Machine Learning-Based Coverage and Capacity Optimization xApp/rApp for Open RAN 5G Campus Networks

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Outline

- Introduction
- Methodology
- System Design and Architecture
- Performance Evaluation
- Conclusion

Introduction

Open Radio Access Networks

Introduced by the O-RAN Alliance [1]

Characteristics:

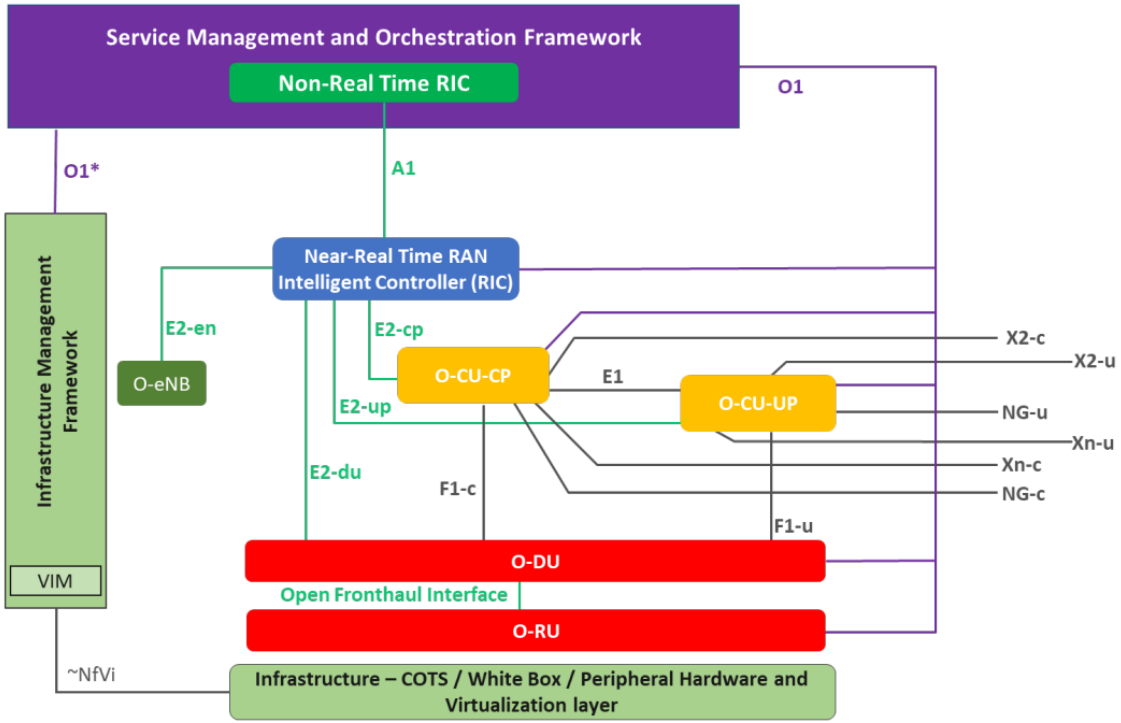
- Open interfaces
- Disaggregated RAN components
- Cloud-native principles

Benefits:

- Vendor Interoperability
- Lower costs
- Innovation

RAN Optimization:

- xApps and rApps
- Data-driven, ML-based applications
- RAN intelligent controllers (RICs)



O-RAN Architecture Overview [2]

