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Big Data Network Optimization for Mobile Cellular Networks in 5G

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Abstract: 5G ensures the provision of intelligent network and application services by means of connectivity to remote sensors, massive amounts of Internet of Things data, and fast data transmissions. Through the utilization of distributed compute architectures and by supporting massive connectivity across diverse devices like sensors, gateways, and controllers, 5G brings about a transformative revolution in the conversion of both big data at rest and data in motion into real-time intelligence. Big Data Analytics play an important role in the evolution of 5G standards, enabling intelligence across networks, applications, and businesses. Administrators of mobile organizations have access to a plethora of opportunities to enhance service quality through big data. Network optimization serves as a crucial method to achieve this task, with network prediction forming the foundation for such optimization. Ensuring network stability and security is essential for 5G mobile communication, considering its significance as an important tool in national life. Therefore, this work focuses on presenting big data network optimization for mobile cellular networks within the context of 5G. In order to improve the Quality of Experience (QoE) for users, this work explores various methods for integrating network optimization and Big Data analytics. The performance of the presented model is evaluated in terms of QoE, Throughput, handover rate, mobility, reliability, and network slicing.

Keywords- Fifth Generation (5G), network optimization, security and Big data Analytics.

I. INTRODUCTION

The advancement of big data is very rapid. Similar to the rapidly expanding and highly influential Internet, this is a new technological revolution that affects all industries of society. In both industry and academia, big data enjoys an extensive variety of acclimation. Because of the massiveness and complexity of its data sets, conventional data processing techniques and management tools cannot handle them. The attributes commonly referred to as the The "5Vs" - variety, velocity, volume, integrity, and value are commonly used to describe big data [7]. Currently, social networking platforms, scientific research, and the Internet of Things (IoT) are the primary sources contributing to the rapid generation of information.

There have been many advances in information and communication technologies recently that have been transforming the world; the world is increasingly becoming a small neighborhood. Cloud computing, wireless communications (including 3G, 4G, and 5G), and the competitive mobile device industry are counted among these technologies [4]. Our way of life can be made easier by the different services offered by mobile devices. The 5G mobile communication network is an essential piece of infrastructure for realizing the interconnection of everything and building a networked society. High levels of network automation are envisaged to be incorporated into the evolution of mobile communications beyond 5G networks [2].

Big data analysis is becoming an essential component of both wireless communication and effective network management, as a result of the rapid growth of big data in wireless networks. Implementing big data applications, especially those operating in near real-time, irrespective of the underlying networking support, presents significant challenges due to their substantial complexity and volume. Applications of big data, such as network, communication, and electric power, have grown in importance with the rapid development of information technology [3].

Telework, e-learning, online gaming, IPTV (Internet Protocol Television), and streaming, all of which were once considered exceptional and have also become common, The amount of data generated is increasing exponentially every minute, and the bandwidth is becoming more and more saturated. Despite their rise to the highest point among the richest companies as far as information volume is concerned, telecom operators became incapable of effectively capitalizing. They need to figure out how to use this data to cut down on operating costs, give customers a personalized experience, reduce customer churn, and find new ways to make money [6].

Big data analytics offers capabilities beyond, what traditional data analytics can provide. By leveraging big data analytics, operators can optimize revenue generation and improve the performance of mobile cellular networks. This approach enables the collection of diverse data sources, allowing for a comprehensive understanding of user behavior and preferences from various angles [5]. The masses of unstructured data that make up big data require real-time analysis as well. Many useful and in-depth pieces of information can be obtained from these datasets with effective organization and management, which leads to finding solutions for various unsolved issues. In order to obtain interesting and informative information from big data in mobile networks, extensive analysis is required [8].

Big data based portable organization enhancement has received intensive efforts from researchers all around the world due to the new progressions in information examination. Before making decisions based on accurate information, MNOs (Mobile Network Operators) can benefit from deep insights into their networks provided by big data analytical techniques [9].

