NETWORK OPTIMIZATION: NON-REAL-TIME RIC TRIAL ANALYSIS

WHITE PAPER

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INTRODUCTION

The Mavenir Non-Real-Time RAN Intelligent Controller (Non-RT RIC) is a containerized application that uses advanced machine learning (ML) algorithms to optimize the performance of the radio access network (RAN). Driven by live RAN data, the Non-RT RIC trains ML models that enable dynamic and adaptive policy and control.

Mavenir recently ran a trial of its Non-RT RIC on a Tier 1 Communications Service Provider (CSP) network to optimize performance. This whitepaper offers insights into the results of the trial and quantifies the performance improvement.

KEY TOPICS IN THIS PAPER

This white paper outlines results of a recent trial of the Mavenir Non-RT RIC in a major Tier 1 network. Aspects include:

- Observed Key Performance Indicators (KPIs)
- Available configuration parameters that were explored
- Mathematical basis for the optimization toolkit
- Quantifying the achieved performance improvement

TABLE OF CONTENTS

TABLE OF FIGURES

1. Trial objective and set-up

The Tier 1 CSP in this trial is replacing its legacy RAN vendor with Mavenir Open RAN base stations. A key concern was to ensure that the performance of the Mavenir Open RAN was on par with the historical performance of the legacy RAN. Mavenir deployed a trial cluster of cells consisting of five sites with three sectors each and carefully tracked Performance Metrics (PMs) and Key Performance Indicators (KPIs).

KPIs of high importance to the CSP included:

- Reference Signal Received Power (RSRP) distribution
- Reference Signal Received Quality (RSRQ) distribution
- Channel quality indicators
- User downlink throughput
- Inadequate handover distribution (missing/wrong/early)
- Call drop rate

These KPIs express quantitative measures of coverage, capacity, and mobility robustness. Therefore, the optimization exercise can be viewed as a combination of Coverage and Capacity Optimization (CCO) and Mobility Robustness Optimization (MRO).

The Mavenir Non-RT RIC, equipped with advanced Machine Learning (ML) algorithms, adjusted the configuration of each cell independently while targeting improvement in each of the above KPIs. The configuration parameters explored included, for each cell, independent values of:

- Reference Symbol boost relative to the traffic channel (rs_boost_a and rs_boost_b);
- A3 Measurement Offset, the ratio by which the signal strength of a neighbor cell reference symbol must exceed that of the current cell before triggering a Measurement Report (MR) from the user equipment (UE) (A3 offset, measured in dB);
- A3 Measurement Hysteresis, the ratio by which the signal strength must decrease below the triggering threshold before un-triggering the MR (A3 hyst, measured in dB);
- Qoffset, a per-neighbor penalty to apply to signal strength measurements of that neighbor during idle-mode reselection (measured in dB); and,
- Qhyst, the ratio by which a neighbor cell must decrease after triggering re-selection before the original serving cell is selected again during idle-mode reselection (measured in dB).

2. Methodology

The main ML algorithm implemented by Mavenir's Non-RT RIC is a form of Bayesian Optimization (BO).[1] BO is a data-driven approach that gradually builds up a knowledge base about the system and its behavior under each configuration. The BO framework then leverages the model by executing an Acquisition Function to determine the next recommended configuration. The Acquisition Function uses a combination of **exploration**, where regions of high uncertainty about the system behavior are considered, and **exploitation**, where the function tries to generate a configuration that will maximize the expected objective function. As the algorithm acquires more data points, it naturally transitions from exploration to exploitation.

The objective function of Mavenir's BO implementation is configurable. The trial was set to a linear combination of the measured KPIs with configurable weights for each one. Good KPIs received a positive weight, while bad KPIs (such as handover failure metrics) received a negative weight. Thus, the BO simultaneously executes a joint optimization for coverage, capacity, and mobility robustness, according to the weights determined at runtime by the CSP's business needs.

