

Bridging the technology divide for mobile traffic management & improving network performance

Vikas Gupta *

Pushpendra Kumar Rajput †

*Department of Computer Science and Engineering
Sharda School of Computing Science & Engineering
Sharda University
Greater Noida 201310
Uttar Pradesh
India*

Manoj Kumar §

*Department of Engineering and Information Science
School of Computer Science
University of Wollongong
Dubai 20183
United Arab Emirates*

Abstract

While fourth generation (4G) network is taking shape in all existing mobile networks & alongside on a worldwide scale the fifth generation (5G) network is expanding quickly. The rapid development of the Internet of Things (IoT) and innovations in technological advancements have culminated in production of an enormous amount of data. The degree of quality of service (QoS) of vertical sectors is significantly affected by network coverage and scalability. One of the most important and vital measures when evaluating a network's performance is its capacity and coverage capability. However, the precision of the current techniques and systems' monitoring important indicators of performance and results is inadequate for rapid results. To enable it to more properly rebuild the current state of 4G and 5G systems, parametric optimization, in this investigation, we build an analysis approach & parametric study of optimization and enhancement of mobile network key performance indicators and service parameters, evaluating them and implement an integrated analysis strategy. Those action results indicate the impact of correcting various parameters yielding the network element throughputs to their optimum capabilities, capacity & excellent

* E-mail: vikasismailed@gmail.com (Corresponding Author)

† E-mail: pushpendrarajputs@gmail.com

§ E-mail: wssmanojkumar@gmail.com

performance results of service indicators. In conjunction with this, we present a meaningful evaluation of the industrial network, which confirms the viability of the methods adopted for network optimization & helping effectively through detecting hidden bottlenecks of network element capacity & weak user perception, boosting the 5G experience for users along with providing additional suggestions for future 5G building. The approach recommended is widely feasible and can be applied to multi-frequency, multi-operator, or even further generation in technological advancement in sixth-generation (6G) networks.

Traditional Network planning and parameters optimization methods are no longer an option to take mobile networks to their highest performance levels. In the past, desktop-based planning with disconnected tools and maps might have been sufficient. For 5G networks, it is no longer a viable option because of the increased complexity - for example, there are countless traffic volume transactions, Network Traffic congestion & controls, end to end effective quality of service, possible beamforming patterns, propagation-sensitive mm Wave radios and frequent software updates. In order to alleviate traffic congestion, traffic management & optimizing control systems are an important tool. These systems strive to boost the efficiency of mobile network to optimize traffic flow on individual network interfaces. The process takes significant CORE, IPTX & RF wisdom and robust analytics, to reach optimal network performance right from the beginning for geographical analysis.

Finally, in this study, through KPI (Key performance indicator) correlation, parametric analysis & traffic management of different interfaces, the mobile operator can test and verify the impact and optimize the network capabilities and quality before deployment of services either in hardware or software form. It also supports to enhance network & user perception both & also helps in driving & improving Operational expenditures & Capital expenses & savings.

Subject Classification (2020): 60K30, 68T05, 60K20.

Keywords: Traffic volume, Load balancing, Resource block, eNB (enodeB), Mobile network capacity, IPTX (Internet protocol & transport networks), LTE (Long term evaluation) & 5G (fifth-generation networks), KPI (Key performance indicators) and resource management, Spectrum usage, Self-optimization.

I. Introduction

The fifth generation, or 5G, is an essential component of addressing user demands for quality of service (QoS) in considering the continual rise in data volumes and the number of devices on wireless networks [3, 6]. Since capacity and coverage quality face a significant effect on system performance and user experience, overall network experience with most effective network quality remains an unavoidable problem, regardless of capacity dimensioning and data rates have been main topic with network mobility key performance indicators, network outage parameters, network voice and data growth, and service indicators. Many research efforts have looked into measurements of capacity and coverage data, offering

assessments in many different kinds of categories, covering business applications, mobility, geography, security, radio access networks, transforming packet core, and transport networks [2]. Yet the studies are not very important for further study if an exact assessment of the real situation is not feasible while correlating all telecom domain in one go like core, Ran & IP Tx network. As a result, it is needed to detect and quantify the impacts of the tangible LTE and 5G network scenario by parametric methods. It is essential to do collaboration analyses through 4G and 5G for all the domains [8, 10].