In mobile networks, comprehensive analysis of big data is imperative to extract valuable and informative data. It empowers knowledge's ongoing dynamic in many applications and furnishes MNOs with extraordinary chances to grasp portable clients' ways of behaving and prerequisites. In mobile networks, comprehensive analysis of big data is imperative to extract valuable and informative data [10].

With the fast improvement of various portable cell organizations, the volume of signaling data grows massively, and the traditional signaling monitoring frameworks have such an enormous number of issues to deal with. In view of the issues with traditional network prediction techniques, which lack user data [1]. Big data network Optimization for mobile cellular networks in 5G is presented as a solution to these issues. The leftover work is organized as below: The literature survey is described in Section II. Big data network optimization for mobile cellular networks in 5G is covered in Section III, and the analysis of the results is covered in Section IV. In section V, the conclusion is presented.

II. LITERATURE SURVEY

Christos Verikoukis and Hatim Chergui et. al., [11] describe Big data for 5G Intelligent Network Slicing Management. Before focusing on their association with ideas of organization slicing and the fundamental compromises, the examination returns to the engineering of this innovation, which incorporates information assortment, capacity, handling, and examination. It then proposes a complete framework for implementing big-data-driven dynamic slicing resource provisioning while respecting SLAs. Examples include resource allocation models, constrained deep learning-based SLA (Service Level Agreement) enforcement, and traffic predictors for low-complexity slices.

Lexi Xu; Xin He, Yong Zhang, Xinzhou Cheng, Jian Guan; Chuntao Song, Kun Chao, et. al., [12] provide a description of An innovative architecture for the analysis of big data is introduced specifically for telecommunications operators. This novel architecture leverages the power of big data to assist telecom operators in their analytical processes. The proposed engineering gathers activity emotionally supportive network information and business emotionally supportive network information from telecom operators. The design makes a picture of every client utilizing this information. The client's direction is then analyzed. Moreover, the service behavior analysis is incorporated into the proposed architecture. At last, the authors applied the proposed enormous information assisted analysis design to the local telecom administrator.

OlegBondarenko, Dmytro Ageyev, Othman Mohammed,et.al., [14] describe the 5G Network Planning Optimization Model. The MILP (Mixed Linear Integer Programming) task-based network planning and optimization model for fifth-generation wireless technologies is the subject of this paper. The model can be used as a mechanism for designing networks, making it possible to create structures for mobile wireless technologies. The primary objective of the proposed model is to maximize operator profits.

Shuangfeng Han Qi Sun, Chih-Lin I, Gang Li, and Sen Wang et. al., [17] describe the design of the analysis and demonstrate the potential of big data analytics in enabling a flexible organizational design that efficiently manages resource orchestration, content distribution, and radio access network optimization for 5G and upcoming mobile networks. The optimization of processing at each layer and the configuration of the protocol stack at every access point are illustrated. The discussion includes important design aspects of the physical layer, such as frame structure and reference signals. Furthermore, utilizing signals in transform domains such as delay, Doppler, and angle can enhance the coherence time of the effective channel. It effectively closes the latency gap between real-time network optimization and big data cloud computing by making physical layer design much simpler.

Hai Thanh Nguyen, Kristoffer Jensen, Thanh Van Do & André Årnes et. al., [18] describe a big data analytics strategy for dealing with vulnerabilities in telecommunications. A technique for the discovery of SS7 (Signaling System No. 7) attacks utilizing big data analytics and machine learning is proposed. The paper explains the vulnerabilities of SS7 networks and how, the suggested methods can make SS7 security better. Also described in detail is a proof-of-concept SS7 protection system that uses big data and machine learning.