3. Algorithm findings and predictions

After initial analysis of the current state of throughput and handovers, Mavenir analyzed Bayesian Optimization (BoTorch) modeling of User Downlink Throughput (User DL T-put).

The configuration parameters for optimizing handovers and User DL T-put span a 75-dimensional mathematical space per cluster, where each dimension could potentially have several value ranges.

Pa/Pb are commonly used optimization parameters. Reference signal boost would typically improve the cell coverage but at the cost of interference and eroding into the power used for data.

With a few cycles of exploration and exploitation, the BoTorch algorithm learned the relationship between Pa/Pb and DL User T-put and accurately quantified this relationship. This insight is presented below, and it provides a data-driven perspective to what wireless network engineers intuitively understand with years of experience.

Correlation of Pa/Pb with change in User DL-Tput:

- Modeling User DL-Tput with BoTorch
- The model predicts that disabling the boost (3dB) would increase:
    - User DL TP: +22%
    - User UL TP: +19%

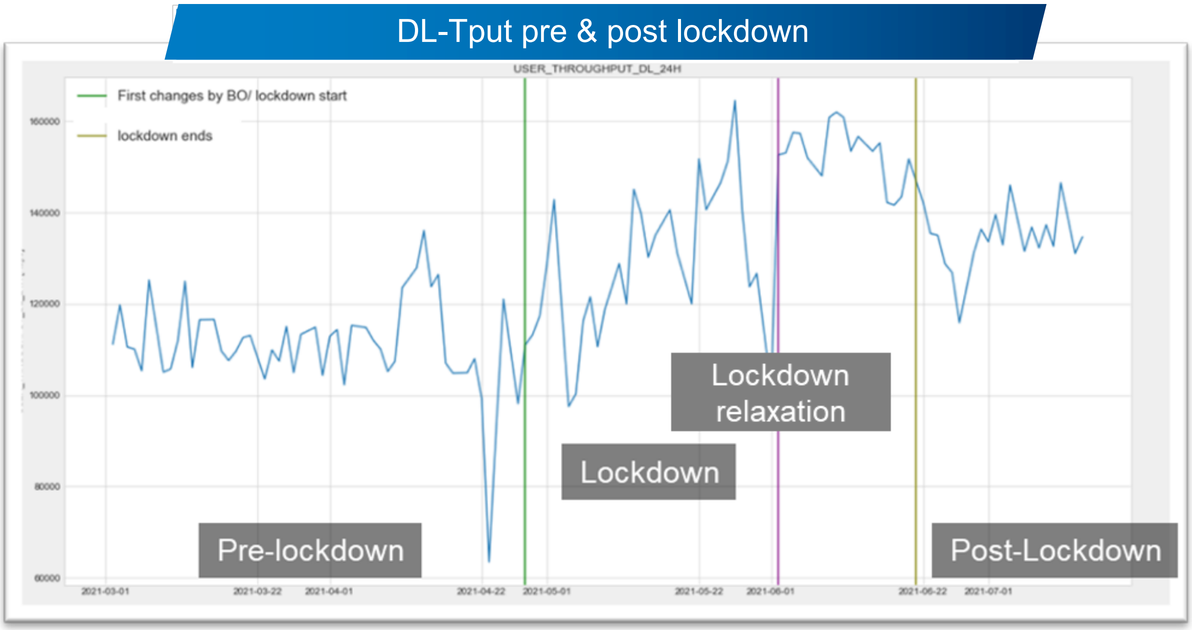

Figure 2: Trend of User Downlink Throughput during different periods of observation

