



ORIGINAL RESEARCH ARTICLE

**KAYUSQOS: A MOBILE-DRIVEN SOFTWARE FRAMEWORK FOR REAL-TIME QOS DATA COLLECTION AND KNOWLEDGE DISCOVERY IN NIGERIAN GSM NETWORKS**

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**ABSTRACT**

The Nigerian telecommunications industry relies largely on expensive and manually intensive drive-test systems for monitoring Quality of Service (QoS), which limits the frequency, coverage and affordability of performance assessment, particularly in semi-urban environments. This study presents KayusQoS, a mobile-driven software framework for automated QoS data collection and knowledge discovery in Global System for Mobile Communications (GSM) networks. The framework integrates an Android-based application for real-time capture of Key Performance Indicators (KPIs) and a Knowledge Discovery in Databases (KDD) analytical process for data preprocessing, analysis and interpretation. The study adopted a hybrid research design combining system development and experimental validation. Using the KayusQoS application, a total of 2,944 valid call records were collected from four major GSM operators, namely MTN, Airtel, GLO and 9Mobile, across selected Local Government Areas of Nasarawa State, Nigeria. Five Key Performance Indicators—Call Setup Success Rate, Call Drop Rate, Handover Success Rate, Received Signal Strength and Retainability Rate—were computed and benchmarked against Nigerian Communications Commission Quality of Service thresholds. Results indicate that the KayusQoS framework achieved full automation and 100 percent geo-tagging accuracy. MTN demonstrated the highest overall Quality of Service performance, while Airtel showed moderate compliance with regulatory benchmarks. GLO and 9Mobile exhibited lower performance levels in several indicators. The study concludes that KayusQoS is a reliable, low-cost and effective alternative to conventional drive-test systems and can serve as a complementary tool for regulatory monitoring and network optimization in Nigeria.

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**1.0 Introduction**

The quest of man for compatible, adequate and intelligent communication system led to the development of Global System for Mobile Communications (GSM). The first public cellular system called Advanced Mobile Phone System (AMPS) was introduced in 1979 in the United States. During the early 1980s, several incompatible analog cellular telephone systems (Total Access Communication System (TACS), Nordic Mobile telephony (NMT), C450 etc.) experienced rapid growth in Europe. The deployment of these incompatible systems resulted in mobile phones being designed for one system that could not be used with another system, and roaming between the many countries of Europe was not possible.

Hence, in 1982, the main governing body of the European post telegraph and telephone (PTT), la Conférence européenne des Administrations des postes et des télécommunications (CEPT), set up a committee known

as Groupe Spécial Mobile (GSM), under the auspices of its committee on harmonization, to define a mobile system that could be introduced across western Europe in the 1990s (Garg, 2007). The CEPT proposed in table I the following criteria for the new mobile wireless system.

**Table I:** CEPT criteria for the GSM system

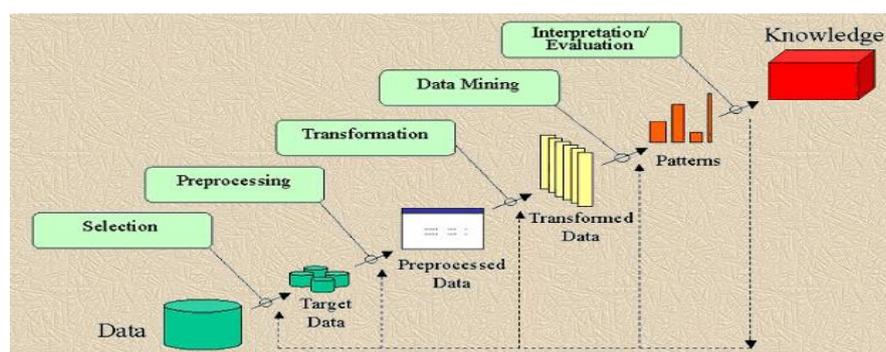
No.	Criterion
i	Allocate the necessary duplex radio frequency bands
ii	Good speech quality
iii	Low terminal and service cost
iv	Support for international roaming
v	Support transmission of sound and data that is compatible with Integrated Services Digital Network (ISDN)

The early years of the GSM (renamed Global System for Mobile communications) were devoted mainly to the selection of radio technologies for the air interface. The interfaces, protocols, and protocol stacks in GSM are aligned with the Open System Interconnection (OSI) principles. Ian (2020) states that the GSM architecture is an open type that provides maximum independence among the elements of the network like the Base Station Controller (BSC), the Mobile Switching Center (MSC), and the Home Location Register (HLR). This move simplifies the design, testing, and implementation of the network system and also favours an evolutionary growth path.

