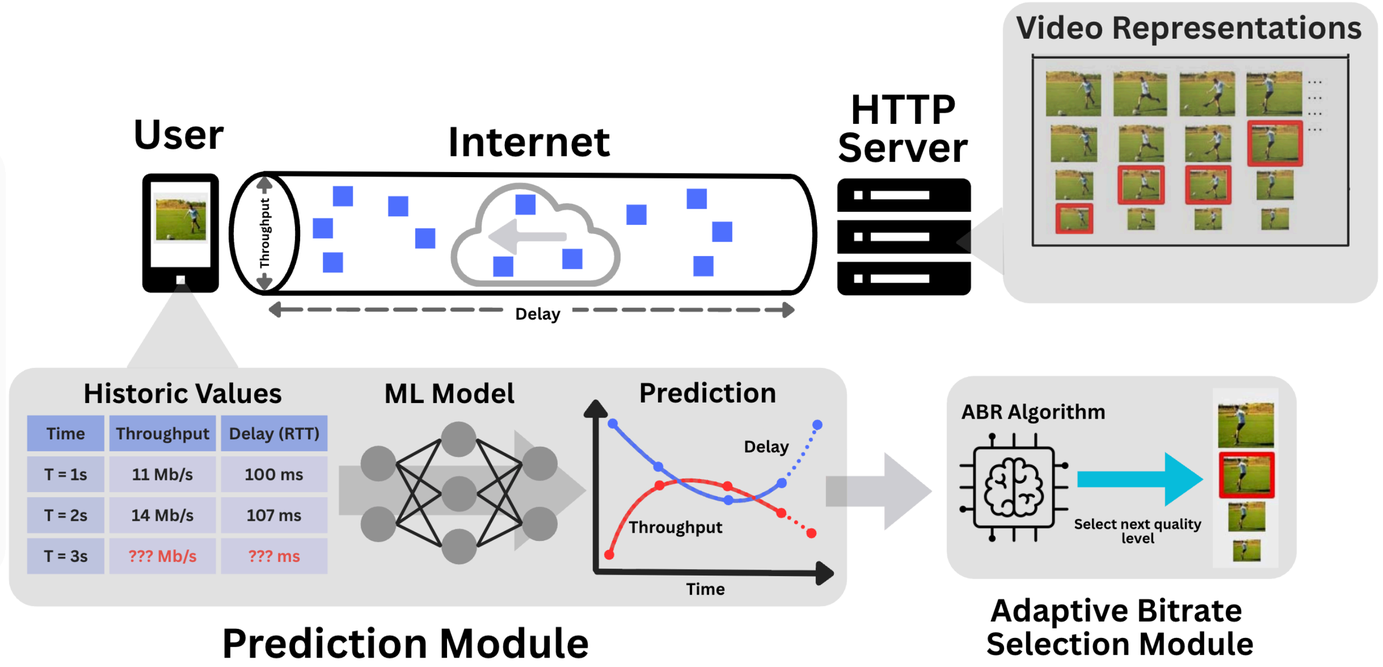
Video Streaming & The Importance of Network Prediction

- Streaming platforms Adaptive Bitrate Algorithms to select the most appropriate video chunk to download
- ABRs require accurate short-term and long-term predictions of **throughput** and **delay** to make good decisions
- However long-horizon network prediction is not well researched



Contributions

1. Detailed empirical study of multi-horizon forecasting, analyzing prediction accuracy against differing horizons.

2. Compare four ML models, highlighting strengths and weaknesses

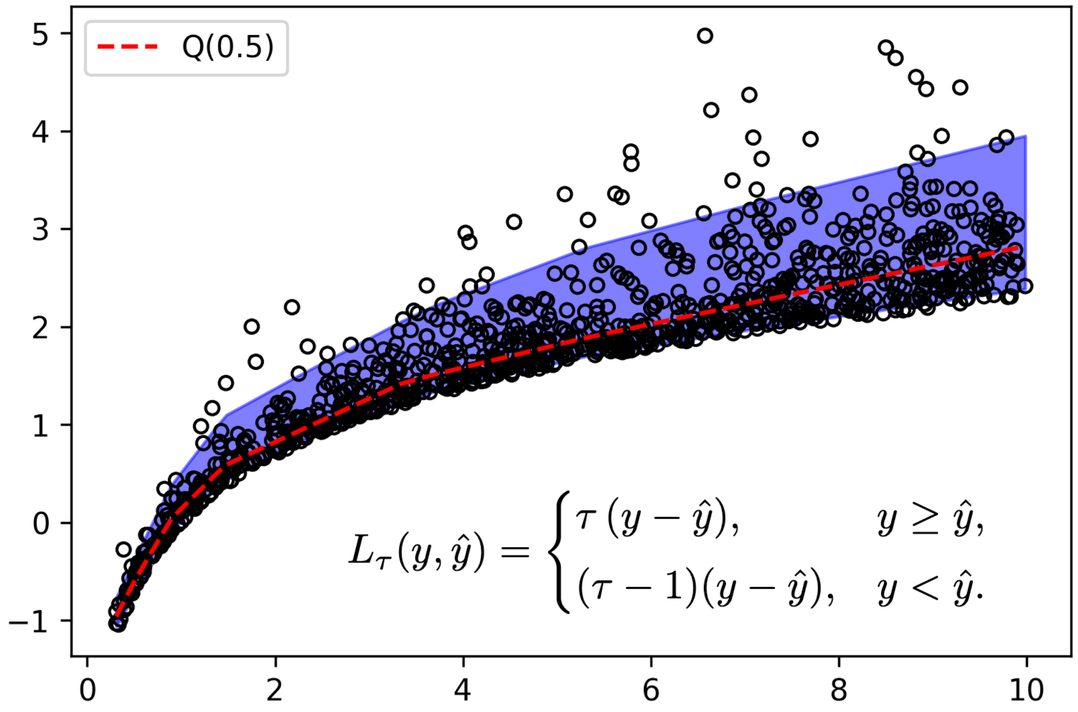
3. Incorporate quantile regression to produce prediction intervals, showcasing the importance of uncertainty estimates as horizon length increases.

