Decoding User Experience On Mobile Broadband in Challenged Networks: An Empirical Analysis

CS 293 PROJECT

TEAM:

ALEX ERMAKOV

DAVID WEINFLASH

VIVEK ADARSH

Challenged Networks…?

- Resource constrained
- Inaccessibility to broadband
- 60% rural vs 4% urban

Possible reasons:

- Lack of economic feasibility/interest
- Lack of Federal initiatives
- Vintage FCC policies

WHY IS THIS IMPORTANT?

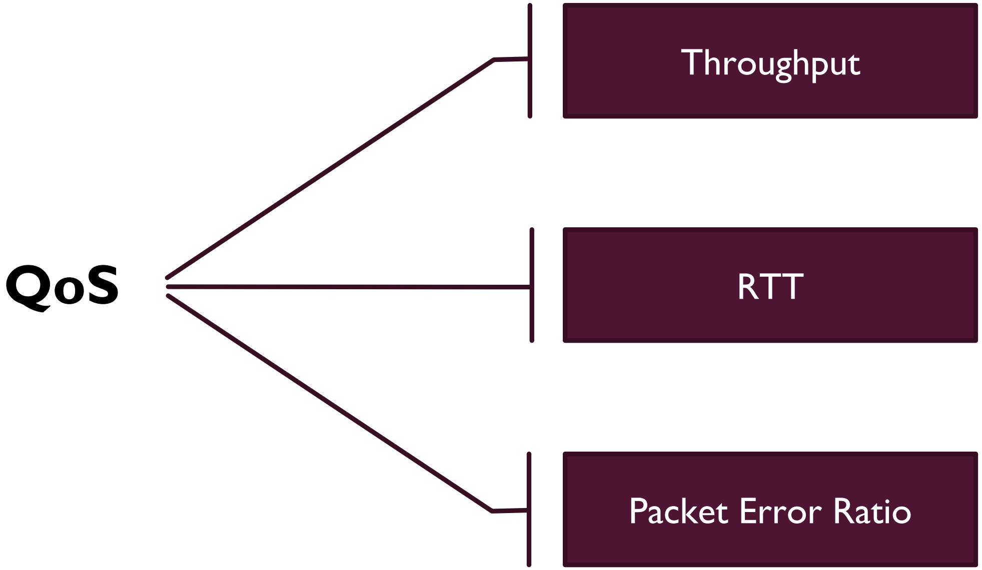
- Network disparity
- Learning about performance differences
- Findings’ impact on FCC policies
- Social impact

RESEARCH QUESTIONS

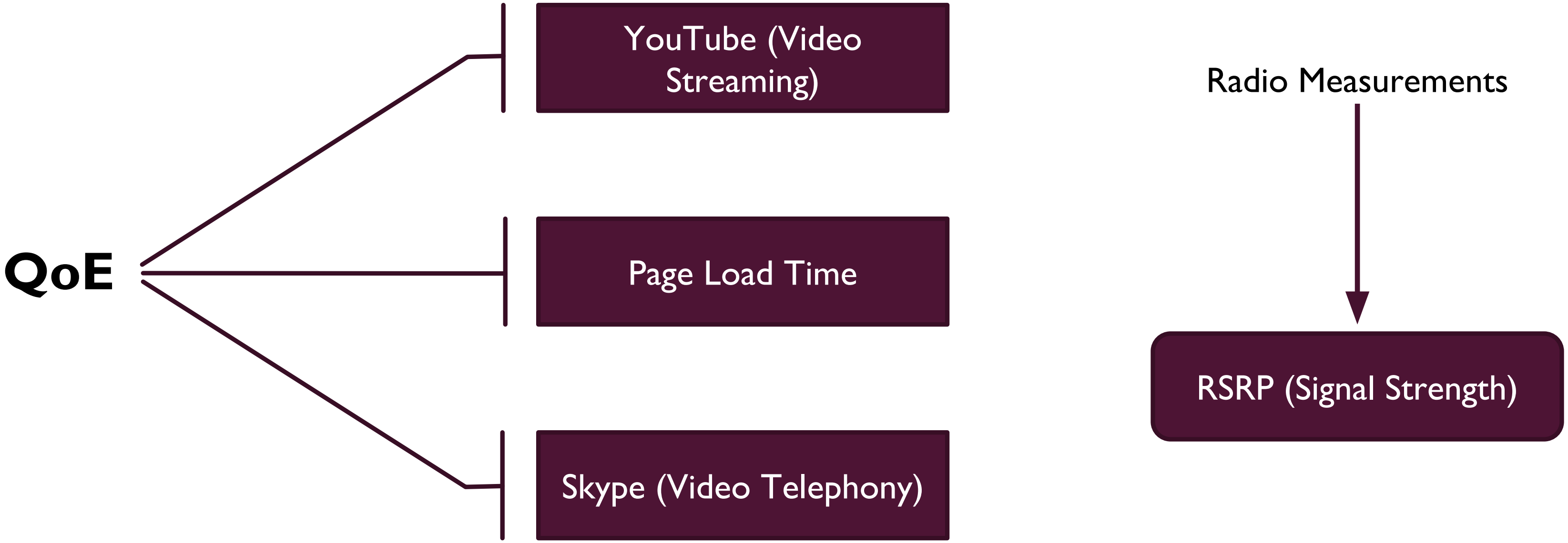
- *How do radio measurements affect QoE/QoS?*
- *Can we estimate QoE metrics for given radio measurements?*
- *How do predictive models differ across different geo/socio-economic locations?*

