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5Galyzer: A Practical, OpenSource Android Implementation Of 5G Network Performance And Analytics

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Abstract: The evolution of 5G networks continues as numerous countries deploy infrastructure. However, there remains uncertainty regarding the security capabilities of 5G in handling critical tasks. This paper provides an overview of key components of 5G, such as its Service Based Architecture (SBA) and Network Functions (NFs), along with recent advancements in safety measures for User Equipment (UE) and Radio Access Network (RAN). Additionally, it discusses security protocols like the 5G AKA protocol and introduces the common API framework (CAPIF). Security concerns are acknowledged, referencing relevant studies, and potential research directions are suggested.

Index Terms **- 5G, Network Automation, Low Latency Communication, Artificial Intelligence in Networking.**

I. INTRODUCTION

The deployment of fifth-generation (5G) cellular networks is actively progressing in numerous countries, primarily in Non-Standalone (NSA) mode. This mode enables the gradual infusion of 5G capabilities into existing 4G networks, facilitating a smooth transition and optimal utilization of current infrastructure. 5G represents a substantial advancement in technological capabilities, promising a wide array of applications across various sectors. Its features, including Enhanced Mobile Broadband (eMBB), Ultra Reliable Low Latency Communications (URLLC), and Massive Machine Type Communications (mMTC), unlock unprecedented opportunities for diverse industries. These include enhanced connectivity for mobile devices, highly dependable and low-latency communications, and efficient communication with a vast number of devices. While 5G doesn't entail a complete redesign of the network architecture, it brings significant enhancements compared to previous generations. Notably, the 5G core network adopts a service-based architecture (SBA). This architectural approach offers considerable flexibility and scalability, catering to the evolving landscape of emerging functionalities and services. Crucially, this design enables the seamless integration of additional functions into the network without requiring a full overhaul of the existing architecture. The modular structure of the 5G core network, facilitated by the service-based architecture, allows for the integration of corresponding functions without disrupting the established network framework. This adaptability ensures swift accommodation of emerging functionalities and services, ultimately providing a more efficient and adaptable platform to meet the evolving needs of modern communication.

II. LITERATURE SURVEY

W S. Alraih, R. Nordin, A. Abu-Samah, I. Shayea, N. F. Abdullah [1] provides a comprehensive overview of the challenges and solutions pertaining to handover optimization in B5G networks. By addressing the unique requirements and specifications of B5G, researchers and practitioners can develop innovative HO optimization techniques to ensure seamless connectivity and enhanced user experience in the era of Beyond 5G mobile networks.

A. A. Bipon, A. Osman, M. S. Islam, A. T. Asyhari and R. Abozariba, [2] represents a significant advancement in the automation of coverage mapping for 4G/5G networks at street level. By addressing the challenges associated with existing measurement tools, Pathfinder provides a reliable and cost-effective solution for assessing network QoS in urban environments. Future work includes expanding the suite's functionality to support additional network technologies and incorporating feedback from users to further enhance its usability and performance.

R. Tan, Y. Shi, Y. Fan, W. Zhu and T. Wu, [3] identifies the energy-saving potential of the fifth generation (5G) Radio Access Network (RAN) and describes the main energy-saving principles and technologies. It explores the utilization of network energy-saving techniques inherited from 4G, such as carrier shutdown, channel shutdown, and symbol shutdown, in the context of 5G

networks. Additionally, enhanced technologies for 5G, like equipment deep sleep and symbol aggregation, are introduced. However, recognizing the need for innovative solutions, the article advocates for the integration of Artificial Intelligence (AI) and big data analysis to develop precise energy-saving strategies tailored to site-specific traffic and conditions. This approach aims to enhance efficiency and reduce manpower.

