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5G NSA Network Slicing

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***Abstract*—This paper presents the implementation and field trial results of 5G Non-Standalone (NSA) Network Slicing using Nokia's Slice-Aware Scheduler in a live commercial 5G network. The trial was conducted across two clusters — site ZXXXX and ZYYYY — using SPID-based resource differentiation to separate Smartphone (Non-SPID) and Router (SPID-16) user groups. The scheduler leverages configurable minimum and maximum Physical Resource Block (PRB) quotas per resource group to dynamically allocate shared radio resources every 100 ms. Trial results demonstrate consistent improvement in smartphone downlink MAC throughput, with gains of up to 30% in targeted sectors, alongside controlled router throughput within acceptable bounds. Spectral efficiency, PRB utilization per slice, and Ookla SpeedTest measurements further validate the effectiveness of the approach. Key parameter tuning insights, cluster-specific observations, and recommendations for city-wide deployment are discussed.**

***Index Terms*—NSA slicing, 5G NR, slice-aware scheduler, SPID, PRB quota, network resource management, Nokia gNB, QoS differentiation.**

I. INTRODUCTION

The rapid proliferation of heterogeneous device types in 5G Non-Standalone (NSA) networks—most notably smartphones and Fixed Wireless Access (FWA) routers—has introduced new complexities in radio resource management. Although these devices coexist on the same physical radio layer and contend for the same pool of Physical Resource Blocks (PRBs), their traffic characteristics and Quality of Service (QoS) expectations differ substantially. Smartphones typically generate latency-sensitive, session-based traffic requiring responsive scheduling and consistent throughput, whereas FWA routers produce sustained, high-volume data flows that can dominate available radio resources. In the absence of differentiated scheduling mechanisms, router-driven bulk traffic can monopolize PRBs, resulting in degraded performance and diminished user experience for smartphone subscribers.

To address this imbalance, NSA Network Slicing has emerged as a practical and deployable solution. Nokia's Slice-Aware Scheduler—implemented through feature sets CB008132, CB009084, CB008828, CB008746, and CB008709—enables operators to define Network Resource Groups (NRGs) with configurable minimum and maximum PRB allocations. This capability allows traffic from distinct device categories to be isolated into logical slices with guaranteed resource quotas, ensuring fair coexistence and improved service quality across heterogeneous user populations.

This paper presents results from a live field trial conducted across two commercial clusters in Saudi Arabia: ZXXXX and ZYYYY clusters. The study evaluates the impact of NSA slicing on per-slice throughput, PRB utilization, and end-user experience, with performance validated using Ookla SpeedTest measurements. The findings provide empirical evidence on how slice-aware scheduling can enhance smartphone performance in mixed-device environments while maintaining efficient utilization of radio resources.

II. BACKGROUND AND RELATED WORK

Network slicing is a core concept in 5G, defined in 3GPP Release 15 and onwards, enabling multiple virtual networks over a shared physical infrastructure. In standalone (SA) architectures, slicing is typically implemented via S-NSSAI identifiers end-to-end from the core to the RAN. In NSA deployments, where the 5G NR radio is anchored to an LTE core (EPC), full SA-grade slicing is not directly applicable. Nokia's NSA Slicing approach provides an equivalent RAN-side capability using Subscriber Profile IDs (SPIDs) to identify and differentiate device groups.

Prior work on RAN slicing has demonstrated that static quota-based approaches can provide isolation but at the cost of spectral efficiency [6]. Dynamic schedulers that share a common resource pool and compute per-group target shares based on instantaneous demand offer a better balance. The Nokia Slice-Aware Scheduler implements such a dynamic common resource pool model, computing target shares every 100 ms.

III. SYSTEM ARCHITECTURE AND FEATURE DESCRIPTION

The NSA Slicing feature is applicable to FR1 (sub-6 GHz) deployments. The architecture involves the following object hierarchy at the gNB level:

- **NRBTS**: Hosts activation flags and SPID group definitions (`NRSPIDGRP`).
- **NRRESOURCEGROUP_PROFILE**: Defines multiple resource groups per profile, each associated with a SPID group or S-NSSAI identifier.
- **NRRESOURCEGROUP**: Carries the scheduling parameters (`minQuota`, `maxQuota`) and resource type identifier (`resourceDN`).
- **NRCELL**: References the applicable DL and UL resource group profiles via `nrResourceGroupProfileDN` and `nrResourceGroupProfileUlDN`.