Methodology

- Dataset: Puffer
- Models: Catboost - MLP - GRU - LSTM
- Objective Functions:
  - MAE
  - Pinball Loss (Coverage area - Interval Width)

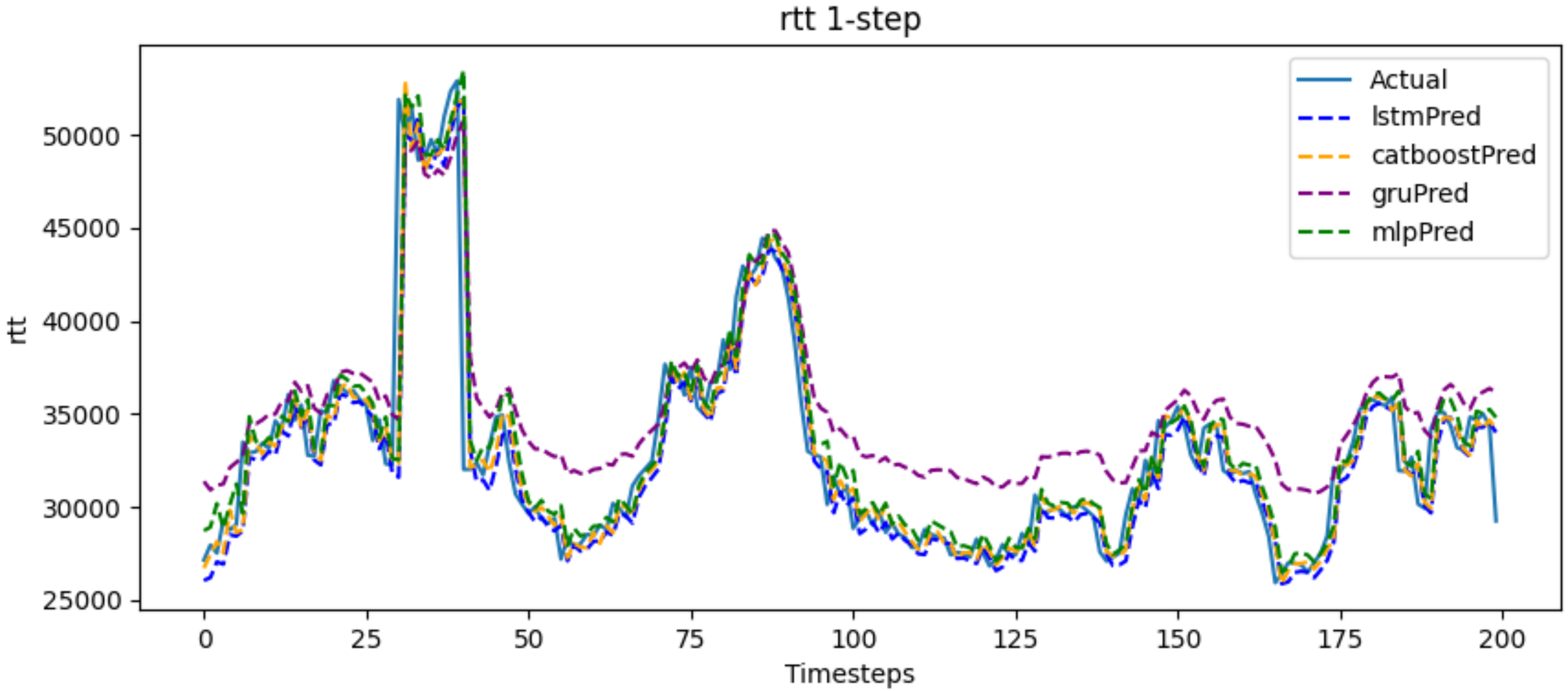
Table 1: Extracted Features from the Puffer Dataset for Forecasting

Feature	Description
`cwnd`	Congestion window size (in number of packets) from TCP stack.
`rtt`	Delay time between client and server (µs).
`delivery_rate`	TCP sender delivery rate estimate (bytes/s).
`buffer`	Playback buffer size at the client (seconds).