In Both 4G & 5G technology for network planning and optimization helps maximize the usage of existing assets and reduce the operational expenses. Commitment in sustainability Maximizing the utilization of existing assets and improved spectral efficiency mean that operators can avoid unnecessary investments in new assets. This helps improve the sustainability of network technologies. As 5G adoption expands, network complexity rises, demanding innovative approaches for sustaining subscribers' satisfaction and accessibility thus to make a significant impact on business outcome, an equally important step is actively driving the entire lifecycle of Core, Radio, IP, Transport network [1, 15].

II. Related Work

Optimization of network service indicator has been a main focus area for LTE and 5G technology working together in most of commercially deployed network across the globe and has been a study & analysis area for many research papers. Huge number of IoT applications & enhanced mobile broadband usage & different use cases, Designing and enhancing the transmission is highly challenging when handling enormous data quantities along with Core & Radio network optimization mechanisms that provide transmission of data with superior scalability and minimal latency. In the present research, an examination of different sets of parameters together with all telecom domain using network performance management tool and its optimization business logic & structure for alleviating such problems whenever occurs during the data transaction involving all major network elements and nodes of different domain of mobile technology that are notices in large scale IoT & data transfer mechanisms not only data but also for voice network. The results shown in the study are based upon the test & execution done in one of the commercially deployed Network [5, 6, 7].

Wireless technology has evolved considerably in the span of few decades. The desire for high bandwidth across consumers has increased further by the newest generation of high-end mobile devices. With increment in device subscriber and network elements, existing network communication methods involve network changes & their handling, delaying the decisions, expensive, and leads to errors. As a result, self-organizing capabilities for network management with minimal human oversight are implemented. Higher end-user Quality of Service (QoS) and lower operating and maintenance costs for telecom service providers will be potential outcomes. A variety of capabilities for self-sufficient cellular network configuration, optimization, and maintenance are included in self-organized cellular networks [11, 12, 15].

One of the primary application scenarios for long-term evolution (LTE) and 5G is network quality, coverage, and capacity optimization with the goal to support high-data-rate solutions, maximize coverage and capacity performance, and minimize operator capital and service expenditures. The coverage and capacity performance of an LTE system is restricted by a variety of settings, namely load, traffic type, user distribution, uplink power setting, inter-cell interference, etc. From a single cell's context, it always attempts at enhancing coverage and capacity by distributing intra-cell resources and optimizing the uplink power setting, although this could lead to adjacent cells functioning worse. As a result, each cell's advantages clash with one another. This paper aids by tracking the effects of all these characteristics and traffic management in order to reconcile all the benefits of every cell and boost the network's overall efficiency. Finally, the outcome indicates that the analysis & method used are helping in boosting performance of network quality, coverage, and capacity in LTE & 5G network from end-user point of view. with attentive focus on techniques that are suitable for self-optimization feature in future cellular networks advancement [13, 16].

A comprehensive study of existing related papers, their analysis study and modalities which are based on categorization of telecom network have been included in this thorough study. Detail previous research efforts focused on specific domain and nit correlating the work & impact in different domain of mobile network interfaces on optimizing radio frequency parameters or transmission parameters in wireless communication systems, therefore their different adopted approaches, techniques, and key findings and the identified gaps are outlined [6, 14, 17, 20].

The existing methods are driven through different kind of categories as below.

- o **Signal level optimization:** Techniques like power control, cell load balancing, and transmitting power adjustments to improve signal quality in different coverage areas [15].
- o **Physical & logical network optimization:** Studies on antenna array configurations, beamforming, and optimal antenna placement for maximizing signal strength and coverage. Studies on how radio waves propagate in different environments to inform RF optimization strategies [5, 14].
- o **Channel modeling:** Research on channel characterization to enable better RF optimization algorithms [6].

