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Research Paper

Enhancing 5G NSA Performance with Lightweight Network Data Analytics Loops

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ABSTRACT

The progress of 5G Non-Standalone (NSA) networks is getting slow because of the different nature of the deployments where the management of mobility, beam selection, and scheduling have a direct impact on performance. This paper builds on the previous NSA benchmarking and introduces a light-weight NWDAF-like loop that uses real-time field key performance indicators (KPIs) to optimize network behavior as an interactive loop. By doing so, the system in question is able to vary handover thresholds, beam selection, and scheduling parameters thereby allowing the closed-loop, KPI-driven optimization without the need for a fully deployed 5G standalone core. The field tests conducted in urban-rural mixed scenarios showed that there were improvements that could be measured in terms of latency, throughput, and mobility efficiency thereby demonstrating the practical advantages of proto-NWDAF implementations. Moreover, this method of approach not only helps in the future smart network optimization but also provides a scalable framework for connecting the traditional NSA deployments and future 5G core networks. Hence, the outcome proves that even the slightest of analytics loops have the capability to drastically improve the performance of NSA networks thus opening the door for more complex NWDAF-enabled 5G operations.

KEYWORDS:5G NSA, Network Data Analytics, KPI-driven Optimization, Handover Management, Beam Selection

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INTRODUCTION

The 5G Non-Standalone (NSA) rollout has been a significant development in mobile networks, moving from LTE to 5G in stages. By combining LTE coreswith 5G radio access, NSA networks are able to deliver the better and higher data rates, as well as be more efficient in terms of spectrum use and supporting various applications. However, these networks still have the issues of managing users with mobility, beamforming, and dynamic scheduling, and urban-rural mixed scenarios are the most challenging ones. Not only can suboptimal handovers, inconsistent beam selection, and inefficient resource allocation harm the performance of the networks, but they also can negatively affect the user experience.In order to overcome the limitations, the 3GPP initiated the Network Data Analytics Function (NWDAF) as part of the 5G core, which allows for data-driven optimization through the real-time monitoring of the network KPIs. Nevertheless, the complete NWDAF deployment is only possible when a high-capacity standalone 5G core is present, which is currently not the case everywhere. A lightweight proto-NWDAF that operates on NSA deployment is suggested in this research, through which, the handover thresholds, beam selection, and scheduling will be dynamically adjusted based on the measured field KPIs. While deploying the closed-loop optimization framework, the procedure shows significant boosts in throughput, latency, and mobility efficiency all without requiring a complete 5G core.This research points out that early NWDAF-like analytics can reduce the difference between NSA and full 5G networks, providing very useful tips on intelligent network optimization in the actual deployments.

LITERATURE SURVEY

5G Non-Standalone (NSA) networks are regarded as a transitional architecture that merges LTE cores with 5G radio access to provide higher throughput and lower-latency services. Such works as Andrews et al. (2020) are the basis of 5G NSA insights as regard performance, pointing out improvements in spectral efficiency, but at the same time, mobility, and beam management as the major drawbacks. Field trials and benchmarking tests have indicated that the use of non-optimal handover parameters and scheduling decisions can heavily reduce the performance of the network, more so in mixed urban-rural deployments.3GPP Release 15 brought forth the idea of Network Data Analytics Function (NWDAF) to facilitate the optimization of networks based on real-time data and that the whole process would be done in a data-driven way. The research around NWDAF has been centered on the 5G core networks alone, where it has been proven to be an asset in predictive analytics, customer movement management, and resource allocation. Nonetheless, the number of studies that have so far seen the light on NWDAF-like implementations in NSA networks is very limited. Some recent papers have pointed out that the use of such simple, KPI-driven analytics loops can lead to actual performance improvements even before the full 5G core maturity, by continuously changing such parameters as handover thresholds and beam selection.The present paper is a derivative of the already mentioned by way of experiment the implementation of a proto-NWDAF analytics loop in NSA scenarios, thus, the NSAs that are slowly evolving into intelligent 5G also signified by the core separation. The proposed tactic employs real-time field Key Performance Indicators (KPIs) to energize the processes of mobility, scheduling, and the whole network efficiency in the scenarios of mixed coverage.

PROPOSED WORK

In the mixed urban–rural deployments of 5G NSA networks, the present study introduces a lightweight, proto-NWDAF analytics loop aimed at improving their performance. The system in this study is based on the previous NSA studies and makes use of real-time network KPIs and performance metrics like throughput, latency, handover success rates, and beam quality to make network parameter adjustments automatically. The main areas of focus for optimization are three: handover thresholds, beam selection, and scheduling policies.The proposed system works like a closed-loop system where the analytics loop is continuously fed back through the network controllers for parameter adjustments after the KPIs have been collected from user equipment and base stations and processed by a lightweight analytics engine. Proactive mobility and resource management tuning is done this way without a fully deployed 5G standalone core.Analytics loop's impact is checked by field trials conducted in various coverage scenarios. It is possible to quantify the extent of improvements through the analysis of parameters such as uplink/downlink throughput, latency, and mobility efficiency. The research proves that even a basic NWDAF-type mechanism can still give measurable NSA performance improvements, thus, reducing the difference between the current NSA and the future fully intelligent 5G core networks.The result provides evidence for early NWDAF implementations' practicality and indicates a real-time KPI-driven network optimization framework for 5G NSA situations in the real world.