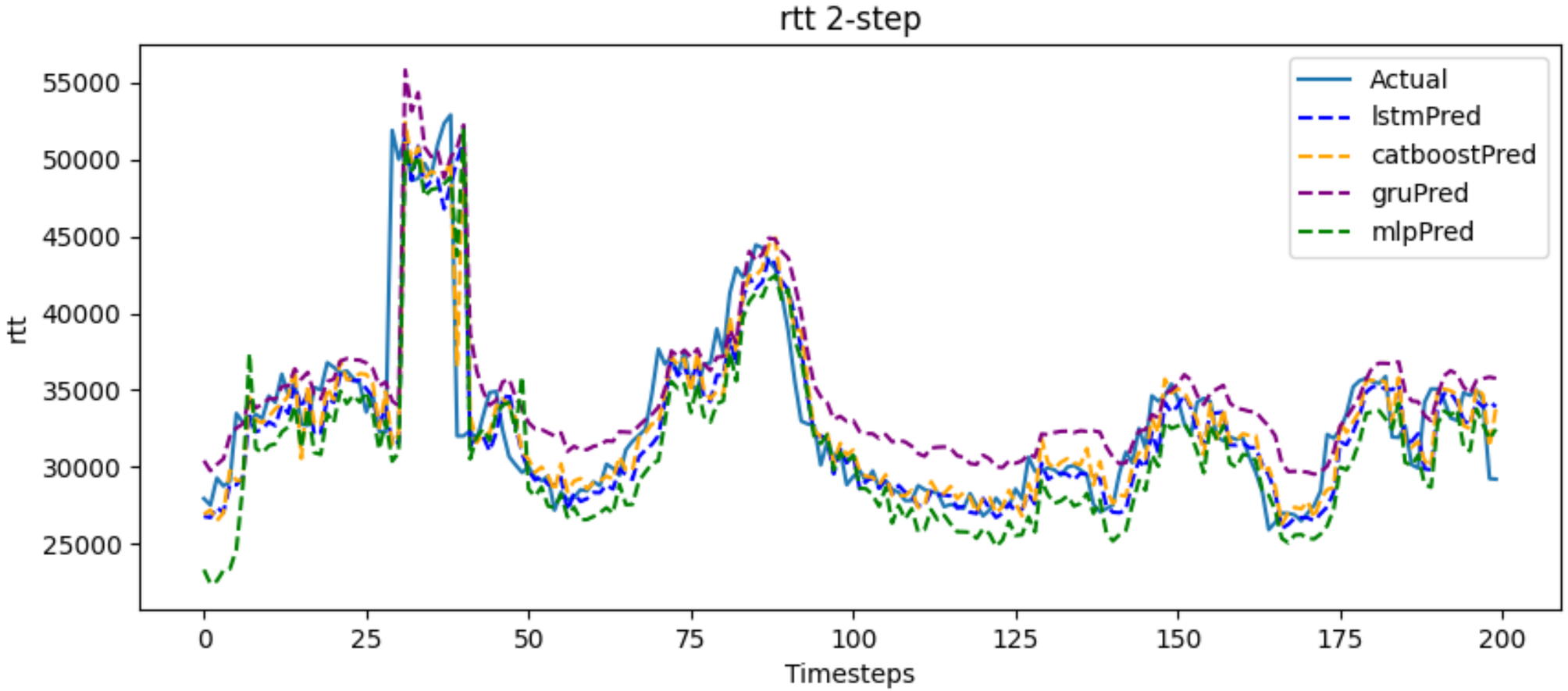
Results (Point-Predictions)

RTT Multi-Horizon



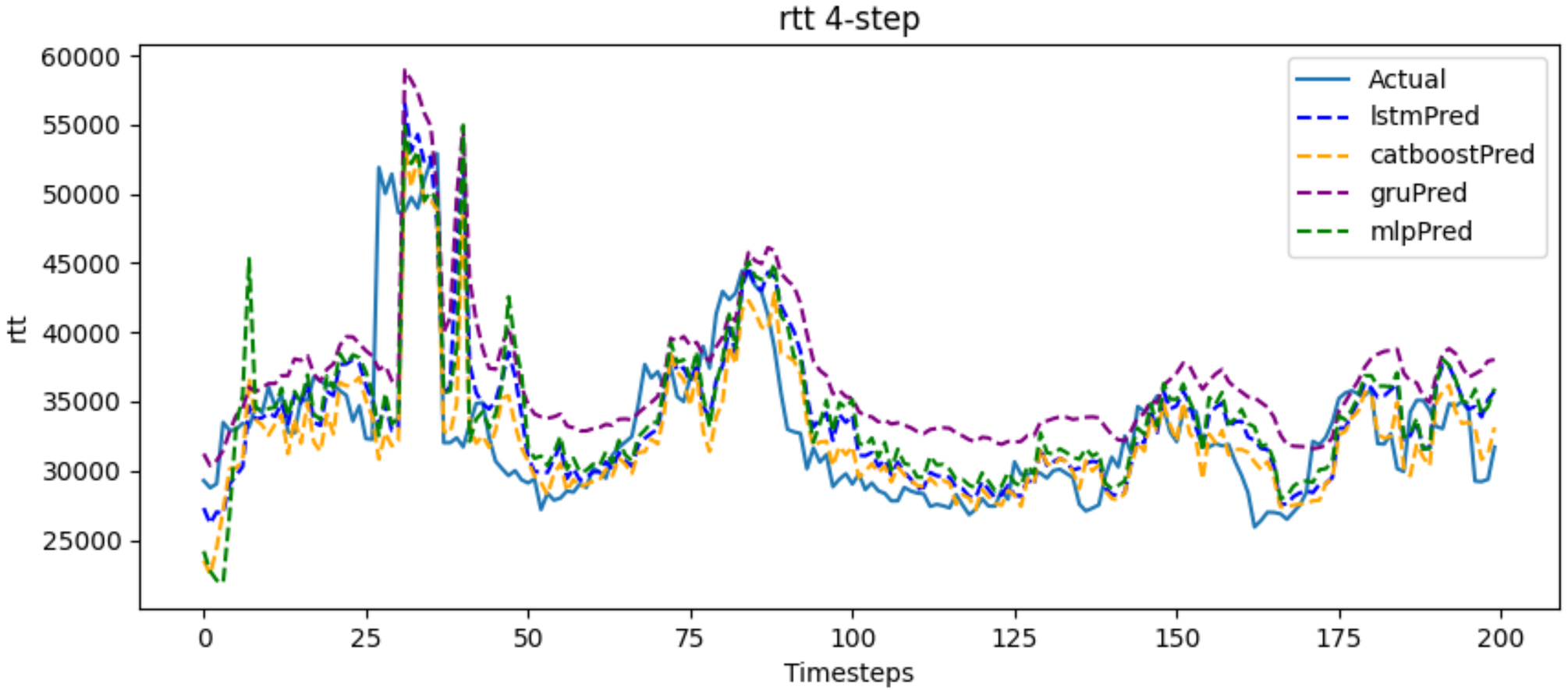
Results (Point-Predictions)