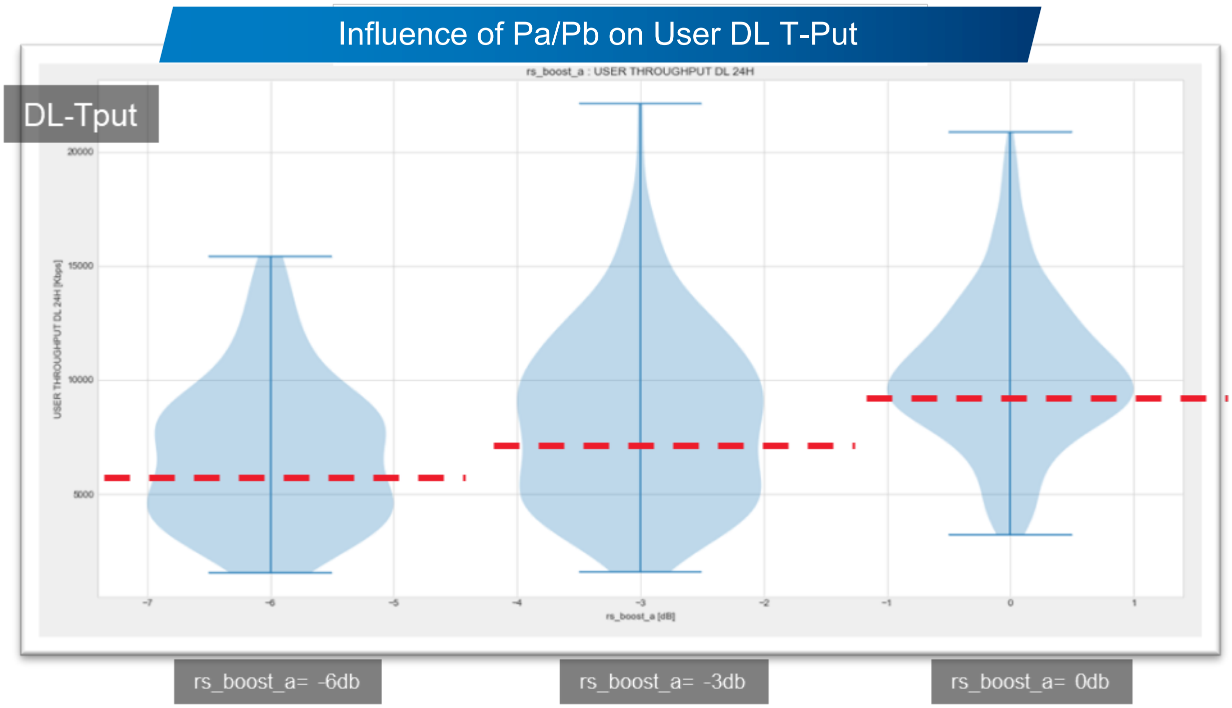

Figure 1: Impact of rs_boost parameters on the User Downlink Throughput

The Mavenir RIC's deployment and validation cycle spanned across the lockdown period, which meant fewer samples (owing to fewer users), less mobility patterns, and sparser data for learning. These factors caused statistically significant drifts in the distribution of predictors, which in turn caused a variation in impact factors and prediction errors. Despite these challenges, the BoTorch algorithm was able to provide 20% improvement in User DL T-put.

4. DL Throughput analysis and improvements

This section provides an analysis of the pre- and post-values of important Radio KPIs, highlighting the benefits of deploying Mavenir's Non-RT RIC.

Analysis

- Figure 3 depicts plots showing RIC performance: BLER, CQI, MCS improve, % of poor SINR UEs reduce