Kiran P, Jibukumar M G, Premkumar C V et. al., [19] this paragraph describes the optimization of resource allocation in LTE (Long Term Evaluation)-A/5G (Fifth Generation) networks using Big Data Analytics. In order to address the existing problem of optimally allocating radio resources to users, this analysis provides a method for the effective exploitation of this large volume of data. This work utilizes the map-reduce data processing approach to build upon the non-orthogonal binary Singular Value Decomposition (SVD) of binary data matrices for fuzzy pattern recognition and grouping. Patterns identified by the proposed method can be efficiently interpreted for resource allocation in wireless networks. The whole framework works in three different stages and identifies the best set of resources for a user based on various KPIs (Key Performance Indicators) and user related parameters, using the proposed algorithm.

III. BIG DATA NETWORK OPTIMIZATION

In this section, Big data network optimization for mobile cellular networks in 5G is presented. The presented approach's workflow diagram is shown in Figure 1. The network optimization framework consists of four main components: I) Big Data collection; ii) Storage management; iii) data analytics, and iv) network optimization. Big Data can be gathered from various sources, including User Equipments (UEs), Radio Access Network (RAN), Core Network (CN), and Internet Service Providers (ISPs). Events from UEs can be collected through user applications or control signaling. At the RAN evolved NodeB (eNB), cell-level data such as exchanged signaling over the air and instantaneous measurement reports are gathered. The Radio Access Network (RAN) is a crucial element within wireless telecommunications systems, establishing a wireless connection that links individual devices to other network components. A radio access technology is used in a mobile telecommunications system, which includes the RAN. Conceptually, it resides between a device to its core network by residing between a computer, mobile phone, or other remotely controlled machine.Data are heterogeneous, real-time, multi-source, and voluminous after they have been collected and stored.

Users' data and network operators' data are the two main categories of data.

Mobile Network Operators (MNOs) can leverage comprehensive analysis of both user data and operator data, to gain valuable insights for network optimization purposes. By breaking down this information, MNOs can perform network planning, spectrum allocation, resource management, and so on. User data: The data collected from User Equipments (UEs) offers valuable insights into users' profiles and behaviours. This data provides information about users' locations, mobility patterns, and communication preferences. With the proliferation of mobile networks and the increasing number of smart mobile devices, applications installed on users' devices generate a significant volume of data. These ap plication-level data serve as one of the primary sources of mobile Big Data.