III. Literature Review & Gap Analysis

A comprehensive literature review with a strict selection criterion guarantees that only relevant papers which are based on categorization of telecom network domain capacity monitoring and Management have been included in this thorough study. The analysis of different domain and their modalities is included.

A. Search Terms Used Credible and reliable databases like PubMed, IEEE, Embase, Scopus, ResearchGate and the Web of Science have been used. Keywords for the research used are “Data science & analysis method of network parameters”, “Mobile Network capacity,” “RAN Capacity,” “Capacity Analysis parameters,” “Prediction analysis” and “Mobile diagnostic,” among others [4, 9, 13].

B. Parametric role in Telcom network for Data analysis & Customer experience, this study also compares the state-of-the-art models & studies done so far with the methods used, their evaluation & gaps in Tables 1 and 2 and Figures 1-6.

IV. System Model & Approach

A. Data Analysis & Acquisition Module:

- i. **Data counter statistical extraction & preprocessing:** This technique involves pre-processing of existing counter measurement of respective object identify to fetch & collect through their mapped operator defined key performance indicators regarding the selected domain, their associated Counter & feature/parameter selection,

Table 1
Presenting the outcome of existing available studies & their Identified Gaps [8], [9], [10]

Reference	Methodology	Accuracy/Outcomes	Gaps
[8]	Pattern identification on data sets through Multivariate deep learning & historical Time series Traffic statistics of eNodeB.	1. Radio parameter estimation based on PRB utilization. (70% sample >= 80%) 2. Identifying QoS (Quality of Service) breakdown point using traffic & PRB trend (PRB utilization>80%, Throughput & QoS is ~0	1. Resource Allocation is not dynamic. Estimating traffic peaks in a particular geographic area during social occasions or eNodeBs 2. Study limited to two parameters (Network traffic & Physical resource block (PRB) utilization) only, lack of correlation with other network responsible parameters. 3. No Optimization efforts (i.e., traffic shifting to neighbor cell) 4. Only study of resource planning, no strategy of radio resource redeployment for capex optimization. 5. Only capable to forecast next two-month traffic & utilization ,that too for only selected & particular eNodeBs. 6. Need more time and processing capability to estimate traffic for a lot many eNodeBS sets up or gatherings of public.
[9]	1. Analysis of transmission power control and trends 2. Packet losses	1.Resource selection during high channel load in the network. 2. Minimize interference and packet/resource clashes by utilizing the established S-SPS and E-ERRA resource allocation procedures	1. leakage in high number of packets drops, thereby impacting latency /QoS performance at the application layer. 2. Algorithm slowness during resource selection to lower the channel Busy ratio and synchronization gap with packet drop approach when the channel load increases considerably, thereby adverse impact on channel efficiency. 3. Only working on the power control parameters, lack of radio & core parameters

Contd...

[10]	1. Radio Resource Management (RRM) Method & Radio access network (RAN) resource allocation 2. Frequency allocation & distribution of service procedures in small cells & metro cells	1. 5G network efficiency metric quantification by the implementation of a service level quality indicator based on QoE. 2. user sessions based QoE weighting & radio resource scheduling technique for setting the throughput to deliver a customized superior experience. (Improvement in radio resources by 25%)	1. Dependancies on special parametric configuration- Using assistance of this application, services at a particular rate can be acquired having an individual QoE level. 2. scopes for improvement in RRM method AI technology to ensure QoE
------	--	--	--

extraction & mapping of relevant network key performance indicator from inventory data and Performance database [6, 7, 16].