RTT Multi-Horizon



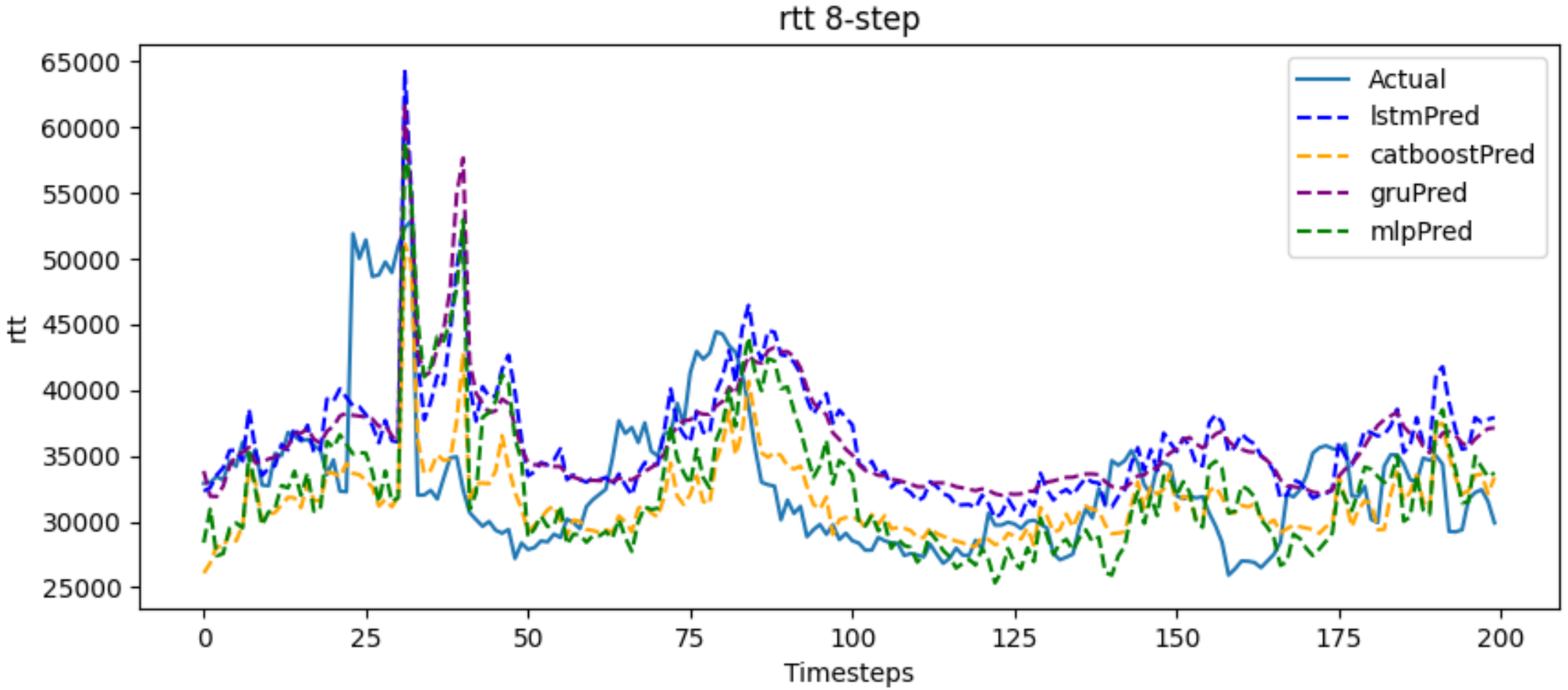
Results (Point-Predictions)