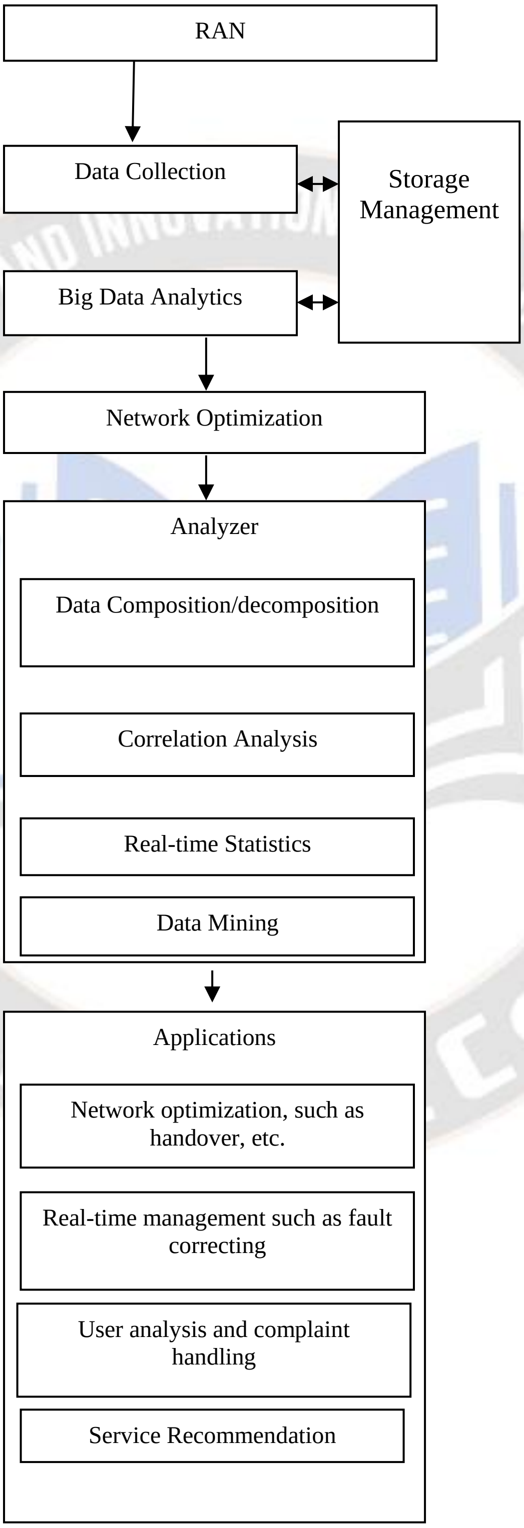

Fig No1: Big data network optimization for mobile cellular networks in 5G is presented. The presented approach's workflow diagram

Operator information: Operators gather data primarily from their Core Network (CN) and Radio Access Network (RAN). The CN contains bearer/service data, including network performance metrics, call success rates, and application usage indexes. The RAN encompasses a huge amount of data, such as cell information (e.g., eNB configuration, resource status, interference), signaling messages exchanged between eNB and UE (e.g., RRC messages for connection establishment and handover), and radio signal measurements. This operator data, combined with user data, enables MNOs to gain comprehensive insights for network optimization purposes.

During the process of data collection, various signaling protocols are replicated from multiple network interfaces without causing any disruptions to regular operations. After that, the protocol processor collects and filters these copies before sending them to the analyzer. Decomposition, correlation analysis, and other algorithms are used to process the data in the analyzer. The types of data sources include mobility, data rate, and packet drop, among others. Over time, various base stations host this data. In order to obtain big data analytics, they must be combined across space and time. Correlation analysis, as a statistical technique, is utilized to evaluate the magnitude of the linear relationship between two variables and determine their association.

Data mining involves the examination of large datasets to discover patterns and relationships that can be sorted by data analysis to tackle business obstacles. By employing data mining techniques and tools, organizations can predict future trends and make informed business decisions. Finally, different applications can make use of the analysis's findings. The methods, tools, and technologies that enable us to maintain, maximize, and enhance performance across all network domains comprise network optimization. When multiple proxies communicate with one another to establish dependable point-to-point connections, network optimization can become distributed and hierarchical.

The transfer of an ongoing call or data session from one channel (the base station) connected to the core network to another channel, without interrupting the session, is referred to as handover or handoff in cellular telecommunications. Effective network resource management is crucial for cellular operators to balance network load and optimize network utilization. An essential aspect of network management is the observation and analysis of traffic, which enables performance analysis, failure detection, security management, and other important functions.

Customer complaints are tracked, categorized, and dealt with using complaint handling. Service recommendation is a method of proactive service discovery that suggests services to users based on their preferences. Large-scale Information examination empowers MNOs (Mobile Network Operators) to oversee networks and offer types of assistance to clients in a systematic way. Over a period of time, continuous monitoring and analysis can be conducted on both the application and service status in each region and the network measurements. The BDN (Big Data Network) optimization functions utilize Big Data analysis to identify issues and determine the appropriate level for optimization, such as the user, cell, or service. The optimization results are then implemented by the control functions in the RAN to bring about improvements. Furthermore, user-level optimization is achievable, especially for users closely located within the same cell, with optimization tailored to their specific service class. Additionally, the BDN optimization functions have the capability to anticipate traffic fluctuations both locally and across the network coverage, thereby enhancing user and network performance.

Because it is in charge of tracking, registering, managing, and authorizing network connections as well as access to subscribed services as devices move between base stations, mobility management is an essential component of any network. Utilizing network analytics, radio resource allocation optimization can be achieved in a BDN system. In order to accommodate natural and traffic fluctuations, resource allocation can be adapted based on data obtained from information analysis. At the MeNB (Master e-nodeb), certain BDN optimization functions can be deployed to collect and analyze real-time raw big data originating from eNBs (evolved node b), including service characteristics and traffic features. This enables service and optimization of performance for each cell and user. This can be achieved by periodically processing raw data to obtain measurements and proactively detect traffic variations and faults. Additionally, this strategy offers users service recommendations based on their preferences.

