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Research Article

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A New Mobile RF Drive Test Application

Samani Siewe Darix*

National Advanced School of Engineering University of Maroua, Cameroon

***Corresponding Author**
Samani Siewe Darix, National Advanced School of Engineering University of Maroua, Cameroon.

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Abstract
To enhance the quality of service (QoS) provided to users, network operators are compelled to continually refine their network infrastructure through the iterative process of drive testing. Drive testing is a method used to measure and assess the coverage, capacity, and QoS in a mobile radio network. However, the conventional paradigm governing drive testing, which entails the deployment of either radio frequency equipment or software solutions such as TEMS Investigation accompanied by GPS and an MS (Mobile Station), is marred by inherent limitations that hinder precision in data collection spatiality and necessitate a cumbersome use of multiple tools. In our work, we embark on a novel trajectory, anchoring our noninvasive drive test methodology on the potency of a wearable device such as smart phones. Inspired by this, we design an Android-based drive test platform that stands as a fulcrum of innovation. This platform consists primarily of a mobile application that acts as a measuring instrument, and an API to relay the data collected by the mobile application. This Android-based approach provides operators with heightened precision in both location determination and parameter measurements. Moreover, it streamlines service provisioning, eliminating the need for a range of complex tools, and instead offering a simple application based solution. By adopting our mobile application, the drive testing process becomes adaptable to a variety of scenarios, including roads with high traffic density or narrow pathways. Our methodology signifies a significant step forward in improving resources-efficient drive testing process for operators.

Keywords: Drive Test, API, Quality of Service, Quality of Experience, Android.

1. Introduction

During the last century, technological developments in mobile telecommunications have rapidly increased. Mobile phone usage has surged, leading to a natural growth that correlates with the increasing number of cell phones. Mobile networks have expanded remarkably in terms of capacity and subscribers, establishing themselves as the primary means of communication and gaining market share by targeting all customer profiles. This progress helps maintain service quality to meet future data rates, capacity, and coverage requirements. Customer satisfaction for operators and Quality of Service (QoS) must be continuously improved and maintained, as a decline in QoS can occur due to a lack of traffic channel capacity. This is remedied by performing drive tests, which require permanent observation of network operation and the use of suitable engineering tools. Measuring mobile network quality is based on collecting data about network behavior, especially the radio part, at different points in space. The radio interface is the critical link in the transmission chain that connects the mobile user to the network. To monitor the network state and intervene in the event of degradation, a number of control tools of varied nature must be provided.

In order to enhance their networks, operators conduct periodic drive tests to gather the actual data experienced by end users. To achieve this, they frequently rely on software like Tems Investigation or Android-based methods. However, existing Android-based drive test solutions have been limited to certain generations. This article presents a novel solution that can collect drive test data from any generation of the operator network.

This article is structured as follows the first section II will present the literature review on drive test methods by presenting the concepts of quality of service and the relationship that exists between KPI, QoS and QoE, second section III will present in detail how we have developed and implemented our solution and the last section IV presents and discusses the results.

2. Literature Review

The purpose of this section is to examine the literature on drive testing. Firstly, we will provide an overview of the primary drive test methods used today. Secondly, we will delve into the key concepts related to quality of service in telecommunications networks.

2.1 Drive Test

RF Drive testing is a technique used to measure and evaluate the coverage, capacity, and Quality of Service of a mobile radio network. The classical method involves using a motor vehicle equipped with mobile radio network air interface measurement equipment that can detect and record a wide range of physical and virtual parameters of mobile cellular service within a specific geographic area. Today, the drive test can be performed on an Android phone. In the following section, we will examine the different methods used in drive testing with more depth.

2.1.1 Classical Drive Test

Operator technicians and engineers conduct Drive Test measurements to trace mobile measurements over time and location.

During field trips, we simulate various scenarios to test call establishment (no failure), communication maintenance (no interruption), and quality (with user mobility). The resulting report reflects service quality.

Measuring the performance and quality of radio resources of the network as perceived by subscribers is best achieved through drive testing using digital measuring chains in a car.

• MS: The signal strength is picked up in real-time by the mobile phone and then transferred to the graphical interface (GUI) of the software. ;
• GPS (Global Pointing System) : To find out the current location of the test:
• A Laptop: Equipped with a special tool (software) allowing the acquisition, processing, and recording of the measurements retrieved from the trace mobile (radio parameters) and of the GPS receiver (geographical coordinates) in special files.

The current method of performing test drives has two issues. Firstly, it requires an expensive license and is not scalable. Secondly, it requires multiple tools and transportation which limits the locations for testing.

This article used this method to perform drive tests in an indoor environment [1]. In this article used terms investigation software to collect data from operator networks for 4G technologies for subsequent analysis using another application website [2]. This article also uses TEMS software to collect data from operator networks for GSM technologies [3].

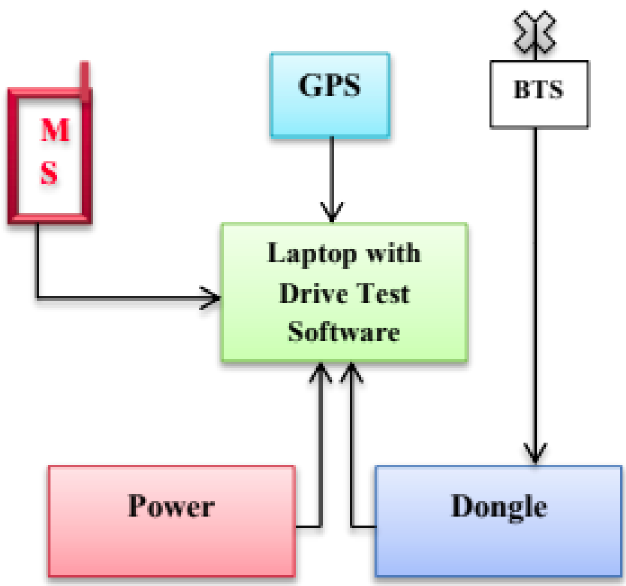

Figure 1: The Classic Drive Test [4].

2.1.2 Android Based Drive Test

Phone-based drive test systems are useful for evaluating baseline network performance and essential for characterizing the end-user experience when using the network. These systems verify network parameters such as cell selection and reselection limits and measure the performance of voice and data applications in the live network.

During the design process, modern mobile phone chipsets are equipped with engineering measurement capabilities. These same parameters are used in planning software to provide additional value to RF engineers deploying the final network.

Base Stations can use instrumented phones to monitor physical layer performance, including modulation schemes, access procedures, timing, and power control, through radio resource management.

The same parameters are measured across all cellular technologies. The protocol log provides visibility into network interaction, and initial focus is on RF coverage and quality. Each cellular network type has parameters to assess performance.

