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Performance Evaluation of N40 Integration Using AZNA in 5G Networks

Mohammed Yahiya Pasha Gulam[1], Younus Mohammed[2], Syed Ashwaq Hussain[3], Hussam uddin Mohammed[4], Shaikh Noman[5], Asif Khan[6] and Abdul Quader Syed[7]
Saudi Telecom Company

***Abstract*—This paper presents a comprehensive performance evaluation of 5G N40 integration utilizing AZNA in a non-beamforming configuration within a live network environment. The study was conducted across multiple operational sites using a 4×4 MIMO setup to assess the impact of mid-band spectrum deployment on network capacity, traffic distribution, and overall user experience. Performance analysis was carried out using a combination of OSS-based key performance indicators (KPIs), detailed drive test measurements, and crowd-sourced Ookla speed test data, ensuring both network-level and end-user perspectives were captured. The results demonstrate a significant improvement in downlink throughput, with notable gains in both average and peak data rates after the activation of the N40 layer. Additionally, traffic analysis indicates a clear shift of user load from LTE to 5G, leading to improved load balancing and reduced congestion across existing layers. Drive test findings further confirm enhancements in radio conditions, including better signal quality, stable mobility performance, and consistent throughput across different coverage scenarios. Despite operating without beamforming, the AZNA-based deployment effectively improves spectral efficiency while maintaining network stability, with key KPIs such as accessibility, retainability, and availability remaining within acceptable limits. Overall, the study validates that N40 integration is a practical, scalable, and efficient solution for enhancing 5G network capacity and delivering improved user experience in high-demand environments**

***Index Terms*—5G NR, N40 Band, AZNA, Throughput Optimization, Carrier Aggregation, Spectral Efficiency, Load Balancing**

I. INTRODUCTION

The rapid growth of mobile data traffic, driven by high-definition video streaming, cloud-based applications, and emerging digital services, has placed significant pressure on modern cellular networks to deliver higher capacity and improved user experience. Fifth Generation (5G) New Radio (NR) technology has been introduced to address these challenges by offering enhanced data rates, lower latency, improved spectral efficiency, and support for massive connectivity. These capabilities make 5G a key enabler for next-generation services and applications in both urban and suburban environments.

Among the various frequency bands allocated for 5G deployment, mid-band spectrum such as N40 plays a critical role in achieving an optimal balance between coverage and capacity. Compared to low-band spectrum, it provides higher throughput, while offering better propagation characteristics than high-band (mmWave) frequencies. As a result, N40 has become a preferred choice for operators aiming to enhance network performance without requiring extensive infrastructure expansion. However, increasing user demand and data consumption often lead to congestion in existing LTE and early 5G layers, especially during peak traffic periods.

To address these challenges, the integration of additional 5G layers such as N40 has emerged as an effective strategy for capacity enhancement and traffic offloading. By introducing a dedicated mid-band layer, networks can redistribute user traffic from legacy LTE systems to 5G, thereby improving overall throughput and reducing congestion. In this context, the use of AZNA in a non-beamforming configuration provides a simplified deployment approach while still enabling significant performance gains through efficient spectrum utilization and MIMO capabilities.

This study presents a detailed performance evaluation of N40 integration in a live network environment. The analysis is based on a combination of OSS key performance indicators, drive test measurements, and crowd-sourced user data to assess improvements in throughput, traffic distribution, and network stability. The findings aim to demonstrate the effectiveness of N40 deployment as a scalable and practical solution for enhancing 5G network capacity and improving user experience in high-demand scenarios.