Introduction

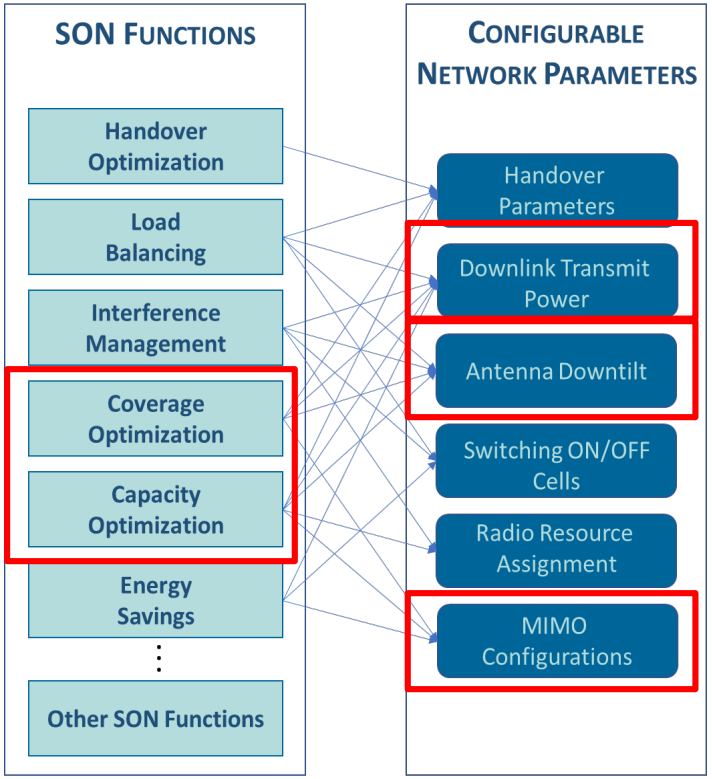
5G Campus Networks

- Heterogeneous use cases in 5G
- Private and localized communications networks due to security concerns
- 3GPP introduced the concept of 5G campus networks [3]
- Characteristics:
  - Operate within a limited area
  - Dedicated spectrum
  - Low-power nodes
  - Prioritizing reliability and data privacy
- Ensuring consistent coverage without significant costs remains a challenge [4]

Introduction

Coverage and Capacity Optimization (CCO)

- 3GPP introduced Self-Organizing Network functions (SFs) [5]
- SFs autonomously optimize network performance
- CCO targets areas with weak signal and capacity issues to enhance QoS and QoE
- CCO optimize antenna and RF parameters:
  - Transmission power
  - Antenna azimuth
  - Antenna downtilt



Introduction

SVD-based Recommender Systems (SVD-RecSys)

- RecSys is a branch of ML algorithms applied to provide suggestions for items likely to be used by a specific user [6]
- Collaborative Filtering based RecSys (CF-based): User-item interactions
- Singular Value Decomposition (SVD- RecSys)

$$SVD(A) = U\Sigma V^T$$

Objective

- Innovative self-organizing machine learning-based xApp and rApp
- Utilizing RecSys to improve coverage and capacity for O-RAN deployments
- Implemented on an open-source O-RAN-compliant testbed
- Marking a significant achievement in this domain to the best of our understanding

Methodology

Configurable Parameter Set (PS)
TX Power

O-RAN Testbed

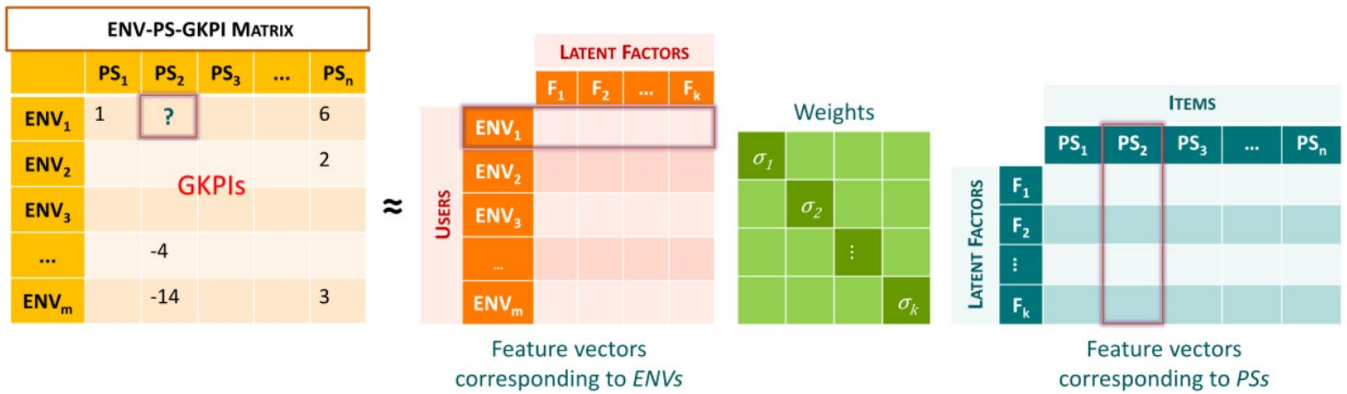
Environmental Variables (ENVs)
RSRP (dBm)
SIR (dB)
No. Of UE
RSRP Outage (%)
SIR Outage (%)
Degree of Inteference Created (DIC)