M. Ramachandran, T. Archana, V. Deepika, A. A. Kumar and K. M. Sivalingam [4] represents the pivotal role of machine learning-based analytics in augmenting 5G network management systems. By harnessing the power of data-driven insights and autonomous decision-making, systems like CygNet MaSoN offer the promise of efficient, adaptive, and self-organizing 5G networks capable of meeting the diverse needs of modern applications and services. Moving forward, continued research and innovation in this domain are imperative to realize the full potential of 5G technology and usher in the era of truly autonomous networking.

A. Nauman, M. A. Jamshed, Y. A. Qadri, R. Ali and S. W. Kim, [5] presents a comprehensive investigation into reliability optimization in narrowband device-to-device communication for 5G and beyond-5G networks. By leveraging D2D communication and reinforcement learning-based relay selection, we demonstrate significant improvements in reliability, energy efficiency, and resource utilization, particularly for delay-sensitive applications. Our findings underscore the importance of considering the unique requirements of IoT applications and the potential of emerging technologies like D2D communication and reinforcement learning in enhancing the performance of NB-IoT networks.

Q. Tang, O. Ermis, C. D. Nguyen, A. D. Oliveira and A. Hirtzig, [6] provides a comprehensive analysis of the security aspects of 5G networks, focusing on the 5G core architecture. By examining key features such as the Service-Based Architecture, security mechanisms, and emerging threats, we offer insights into the evolving landscape of 5G security and identify areas for future research and development. It is imperative that stakeholders remain vigilant and proactive in addressing security challenges to realize the full potential of 5G technology.

M. Vincenzi, E. Lopez-Aguilera and E. Garcia-Villegas [7] provides a comprehensive overview of the research landscape surrounding network slicing in 5G, with a focus on maximizing revenue for infrastructure providers. It contributes a novel admission control mechanism and offers insights into the economic implications of network slicing, addressing a critical gap in the existing literature. It emphasizes the importance of considering both technical and economic factors in the design of network slicing solutions.

III. PROPOSED SYSTEM

Introducing an advanced system poised to redefine the landscape of 5G network comprehension and interaction. This groundbreaking platform amalgamates a comprehensive array of functionalities to furnish users with a holistic perspective of their 5G encounters. At its nucleus, this system conducts real-time 5G speed evaluations, furnishing precise insights into network performance. Yet, its capabilities extend far beyond mere surface evaluations; it delves into assorted facets of 5G network velocities, encompassing latency, jitter, and ping times. Through this meticulous analysis, it ensures users can delve into the intricate details pivotal for assessing network integrity.

What distinguishes this system is its adeptness in translating this intricate data into a user-friendly and intuitive application framework. No longer is there a need to decipher technical terminology or sift through complex charts. Instead, this system renders intricate network nuances in easily understandable language, as if the network itself communicates, demystifying the complexities of 5G. At the core of the application, users gain access to a wealth of information concerning their connected 5G network.

It transcends merely knowing network speed; it entails comprehending the network's essence. This system furnishes insights into the connected 5G network, encompassing signal strength, available bands, and coverage areas. Consequently, users remain informed about their connection quality, enabling informed decision-making, whether streaming a movie or engaging in critical video conferencing.

Moreover, this system simplifies convoluted terminologies, presenting information in concise, highly accessible language. Recognizing that not all users are tech-savvy, we have endeavored to streamline data presentation without compromising on depth and relevance. We firmly believe in technology's capacity to empower and inform, a principle embodied by this system.

This proposed system heralds a paradigm shift in 5G network assessment, seamlessly blending real-time speed assessments, in-depth scrutiny, and simplified presentation to provide users with an unparalleled comprehension of their 5G encounters. In an era increasingly reliant on swift and dependable connectivity, this system equips individuals to make informed decisions regarding their network utilization, bridging the chasm between technology and everyday users.

