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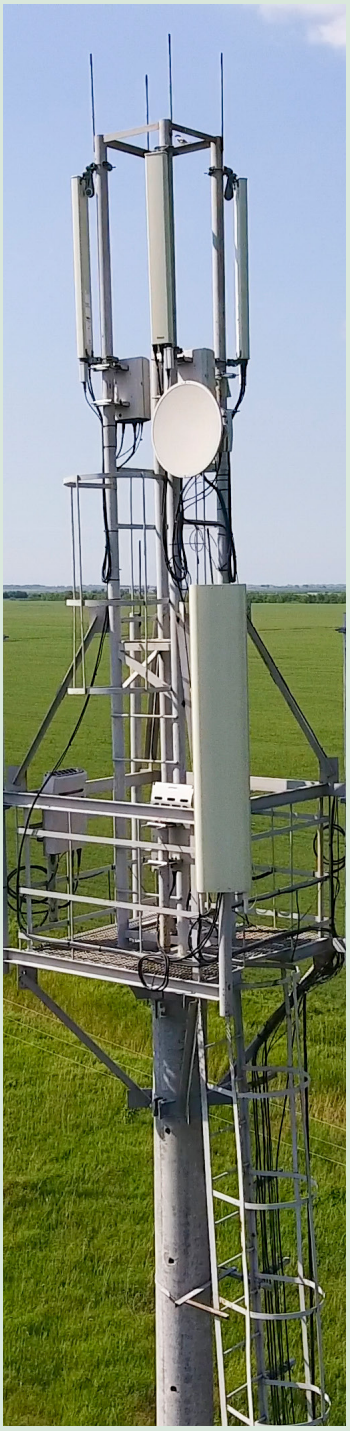
WHITE PAPER



AI ENABLED RAN ENGINEERING FOR PERSONALIZATION & SUPERIOR CUSTOMER EXPERIENCE IN 5G NETWORKS

Abstract

The ever-increasing demand for 5G Wireless connectivity necessitates superior performance and experience both in Private and Public Networks. Radio Access Network (RAN) plays a crucial role in achieving this, by continuous planning, Design and Optimization. This whitepaper is Part1 of the series, and explores the unique challenges and a transformative approach of leveraging AI enabled solutions for RAN Engineering.

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Introduction

The demand for 5G connectivity is growing rapidly across all industry sectors, driven by consumer needs, enterprise requirements, technological advancements and innovative applications. Manufacturing, Healthcare, Transportation, Energy, Entertainment are actively adopting 5G.

The global 5G services market was valued at USD 84.31 billion in 2023 and is expected to grow at a CAGR of 59.4% to reach approximately USD 2,208.25 billion by 2030. Another report estimates an increase from USD 100.9 billion in 2024 to around USD 4,146.3 billion by 2034, reflecting a CAGR of 45%

While the growth projections are promising, ARPU and profitability remains a stress for Mobile Service Providers. This is where Personalization and Customer experience are becoming the key for success which help to go beyond just connectivity. For example, Business services that provide travel alerts, daily health for patients with lifestyle diseases, AR/VR Sports streaming etc. are to name a few.