- **Locations**
  - New Mexico
    - Tribal, Rural
    - Non-Tribal, Rural
    - Non-Tribal, Semi-Urban
  - San Francisco
  - San Diego (2)

DATASET



DATASET

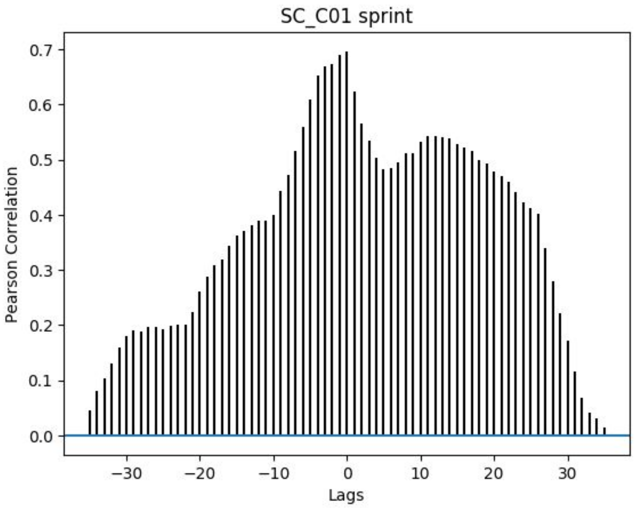

QoE
YouTube (Video Streaming)
Page Load Time
Skype (Video Telephony)
Radio Measurements
RSRP (Signal Strength)

DATASET

DATASET
Network Quality Metrics - QoS/QoE

- Network Quality Metrics
  - Rsrp, thput, buffer_size, avg_res
  - Radio and Network Level measurements
- 15,000+ samples
- Temporally varying data points
- Goal: *Determine contribution of metrics on Quality of Experience*

Cross-correlation between RSRP and buffer size (YouTube)



Initial Analysis

SVD (plot 2): Eigenvalues, s = [**1.39860759e+06**, 8.82029463e+02]

Recurrent Neural Network - LSTM

Using rsrp to predict buffer size

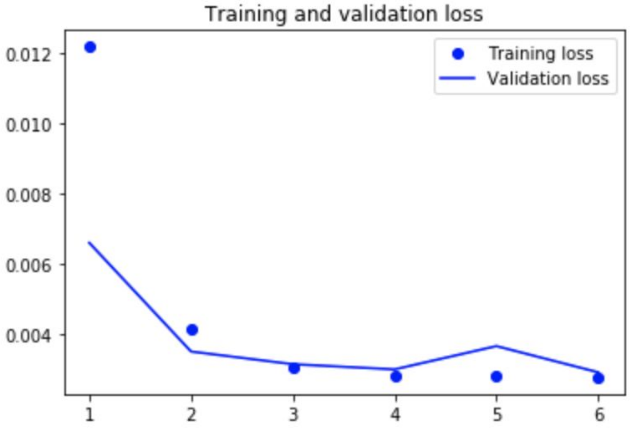
Property	Result
Layers	4
Cells per Layer	30
Parameters	18,631
Optimizer	Adam
Loss Function	Mean Square Error