The rapid growth of the telecommunications industry over the past two decades has resulted in an enormous volume of data generated daily from various network operations, customer interactions, and mobile devices (GSMA, 2025). These data contain valuable information about network behavior, service quality, and customer usage patterns. However, due to their large size and complexity, extracting meaningful knowledge from such data remains a major challenge for telecommunication operators and regulators (Oughton & Frias, 2023; Nigerian Communications Commission (NCC), 2025). Traditionally, network performance analysis has relied on manual or semi-automated methods, where engineers compute and interpret Key Performance Indicators (KPIs) such as Call Setup Success Rate (CSSR), Call Drop Rate (CDR), Handover Success Rate (HOSR), Received Signal Strength (RSS), and Retainability Rate (RetR) (NCC, 2024). While these indicators provide useful performance metrics, they do not by themselves reveal hidden relationships, patterns, or predictive trends necessary for proactive network optimization (Ali et al., 2022; Imran et al., 2019).

With the emergence of data mining and knowledge discovery techniques, it is now possible to uncover hidden patterns and predictive relationships from large datasets automatically (Fayyad et al., 1996). Data mining, a core phase of the Knowledge Discovery in Databases (KDD) process, provides computational methods such as correlation, regression, clustering, and neural networks for identifying patterns that support intelligent decision-making (Han et al., 2022; Witten et al., 2017).

This paper presents KayusQoS – a mobile-driven software framework that integrates automated QoS data collection with the full KDD process to enable efficient knowledge discovery in the telecom industry, addressing the limitations of traditional methods in the Nigerian context. GSM's open architecture provides independence among elements (Ian, 2020). Traditional drive tests are costly and limited (Ozovehe & Usman, 2015). KDD (Fayyad et al., 1996) and data mining techniques (Han et al., 2022) enable pattern discovery. Recent studies highlight mobile-based collection (Mehmood et al., 2023) but lack integrated frameworks for GSM in developing markets.



**Figure I:** Standard KDD Process (Fayyad et al., 1996)

## 2. Materials and Methods

The framework follows the KDD process and hybrid research design (developmental and experimental) (Hevner et al, 2004). This framework follows the standard KDD process but is customized for voice QoS parameters in the Nigerian telecom environment with the developed app helped in data collection, data cleaning, data integration, Data selection, Pre-processing, Transformation, Datamining, Interpretation/Evaluation as illustrated in Figure 2.