- ii. **Performance and Optimization Logic:** The system tries to make intelligent, efficient, and cost effective and can be used to all telecom operators, Original Equipment Manufacturer (OEM) & ease of deployment The scalability of our approach by extending it to multi-technology and multi-vendor networks. Network Performance Management tool offers viewers the ability to retrieve essentially real-time information about the network's overall efficiency and health. Either directly from network devices or via environment monitoring systems (EMS), it receives raw data. Featuring user defined KPIs and thresholds as well as a business intelligence structure for dashboards and reporting capabilities, it is remarkably agile. it uses & runs on the operating platform to modernize any network and have operations be driven by software and data using state of the art technology, automation and operational processes used. it has the capability to correlate the inter domain counter measurement file and use all pre-defined object and counter to select and map with available repository of statistical correlations [18, 20].

B. Parameter dimensioning & Optimization scope.

In LTE network capacity & coverage optimization along with "IP & Transport" refers to the management and optimization of the underlying IP network that carries LTE data traffic, ensuring sufficient bandwidth and efficient routing to maximize user throughput and network performance, essentially focusing on the transport layer that connects the radio access network (RAN) to the core network, ensuring smooth data flow between users and the internet [6, 9, 11].

Key aspects of optimization:

- **Network Dimensioning & Traffic engineering:** Accurately calculating the required bandwidth on the transport, RAN & core network based on user traffic patterns and cell load to prevent bottlenecks and ensure adequate capacity. Implementing routing protocols and load balancing mechanisms to distribute traffic evenly across the network, preventing congestion in specific areas [12, 19, 21].
- **Traffic prioritization & Link aggregation:** Designing a dedicated IP network specifically for mobile data, which can dynamically adjust

to changing traffic demands and optimize routing and Utilizing Ethernet technology as the primary transport medium for efficient data transfer, often with features like Quality of Service (QoS) to prioritize critical traffic and combining multiple physical links to achieve higher bandwidth and redundancy [14, 19, 22].

Table 2
Description & Illustration of the Couter study and their operating limits in the different network domains [12]

Domain	Element	Factor	Designed capacity	Limit
Enterprise	routers	Bandwidth	70	<70
Enterprise	TOR/Edge-Sw	CPU utilization	70	<70
Transport	route	link per interface	65	<60
IP	route	Interface agent	65	<60
Core	ASBC	Sessions and Subs	1 Mn sessions & Subscribers per VNF	CPU<70%
Core	CSCF	CPS, No. of registered subs	200 CPS per VNF, 1.5 M Subs per VNF	CPS < 75%
				Subs < 80%

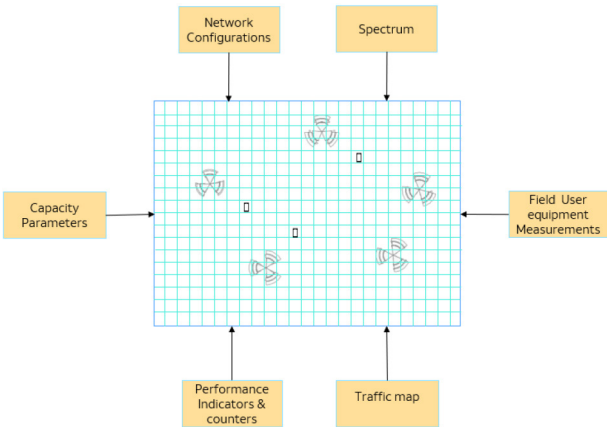


Figure 1
Focuses on Network Parameter Flow based on 4G/5G Radio access type [1, 6]

V. Testing & Results

I. **Call attempts & data usage per element:** after redeployment of resource elements and server dimensioning, the call attempts overflow problem eliminated and there was improvement in call attempts per node from 2.34K to 2.49 K and 1.41K to 1.50K respectively.

With these corrections, there was enhancement observed in data usage per element as well, it grew from 0.63 Gigabyte to 1.19 Gigabyte per node.

