Network Foundation Model for RAN Optimisation

Network Foundation Model Use Case: RAN Optimization

Foundation model built & fine-tuned to optimize Radio Access Network (RAN) parameters in a metro location

Increase capacity utilization (spectrum efficiency)

Improve service quality & customer satisfaction

New cell site planning

Objectives:

First (warm-up) objective is to predict downlink throughput.

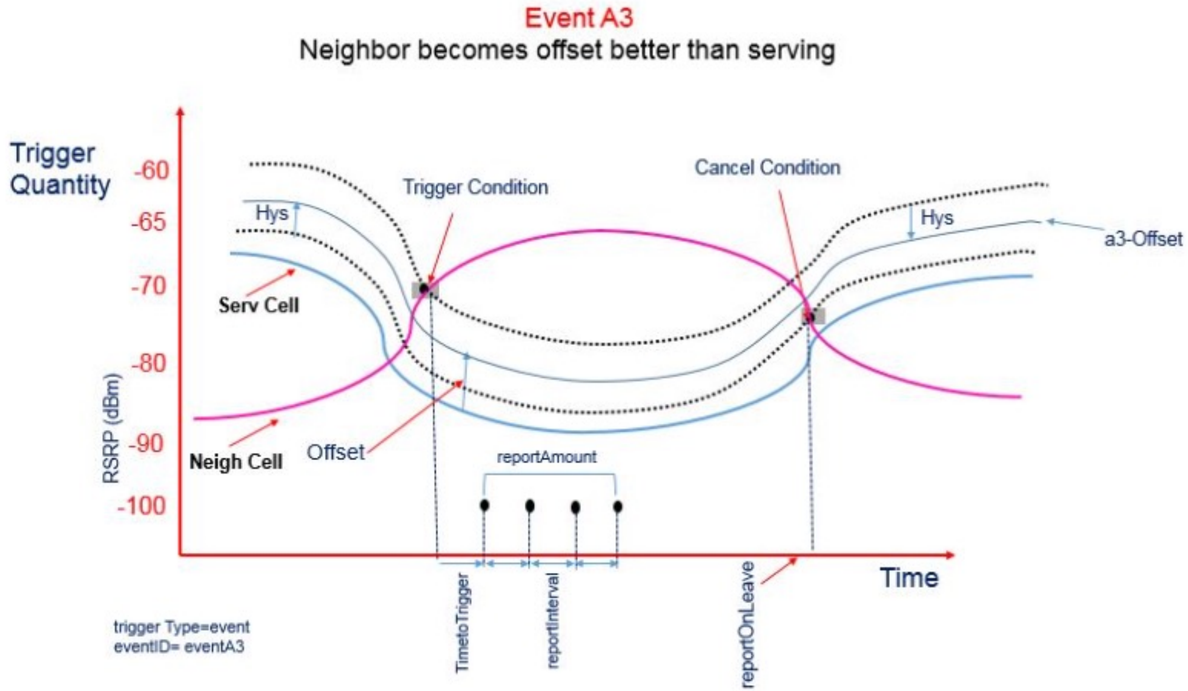
Second (main) objective is to have the model adjust configurable parameters, to reach desired levels for quality metrics for cellular networks.

Dataset: Drive Test + RAN Data

- Data collected during drive test in 4 metros to evaluate performance & coverage of cellular network
- Data includes measurements of various RF parameters and characteristics of the network Corresponding RAN/L3 measurement data taken at the same time as drive test
- In total we had many hundreds of columns and millions of rows

Events Associated with Handover

- **Event A1 (Serving becomes better than threshold)**
- **Event A2 (Serving becomes worse than threshold)**
- **Event A3 (Neighbor becomes offset better than SpCell)**
- **Event A4 (Neighbor becomes better than threshold)**
- **Event A5 (SpCell becomes worse than threshold1 and neighbor becomes better than threshold2)**
- **Event A6 (Neighbor becomes offset better than SCell)**
- **Event B1 (Inter RAT neighbor becomes better than threshold)**
- **Event B2 (PCell becomes worse than threshold1 and inter RAT neighbor becomes better than threshold2)**



- Mn + Ofn + Ocn – Hys > Mp + Ofp + Ocp + Off (Trigger Condition)
- Mn + Ofn + Ocn + Hys < Mp + Ofp + Ocp + Off (Cancellation Condition)

Reusable Pipeline

- IBM pipeline to pre-train encoder-only Foundation Model
- Use techniques similar to pretraining of Large Language Models but adjusted to non-language data
- Pretrained model can be used on its own or in conjunction with further fine-tuning

Data Preprocessing

- Merge Datasets
- Feature selection
- Discretize continuous variables into bins
- 80/20 split for train/test

Tokenization

- Define customized tokenizer based on domain expertise
- Tokenize data

Pre-train Model

- Pre-training recipe from IBM Foundation Model Stack
- Train Roberta model (MLM pre-training task)