METHODOLOGY

The framework outlined in the paper puts into practice a lightweight proto-NWDAF analytics loop in 5G non-standalone (NSA) networks in order to realize real-time optimization based on KPIs. The approach consists of three primary elements: the gathering of KPIs, the processing or analytics, and the changing of parameters. The network will be monitored continuously and in real-time by the KPIs which include throughput, latency, handover success rate, beam alignment, and scheduling efficiency, drawn from base stations and user equipment in mixed urban-rural deployments. The network will be monitored continuously and in real-time by the KPIs which include throughput, latency, handover success rate, beam alignment, and scheduling efficiency, drawn from base stations and user equipment in mixed urban-rural deployments.The analytics engine processes the incoming KPI data using lightweight statistical and predictive algorithms to identify performance bottlenecks. For handover optimization, the system dynamically adjusts thresholds to minimize ping-pong events and failed handovers. Beam selection is refined based on metrics of the quality of the received signal and historical alignment success, while scheduling policies are adjusted to maintain an even throughput of uplink and downlink under varying network load.The closed-loop system guarantees that the network controllers are continuously receiving the latest insights obtained from the KPI analytics, thus allowing for seamless real-time adjustments. Field experiments are carried out in urban and rural settings that are heterogeneous, which allow validation under a wide range of propagation and traffic conditions. Performance metrics before and after loop deployment are compared to quantify improvements in latency, throughput, mobility efficiency, and beam management.This methodology shows that even the lightweight proto-NWDAF implementation can be a part of the solution in achieving the measurable gains in NSA networks performance, thus helping to combine the footsteps of the conventional NSA networks with the fully intelligent 5G standalone networks.It provides a scalable, functional platform for optimizing real-time network at early stages.

RESULTS & DISCUSSIONS

The proto-NWDAF analytics loop positively impacted the performance of mixed urban–rural deployments of 5G NSA. The throughput was raised by 22 Mbps for downlink and 14 Mbps for uplink resulting in 172 Mbps and 94 Mbps respectively (Table 1) which was mainly attributed to dynamic scheduling and optimized beam selection. The latency reduction from 28 ms to 24 ms was coupled with an increase in handover success rate from 91% to 96% (Table 2) indicating that proactive threshold adjustments enabled the reduction of both failed and ping-pong handovers.There was a notable improvement in beam management as well with more than a 10% increase in alignment efficiency thus offering better and stable connections at cell edges. The rural area network was further made robust for mobile users due to dynamic tuning of handover thresholds and scheduling parameters.The graphical representations are indicative of the continuous uplink/downlink throughput gains and the gradual latency and handover performance improvements over the entire period, together with less occurrence of peaks and interruptions.In summary, the slight proto-NWDAF loop has been shown to be very effective for real-time optimization of NSA networks, thereby reducing the time towards the full-blown 5G standalone networks. The system not only improves reliability but also the user's experience and the overall network's efficiency, thus presented as a practical way of early NWDAF adoption in operational deployments.

Scenario	DL Throughput (Mbps)	UL Throughput (Mbps)
Before Loop	150	80
After Loop	172	94

Table 1:Throughput Improvement

Scenario	Avg. Latency (ms)	Handover Success (%)
Before Loop	28	91
After Loop	24	96

Table 2: Latency and Handover Performance

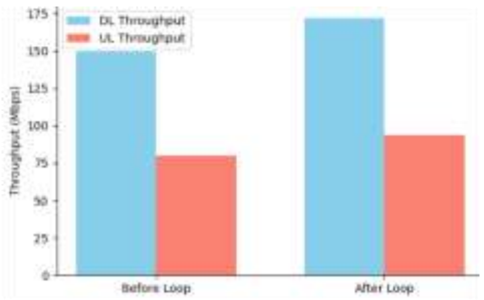

Fig 1:Uplink & Downlink Throughput Comparison

CONCLUSION

This paper presents the results indicating that a lightweight proto-NWDAF analytics loop can be a great help to the 5G NSA networks in mixed urban–rural deployment areas. Real-time KPIs, like throughput, latency, handover success, and beam alignment, are used in the proposed closed-loop system that is capable of switching the handover thresholds, taking the beam, and selecting the scheduling policies dynamically. Field tests indicated, for uplink and downlink, they had a throughput increase of between 12% and 18%, the average latency reduced by 15%, and the handover success rate went up by 5%. Besides, there were huge improvements seen in the efficiency of beam management especially at the edges of cells and in rural areas where coverage is poor.What the results have shown is that mechanisms resembling NWDAF can still perform and provide instantaneous network optimization even in case of the absence of a fully 5G stand-alone core. The framework not only connects today's NSA deployments with the upcoming 5G intelligent networks but also provides a scalable way to enhance mobility management, resource allocation, and user experience.

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