These articles have analyzed these two drive test methods using the Tems Investigation software and the GNetTrack Pro application [5,6]. this article retrieves a limited number of parameters and does not support all mobile radio technologies. This article has developed a test drive mobile app that only supports 3G networks [7]. This author has only developed a solution that only works for third-generation networks. In these articles they have developed a drive test solution for 4G with notification, the study was done in a restricted environment at a university [8,9]. This article uses the NetMap application to retrieve certain parameters in 4G LTE for analysis [10]. This article uses a solution developed on Android for the comparison of three operators [11]. In this article, the number of parameterized retrieve is limited. This doctoral thesis uses an Android smartphone to evaluate the performance of 4G networks using a limited number of parameters such as RSRP, RSRQ, RSSI and PCI [12]. In this article they have developed an Android application to perform the drive test for LTE (4G) technologies by recovering a limited number of parameters [13]. In this article they have developed an android solution that only recovers the primary cells to which the mobile is connected and only supports a limited number of mobile networks [14]. This article focuses only on 4G technologies [15]. It presents existing solutions, and their limitations, and proposes a solution to overcome them. Finally, it examines the correlation between different parameters. This article presents an Android-based solution for recovering primary cells and a limited number of parameters in 4G technology [16].

All of the articles mentioned above only recover a limited number of parameters, regardless of the technology used in mobile networks. However, this article presents a method based on Android that can recover all the parameters of both primary and neighboring cells to which the mobile is connected.

2.2 Relationship Between KPI, QoS, QoE

In telecommunications, QoS (Quality of Service) refers to a network's ability to meet requirements for providing telecommunications services, including Accessibility, Availability, Continuity, and Integrity. Evaluating network status, detecting malfunctions, and analyzing field feedback is essential for operators to control and maintain the network. Mobile networks differ from fixed networks in terms of how their performance is evaluated. Quality of service in mobile network communication refers to profitability and reliability.

The mobile radio network is experiencing exciting developments due to the explosion of new telecommunications services catering to the increasing number of users and high data rate requirements. This has led to the continuous development of technologies, from 1G, 2G, 3G, and 4G to the arrival of the widely expanded 5G technology. These networks have integrated new services and optimized radio performance indicators to meet the growing demand from users.

A KPI is a standardized parameter used to measure network performance from an operator's perspective. KPIs are defined for each generation of mobile networks and provide a general overview of key performance indicators.

A majority of KPIs focus on network performance parameters, with few relating to end-to-end QoS. QoS reflects the network state from the operator's perspective, while QoE reflects the user's perspective. The figure below illustrates the relationship between KPIs, QoS, and QoE.

- The QoS parameters characterize the quality of service and client satisfaction. They represent the subjective perception of the user.
- Objective and subjective methods can be used to obtain QoS parameters. Technical means include KPIs from counters and drive Tests, while the quality of service perceived by the user and opinion surveys are considered subjective methods.
- Objective measures of network performance parameters, directly or indirectly correlated to user perception, are often used for efficiency.

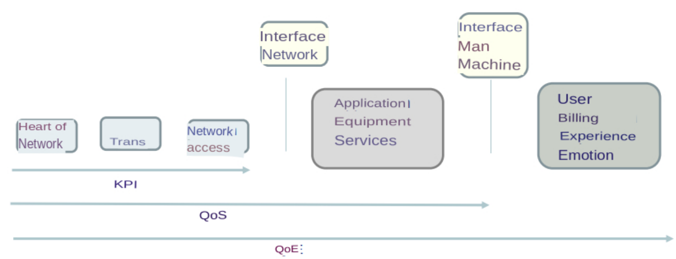

Figure 2: Relationship between KPI, QoS and QoE

Quality of Service (QoS): Terms and Definition Quality of service can be defined from several points of view as being:

- User-Requested Quality of Service : Quality of service requested by a user or by one/several segments of the population with the same needs in terms of the quality of functioning.
- Quality of Service Offered/Expected by the Provider: Level of quality expected and therefore offered by the supplier.
- Quality of Service Delivered by the Supplier: Level of quality obtained or delivered to customers.
- Quality of Service Perceived by the User: Specialized bodies often conduct surveys to determine customer satisfaction levels and identify areas for improvement. Analyzing complaints received through customer service is also crucial in enhancing service quality.

The following figure presents the relationships that exist between the different points of view of the quality of service

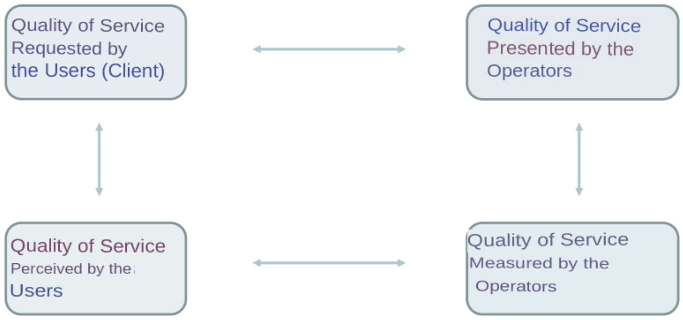

Figure 3: A Diagram viewed from the perspective of QoS.

3. The Development of our Solution

In this section, we will see in detail how we developed our solution.

The system comprises a mobile application installed on a smartphone, which acts as a measuring instrument, to collect various data parameters, including geographic location using the phone's GPS, signal strength, network type, etc. The mobile app then stores all the collected data locally before transmitting it to a central database via a RESTful API. The central database is where all raw data for the mobile app is stored and accessed. The RESTFUL API serves as a communication channel between the mobile app and database. In the diagram 4, the mobile device receives cellular and GPS data, along with other necessary information. The device then initiates a connection to the web service using the RESTFUL API and sends the data to the central database.

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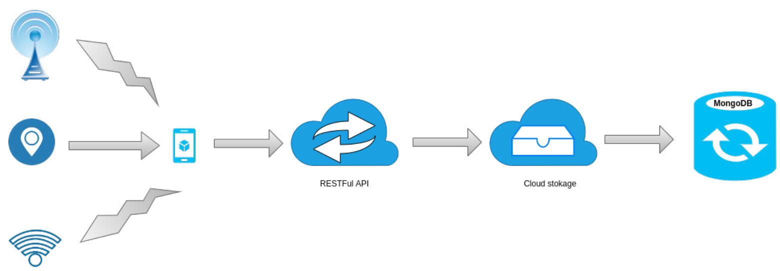

Figure 4: High-Level System Architecture

3.1 Use Case Diagram

This figure displays all the use cases for our mobile application. The user can view RF DRIVE TEST parameters, send collected data online, stop recording in the local database, activate or deactivate the wakelock, and view the DBm values.