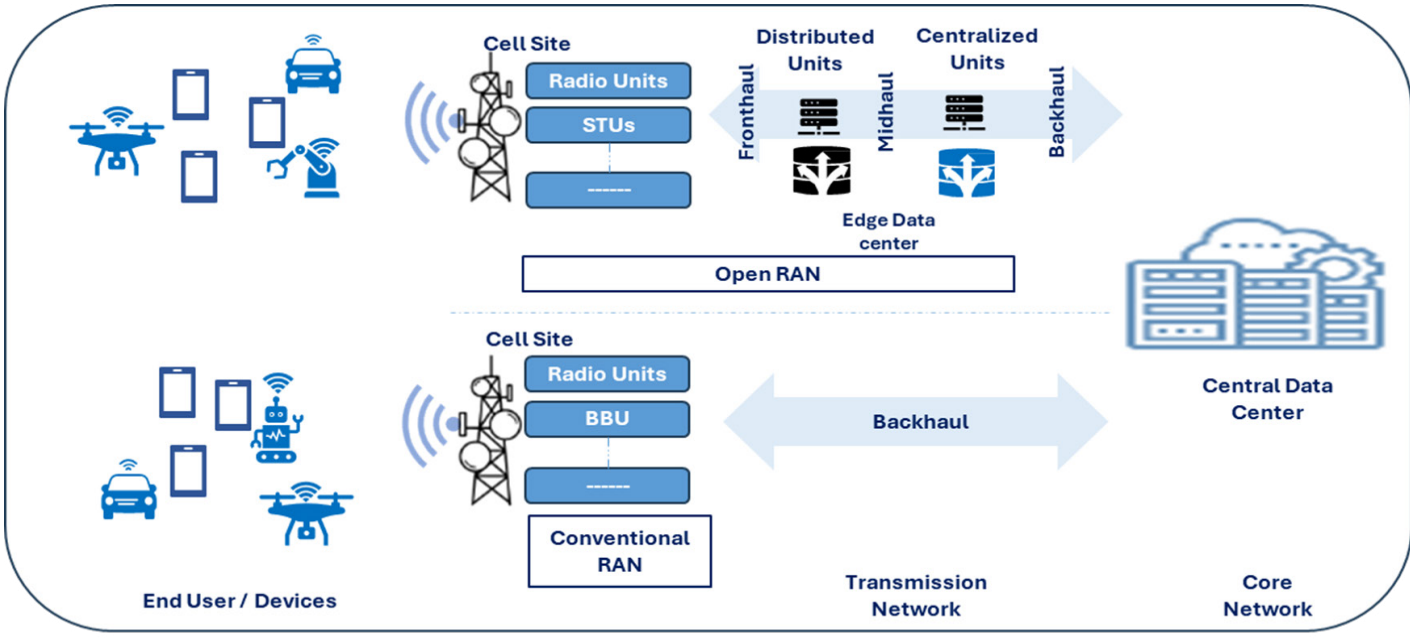
Now the obvious question is: "What is the first step in this journey and how Mobile Network Operators can ensure Personalization & experience for their customers?" The answer is "Better and Intelligent RAN"

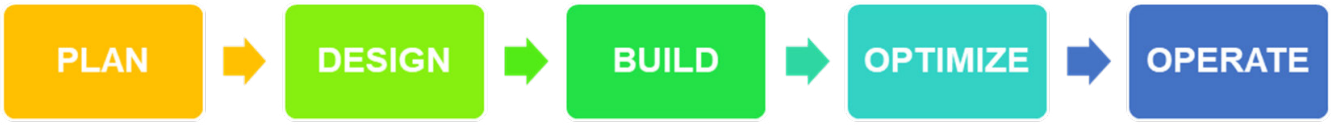
This paper will examine the importance of RAN engineering to ensure "Better and Intelligent RAN" and how AI enabled RAN can be a Game changer.

Importance of Radio Access Network (RAN) Engineering and its Life Cycle

Radio Access Network (RAN) is the most critical part of 5G networks which has direct impact user experience. A poorly performing RAN can lead to dropped calls, slow speed, unreliable connections, production loss. Hence RAN segment of the 5G network needs right level of engineering and management for delivering Enhanced Connectivity, Increased Capacity and Coverage, Low Latency, application aware Network Slicing, Energy Efficiency.

RAN Engineering involves a complex process of Planning, Designing, Building and Optimization of Radio Access Network (RAN). Hence it is important to understand these engineering Life Cycle stages before exploring the challenges and AI enabled solutions for it.





A. PLAN: In the planning phase, the focus is on establishing a comprehensive strategy for network rollout. Some of the Key activities are as listed below

- Define RAN deployment objectives and scope as per business requirements
- Develop a detailed project timeline
- Spectrum Identification & Readiness
- Secure necessary regulatory approvals.
- Allocate budget and resources.
- Selection of appropriate OEM solutions
- Nominal planning & Site surveys
- Planning for network capacity and coverage augmentation

B. DESIGN: In the design phase, a blueprint of network design is developed based on the planning phase findings to ensure seamless network performance. Some of the Key activities are as listed belows

- Analyzing hardware, software and networking specifications
- High Level Design & Low-Level Design preparation
- Creating orderable Bill of Quantities (BoQ)
- Golden network parameter standardization
- Pre-Staging lab- Testing and validation (RAN Solution)
- End to End solution validation
- Use-case testing analysis (Enterprise network)
- End device testing for target network compatibility

C. BUILD: In the build phase physical deployment of the network infrastructure takes place based on the network design to establish a functional and reliable network. Some of the Key activities are as listed below