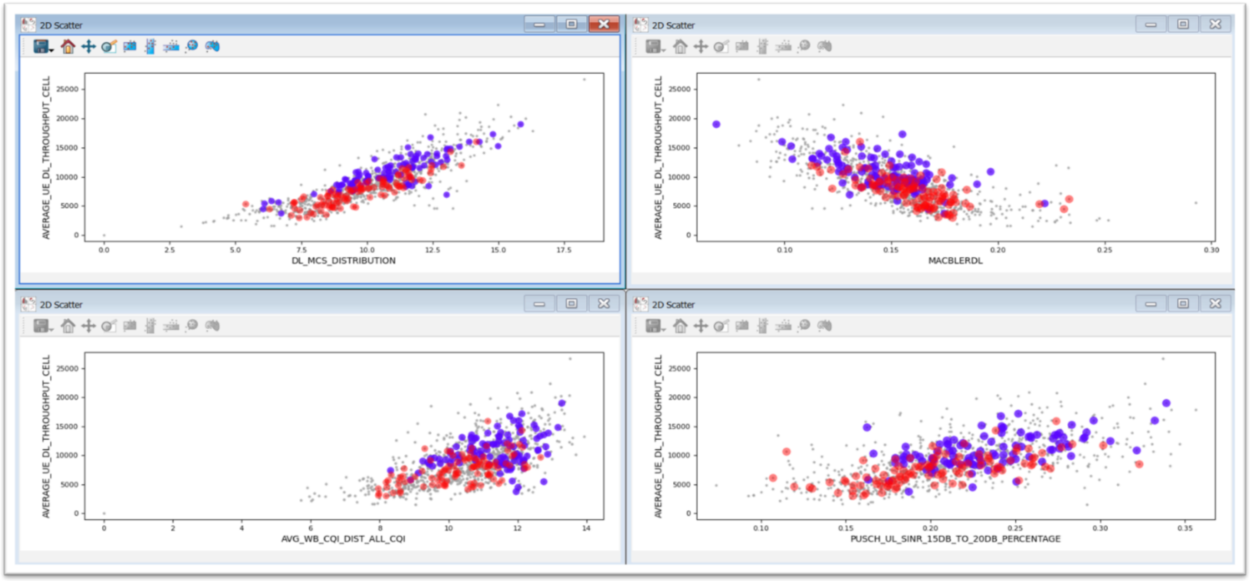

Figure 3: Plot of cell-cluster where each dot represents a cell. 'Red': before RIC, 'Blue' after RIC

- Figure 4 illustrates further analysis focused on plots showing RIC performance: PRB utilization is better, DL & UL BLER is improved (initial BLER)

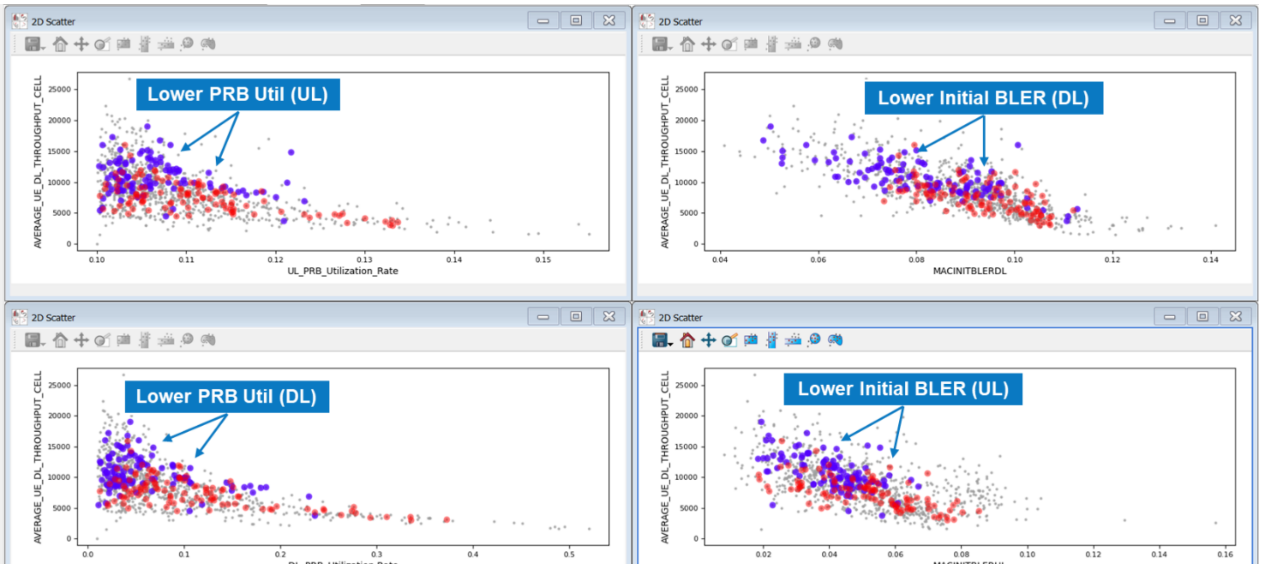

Figure 4: Plot of cell-cluster where each dot represents a cell. 'Red': before RIC, 'Blue' after RIC