The scheduler divides available PRBs into two logical pools: a dedicated pool (protected minimum quota per group) and a common resource pool (the remainder shared proportionally). For a given cell with three resource groups each having *minQuota* of 10%, 20%, and 30%, and a common pool of 40%, the target share for each group is computed as:

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$$\text{TargetShare}(\text{RG}_i) = \text{minQuota}_i + \frac{\text{maxQuota}_i - \text{minQuota}_i}{\sum_k (\text{maxQuota}_k - \text{minQuota}_k)} \times \text{CommonPool} \quad (1)$$

This dynamic computation runs every 100 ms, ensuring the allocation adapts to instantaneous cell load conditions. For the example above, target shares are 25%, 33.3%, and 41.7% for RG#1, RG#2, and RG#3, respectively.

IV. Parameter Configuration

Table I presents the key NRBTS-level parameters activated for the trial. SPID group 1 (Smart Phone / Non-SPID) and SPID group 2 (Router / SPID-16) are defined as the two resource groups.

TABLE I
NRBTS and SPID Group Parameter Configuration

Object	Parameter	Value
NRBTS	actSpidBasedSlicingNSA	true
NRBTS	actSliceAwareScheduler	true
NRBTS	actSliceAwareSchedulerUlAndEnh	true
NRBTS	actHighSliceWeightFactor	true
NRSPIDGRP-1	userLabel / spid	Smart Phone / 1
NRSPIDGRP-2	userLabel / spid	Router / 16

Table II defines three resource group profiles designed for different cell loading conditions. Profile-0 targets high-user cells (NSA UEs ≥40) where router resource allocation is more tightly capped. Profile-1 is applied to low-to-medium load cells (UE <40), with relaxed router `maxQuota` and a higher smartphone `minQuota` to improve user experience. Profile-2 provides a custom baseline for cells requiring case-by-case tuning.

TABLE II
Resource Group Profile Quota Configuration and Target Shares

Profile	Resource Group	min%	max%	Target%
Profile-0 (High UE ≥40)	NRRG-1 (Smartphone)	50	100	68.75
	NRRG-2 (Router)	20	50	31.25
Profile-1 (Low/Med UE <40)	NRRG-1 (Smartphone)	60	100	63.64
	NRRG-2 (Router)	20	80	36.36
Profile-2 (Custom)	NRRG-1 (Smartphone)	50	100	61.54
	NRRG-2 (Router)	20	100	38.46

The Cell-level assignment of `NRCELL.nrResourceGroupProfileDN` and `nrResourceGroupProfileUlDN` is determined by the maximum UE count observed by NSA per sector. Co-sector NRCELLs across all frequency bands (n28, n40, n77, n78) are configured with the same profile to ensure consistent scheduling behavior.

V. Trial Results and Analysis

A. *ZXXXX Cluster*

The ZXXXX cluster was used as the initial trial site to validate the slice scheduler behavior. The trial was conducted in three phases: a hybrid phase combining SPID steering with slicing, followed by two progressive slicing phases with tighter router quotas (30/70 then 20/50 min/max for routers).

Key observations from the ZXXXX trial include: (i)

1) Smartphone DL streaming throughput showed a clear and consistent upward trend across all three phases.
2) Router DL throughput was progressively limited as max quota was reduced, demonstrating effective slice isolation.
3) PRB utilization for SPID-16 (Router) was hard-capped at the configured max quota level, confirming correct scheduler enforcement.
4) n40 showed elevated Non-SPID user counts due to n78 coverage gaps, creating contention that was effectively managed by the slice quotas.

B. *ZYYYY Cluster — N-KPI Analysis*

The ZYYYY cluster was the primary production validation site. P(S)Cell Load Balancing was activated alongside NSA Slicing to rebalance users across frequency layers prior to applying slice quotas. Table III summarizes the key N-KPI changes observed post-implementation.