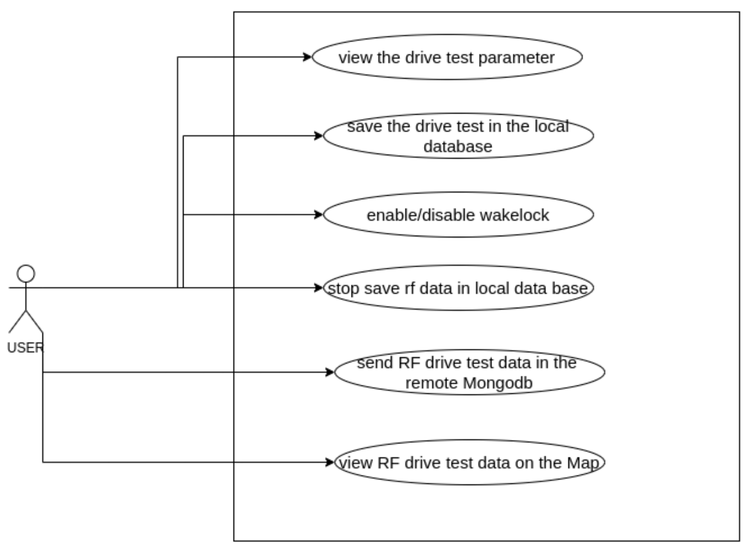

Figure 5: Use Case Diagram

3.2 Activity Diagram

When the application starts, the user must grant permission to collect test drive data which is then saved in the smartphone's SQLite database every second. The user can access various pages while the data collection runs in the background.

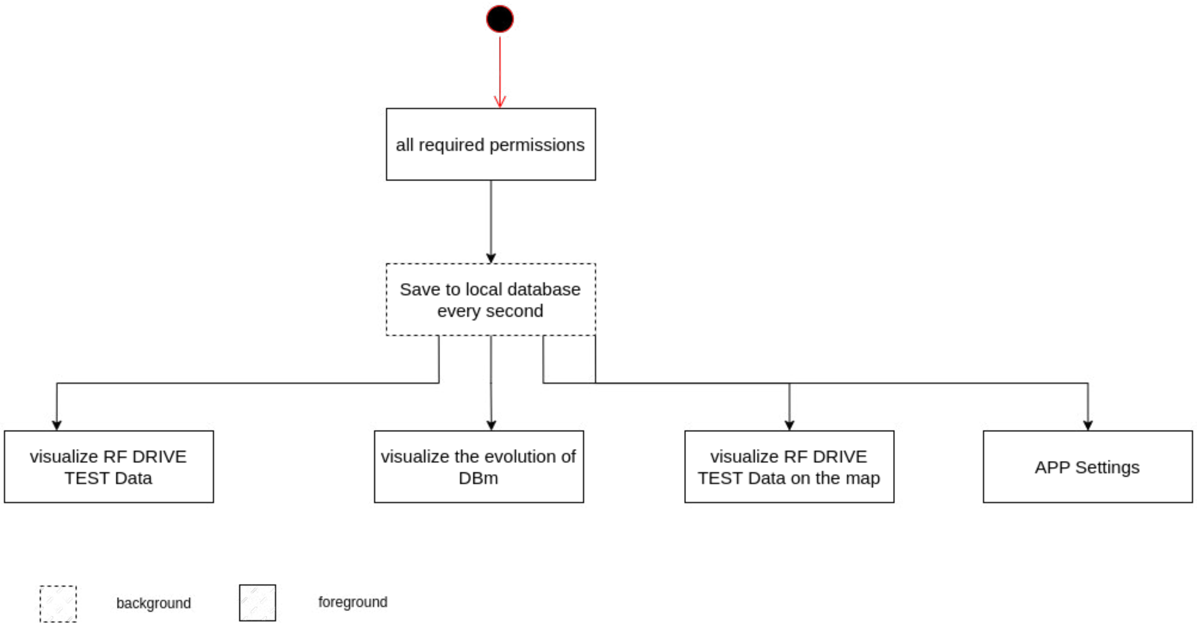

Figure 6: Activity Diagram

3.3 Class Diagram

Our class diagram is simple because we only need to collect data such as signal strength, band, and cell information, etc...

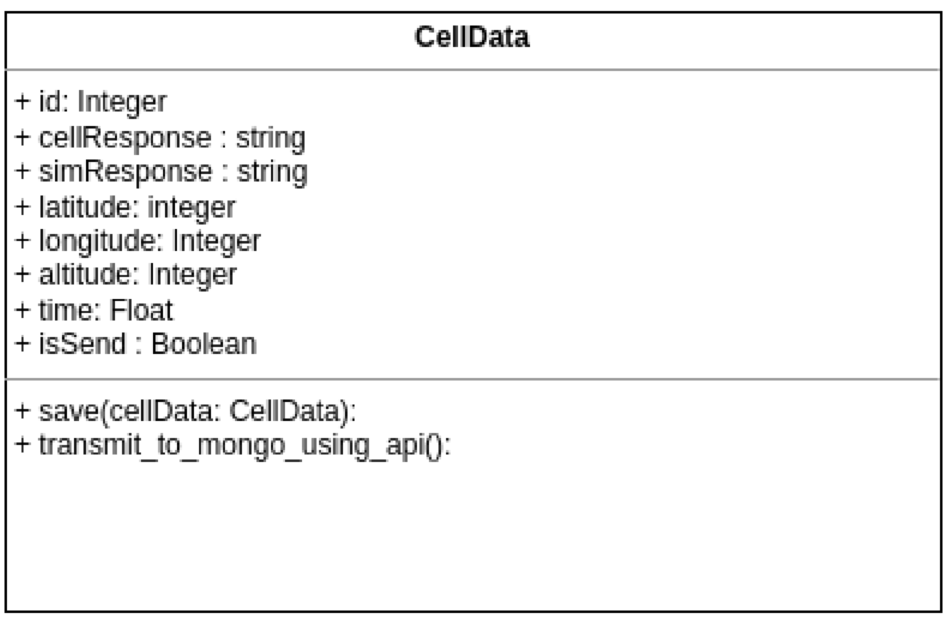

Figure 7: Class Diagram

Name	meaning
id	This represents the identifier for the class.
cellResponse	This represents the encoded ToString value of the CellResponse class instance.
simResponse	This represents the encoded ToString value of the simResponse class instance.
Latitude	Latitude, in degrees
Longitude	Longitude, in degrees
isSend	to know if the data has already been sent online or not
time	represents the timestamp system that gives the number of times in seconds that have elapsed since January 1, 1970, at 00:00

Table 1: Data Dictionary

Figure C shows us the class diagram of the CellsResponse and SIMInfoResponse objects.