Accuracy Evaluation

- Mask one token and predict value
- Count exact matches as 100% accurate
- Compute F1 score for each class

Fine-Tuning

- Scripts to fine-tune models for classification and linear regression
- Determine R^2

Network Foundation Models

Objective:

Optimize radio access networks (RAN) with network foundation models for:

- Spectrum efficiency
- Improved service quality and NPS
- New cell site planning

Results:

+20%

- ✓ Improvement in R^2 Score
- ✓ **72% to 94%**
- ✓ Downlink throughput prediction

Approach

Downstream Tasks: Handover Classification

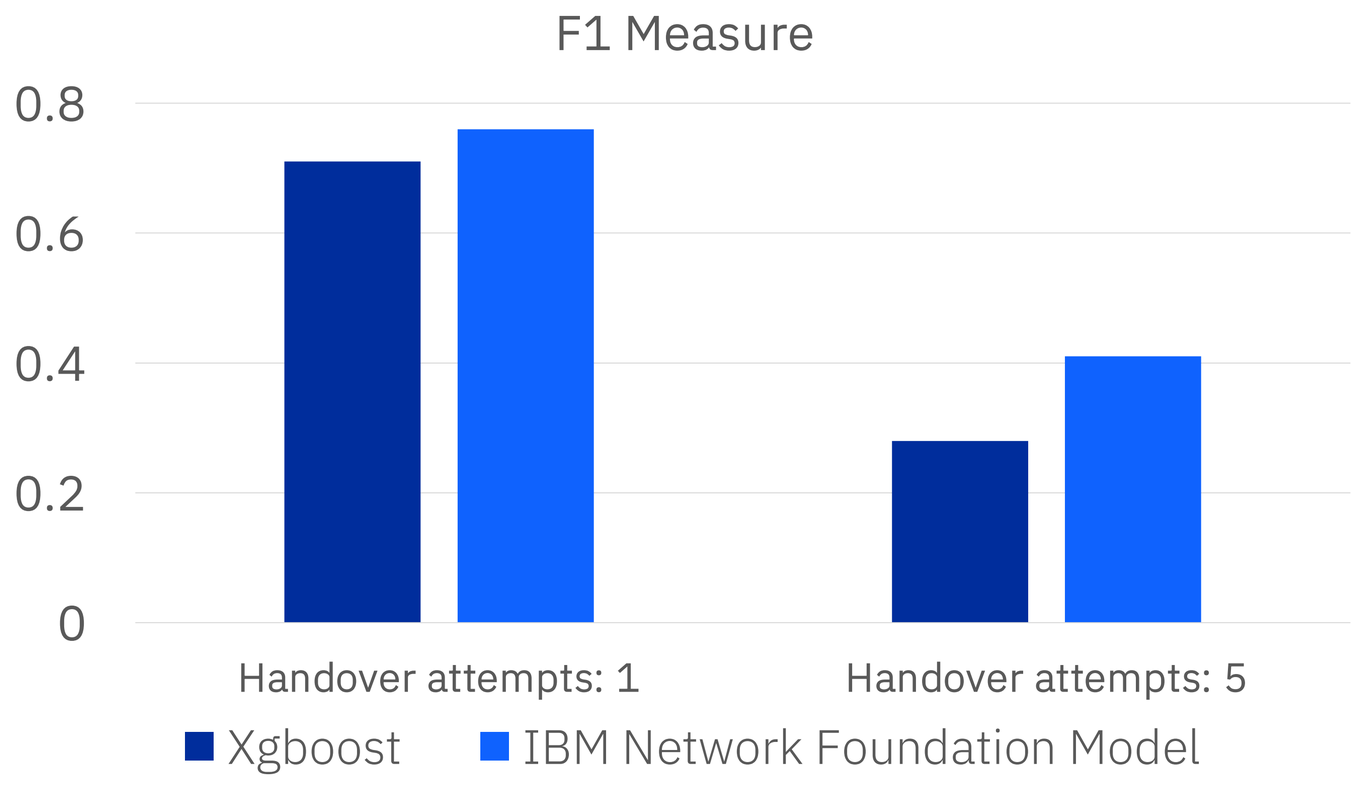
Objective:

Show the performance of classification tasks:

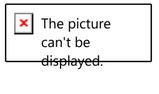
- Handover Attempts – N-”ary” classification
- Handover Attempts – binary classification
- Use macro F1 as a metric

Results:

+5 -13%



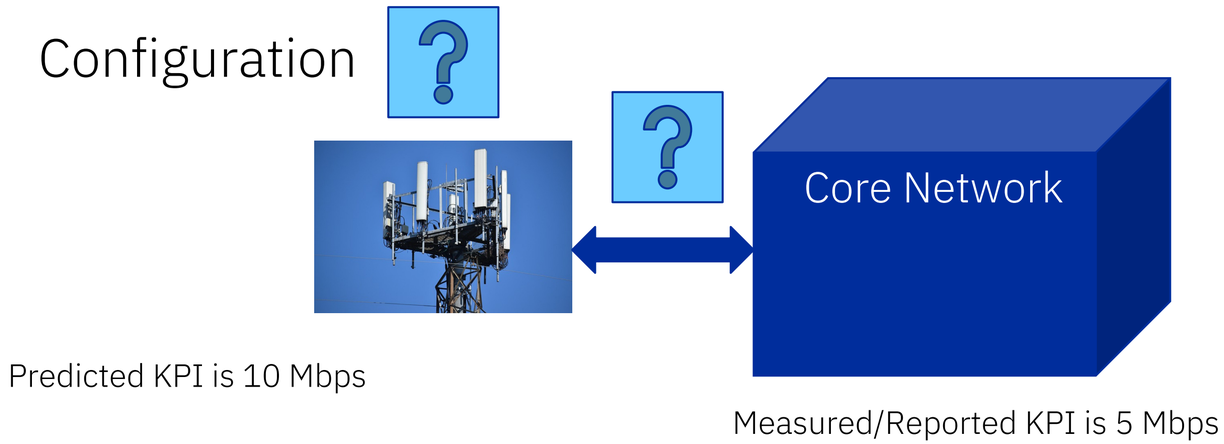
Trained Foundation Model can be used in multiple use cases thanks to its superb prediction performance



Use Case 1 – Bad Cell Identifier

- Based on predicted KPI vs one measured/reported (by the network) bad cell (low KPI) will be identified.

- For example, if predicted KPI is 10 and reported KPI is 5, it would mean that there is a problem in the network somewhere outside of the base station or the problem is in the configuration parameters that were not fed to the Foundation Model.



Use Case 2 – Optimal Configuration Parameters Identification –

- For each cell we compare predicted configuration parameter(s) vs the real one(s). Assuming that the model is a good predictor, big difference between the two will indicate a potential anomaly.

- Foundation Model will try to identify a configuration parameter responsible for low KPI. Here network will identify a cell with KPI lower than expected and Foundation Model will try to find a configuration parameters responsible for low KPI by finding which parameter has the most impact on the KPI.

Configuration 

Low KPI 

Foundation Model is trained on information from many cells and can identify discrepancies in configuration of a cell in question

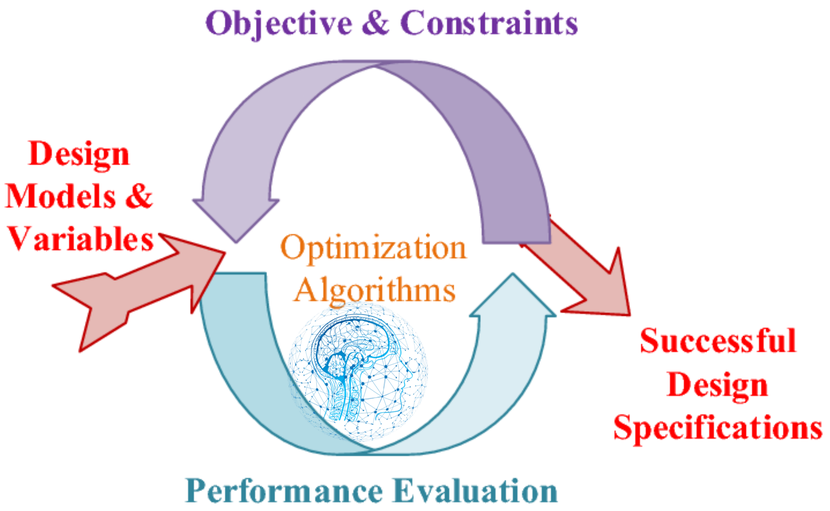
Use Case 3 – Saving cost/time for pre-deployment Scenario of a New Base Station

- Predict KPIs based on the suggested configuration (prepared with a certain desired KPI in mind)
- If predicted KPIs are on par with similar cells, we assume configuration is OK. Otherwise, Foundation Model can try and identify which configuration parameters is responsible for the discrepancy in KPIs.
- Such process will be performed multiple times until good correlation is obtained between a predicted KPI and a desired one.

Foundation Model is trained on information from many cells and can identify discrepancies in predicted KPIs and configurations

Use Case 4 – Optimization of Configuration Parameters

- Foundation Model can be used as a network simulator. One can change a certain configuration parameter and use Foundation Model to predict the effect of the change (by predicting a certain KPI). Given the prediction, the direction and magnitude of consecutive change of the above configuration parameter are decided upon and the process continues.
- Such approach can be used for the tuning of configuration parameters with the goal of further optimizing network KPIs.



Performance evaluation is done by Foundation Model

THANK YOU!