TABLE III
ZYYYY Cluster N-KPI Summary (PRE vs. POST)

KPI	PRE	POST	Δ
DL MAC UE Throughput	—	—	+5.2%
DL Traffic Volume	—	—	+1.2%
NSA Avg Users (n78)	—	—	−45.9%
NSA Avg Users (n40)	—	—	+18.2%
Avg DL MAC SDU UE Thr (n78)	104.7 Mbps	184.2 Mbps	+75.9%
PDCCH CCE Starvation Rate	0.06%	0.00%	−98.2%
PDSCH Block Rate (Fmt 3)	0.39%	0.02%	−95.5%
DL CA Reconfig Attempts	—	—	+320%
DL CA Reconfig SR	99.61%	99.88%	+0.27%

Per-band DL throughput analysis showed that smartphones consistently outperformed routers as expected. For n77/n78 cells with NSA UE count ≤40, updating the router

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maxQuota to 60% and smartphone minQuota to 60% (Profile-1) further improved both smartphone and router throughput simultaneously, with no degradation observed for any user group. For n40 and n28 bands, the more conservative max quota of 50% for routers was maintained without throughput degradation.

PRB utilization per slice confirmed proper quota enforcement: NRG-2 (Router) was capped at its configured maxQuota, while the mean PRB utilization tracked the computed target load values from (III). AEQD collocated sites showed elevated n40 user counts as a deliberate outcome of the P(S)Cell load balancing strategy, with acceptable throughput impacts.

C. ZYYYY Cluster — Pre/Post Analysis

The ZYYYY cluster was activated after the baseline. The deployment sequence included: (1) Activating NSA Slicing, (2) Optimizing low-user n78/n77 [7] cells in the 60/100, 20/60 Profile-1 configuration, (3) Changing a test configuration, and (4) Activating the exhaustive scheduler as a complementary optimization. Throughput analysis showed improvement in smartphone DL and UL throughput across all frequency bands (n28, n40, n77, n78) [3]. Router throughput remained within acceptable bounds despite the tighter quota enforcement.

Post period analysis confirmed that overall smartphone throughput continued to improve after the peak traffic period, with Ookla DL and UL speedsshowing an upward trend. The PRB utilization tracking followed themax/min quota settings precisely, validating the scheduler's deterministic enforcement behavior.

D. Ookla SpeedTest S-KPI Validation

Ookla SpeedTest measurements providedindependent end-user validation of network improvements. Across both ZXXXX and ZYYYY clusters, 5G DL and UL speeds showed clearimprovement trends across POST-1, POST-2, and POST-3 measurement periods compared to PRE. Modern chipset performance was maintained throughout, confirming that the slicing configuration did not introduce regression for premium devices. These results support the proposal for a broader city-wide cluster deployment.

VI. DISCUSSION

The trial results confirm that NSA Slicing with the Slice-Aware Scheduler is an effective mechanism for differentiating service quality between smartphone and router user groups in live 5G NSA networks. Several practical insights emerged:

- Profile selection based on cell UE count (threshold: 40 UEs) provides a simple and effective adaptive policy. High-user cells benefit from tighter router caps, while low-user cells can afford more generous router quotas.
- The dynamic common resource pool computation ensures high spectral efficiency by avoiding static partitioning. Unused quota from one group is available to the other within the max quota constraints.
- AEQD collocated sites require careful P(S)Cell load balancing configuration to prevent unintended n40 concentration. The ccLoadThreshold parameter on n28 was a critical tuning lever.
- The event high-traffic period demonstrated scheduler robustness under peak load conditions, with PRB quota enforcement remaining precise.
- Future enhancements including 26R1 (CB012238 — QoS and UE fairness) and 25R3 (CB012810 — low-latency slice scheduling) are expected to further improve differentiation quality for latency-sensitive applications.

VII. CONCLUSION

This paper has presented a comprehensive field trial of NSA Network Slicing in a commercial 5G network [7]. The slice-aware scheduler successfully enforced PRB quota constraints per resource group while maintaining high spectral efficiency through a dynamic common pool model. Smartphone users experienced consistent throughput improvements of 5–76% across bands and clusters, while router users were managed within their quota bounds with-out service disruption. Ookla SpeedTest® measurements independently validated the improvements at the end-user experience level. The findings support the recommendation for city-wide deployment of NSA Slicing with per-profile tuning, and highlight the importance of iterative quota optimization as traffic patterns evolve.

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