IV. SYSTEM ARCHITECTURE

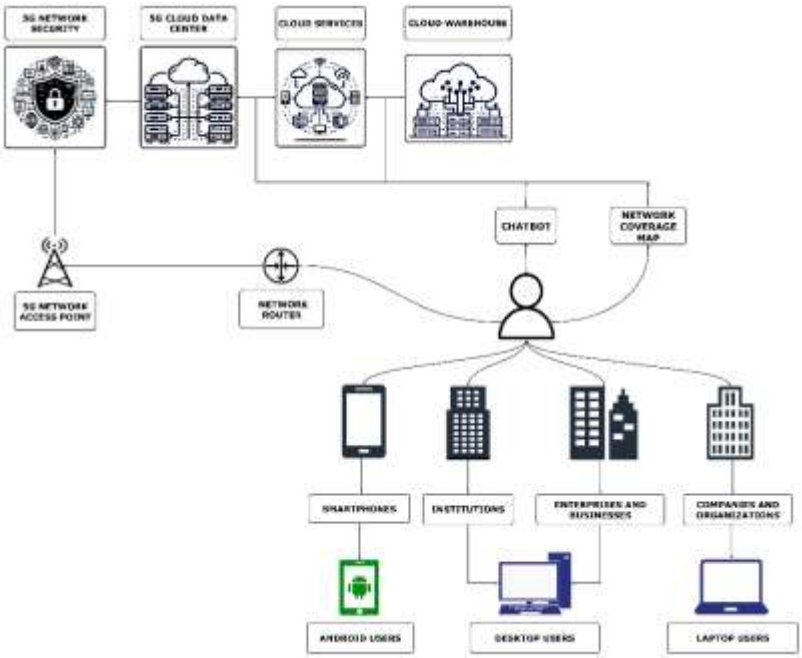

Fig. 1.0: 5g high-level system architecture diagram

The Figure shows a cloud-based system architecture of the proposed system with the following components:

1) **Network Router:**

This block represents a device that forwards data packets between different networks. Routers play a crucial role in directing traffic within the network and connecting the user's device to the broader internet.

2) **Cloud Warehouse:**

This block represents a centralized repository in the cloud that stores large amounts of data. This data could be used for various purposes, such as training and improving the AI-powered chatbot or providing historical data for network analysis (e.g., past speed test results).

3) **Cloud Services:**

This block represents various cloud-based services that the application leverages. This could include cloud storage for user data or application data (if applicable), backend services that process data or perform computations, and chatbot services (if the chatbot functionality is powered by a cloud-based service).

4) **Network Access Point:**

This block represents the physical infrastructure that provides network connectivity to user devices, such as cell towers and other radio access network (RAN) elements.

5) **Security Center:**

This block represents the security measures in place to protect user data and ensure the overall security of the application. This may involve encryption, authentication protocols, and secure communication channels.

6) **Users:**

This block represents the people interacting with the application on various devices to assess different aspects of 5G connectivity.

7) Android Users:

This block represents the current user base that consists of smartphone users with Android devices.

8) Desktop Users & Laptop Users:

These blocks represent potential future user groups that the application may target in future iterations to expand its reach beyond Android devices.

9) Chatbot:

This block represents a virtual assistant or chatbot integrated within the application. The chatbot leverages AI to interact with users in over 100 Indian languages and answer their questions about 5G technology or provide troubleshooting support for 5G-related issues.

10) Network Coverage Map:

This block represents a map that the application retrieves and displays to users. This map illustrates the areas covered by a 5G network.