II. OBJECTIVE AND TRIAL SETUP

A. *Objective*

The primary objective of this study is to evaluate the performance impact of integrating 5G N40 cells using AZNA in a non-beamforming configuration within a live network environment. The study aims to analyze how the introduction of the N40 layer enhances overall network capacity and improves user experience. A key focus is on measuring improvements in downlink throughput, both at network and user levels. Additionally, the study evaluates the effectiveness of traffic offloading from existing LTE layers to the newly deployed 5G layer. The impact on key performance indicators such as PRB utilization, load distribution, and spectral efficiency is also examined. Another objective is to assess whether stable network performance can be maintained without beamforming capabilities. The study further aims to validate the practicality of AZNA deployment for real-world scenarios. Overall, the objective is to determine the efficiency and scalability of N40 integration as a capacity enhancement solution

B. *Trial Cluster*

The trial was conducted across a cluster of seven selected sites, labeled as Site 1 through Site 7, representing a real operational network environment. These sites were chosen to reflect

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typical traffic conditions and user distribution patterns within the cluster. The selection ensured a mix of different coverage areas, including near, mid, and far user scenarios. The trial cluster was designed to capture performance variations across multiple locations under consistent network configurations. Integration activities were carried out in a phased manner across the selected sites to observe pre- and post-deployment performance. This approach enabled a comparative analysis of network behavior before and after N40 activation. The cluster-based evaluation also helped in understanding traffic redistribution across neighboring cells. Overall, the selected sites provided a reliable basis for assessing the impact of N40 deployment at a cluster level

C. Hardware Configuration

The deployment utilized AZNA hardware configured with a 4×4 MIMO setup to support the N40 frequency band. This configuration was selected to provide a balance between performance enhancement and deployment simplicity. The system operated without beamforming, allowing the study to evaluate baseline performance improvements achievable through spectrum addition alone. The N40 layer was introduced alongside existing LTE layers, enabling multi-layer operation within the network. The hardware setup ensured compatibility with current network infrastructure without requiring major modifications. The 4×4 MIMO configuration contributed to improved spatial diversity and throughput performance. The integration also allowed efficient utilization of available bandwidth for enhanced capacity. Overall, the hardware configuration was optimized to support scalable deployment while maintaining cost and complexity considerations

D. Tools Used

Performance evaluation was carried out using a combination of field and network-level tools to ensure comprehensive analysis. Nemo Outdoor was used for conducting drive tests and capturing real-time radio measurements across different coverage conditions. Actix was utilized for post-processing and detailed analysis of collected drive test data. In addition, OSS-based key performance indicators (KPIs) were analyzed to evaluate network-level performance trends over time. Crowd-sourced Ookla speed test data was also incorporated to assess user-experienced throughput and validate field results. The combination of these tools provided both technical and user-centric insights into network performance. Measurements were conducted across different time periods, including peak and non-peak hours, to capture realistic traffic conditions. Overall, the use of multiple tools ensured accurate and reliable evaluation of the N40 integration performance.

III. NETWORK CONFIGURATION

Before the integration of the N40 layer, the network was operating solely on LTE TDD, which handled all user traffic and capacity requirements within the cluster. While LTE provided stable coverage and acceptable performance, increasing data demand and user density led to higher resource utilization and congestion, particularly during peak hours. This limitation affected overall throughput and reduced the network's ability to efficiently manage growing traffic loads.

Following the integration, a 5G N40 layer with a bandwidth of 60 MHz was introduced alongside the existing LTE layer, which continued to operate with 20 MHz bandwidth. This resulted in a multi-layer network architecture where both LTE and 5G operated simultaneously, enabling better utilization of available spectrum resources. The addition of the N40 layer significantly increased the total available bandwidth, providing enhanced capacity to support higher data rates and improved user experience.

The coexistence of LTE and 5G layers allowed effective traffic distribution between the two technologies, reducing congestion on the LTE layer while offloading users to 5G. This multi-layer configuration improved overall network efficiency, enhanced throughput performance, and ensured a more balanced load across the network. As a result, the integration contributed to better resource utilization and improved service quality without compromising network stability

IV. THEORETICAL BACKGROUND

The performance improvement observed after the integration of the N40 layer is primarily driven by increased bandwidth availability and enhanced resource utilization. In a single-layer LTE configuration, network capacity is limited by the available spectrum and high utilization of physical resource blocks (PRBs), which can lead to congestion during peak traffic conditions. The introduction of the 5G N40 layer significantly expands the available bandwidth, enabling improved traffic distribution and higher data rates.