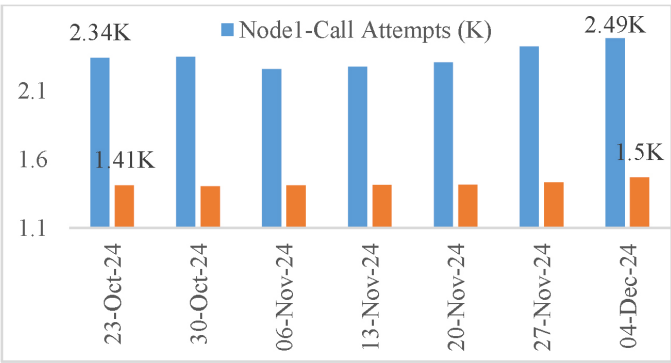


Figure 2

Statistical view of Daily network wide Node call attempts

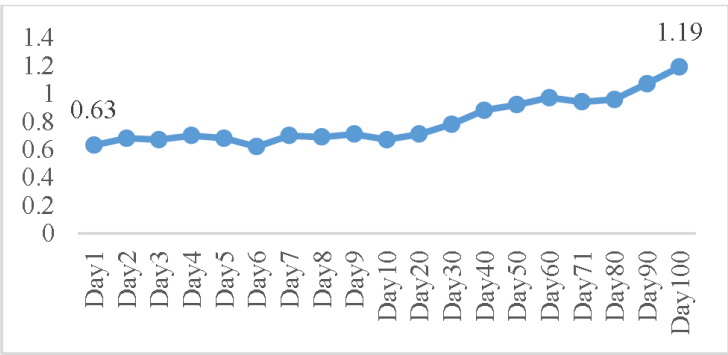


Figure 3

Day wise distribution of network Data volume usage per element (Gigabyte)

II. **Query response & session success rate:** Interface wise session requests were analysed and the congested path where resiliency limit >80% were targeted to defined with override situation, this has helped in enhancing query response and evolved packet core session success rate from 99.78% to 99.90%.

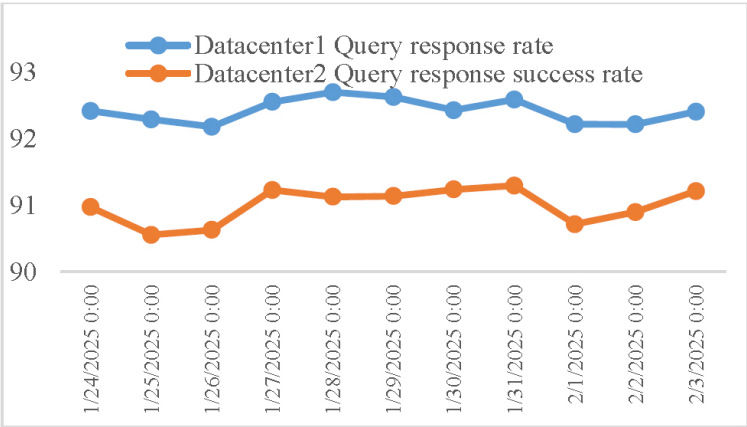


Figure 4
Datacenter Query response success rate (%) & overall response rate (%) daily trend

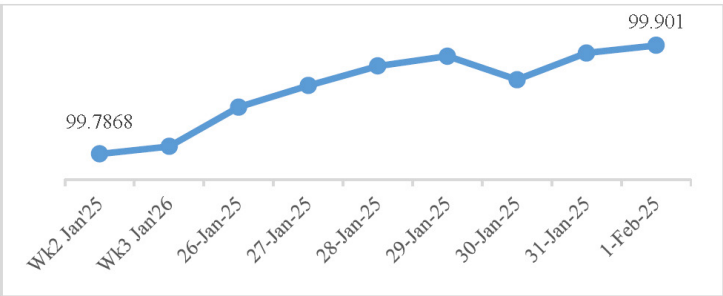


Figure 5
Network wide EPC Session success rate (%) in network on daily basis

III. **Traffic calls distribution:** traffic class type re-engineering was done through augmenting the capacity & migrating the subscriber within node has helped in achieving the traffic distribution.