SVD-RecSys Optimization (training & inference)

Rating: Global KPI [7]
α = 0.8

$$GKPI = \alpha \cdot \widetilde{RSRP} - (1-\alpha) \cdot \widetilde{IFC}$$

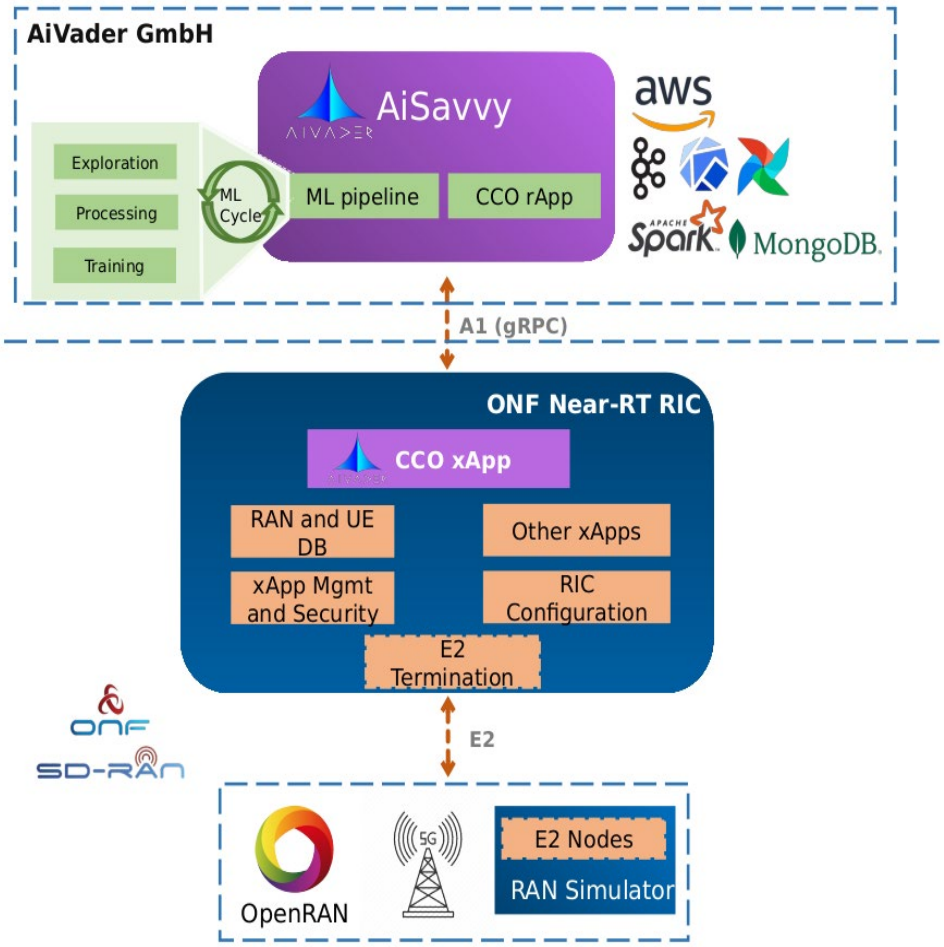
$$A_k \approx U_k \, \Sigma_k \, V_k^T$$
$m \times n$ $m \times k$ $k \times k$ $k \times n$



Truncated Singular Value Decomposition (SVD)[8]

System Design and Architecture

- SD-RAN from the Open Networking Foundation (ONF) [9]
- Two applications:
  - xApp within the ONF Near-RT RIC
  - rApp within AiSavvy tool



Overall architecture of SVD-RecSys-based CCO-xApp/rApp in O-RAN framework

Performance Evaluation

Simulation:

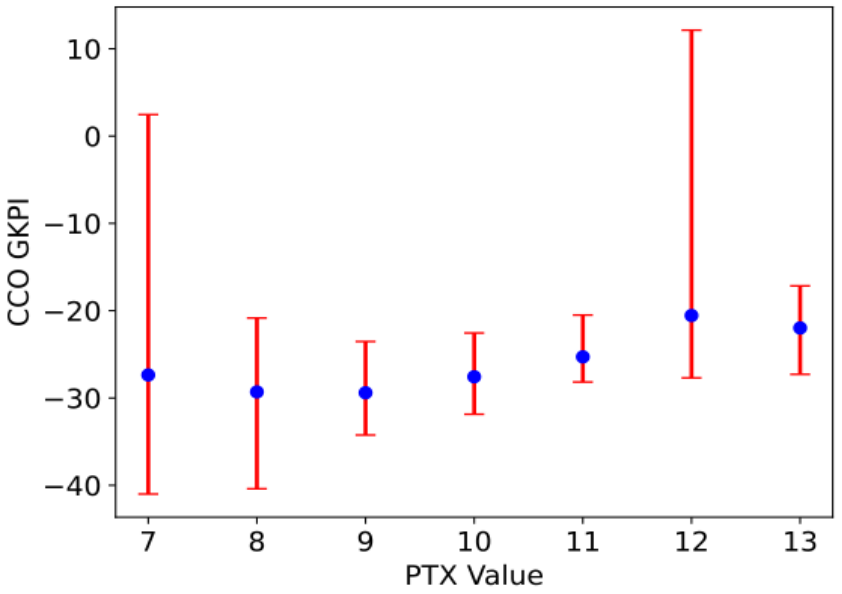
A medium-sized campus network

- 7 omni-directional cells
- ISD of 250 m
- 100 randomly distributed UEs
- Random-walk mobility
- Free Space Pathloss at 3.6 GHz

First Phase:

Random Exploration Phase

- Data Collection, preparation and ML training
- SVD model Performance: 2.6 RMSE and 1.6 MAE



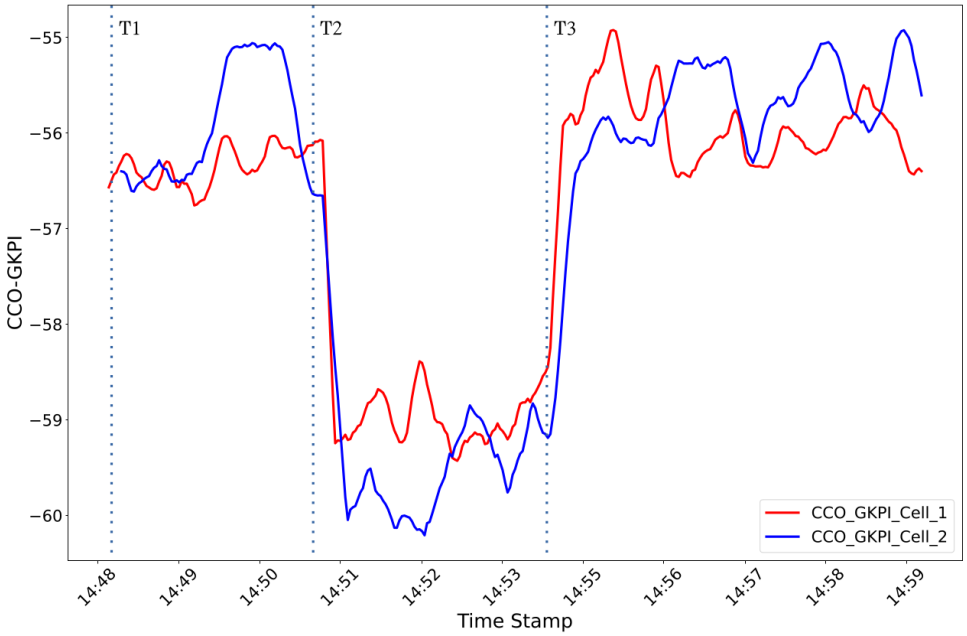
Minimum, maximum, and mean value of GKPI across various PTX levels

Performance Evaluation

Second Phase:

Online Recommendation Phase

- Closed-loop CCO solution
- Periodic recommendations
- Fast fading scenarios
- **Result:** Restored CCO GKPI



GKPI of the studied cells with fast fading scenarios

Conclusion

- Successful deployment and demonstration CCO-xApp and rApp
- O-RAN-compliant testbed
- Marking a pioneering accomplishment in this field within our knowledge

Future Directions

- Enhance the SVD model performance
- Integrate the SVD-RecSys-based CCO-xApp/rApp into real, robust ORAN deployments for realistic campus networks scenarios

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INNONT INNOVATIVE NETZTECHNOLOGIEN

Thank You!

Q&A!

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