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 50, 30)            3960
_________________________________________________________________
lstm_2 (LSTM)                (None, 50, 30)            7320
_________________________________________________________________
lstm_3 (LSTM)                (None, 30)                7320
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 31
=================================================================
Total params: 18,631
Trainable params: 18,631
Non-trainable params: 0
```

Recurrent Neural Network - LSTM

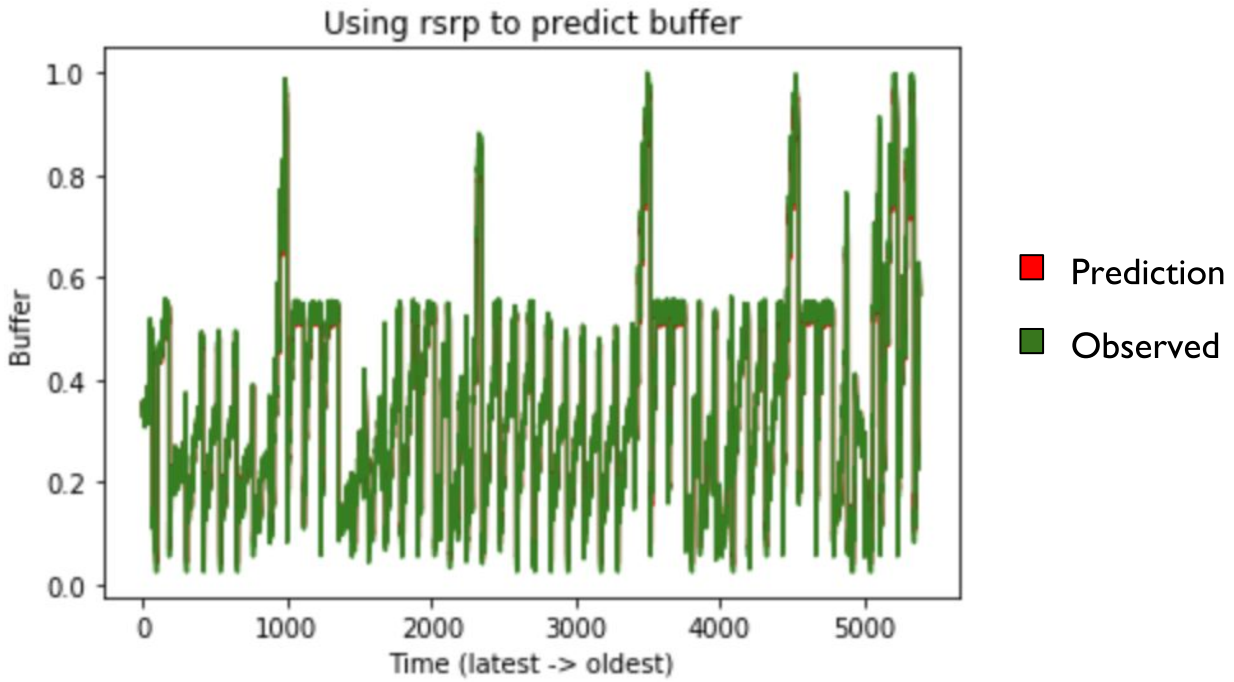
Using rsrp to predict buffer size

Metric	Result
Batch Size	32
Time per Epoch	130 sec.
Loss	Too low?
MSE	Too low?



Recurrent Neural Network - LSTM

Using rsrp to predict buffer size



Recurrent Neural Network - LSTM

Quantile and Uniform Binning

Metric	Quantile Binning	Uniform Binning
Accuracy	0.780468	0.805859
Precision	0.780514	0.805612
Recall	0.780468	0.805859
MAE	2.089936955	-
MSE	28.92972955	-
RMSE	5.378636403	-

Random Forest

Quantile and Uniform Binning

Metric	Quantile Binning	Uniform Binning
Accuracy	0.4981219	0.87633631
Precision	0.5370021	0.88293638
Recall	0.4981219	0.87633631

ARIMA

Quantile and Uniform Binning

Metric	Quantile Binning
MAE	2.459093
MSE	43.44281
RMSE	6.591119

Model	Accuracy	Precision	Recall	MAE	MSE	RMSE	Training Time	Prediction time
Random Forest (Quantile Binning)	0.49	0.53	0.49	---	---	---	46.565	1.920
Random Forest (Uniform Binning)	**0.87**	**0.88**	**0.87**	---	---	---	44.44	2.05
ARIMA	---	---	---	2.45	43.44	6.59	---	---
LSTM (Quantile Binning)	0.78	0.78	0.78	---	---	---	92.233	0.170
LSTM (Uniform Binning)	**0.8**	**0.8**	**0.8**	---	---	---	76.12	0.17
ADA Boost	0.35	0.21	0.35	---	---	---	1.587	0.135
ADA Boost Regression	---	---	---	3.89	25.46	5.04	0.21	0.001
Extra Randomized Tree	0.76	0.76	0.76	---	---	---	0.008	0.005
Extra Randomized Tree Regression	---	---	---	2.64	30.92	5.56	0.022	0.0006
Bagging	**0.87**	**0.87**	**0.87**	---	---	---	0.603	0.006
Bagging Regression	---	---	---	2.38	18.03	4.24	0.618	0.006
Boosting	**0.88**	**0.88**	**0.88**	---	---	---	29.14	0.025
Boosting Regression	---	---	---	2.22	14.81	3.85	2.001	0.002
Naïve Bayes	0.31	0.18	0.31	---	---	---	0.003	0.002
KNN	0.15	0.13	0.15	---	---	---	0.013	0.094
KNN Regression	---	---	---	22.37	718.47	26.8	0.012	0.271
SVM	0.17	0.05	0.17	---	---	---	10.09	1.383
Decision Trees	0.8	0.8	0.8	---	---	---	0.104	0.0004
Decision Trees Regression	---	---	---	2.59	29.99	5.47	0.102	0.0006

Thank you!