RTT Multi-Horizon



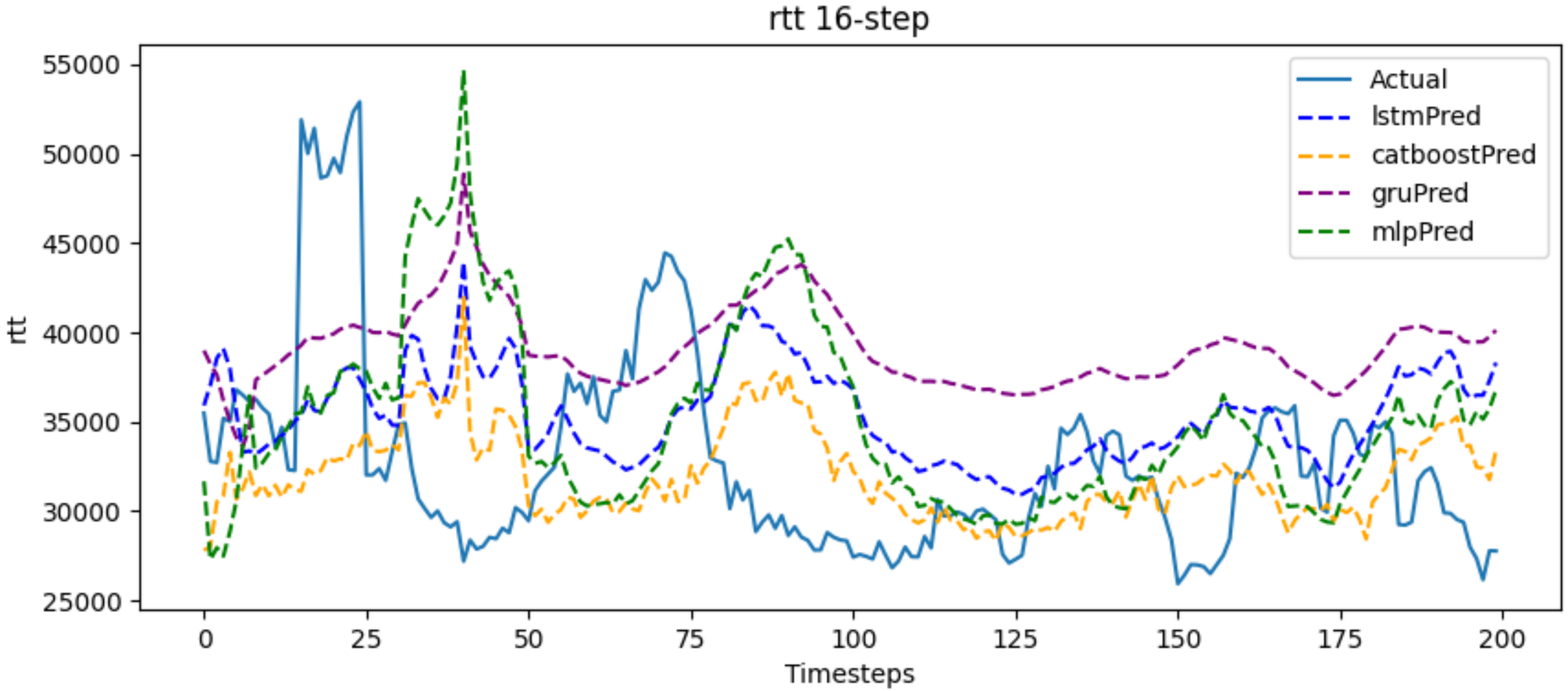
Results (Point-Predictions)

RTT Multi-Horizon



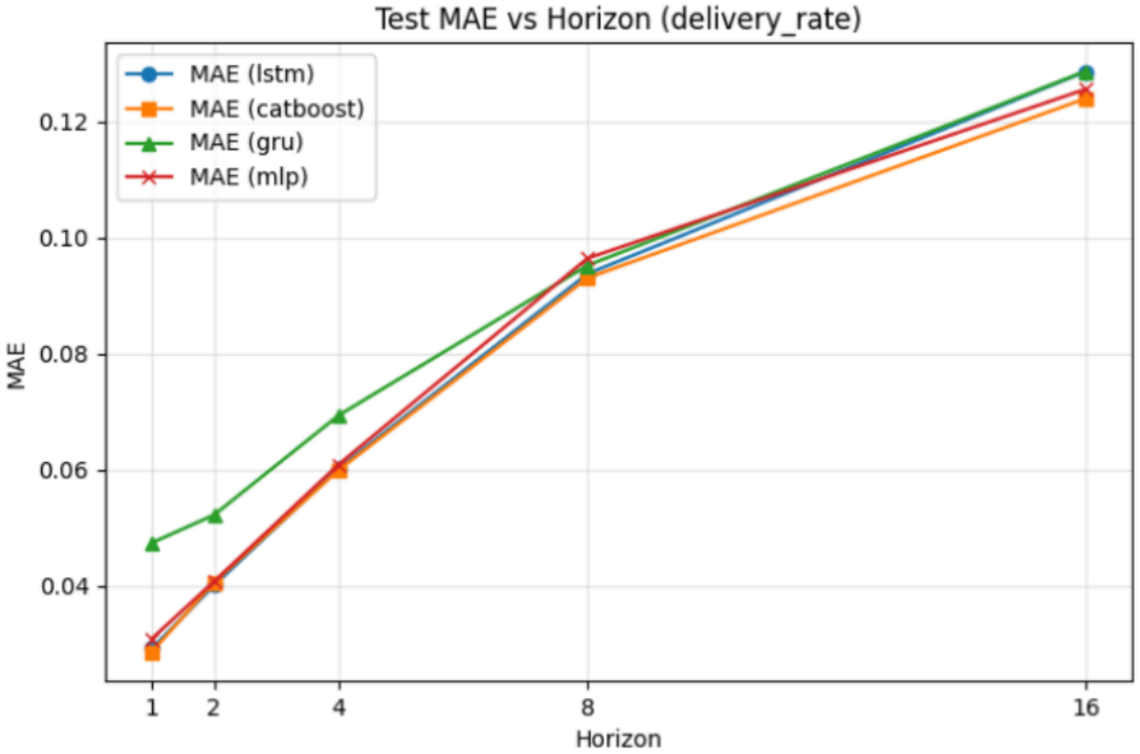
Results (Point-Predictions)