From a theoretical perspective, the achievable throughput in a wireless system is directly proportional to the available bandwidth and spectral efficiency, which can be expressed as:

$$Throughput = Bandwidth \times Spectral\ Efficiency \quad (1)$$

With the addition of the N40 layer, the total usable bandwidth increases, resulting in higher throughput and improved network capacity. This allows the system to support more users and higher data demand without degrading performance.

Furthermore, the relationship between system capacity and signal quality can be explained using the Shannon capacity theorem:

$$C = B \log_2(1 + SNR) \quad (2)$$

where C represents the channel capacity, B is the bandwidth, and SNR is the signal-to-noise ratio. This equation highlights that increasing bandwidth, as achieved through N40 integration, leads to a proportional increase in capacity under similar radio conditions.

In scenarios where carrier aggregation is applied, the total effective bandwidth is the sum of individual component carriers, which can be represented as:

$$B_{total} = B_1 + B_2 + \cdots + B_n \quad (3)$$

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TABLE I
SITE INTEGRATION TIMELINE

Site ID	Integration Date
Site 1	30-Dec-2024
Site 2	21-Jan-2025
Site 3	21-Jan-2025
Site 4	22-Jan-2025
Site 5	22-Jan-2025
Site 6	23-Jan-2025
Site 7	26-Jan-2025

This aggregated bandwidth enables higher peak data rates and improved resource allocation across multiple layers. Overall, these theoretical principles explain the observed improvements in throughput, traffic distribution, and overall network performance following the integration of the N40 layer.

V. OOKLA PERFORMANCE ANALYSIS

A. Integration Timeline

The integration of the N40 layer was carried out in a phased manner across the selected sites, as summarized in Table I. The deployment started with Site 1 on 30-Dec-2024, followed by multiple sites integrated on 21-Jan-2025 and 22-Jan-2025, with the remaining sites completed by 26-Jan-2025. This staggered implementation approach ensured controlled deployment and allowed sufficient time to monitor network behavior after each integration step. The timeline presented in the table provides a clear view of the rollout sequence and helps in correlating performance improvements with the integration period. It also enables a structured comparison between pre- and post-integration network conditions across the cluster. Overall, the phased integration ensured minimal disruption while facilitating accurate performance evaluation

B. Performance Improvement

Following the integration, a significant improvement in network performance was observed. Cellular throughput increased from 264 Mbps to 376 Mbps, reflecting an overall gain of approximately 42%, indicating enhanced capacity and better resource utilization. In addition, 5G throughput showed a substantial increase from 53 Mbps to 311 Mbps, corresponding to an improvement of around 486%. These gains highlight the effectiveness of the N40 layer in boosting data rates and improving user experience. The increased bandwidth and efficient traffic distribution contributed to reduced congestion on existing layers. Overall, the results confirm that N40 integration plays a critical role in enhancing network performance and supporting higher data demand.

VI. DRIVE TEST RESULTS

A. Static Throughput

The static drive test results indicate a significant improvement in throughput performance after the integration of the N40 layer. Measurements conducted at different locations (near, mid, and far) show that 5G throughput reached peak values of up to 472 Mbps. Additionally, when combined with LTE (4G+5G), the overall throughput increased further, achieving up to 713 Mbps. These results demonstrate the benefit of multi-layer operation in enhancing data rates. The consistent performance across different coverage zones highlights the effectiveness of N40 deployment in improving capacity and user experience. Overall, static testing confirms strong throughput gains and stable performance.

