Comparison of machine learning models for predicting near-future traffic demand

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Background

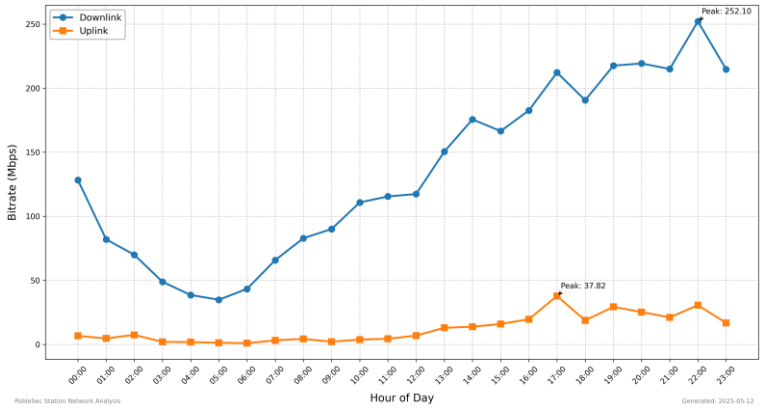
As humanity grows more dependent on the mobile networks, the need for accurate predictions of traffic demand becomes more evident. With virtualization of the 5th generation network new opportunities arose for more sophisticated traffic prediction approaches, particularly those based on machine learning.

Research Questions

1. How do different ML models compare in terms of computational resource requirements?
2. What is the optimal trade-off between model complexity and prediction accuracy for near-future traffic demand?
3. Which model architecture demonstrates the best generalization performance on unseen traffic patterns?

Dataset

For the experiments run during this study we used the data of approximately 27,000 samples from 3 distinct base stations in Barcelona, Spain [1]. The data had to be pre-processed to help models recognise temporal patterns.

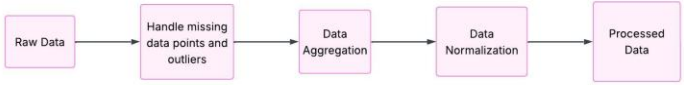


Methodology

The models forecasted the next timestep and were evaluated on the test set of 20% of all data.

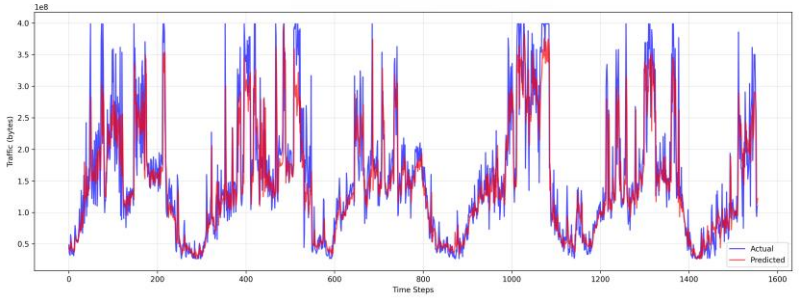
The models selected were:

- SARIMAX – baseline, for comparison of statistical to neural network forecasting
- RNN – simple ML approach for time series forecasting
- LSTM – more complex RNN, better for long-term dependencies
- timesFM –pretrained model for forecasting made by Google research team



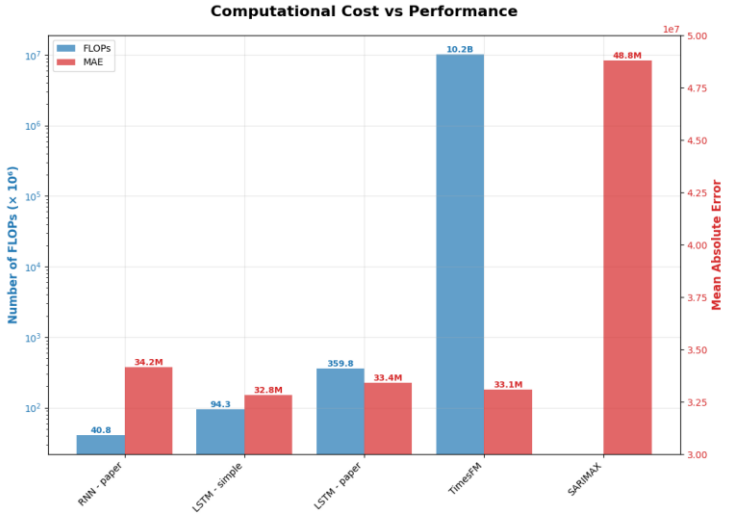
Experiments

To ensure the models' results are optimized several experiments were run to find values for training specific, model hyperparameters and data aggregation. Finalised models were trained on 50 epochs, with a sequence length of 12 hours on data aggregated at 5 minute intervals. The graph below shows the predictions of simple 2-layer LSTM:



Evaluation

Computational cost and model performance was compared using the numer of floating point operations (FLOPs) and Mean Absolute Error (MAE), respectively.



Conclusions

- Neural networks are a great alternative to statistical models for forecasting near-future traffic demand.
- Increasing complexity doesn't always yield better results.
- Even geographically close (~5 km) stations have different traffic patterns.
- Google TimesFM demonstrated the best generalization performance on unseen traffic patterns.

References

[1] Vasileios Perifanis et al. "Federated Learning for 5G Base Station Traffic Forecasting". In: Computer Networks 235 (2023).
[2] Abhimanyu Das, Weihao Kong, Rajat Sen, and Yichen Zhou. A decoder-only foundation model for time-series forecasting, 2024.