- Procure necessary equipment and materials
- Site Survey (TSSR)
- Material Planning & warehousing
- Infrastructure readiness (Cell Site & Data Center)
- Installation, commissioning & Integration of RAN components
- Integrate with core and transmission network elements
- Conduct field functional testing and troubleshooting (site location)

D. OPTIMZE: In the optimization phase, the focus shifts to fine-tuning the network to achieve optimal performance to provide the best possible user experience and meet service-level agreements (SLAs). Some of the Key activities are as listed below

- Continuous monitoring of RAN KPI metrics
- Identifying bottlenecks, and making necessary adjustments to improve coverage, capacity, and quality
- Conduct regular Parameter audits, drive testing and optimization.
- Feature implementation (as per 3GPP Rel. standards)

E. OPERATE: In the Operations phase, the focus is on maintaining the network to ensure superior performance and user experience. Some of the Key activities are as listed below

- Continuous monitoring
- FCAPS
- Ensure compliance with regulatory standards
- Conduct regular audits and assessments

Key Challenges in RAN Engineering across Life cycle

Having understood the phases and activities of the RAN Engineering, now let us look at the typical challenges faced by Telcos and Network Operators which need careful engineering of RAN to ensure experience and personalization needs of their customers/consumers.

The table below depicts the analysis of key challenges in RAN LC stage and its impact to Cost, Experience, Time-to-market.

	Challenge Category	Challenges	Impacts [Cost/Experience/TTM/Compliance	Public/ Private Network
Planning	Coverage gaps identification	• High operational cost (OPEX) involved in regular drive test • Careful analysis and implementation of radio power changes to avoid Regulatory constraints • Large amount of data needs to be processed for implementing any new features (e.g. MDT)	• Poor user experience (coverage related issues) • Regulatory compliance issues	Public
	Capacity planning & Traffic Forecasting	• Forecasting accurate capacity requirement is difficult in manual processes • Analyzing seasonal variations, user behavior data (collection and analysis)	• Network congestion, Service quality degradation • Underutilized/Overutilized radio resources • Poor user experience and customer churn	Public
	Data Quality for Network Asset/ Inventory and Configuration	• Manual Data entry errors, Outdated information, Vendor specific data models	• Inaccurate network planning • Increased cost during design and build • Performance degradation	Public
Design	RAN Solution design	• Manual effort in preparation & maintenance of high-level and low-level site diagrams, leading to errors and inaccuracy • Site configurations management • Identifying test scenarios for different testing requirements, creation of detailed test case and automation of test cases • Resolving bugs within the SLA through co-ordination with multiple parties, including OEMs and internal teams, during the pre-staging lab testing activities • Speed of Bill of Quantities (BOQs) generation	• Inefficiencies and higher cycle time • Delay in network improvements and expansions • Higher Cost and Resources	Public & Private
Build	Material planning & Forecasting	• Managing a large number of RAN sites necessitates precise material ordering and forecasting to ensure materials are ready for timely deployment.	• Delays in deployment can lead to increased manpower requirements and higher costs.	Public
	On-field Assistance	• Field team would need support on critical issues faced in deployment, like information about connectivity and design.	• Delay in Network Rollout • Cost impact due to revisits in field	Public & Private
	Regulatory Compliance	• Managing multiple regulatory approvals from various regulatory bodies (e.g. in India SACFA, DoT and TERM Cell for EMF) • Handling extensive documentation and reporting, keeping up with regulatory changes • Coordinating with regulatory bodies and implementing compliance measures.	• Delays to Network Rollout • Increased costs • Potential compliance and legal issues.	Public & Private
Optimize	Finding RCA for Performance degraded cells	• Complexity in monitoring data for a large number of cells with huge amount manual effort • Issues with historical data collection to identify underlying issues.	• Poor user experience and customer churn • Customer churn • Poor Operations experience • Increased operational costs	Public & Private
	Load Balancing	• Very difficult to manually identify the over utilized and under-utilized cells in a large network and propose load balancing and configuration changes in respective cells in a network	• Impact on user performance leading to user dissatisfaction	Public Network
	Drive test effort minimization	• Manual data collection, Skilled labor availability, managing field resources, conducting drive tests to gather data for network optimization, which can be time-consuming and resource intensive.	• Increased operational costs	Public Network
	Mobility Optimization	• Maintaining stable network connections for users on the move can be challenging. • As users travel through different areas, they often experience dropped calls and poor connection quality. • This is often due to delayed or missed handovers, due to unforeseen issues in the network and when users move quickly between the source and target cells	• Impact on user performance leading to customer churn	Public & Private
Operate	Fault Management-Premonition	• Predicting network faults before they occur requires continuous monitoring and analysis of vast amounts of data.	• Network faults can lead to significant service interruptions, affecting customer satisfaction and leading to potential revenue loss. • Frequent faults and the need for manual intervention increase operational costs	Public & Private
	Power Consumption minimization	• RAN consumes a significant portion of the network's energy, especially with the deployment of 5G, which requires more power than previous generations	• High energy consumption leads to increased operational costs	Public & Private