V. IMPLEMENTATION DETAIL

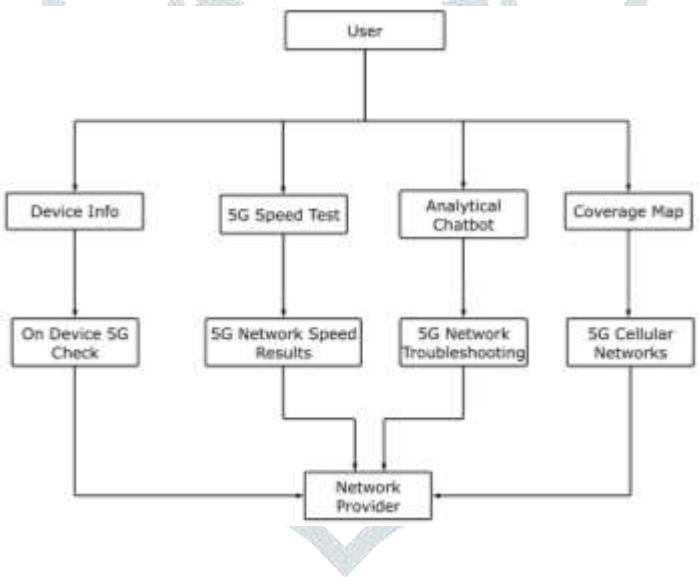

Fig. 1.1: Structural view of application features

The figure shows the application features with the following modules:

1) Device Info Module:

This module enables users to perform a self-service diagnostic test to confirm their device is compatible with the network provider's 5G network. This can expedite troubleshooting efforts by isolating the issue to the network or the device itself.

2) 5G Speed Test Module:

The purpose of this module is to assess the speed of the user's 5G connection. It initiates a speed test, measures download and upload speeds, and provides real-time results. The results from this module help the user understand the quality of their network connection and whether it meets their expectations.

3) Analytical Chatbot Module:

The chatbot module serves as an interactive assistant. Users can ask questions related to network issues, troubleshooting, or general inquiries. It analyses user queries, provides relevant responses, and may even suggest solutions for common problems. For instance, if a user experiences slow internet speed, the chatbot might recommend checking their device settings or contacting the network provider.

4) Coverage Map Module:

The coverage map module offers a visual representation of network coverage areas. It displays a map with different shades indicating signal strength across various locations. Users can explore the map to find areas with strong 5G coverage or identify potential dead zones.

5) Connection to the Network Provider:

All these modules connect to the network provider, allowing seamless communication between the user and the provider. When the user interacts with any of these modules, relevant data (such as device info, speed test results, chatbot queries, or coverage map preferences) is transmitted to the network provider. The network provider processes this information to optimize network performance, troubleshoot issues, and enhance overall user experience.

Finally, this mobile application serves as a self-service toolkit for users to manage their 5G experience. It empowers users to perform compatibility checks, obtain reliable speed measurements, troubleshoot connectivity issues, and access up-to-date coverage maps. This proactive approach streamlines support and enhances user satisfaction with their 5G service.

VI. SUMMARY

Our innovative system offers a fresh approach to understanding and utilizing 5G networks. By conducting real-time speed tests and analyzing key aspects such as latency and ping times, it provides users with a comprehensive overview of their 5G experience. What makes our system unique is its ability to present complex data in a user-friendly format, translating technical details into plain language. Users can easily access important information about their 5G network, including signal strength and coverage areas, empowering them to make informed decisions about network usage. By simplifying terminology and prioritizing accessibility, our system ensures that all users, regardless of technical expertise, can benefit. Overall, our system revolutionizes 5G network assessment by combining real-time testing, thorough analysis, and simplified presentation to offer users a deeper understanding of their connectivity experience. In a world where reliable connectivity is increasingly vital, our system bridges the gap between technology and everyday users, enabling informed decision-making and enhancing user empowerment.

Here are some key advantages of our proposed system:

- It offers a holistic view of the 5G experience, integrating real-time speed tests and detailed network performance analysis.
- The system presents intricate data in a user-friendly and intuitive manner, ensuring accessibility for all users.
- Users gain access to detailed information about their connected 5G network, enabling informed decision-making and problem resolution.
- By bridging the divide between technology and everyday users, our system enhances the accessibility and enjoyment of 5G for all.

With its potential to cater to both casual users and enterprise customers alike, our system stands poised to become an invaluable tool in the realm of 5G network management.

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