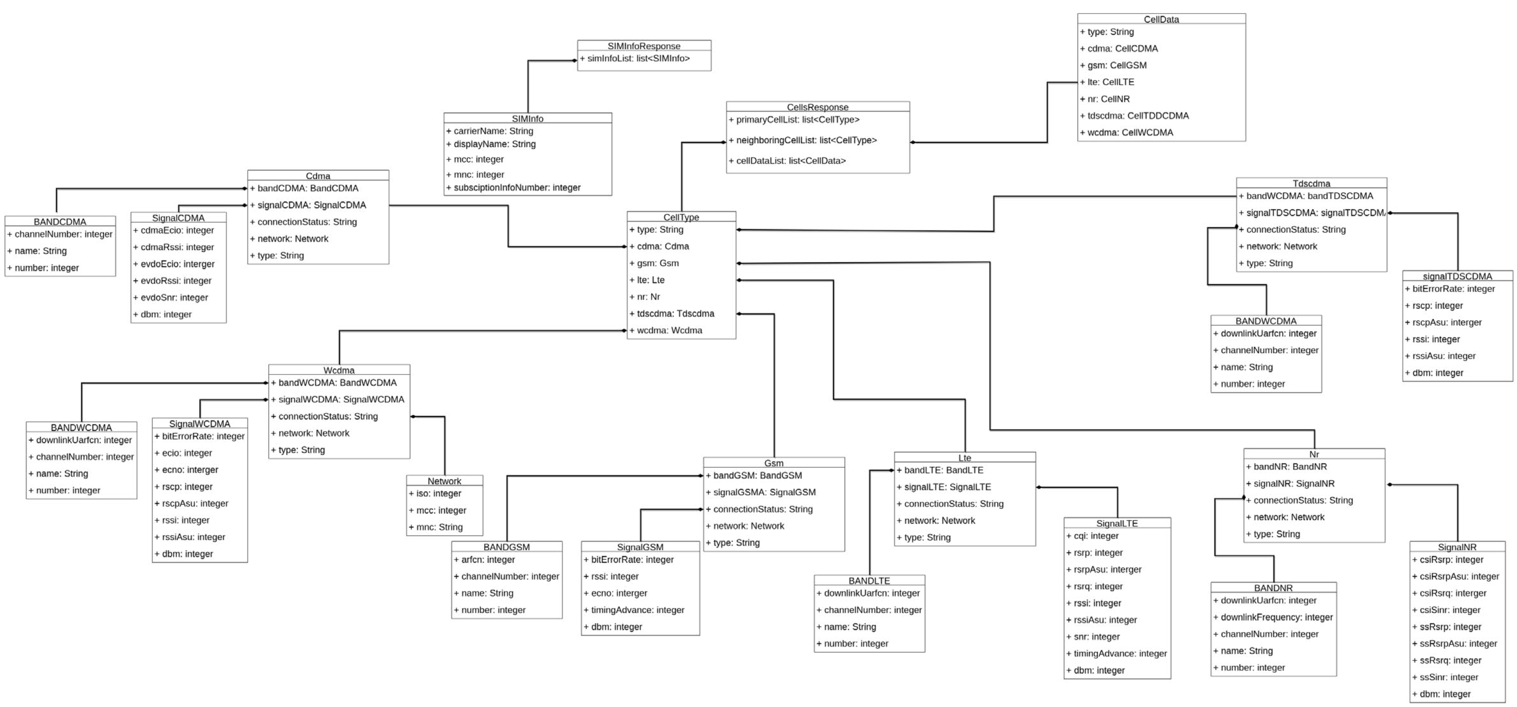

Figure 8: Class Diagram of the CellResponse and SIMinfoResponse Object

3.4 Implementaion of our Solution

To implement our solution, we utilized various tools, including but not limited to:

• Flutter: We chose Flutter to develop your application due to its faster learning curve compared to native solutions. we have used this package [17].

• SQlite: We utilized this technology to store drive test data in a database located locally in the smartphone

• FastApi: we used this technology to develop our API

• OpenStreetMap: we have used this technology to visualize on a map the value of the DBm

• Docker: We used docker to make our API portable

• MongoDb: We used MongoDB to store the raw data of the test drive transmitted through the API

4. Results and Discussion

In this section, we will present the results of our study.

4.1 Request Necessary Permissions

To collect data on an Android phone, our app needs permission to access certain features. The following figure shows an example of a permission request when launching the application.