IV. RESULT ANALYSIS

This section demonstrates Big data network optimization result analysis for mobile cellular networks in 5G. Handover rate, throughput, mobility, reliability, and network slicing are used to assess the effectiveness of the presented approach. In the process of setting up mobile-cellular networks, the handover rate is one of the primary concerns. Network performance may cause as a result of an increased handover rate. In terms of extended interruption times and throughput deterioration, these factors directly affect communication quality. Throughput: The data rate, which measures, how quickly cellular networks can access the Internet, is the most important performance metric. The efficiency with which mobile networks use the spectrum affects the throughput.

Mobility: 5G is used to deliver wireless broadband. The number of people who are using smart phones increases the mobility of the system.

Reliability: A service requirement known as URLLC (Ultra-Reliable Low Latency Communications) is used to determine a 5G network's reliability. The length of time that infrastructure runs without interruption is the metric used to measure network reliability.

Network slicing: Full network functionality, including Radio Access Network (RAN) and central network functions, can be provided by a network slice.

Quality of Experience (QoE) is a measure of the overall level of consumer satisfaction with a seller.

The Fig. 2 shows the handovers comparison.

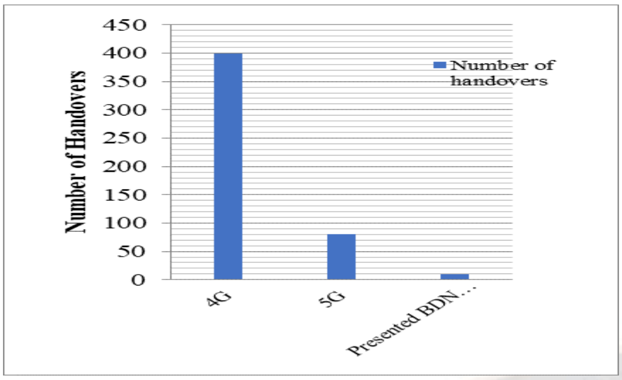

Fig. 2: Handover Rate Comparison

In figure 2, the x-axis shows the mobile cellular generations whereas y-axis represents number of handovers. Compared to 4G, 5G has very less handover rate. However presented BDN approach has significantly reduced the 5G handover rate to very less. The Fig. 3 shows the throughput comparison.

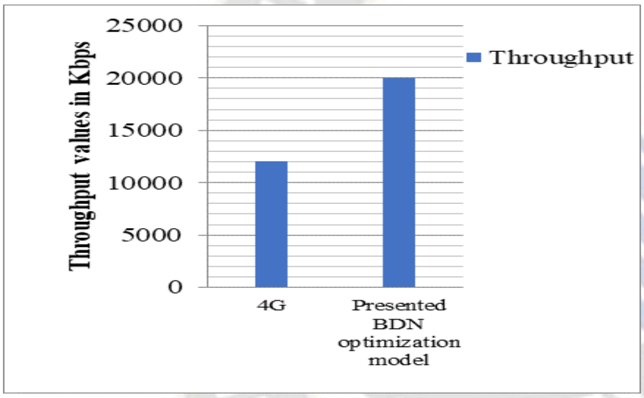

Fig. 3: Throughput Performance Comparison

In figure 3, the x-axis shows the mobile cellular generations whereas y-axis represents the Throughput in terms of Kbps (Kilo bytes per second). Presented BDN optimization has very high throughput. The table 1 shows the performance evaluation.

Table 1: Performance Analysis

Metrics/Methods	**5G network**	**Big data network optimization for mobile cellular networks in 5G**
Mobility (%)	90.12	95.63
Reliability (%)	88.45	96.12
Network slicing (%)	90.36	95.34

Compared to 5G network, presented Big data network optimization for mobile cellular networks in 5G has better results in terms of mobility, reliability and network slicing. The Fig. 4 shows the graphical representation of performance comparison where x-axis indicates different approaches and y-axis indicates performance values in terms of percentage.