Improvements

- With the Mavenir Non-RT RIC in place, the provider saw significant improvements in network performance. Comparing one week of data with and without the RIC, the reference KPIs versus the KPIs optimized with the RIC showed a 20 percent increase in user DL throughput for similar call volumes.
- Additionally, the total user payload in GB increased 5.3 percent
- CQI distribution increased 3.12 percent
- MCS improvement was up 2.85 percent (DL) and increased 5.9 percent (UL)
- PRB utilization was reduced 13.6 percent (DL) and lowered by 1.4 percent (UL)

5. Handover analysis and improvements

This section provides an analysis of the pre- and post-values of important handover KPIs, highlighting the benefits of deploying Mavenir's Non-RT RIC.

Analysis

- Figure 5 illustrates plots showing RIC performance: More LTE Drops, Abnormal Release, and Timing Advance (TA) values during pre- and post-RIC deployment.

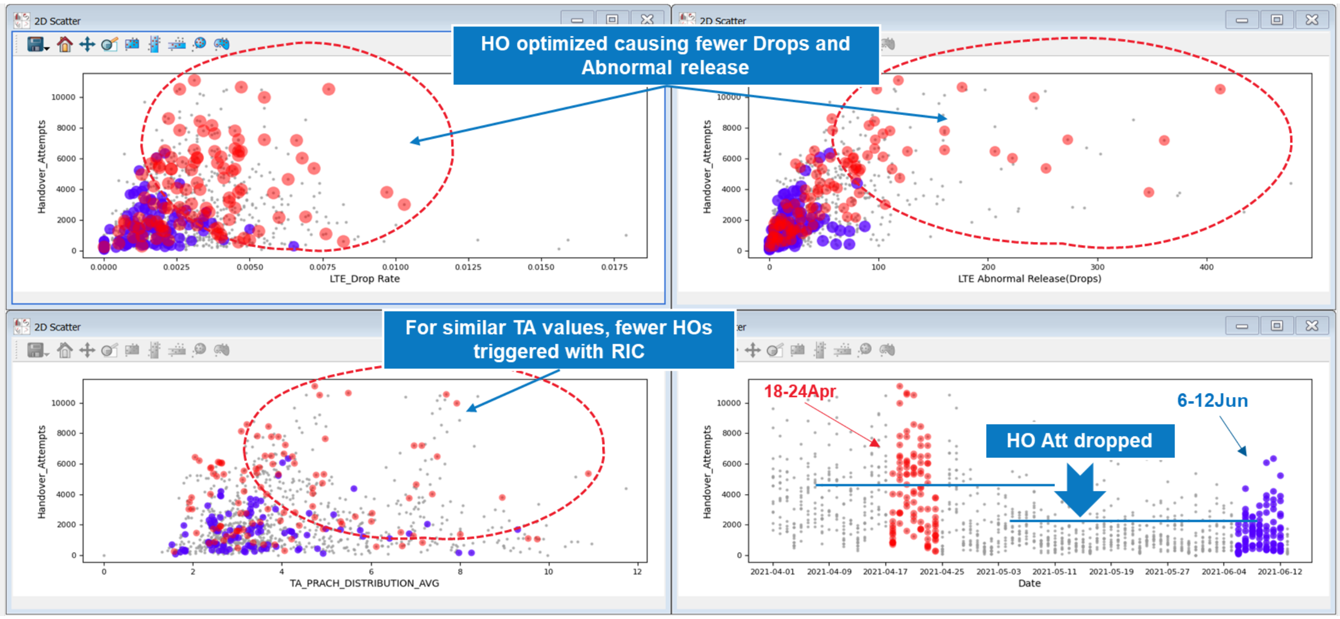

Figure 5: Plot of cell-cluster where each dot represents a cell. 'Red': before RIC, 'Blue' after RIC