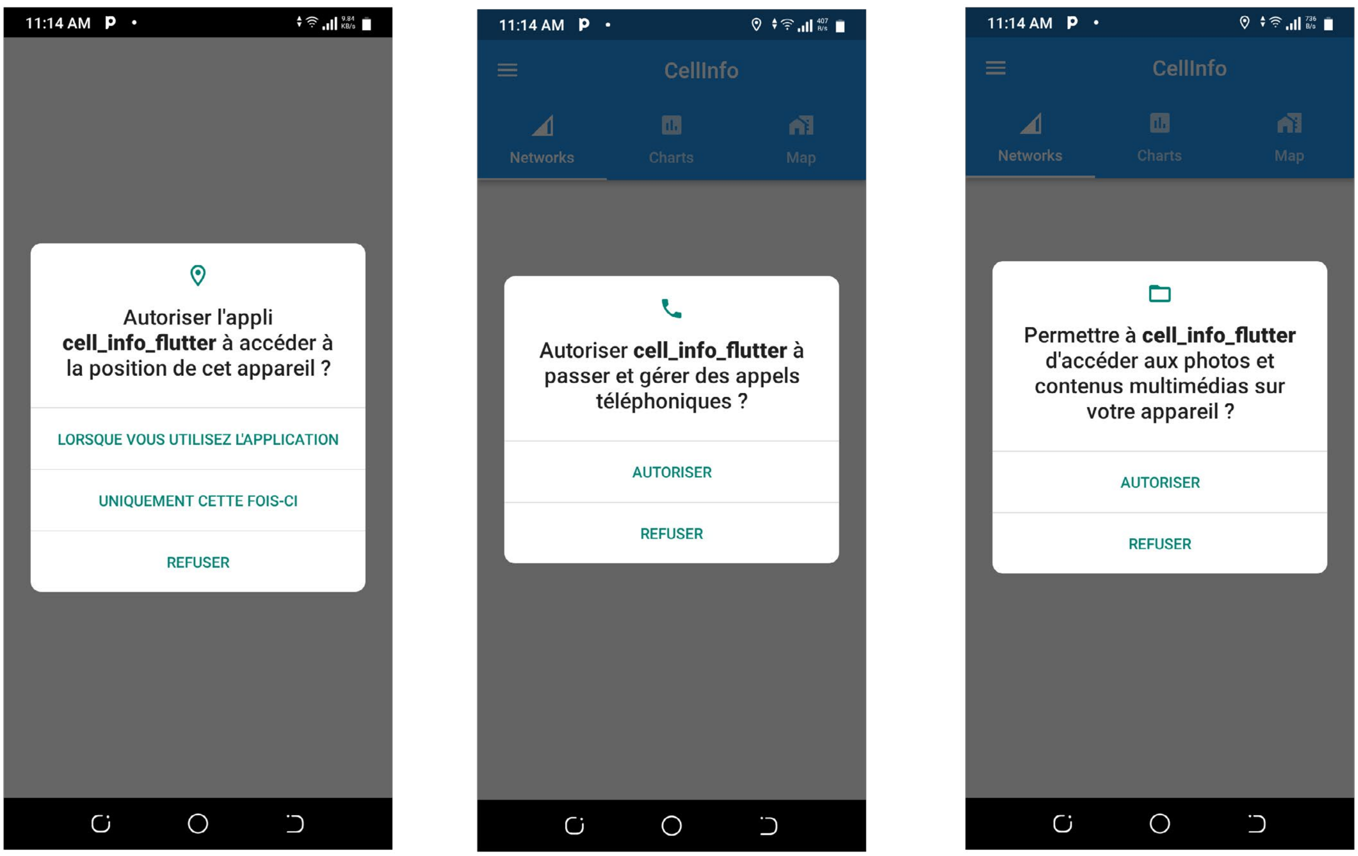

Figure 9: Permissions Required for our Application

4.2 Visualize Test Drive RF Parameters using the Use Case Interface

The interface for the use case displaying RF parameters of the drive test lists the primary and neighboring cells the mobile is connected to, along with information on the mobile's SIM card and location. On this interface, the user can view the drive test parameters that have been recovered with a frequency of one second.

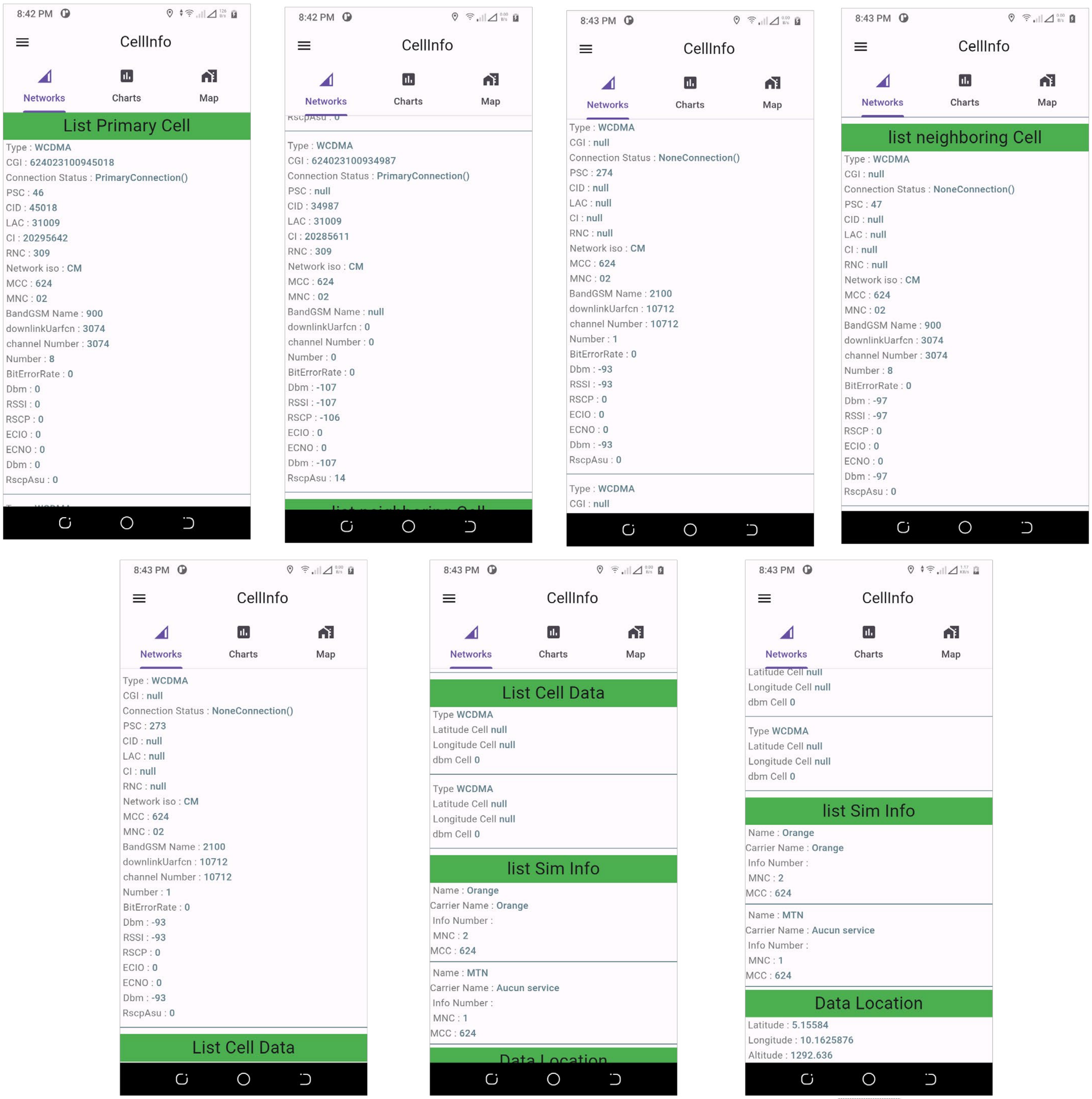

Figure 10: Use Case Interface Visualizes the RF Parameters of the Test Drive

4.3 Interface of the Use Case Visualize on a Graph the Evolution of the RSSI (dbm)

The following figure shows us the interface of the use case to visualize on a graph the evolution of the RSSI (dbm).