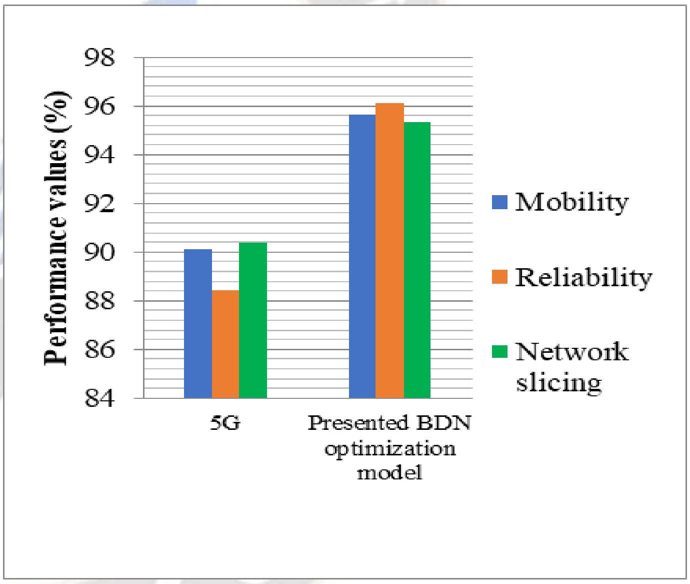

Fig. 4: Performance Comparison

Compared to 5G, presented Big data network optimization for mobile cellular networks in 5G has very good performance in terms of mobility, reliability and network slicing. Presented BDN optimization model has significantly improved the performance of 5G network. As a result, QoE is also improved which is shown in Fig. 5.

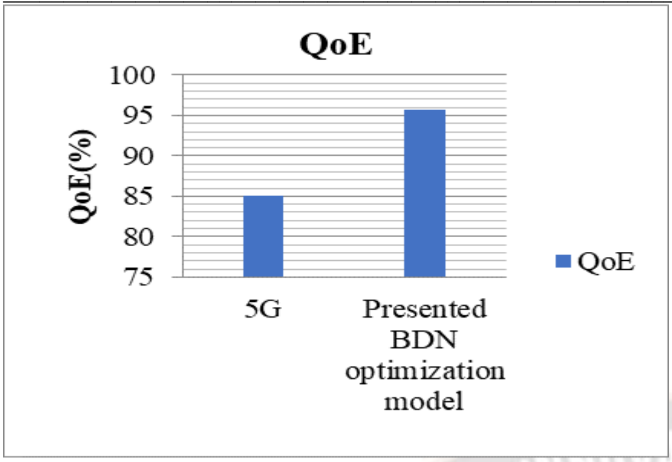

Fig. 5: QoE Comparison

In the context of mobile cellular networks, Big Data network optimization for 5G offers superior Quality of Experience (QoE) compared to 5G alone.

V. CONCLUSION

This work introduces the optimization of 5G mobile cellular networks through the utilization of big data. Mobile network operators have a plethora of opportunities to enhance service quality because of big data. This work investigates various approaches to integrating big data analysis with network enhancement, aiming to advance the objective of enhancing user quality of experience. The data collected is extensive, diverse, real-time, and sourced from multiple origins. The data can be broadly classified into two categories: users' data and network operators' data. The BDN optimization functions can analyze Big Data to identify issues and determine the appropriate level of optimization, such as the user, cell, or service. The evaluation of the presented model focuses on performance metrics such as handover rate, throughput, mobility, reliability, Quality of Experience (QoE), and Network slicing. Efficient data analytics is considered a crucial enabling technique in this Big network optimization, as it reduces deployment costs and enhances user QoE. Compared to previous technologies, the presented BDN optimization model exhibits superior performance and achieves enhanced QoE.

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