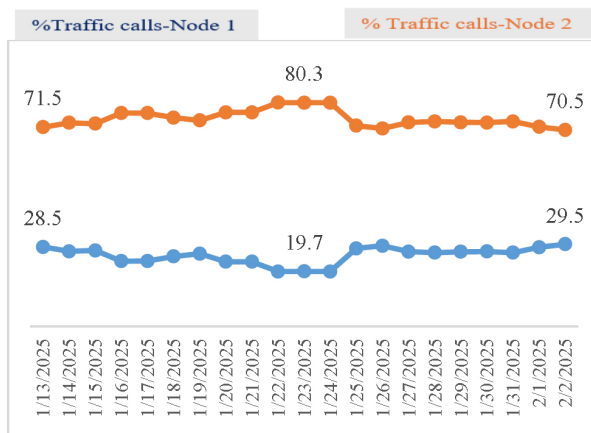


Figure 6

Daily distribution of network wide Traffic call pattern (%)

VI. Conclusion & Future Scope

Test simulated results implemented in commercial deployed network are indicative enough to show the improved & optimized network performance & technology assessment, but highly recommendable as able and applicable, it can be developed as a crucial facilitator for the majority of use cases utilizing AI-based automation, covering parameter anomaly finder, identifying capacity & interface level congestion gaps. Moreover, Network configuration can be governed for supporting enhanced mobile broadband & ultra-reliable latency improvement & many IoT use cases.

It is essential to extend this innovative trend to deployments. & inclusion of many unexplored parameters in the area of enterprise business, security & cloud platforms for 5G and beyond, with more scalable use case for Data anomaly detection & prevention for enhancing performance & resource balancing through fully automated process. These are exciting avenues for further investigation to build on current effort.

References

- [1] H. Elsherbiny, H. Abbas, H. Abou-Zeid, H. Hassanein, and A. Nouredin, "4G LTE network throughput modelling and prediction," in *Proc. IEEE GLOBECOM*, pp. 1-6 (2020), doi: 10.1109/GLOBECOM42002.2020.9322410.

- [2] N. Bui, M. Cesana, S. A. Hosseini, Q. Liao, I. Malanchini, and J. Widmer, "A survey of anticipatory mobile networking: Context-based classification, prediction methodologies, and optimization techniques," *IEEE Commun. Surveys Tuts.*, vol. 19, no. 3, pp. 1790–1821 (2017), doi: 10.1109/COMST.2017.2694140.
- [3] V. Gupta, A. K. Chakraverti, and M. Kumar, "Challenges in mobile network capacity monitoring & solutions to improve capacity problems using various parameters," in *Proc. 4th Int. Conf. Technological Advancements in Computational Sciences (ICTACS)* (2024), doi: 10.1109/ICTACS62700.2024.10841185.
- [4] B. Bangerter, S. Talwar, R. Arefi, and K. Stewart, "Networks and devices for the 5G era," *IEEE Commun. Mag.*, vol. 52, no. 2, pp. 90–96 (2014), doi: 10.1109/MCOM.2014.6736748.
- [5] U. Siddique, H. Tabassum, and E. Hossain, "Spectrum allocation for wireless backhauling of 5G small cells," in *Proc. IEEE Int. Conf. Commun. (ICC)*, pp. 122–127 (2016) doi: 10.1109/ICCW.2016.7503775.
- [6] S. Park, M. Agiwal, H. Kwon, and H. Jin, "An evaluation methodology for spectrum usage in LTE-A networks: Traffic volume and resource utilization perspective," *IEEE Access*, vol. 7, pp. 67863–67873 (2019), doi: 10.1109/ACCESS.2019.2918646.
- [7] S. T. Nabi, M. R. Islam, M. G. R. Alam, M. M. Hassan, S. A. AlQahtani, G. Aloï, and G. Fortino, "Deep learning based fusion model for multivariate LTE traffic forecasting and optimized radio parameter estimation," *IEEE Access*, vol. 11, pp. 14533–14549 (2023), doi: 10.1109/ACCESS.2023.3242861.
- [8] S. Sabeeh and K. Wesołowski, "Congestion control in autonomous resource selection of Cellular-V2X," *IEEE Access*, vol. 11, pp. 7450–7460 (2023), doi: 10.1109/ACCESS.2023.3238466.
- [9] M. Beshley, N. Kryvinska, and H. Beshley, "Energy-efficient QoE-driven radio resource management method for 5G and beyond networks," *IEEE Access*, vol. 10, pp. 131691–131710 (2022), doi: 10.1109/ACCESS.2022.3228758.
- [10] Nokia, *India Mobile Broadband Index (MBiT) 2023*, 10th ed. (2023).
- [11] Y. Azimi, S. Yousefi, H. Kalbkhani, and T. Kunz, "Applications of machine learning in resource management for RAN-slicing in 5G and beyond networks: A survey," *IEEE Access*, vol. 10, pp. 106581–106612 (2022), doi: 10.1109/ACCESS.2022.3210254.
- [12] Rakuten Mobile, Inc., "Company Overview" (2025). [Online]. Available: <https://corp.mobile.rakuten.co.jp/english/about/overview/>