Improvements

- By implementing Mavenir's Non-RT RIC, the CSP experienced a decrease in handover attempts of 57.1 percent for similar call volumes.
- The results indicate a positive Handover Success Rate (HOSR)

6. Optimizing the user experience with Non-RT RIC

This section offers an analysis of the application of the Non-RT RIC and how it impacts network performance, which ultimately enhances the user experience.

- Discuss how DL TP impacts user experience
- Discuss how handover affects user experience

The charts listed below in Figures 6-9 quantify the percent improvement delivered by the Non-RT RIC's CCO and MRO Modules.

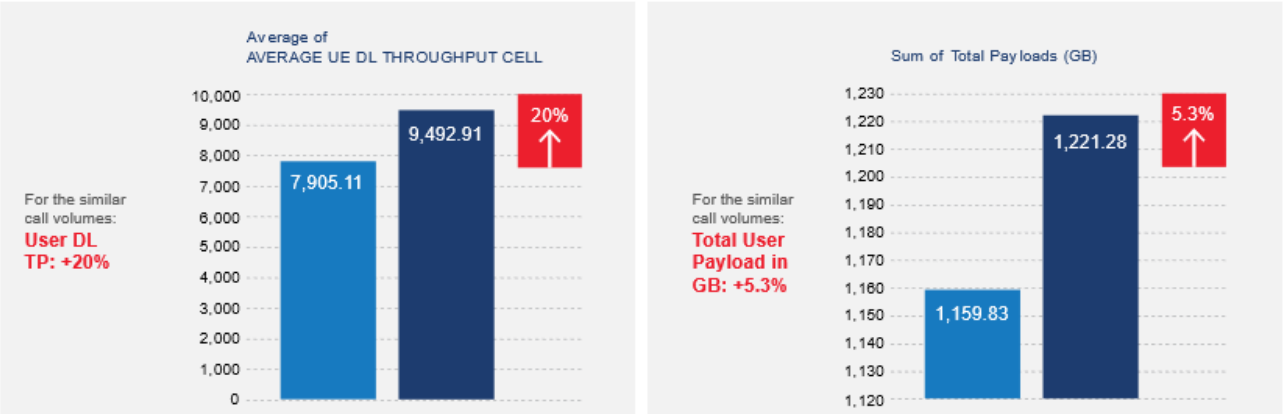

Figure 6: % improvement in DL User Throughput & Delivered Payload pre and post RIC (pre: light blue, post: dark blue)

Figure 7: % improvement in CQI and MCS distribution pre and post RIC (pre: light blue, post: dark blue)