Table 1: Key Challenges faced by Telco in RAN Engineering

As can be seen from the above analysis, many of the challenges for RAN engineering stages would directly impact customer experience when not addressed efficiently. The current generation of customers are very sensitive when it comes to service quality or experience issues. And the result is customer churn and switching to competition in no time which is the last thing that Mobile Service Providers want to see.

Solution Approaches and AI enabled RAN

To effectively address these challenges, Mobile Service Providers and Network Operators need to adopt a multi-faceted strategy, which will help in cost reduction, customer experience enhancement and edge over the competition for Time-to-market. Following are 3 Key Solution approaches which will address most of the challenges discussed.

1. Leveraging AI and GenAI based Solutions in RAN engineering: With rapid developments and advanced technologies in AI & GenAI, many of the RAN engineering activities that require predictability, assisted operations, recommendations, data-driven decision making can be powered with AI. The advancements in Large Language Model (LLM) help to support Operations use cases in AI chatbot style interface.

   E.g. fault premonitions with machine learning leveraging log and telemetry data, traffic forecasting with AI and ML leveraging ToD traffic, consumption pattern, event calendar.

2. Leveraging Automation and tools-based Solutions in RAN engineering: Automation and tools-based solution help in significant reduction of manual efforts spent in plan and design tasks. While Network Operators have built automation in key areas of RAN engineering, there are still manual touch points, paper-based process, siloed automation.

   E.g., collecting events/ alarms/ performance KPIs, formatting the collected data in required format, test automation, GIS based plan and design automation.

3. Continuous process optimization and re-engineering: Wireless Network Operators follow well defined process and workflows. These are built over the years and augmented based on business and technological requirements. However, the processes and workflows are not agile enough to accommodate changes without increasing the cycle time. Process optimization helps in streamlining workflows and avoiding repetitive tasks. This ensures faster implementation, more efficient resource utilization and low cost.

   E.g., Material ordering and Job order Workflow approval, RAN Design change lagging Agile POD efficiency are few areas for process optimization.

Below Table illustrates a quick analysis of these 3 solution approaches in addressing the challenges discussed earlier.

	AI and GenAI	Automation & Tools	Process optimization
Coverage gaps Identification	✔	✔	
Capacity planning & Traffic Forecasting	✔		
RAN Solution design	✔	✔	
Material planning & Forecasting	✔	✔	✔
On-field Assistance	✔		
RCA for Performance degraded cells	✔	✔	✔
Drive Test effort minimization	✔	✔	
Power Consumption minimization	✔	✔	
Load Balancing	✔	✔	
Fault Management	✔	✔	✔
Database Reconciliation		✔	✔
Regulatory Compliance		✔	✔
Workflow Management		✔	✔

Table 2 RAN Engineering Challenges and Solution approaches

Legend | Most Effective | Moderately Effective | Considerable Results

Among these approaches, our analysis indicates that AI enabled RAN Engineering can bring significant improvement in service experience perceived by the users. In addition, it can bring improved efficiency and operations experience for the RAN engineering stakeholders. And for the Telcos, AI-RAN is a window of opportunities which they can monetize to introduce innovative offering, use cases and applications.

AI Enabled RAN Engineering

Having understood the RAN Engineering Life cycle and the challenges across LC stages, let us

explore some potential AI driven solutions that can revolutionize personalization and experience management in 5G networks.

Below table illustrates few of the AI enablement solution ideas for RAN Engineering.