- [13] A. Mahmood, M. L. Mat Kiah, M. R. Z'aba, A. N. Qureshi, M. S. S. Kassim, Z. H. A. Hasan, J. Kakarla, I. S. Amiri, and S. R. Azzuhri, "Capacity and frequency optimization of wireless backhaul network using traffic forecasting," *IEEE Access*, vol. 8, pp. 23264–23276 (2020), doi: 10.1109/ACCESS.2020.2970224.
- [14] X. Li, R. Ni, J. Chen, Y. Lyu, Z. Rong, and R. Du, "End-to-end network slicing in radio access network, transport network and core network domains," *IEEE Access*, vol. 8, pp. 29525–29537 (2020), doi: 10.1109/ACCESS.2020.2972105.
- [15] Ericsson, "Network performance" (2023). [Online]. Available: <https://www.ericsson.com/en/ran/network-performance>
- [16] N. Zarin and A. Agarwal, "Hybrid radio resource management for time-varying 5G heterogeneous wireless access network," *IEEE Trans. Cogn. Commun. Netw.* (2021), doi: 10.1109/TCCN.2021.3063132.
- [17] A. Mostafa, M. A. Elattar, and T. Ismail, "Downlink throughput prediction in LTE cellular networks using time series forecasting," in *Proc. 2022 Int. Conf. Broadband Commun. Next Generation Networks Multimedia Appl. (CoBCom)*, pp. 1–4 (2022), doi: 10.1109/CoBCom55489.2022.9880654.
- [18] G. O. Ferreira, C. Ravazzi, F. Dabbene, G. C. Calafiore, and M. Fiore, "Forecasting network traffic: A survey and tutorial with open-source comparative evaluation," *IEEE Access*, vol. 11, pp. 6018–6044 (2023), doi: 10.1109/ACCESS.2023.3236261.
- [19] C. Zhang, P. Patras, and H. Haddadi, "Deep learning in mobile and wireless networking: A survey," *IEEE Commun. Surveys Tuts.*, vol. 21, no. 3, pp. 2224–2287 (2019), doi: 10.1109/COMST.2019.2904897.
- [20] F. W. Alsaade and M. H. Al-Adhaileh, "Cellular traffic prediction based on an intelligent model," *Mobile Inf. Syst.*, vol. 2021, pp. 1–15 (2021), doi: 10.1155/2021/6050627.
- [21] A. P. Singh and M. Singh, "Real time malware detection in encrypted network traffic using machine learning with time based features," *J. Discrete Math. Sci. Cryptogr.*, vol. 26, no. 3, pp. 841–850 (2023), doi: 10.47974/JDMSC-1760.
- [22] R. Yadav and R. Singh, "A multi objective optimization in wireless sensor network using enhanced NSGA-3 algorithm," *J. Discrete Math. Sci. Cryptogr.*, vol. 26, no. 7, pp. 1925–1937 (2023), doi: 10.47974/JD-MSC-1727.

Received December, 2025