RTT Multi-Horizon

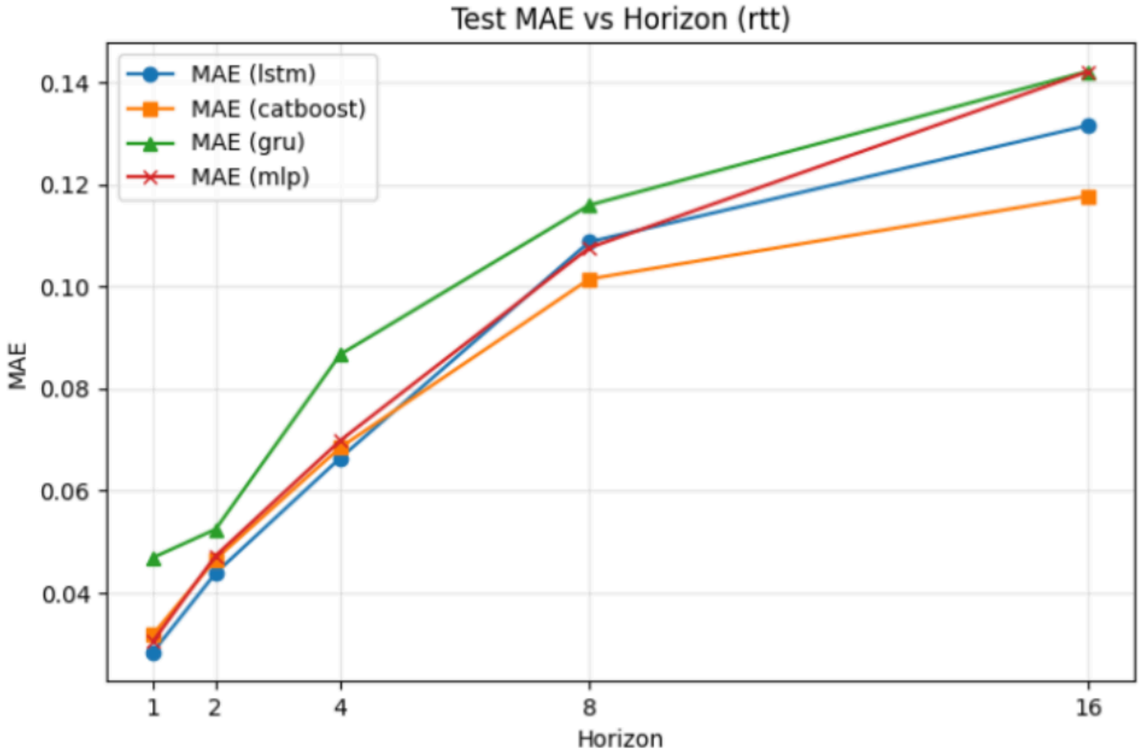


Results (Point-Predictions)

Model Degradation with Horizon



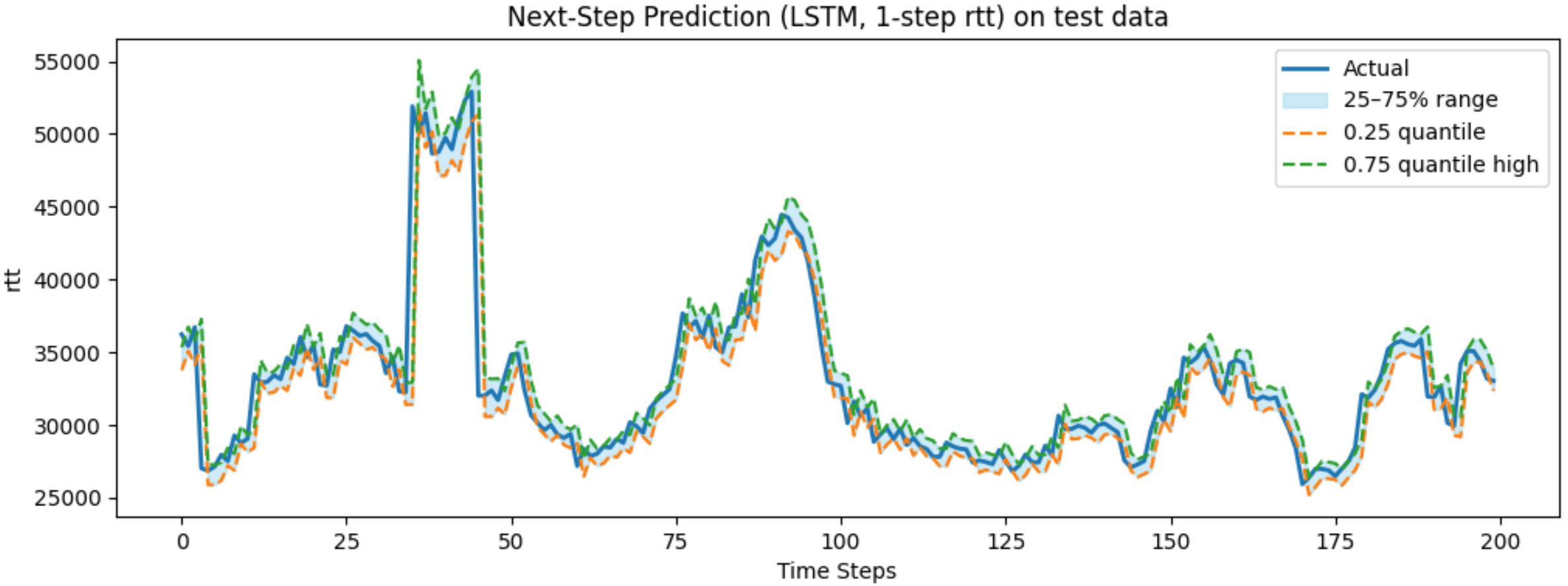
(a) Delivery rate (throughput)