#	RAN Engineering	AI enablement	Description
A	AI for Coverage and Site Selection	AI-driven coverage prediction models identify coverage gaps and optimize site selection.	• These models analyze Measurement Reports, MDT data, third-party tool analytics (e.g., Facebook, Google), and Speed Test data to pinpoint areas with limited coverage. By leveraging AI, initially optimization of existing network cells by configuration changes (Radio Parameters) in existing cells to meet coverage gaps. If this does not meet the requirements, it recommends optimal site placement, reducing the need for extensive field testing and minimizing the costs.
B	AI for Capacity Planning and Traffic Management	AI-based tools forecast demand and optimize traffic distribution	• AI-based capacity planning tools predict network demand, analyze seasonal trends, and user behavior to ensure the network can handle varying traffic loads efficiently. Additionally, AI based traffic steering solutions distribute traffic optimally among available cells, enhancing network performance and user experience.
C	AI for RAN Design and Implementation	Generative AI and automation streamline network design and material planning.	• Generative AI combined with Agentic AI automates the creation of high-level and low-level designs, OEM-specific orderable BOQs, and connectivity diagrams, ensuring accuracy and efficiency. Automation in material planning ensures timely availability of materials, reducing deployment delays and costs. • Generative AI could be used for identification of test scenarios for various testing requirements • GenAI-based Chatbots provide real-time support to field teams, delivering accurate connectivity and design information.
D	AI for Performance Monitoring and Optimization	AI optimize performance and reduce drive test efforts	• AI-driven RCA and KPI improvement solutions monitor and analyze data from numerous cells, identifying root causes of performance degradation and suggesting corrective actions. • AI-based mobility optimization & beam management to ensure seamless connectivity, user mobility & enhanced user experience. • AI based automated drive test minimization to plot RF measurement data (signal, quality) on geo map which significantly reduces time and effort. • AI-driven predictive analytics detect faults early by analyzing network data for patterns and anomalies.
E	AI for Energy Efficiency	Energy Efficiency improvement by using AI methodologies	• AI-based power optimization dynamically adjusts power usage based on real-time traffic patterns, reducing power consumption during low traffic periods.
F	AI for Mobility Optimization	AI based mobility optimization to ensure seamless mobility and high quality of service	• AI-based mobility optimization to enhance network performance by dynamically adjusting network parameters to optimize user mobility. • AI algorithms continuously analyze network data to predict and respond to changes in user mobility patterns. • The system autonomously adjusts handover parameters and other network settings to maintain a stable connection for users on the move. • By optimizing mobility, the network can provide consistent service quality, reducing dropped calls and improving user experience.
G	AI Based Beam Management	AI Based Beam Management to enhance Network Performance	• AI techniques are used to predict optimal beam directions, dynamically adjust beams, and enhance overall network performance. • These techniques help in addressing the challenges of high mobility and varying environmental conditions, ensuring stable and efficient communication • AI driven beam management minimizes latency by quickly adapting to changes in user location and network conditions. This results in a more responsive and enjoyable user experience

Table 3 AI Enabled RAN Engineering Solution Examples

Conclusion

The demand for 5G will continue to grow in the coming years driven by consumer and industrial use cases which need connectivity.

Superior Customer experience, Operational efficiencies, New Revenue opportunities and Competitive advantage are the key elements for Mobile Network Operators to unlock the growth and stay ahead in the game. It is evident that AI will play crucial role in enabling this growth like other sectors and solutions. And AI enabled RAN engineering will be the strategic step towards that direction.

This whitepaper has attempted to demystify the transformation potential of leveraging AI enabled RAN engineering in delivering superior customer experience and personalization.

We strongly believe in this transformation approach, and Telcos to embrace AI with focused investments in data analytics, AI/ML skills, AI/GenAI infrastructure, collaboration with AI solution vendors and system integrators.It is evident, however, that engineering standards, budget sizes, rollout targets, IT ecosystems, and data quality vary across regions and different telecommunications companies. While a framework solution may work in solving common challenges that various telecommunications companies face, there is certainly a need for pointed AI solutions to ensure quicker return on investment, to capitalize on quick wins, and to meet market commitments. This paper has been structured in that direction to share the possibilities of AI in Fiber rollout journey for all its stakeholders.

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About the Author

Balaji Thangavelu

Industry Principal with Infosys

Veeravenkata Krishnaneel Chinagandham

Digital solution specialist

Praneeth Kumar Tekkam

Senior Consultant with Infosys

Thank You Note

The authors thank **Sreekanth Sasidharan, Jayram Govindarajan, Amit Surana, Kamal Goel**, for their inputs and guidance for this Thought Paper.

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