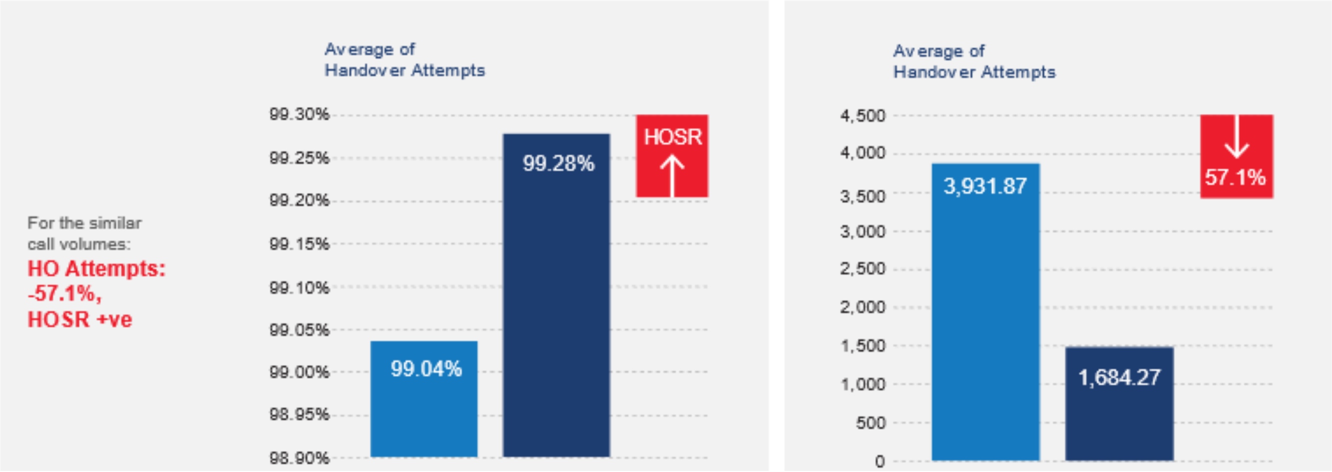

Figure 9: % improvement in HOSR and HO Attempts pre and post RIC (pre: light blue, post: dark blue)

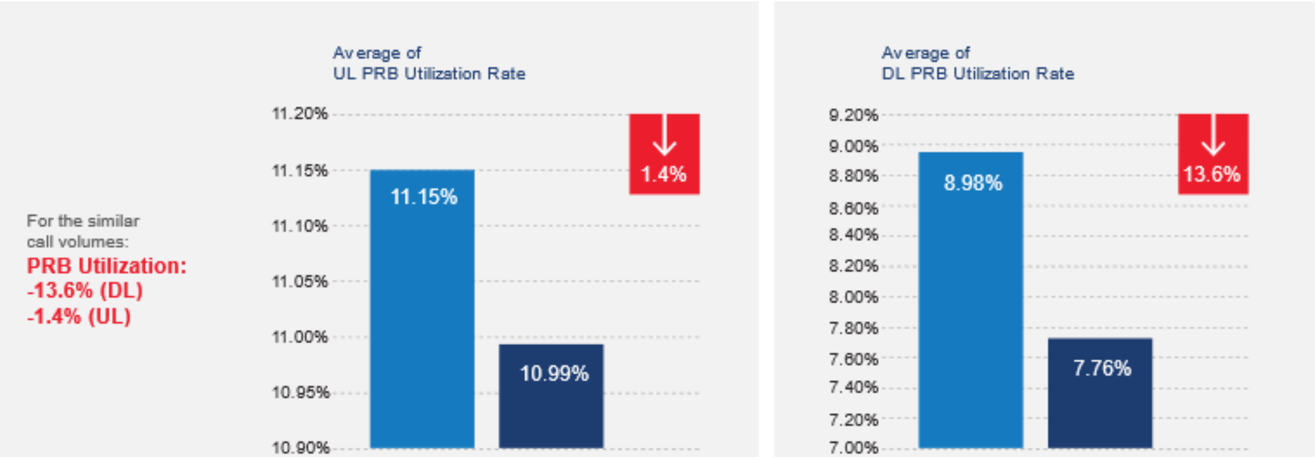

Figure 8: % improvement in PRB Utilization pre and post RIC (pre: light blue, post: dark blue)

- These charts indicate that for the same call profile (user volumes and characteristics), the Non-RT RIC is able to configure the network to provide a better end-user experience quantified by higher Downlink Throughput, higher payload, higher MCS and CQI at a lower cost of network resource, such as PRB Utilization.
- In addition, the decrease in Handover Attempts and improvement in Handover Success Rate indicate better balanced mobility profiling lowering the too-early, too-late or ping-pong handover scenarios which affect the end-user experience and consume additional network resources.
- The BoTorch modules were engineered to run with a joint BO objective function to prevent optimization collisions. Under the hood, BoTorch helps bring down the hyper-parameter tuning space by using Bayesian reasoning. It iteratively attempts to find the best configuration combination, or acquisition function, that optimizes the “objective function,” or coverage, capacity, and mobility optimization in this case.