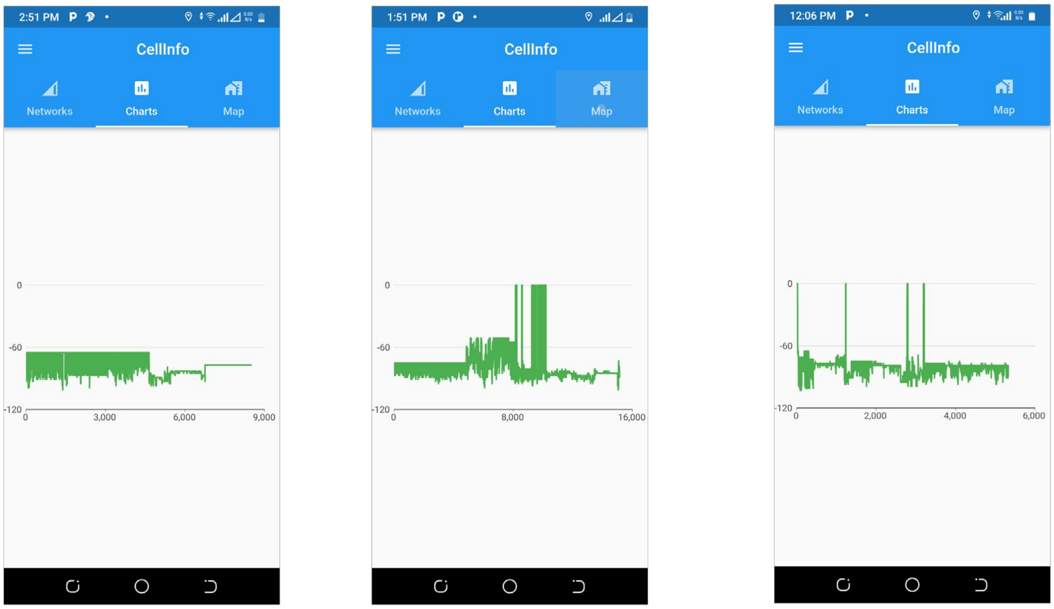

Figure 11: Use Case Interface on a Graph of the Evolution of the rssi (dbm)

4.4 Visualize RSSI Values on a Map Range

The following figure shows us the interface of the visualizer use case on a map of the value of the RSSI (dBm) according to a range of values. In this interface, we display the data according to the GPS position of the collected data.

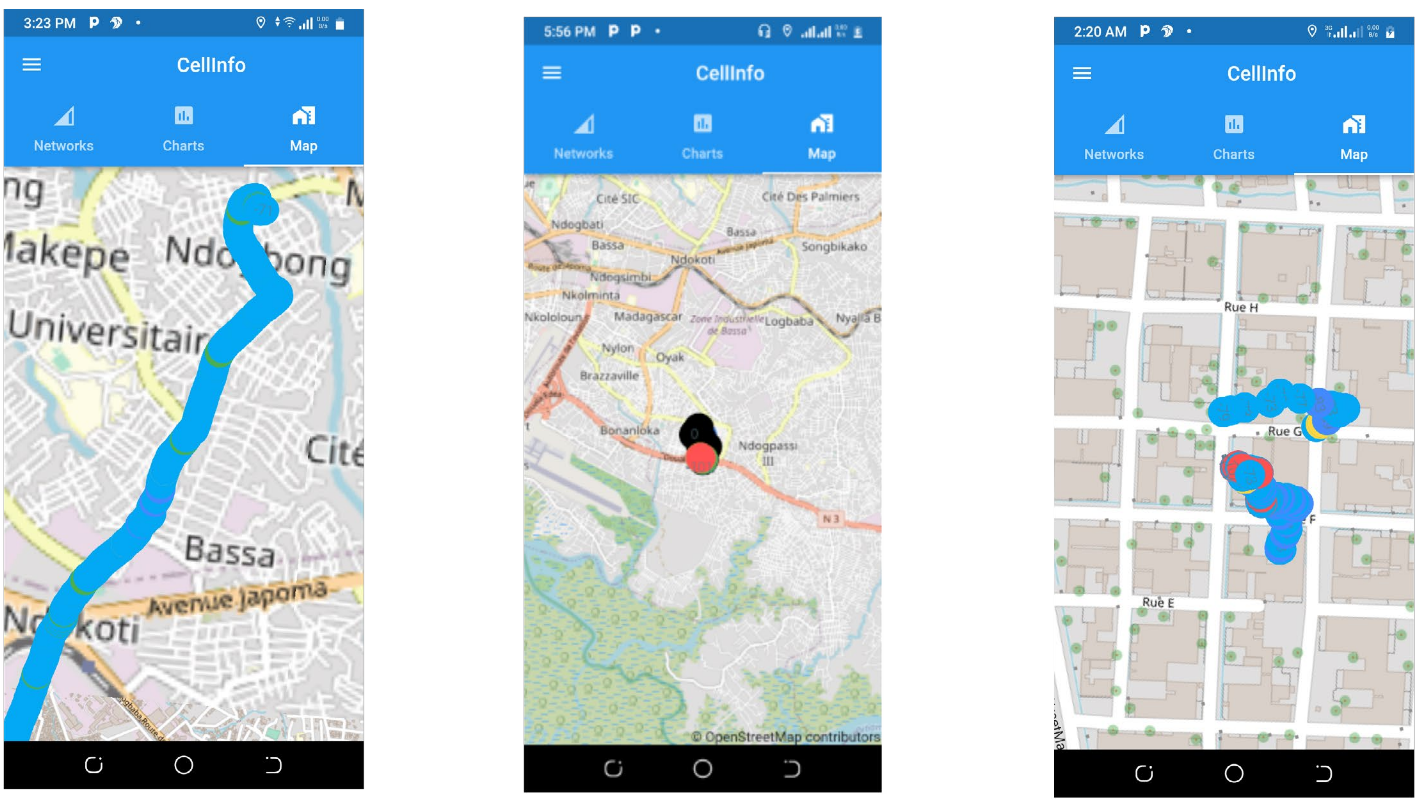

Figure 12: The Interface Displays RSSI Values on a Map Based on GPS Data.

4.5 App Configuration Interface

The following figure shows us an interface of the use cases: prevent the screen from going to sleep, send the data online, stop recording in the local database and continue to run the application in the background.