(b) RTT (delay)

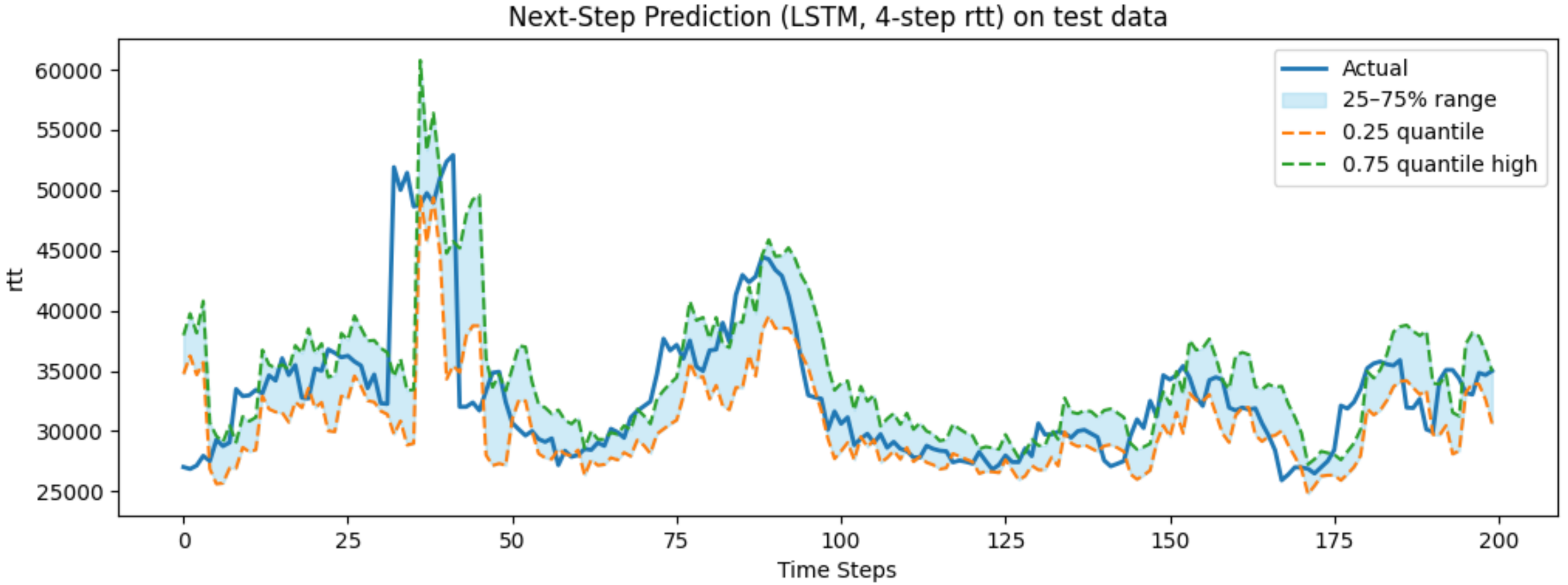
Results (Quantile-Predictions)

RTT 50% Confidence Bound (1-step)