7. Conclusion

Mavenir’s Non-RT RIC’s ML algorithms are engineered to optimize the network considering multiple objectives simultaneously. This feature enables operators to achieve holistic improvements in a data-driven way.

In the current trial, Mavenir’s Non-RT RIC successfully demonstrated bringing an improved quality of experience (QoE) for the end-users while also optimizing the network resources in the process. The improvement of 20 percent User DL-Tput guaranteed a higher Mean Opinion Score (MoS) for the CSP and, at the same time, brought down OPEX by improving spectral efficiency and resource usage by 13 percent.

As evidenced in Mavenir trials for a Tier 1 operator, Mavenir’s Non-RT RIC has the potential to greatly impact network performance using advanced AI and ML algorithms that can address faults and make improvements.

About Mavenir

Mavenir is building the future of networks and pioneering advanced technology, focusing on the vision of a single, software-based automated network that runs on any cloud. As the industry's only end-to-end, cloud-native network software provider, Mavenir is transforming the way the world connects, accelerating software network transformation for 250+ Communications Service Providers in over 120 countries, which serve more than 50% of the world’s subscribers.

For more on Mavenir Solutions please visit our website at www.mavenir.com

APPENDIX

References

[1] https://papers.nips.cc/paper/5086-multi-task-bayesian-optimization.pdf, https://arxiv.org/abs/1805.12168 , https://papers.nips.cc/paper/8997-max-value-entropy-search-for-multi-objective-bayesian-optimization.pdf

Acronyms

3GPP	3rd Generation Partnership Project
5G	5th Generation
CA	Certification Authority
CI/CD	Continuous Integration/Continuous Delivery
CIS	Center for Internet Security
CMP	Certificate Management Protocol
CNF	Cloud native Network Function
CP	Control Plane
CPRI	Common Public Radio Interface
CRI-O	Container Runtime Interface for OCI compatible runtimes
CRMT	Core Root of Trust Measurement
CSP	Cloud Service Provider
CU	Central Unit
CUS	Control, User & Synchronization
DOS	Denial of Service
DDOS	Distributed Denial of Service
DTLS	Datagram Transport Layer Security
DU	Distributed Unit
EST	Enrollment over Secure Transport
FIPS	Federal Information Processing Standards
GSMA	Global System for Mobile Communications Association
HSM	Hardware Security Module
ICAM	Identity, Credential and Access Management
LLS	Lower Layer Split
LUKS	Linux Unified Key Setup
MAC	Mandatory Access Control
MEC	Multi-access Edge Computing
MITM	Man-in-the-Middle
NDS	Network Domain Security
NESAS	Network Equipment Security Assurance Scheme
NF	Network Function
NIST	National Institute of Standards and Technology
NR	New Radio
NR-RIC	Near Real Time RIC
OCI	Open Container Initiative
O-CU	O-RAN Central Unit
O-DU	O-RAN Distributed Unit
O-RAN	Open Radio Access Network
O-RU	O-RAN Radio Unit
PDCP	Packet Data Convergence Protocol
PNF	Physical Network Function
RAN	Radio Access Network
RBAC	Role Based Access Control
RIC	Radio Intelligent Controller
RLC	Radio Link Control
RT-RIC	Real-Time Radio Intelligent Controller
RRM	Radio Resource Management
RRU	Remote Radio Unit
SAST	Static Application Security Testing
SCRM	Supply Chain Risk Management
SDAP	Service Data Adaptation Protocol
SDLC	Software Development Life Cycle
SIEM	Security Information and Event Management
SLA	Service Level Agreement
SMO	Service Management and Orchestration
SSH	Secure Shell
STG	Security Task Group
SUCI	Subscription Concealed Identifier
TCO	Total Cost of Ownership
TLS	Transport Layer Security
TPM	Trusted Platform Module
UE	User Equipment
UP	User Plane
VNF	Virtualized Network Function
ZTA	Zero Trust Architecture