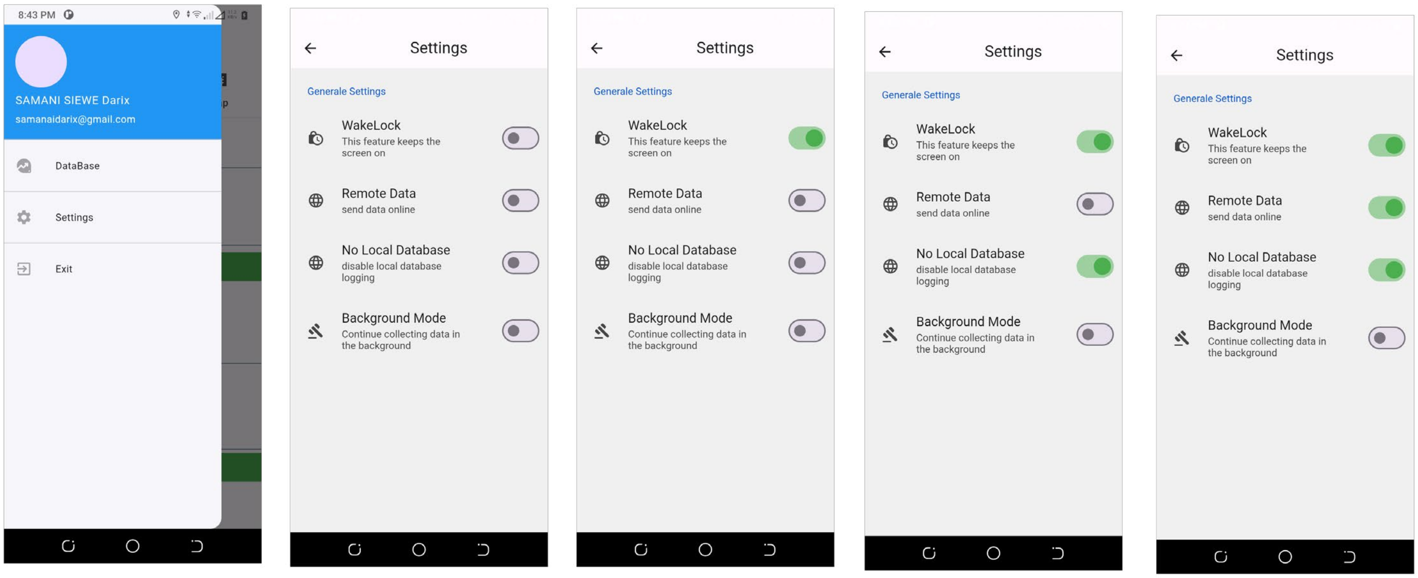

Figure 13: App Configuration Interface

4.6 Database Use Case Interface

The following figure shows us the user interface of all the use cases related to the database, namely the use cases: delete all data from the local database, delete all data that has been sent local database online, and export all local database data to JSON format.

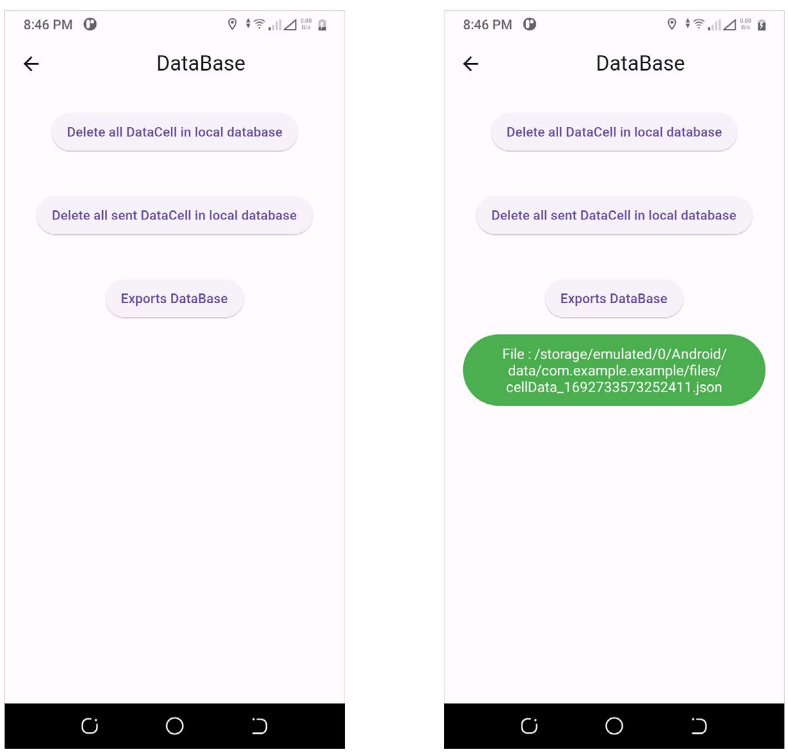

Figure 14: Database Use Case Interface

4.7 API Documentation

The following figure shows us documentation of the API that we have implemented to collect data from operator networks.

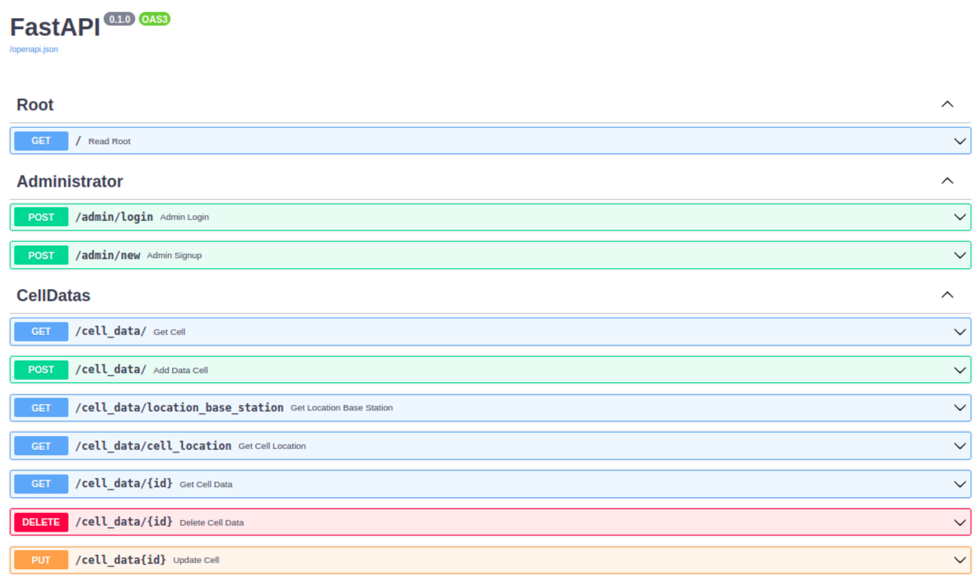

Figure 15: API Documentation Interface

4.8 A URI to Locate the cell

The tool or plugin we use to retrieve data from operator networks does not directly provide us with cell locations [17]. By performing research we saw that it was possible from four parameters to know the location of the cell namely LAC, MCC, MCN and Cell ID which constitutes the GCI (Global Cell Identifier) by exploiting an open source database containing the location of the cell of the cellular networks in the world [18].