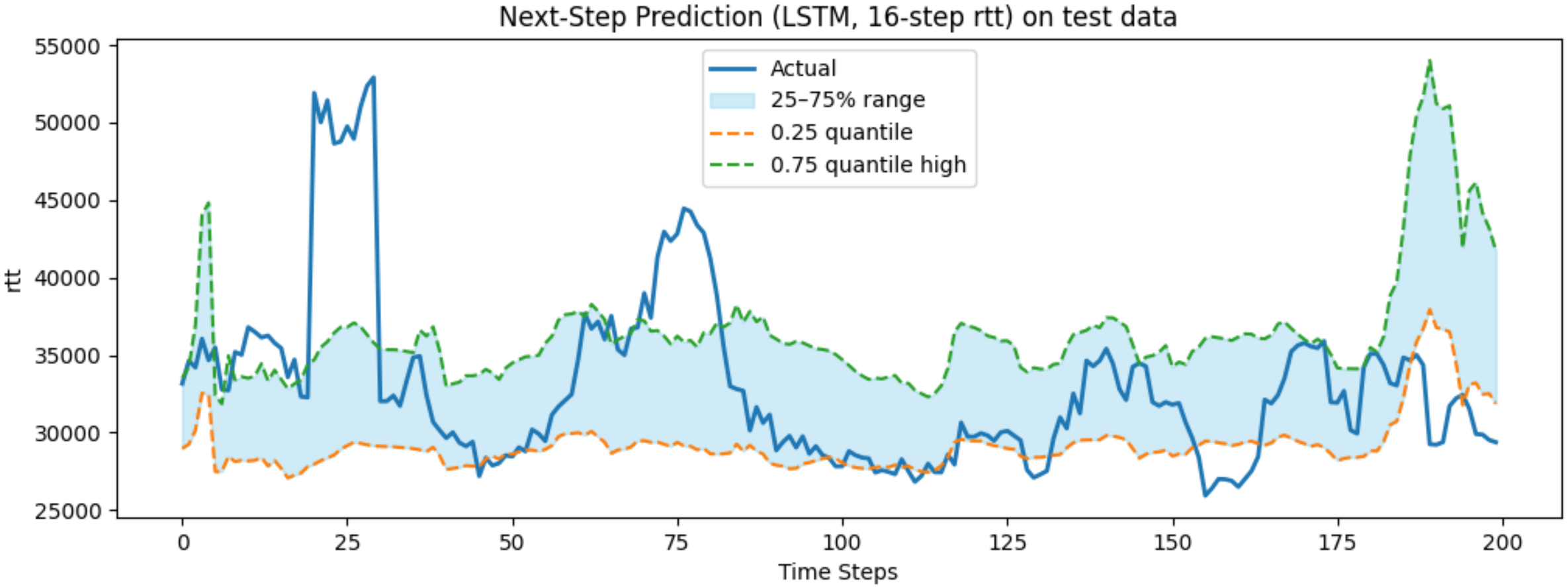
Results (Quantile-Predictions)

RTT 50% Confidence Bound (4-steps)



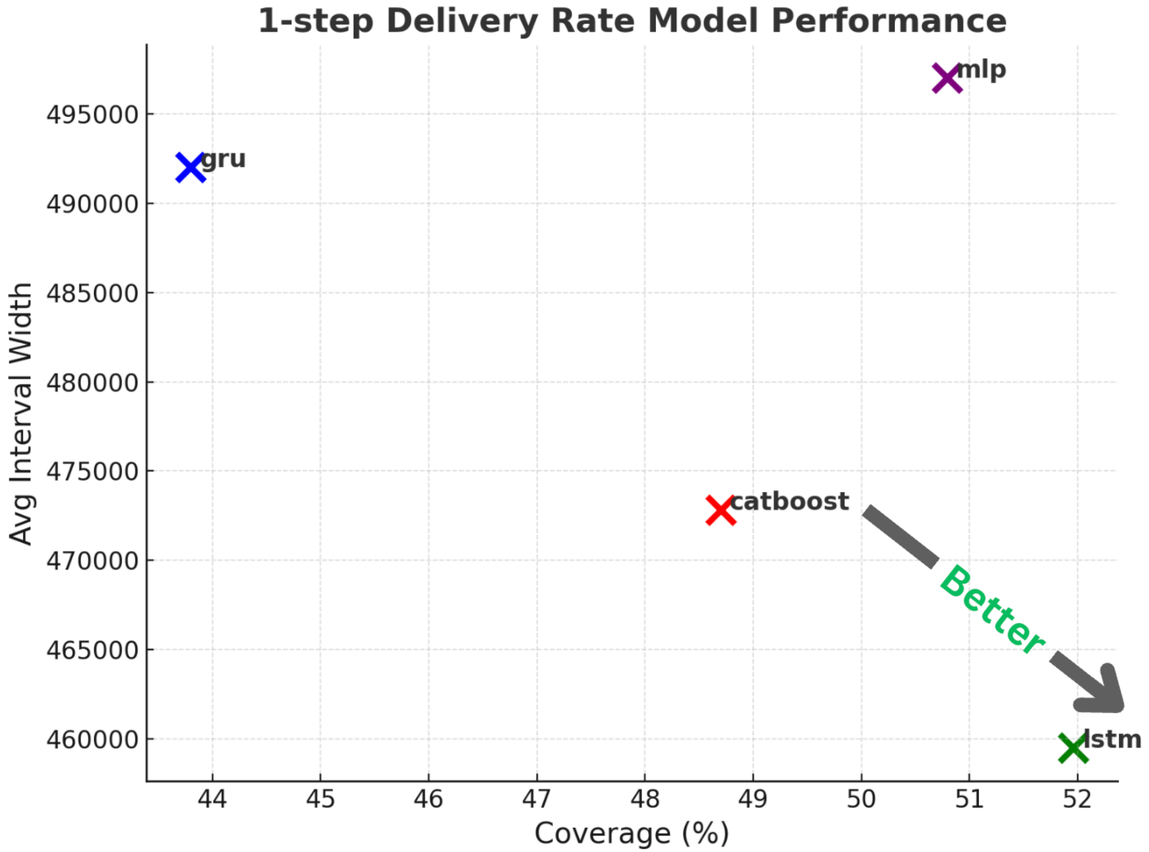
Results (Quantile-Predictions)

RTT 50% Confidence Bound (16-steps)



Results (Quantile-Predictions)

Model Comparison



Conclusion

- Catboost is the best model for point-predictions
- LSTM is among the top models for quantile regression
- For long horizons, quantile regression makes more sense than point prediction (gives us an estimate of model uncertainty while normal regression does not)

- More plots in paper + full code on GitHub

The End