B. Carrier Aggregation

Carrier aggregation performance was evaluated to assess the combined operation of multiple frequency layers. The results confirm successful aggregation between N40 and N78, enabling higher bandwidth utilization and improved data rates. During testing, peak throughput values reached up to 1200 Mbps under aggregated conditions. This demonstrates the capability of the network to support high-capacity scenarios using multi-band aggregation. The results also indicate efficient coordination between layers without performance degradation. Overall, carrier aggregation significantly enhances throughput and network efficiency

C. Mobility KPIs

Mobility drive test results show stable and consistent radio performance across the network. Key indicators such as RSRP and SINR were maintained at acceptable levels, with average values around -86.5 dBm and 9.9 respectively. The average downlink throughput during mobility was observed to be approximately 220 Mbps, while uplink throughput reached around 43 Mbps. These results confirm reliable performance under movement conditions, ensuring seamless user experience. The network also maintained stable handovers and connectivity throughout the test routes. Overall, mobility KPIs indicate that N40 integration does not negatively impact network stability.

VII. KPI ANALYSIS

A. Traffic Distribution

The traffic distribution analysis indicates a notable shift in user load following the integration of the N40 layer. Approximately 30% of the total traffic was offloaded from the 4G network to 5G, demonstrating effective utilization of the newly introduced capacity layer. As a result, the N40 band experienced a significant increase in traffic of around 110%, highlighting its ability to handle higher data demand. This redistribution helped in reducing congestion on the LTE layer while improving overall load balancing across the network. The efficient traffic migration also contributed to better resource utilization and enhanced network performance. Overall, the results confirm that N40 integration plays a key role in optimizing traffic distribution and supporting increased user demand

B. 4G Impact

The impact on the 4G network after N40 integration remained stable and well-balanced. Despite a noticeable shift of users from 4G to 5G, the overall 4G user throughput was

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TABLE II
KEY PERFORMANCE SUMMARY

Metric	Value
Cellular Gain	42%
5G Gain	486%
Traffic Shift	30%
Peak Throughput	1200 Mbps

maintained without degradation. The reduction in active LTE users helped in lowering congestion and improving resource availability within the 4G layer. Additionally, while advanced features such as higher-order carrier aggregation were reduced, the traffic offloading to 5G compensated for this change. Overall, the results indicate that N40 integration supports efficient load balancing while preserving stable 4G performance

VIII. RESULT SUMMARY

The overall performance improvements achieved after the integration of the N40 layer are summarized in Table II. As presented in the table, cellular throughput shows a notable increase of 42%, indicating enhanced overall network capacity and efficiency. The 5G layer demonstrates a substantial improvement of 486% in throughput, highlighting the strong impact of N40 deployment on user experience. In addition, approximately 30% of traffic was successfully shifted from 4G to 5G, reflecting effective load balancing and optimized resource utilization. The peak throughput achieved reached up to 1200 Mbps through carrier aggregation, demonstrating the network's capability to support high data rate scenarios. Overall, the results confirm that N40 integration significantly enhances performance while maintaining network stability.

IX. DISCUSSION

The results demonstrate that the integration of the N40 layer significantly enhances overall network performance by increasing available bandwidth and improving resource utilization. The observed improvements in both cellular and 5G throughput confirm that the additional spectrum effectively reduces congestion on existing LTE layers. The shift of traffic from 4G to 5G further supports efficient load balancing and better distribution of network resources.

Additionally, the deployment using AZNA in a non-beamforming configuration shows that considerable performance gains can be achieved even without advanced beamforming techniques. The stability of key KPIs, including accessibility and mobility, indicates that the integration does not negatively impact network reliability. Overall, the findings highlight that N40 deployment is a practical and scalable approach for capacity enhancement and improved user experience in high-demand network environments.

X. CONCLUSION

This study evaluated the performance impact of integrating the 5G N40 layer using AZNA in a non-beamforming configuration within a live network environment. The results demonstrated significant improvements in throughput, traffic distribution, and overall network efficiency following the deployment. A substantial shift of traffic from 4G to 5G was observed, leading to better load balancing and reduced congestion on legacy layers.

Despite the absence of beamforming, the network maintained stable performance across key KPIs, confirming the reliability of the deployment. The achieved gains in both cellular and 5G throughput highlight the effectiveness of N40 as a capacity enhancement layer. Overall, the findings validate that N40 integration is a practical, scalable, and efficient solution for supporting increasing data demand and improving user experience in modern 5G networks

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