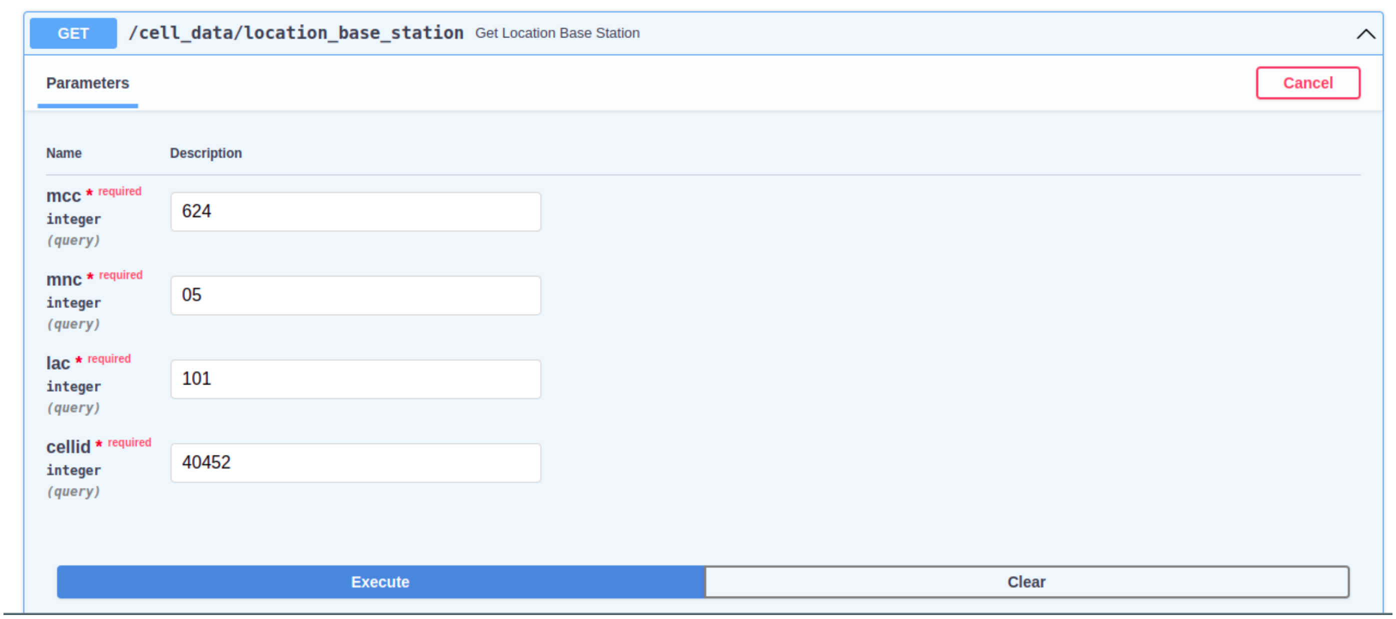

Figure 16: Sample Cell Location Query

Figure 17: Example of Cell Location Response

4.8.1 Cloud Database

When the user sends raw data through the API, it is saved in a document-oriented cloud database.

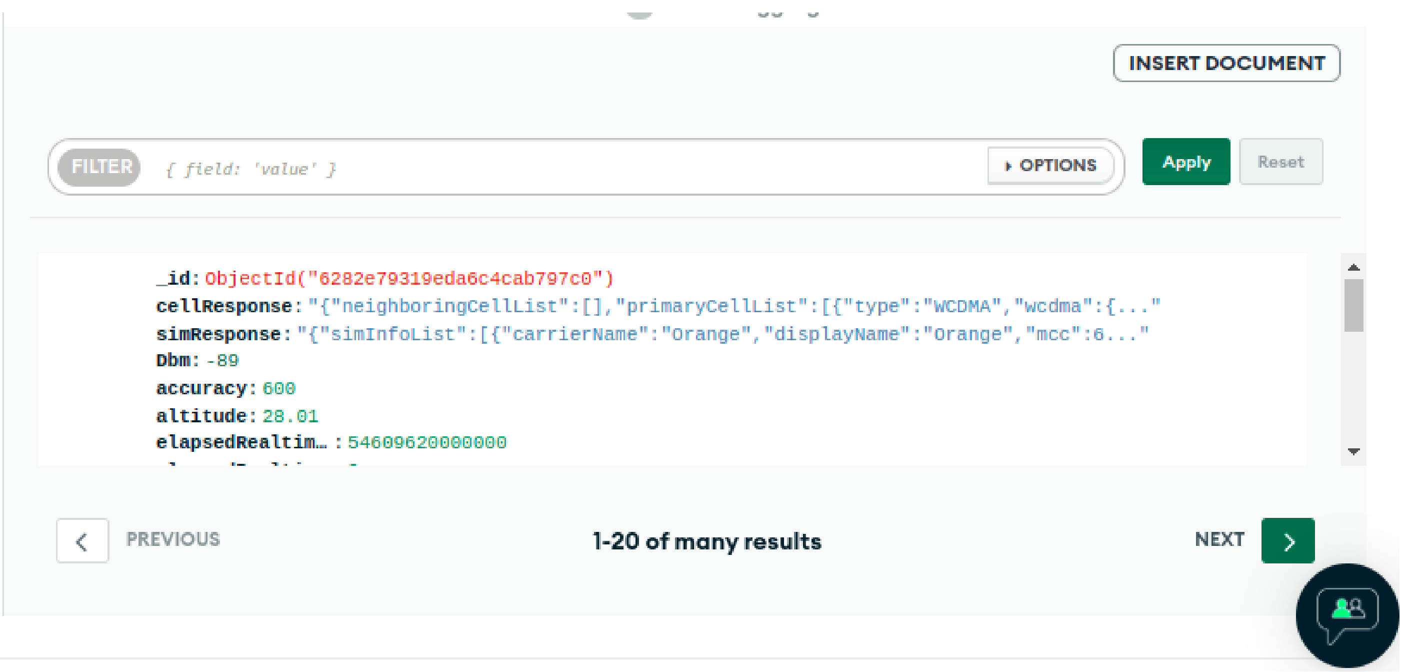

Figure 18: Saving Data in MongoDB Database

5. Conclusion

Throughout this article, we have delved into the merits inherent in adopting a mobile application-based approach for drive testing. Our Android-centric solution significantly streamlines the efforts of engineers by substituting an unwieldy range of tools with a singular, cohesive application. Furthermore, we have successfully engineered a mobile application that exhibits the capability to retrieve data from operator networks, irrespective of the underlying mobile radio technology in use. While mobile applications offer the potential for providing comprehensive measurements, it's worth noting that specific scenarios might necessitate the employment of scanners for optimal results.

The outcomes of our study lay the foundation for future extensions of our research. One avenue involves the training of AI models leveraging mobile data to proactively predict and address service anomalies, thus allowing for preemptive parameter adjustments [19]. Moreover, we advocate for the development of a web application to enhance data analysis capabilities, alongside refining the user interface of our mobile application for an even more user-friendly experience.

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