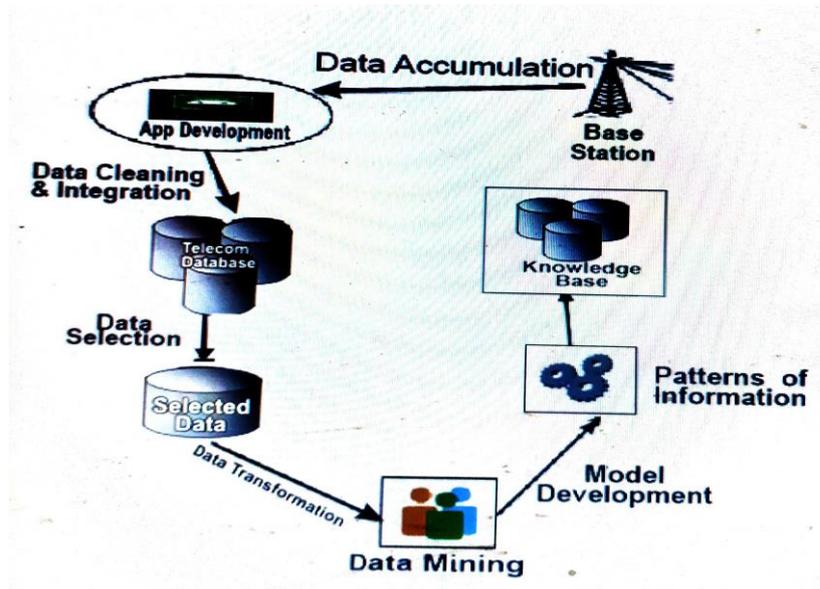


Figure 2: KDD Process Integration in KayusQoS

### 2.1 KayusQoS Android Application

The KayusQoS mobile application uses TelephonyManager, SignalStrength, LocationManager to develop an android app and deployed on android smartphones to capture live KPIs measurements across selected Local Government Areas (LGAs) in Nasarawa State. Table 2 shows the android Application Programming Interfaces (APIs) used in KayusQoS app. This app aligned with ITU-T and NCC standards to logged multiple Key Performance Indicators (KPIs) like Call attempts, call successes, call failures, call drops, handover attempts, handover completions, Received Signal Strength, Cell ID, Timestamp, GPS coordinates, and Location Area Code

Table 2: Android APIs used in KayusQoS

Functionality	API	Purpose
Call events	TelephonyManager	Detect setup/drop/handover
Signal strength	SignalStrength	RSS measurement
Location	LocationManager	Geo-tagging
Storage	SQLite	Local database

### 2.2. KayusQoS Framework Architecture

The development of the KayusQoS mobile application followed the Agile software development paradigm, which emphasizes flexibility, iterative progress, and continuous collaboration between developers and stakeholders. The Architectural design of the KayusQoS-based Knowledge discovery system adopts a modular three-tier architectural layers: Presentation layer, Logic layer, and Data layer.

#### 2.2.1 Presentation layer

This is the user interface for initiating and monitoring field tests. The KayusQoS Android mobile application user interface provides an intuitive touch-based graphic user interface that allows user to initiate test calls, monitor live network performance, view computed KPIs in real time, and export collected datasets with a single tap.

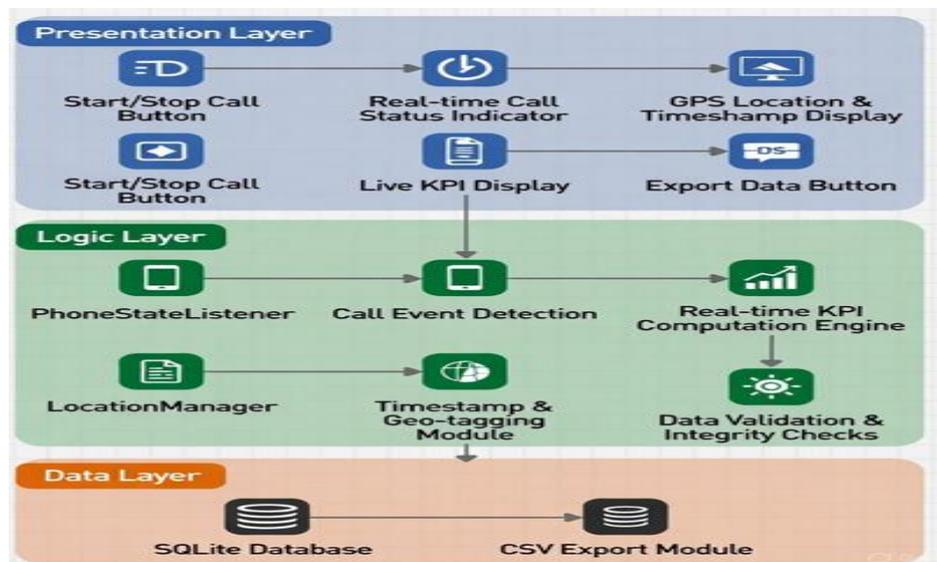
### 2.2.2 Logic layer

This is responsible for KPI computation and call-event processing. It is where the core intelligence of the system resides. Using Android’s TelephonyManager and LocationManager APIs, the application listens passively to call state changes and automatically triggers KPI calculation the moment a call ends. GPS coordinates and precise timestamps are attached immediately, ensuring 100 % geo-tagged, time-synchronized records which serves as a significant improvement over TEMS logging.

### 2.2.3 Data layer

This is where all local storage using SQLite with CSV export for data analysis are done. All processed records are stored locally in a structured SQLite database. The schema is optimized for direct import into R for the subsequent stages of the KDD process of pre-processing, transformation, data mining, and interpretation. A one-click CSV export function allows seamless transfer to desktop analysis environments.

This lightweight, fully mobile three-tier architecture replaces the traditional multi-million-naira drive-test setup (vehicle + TEMS + laptops + dedicated engineers) with a single low-cost Android smartphone, while producing richer, more accurate, and immediately actionable datasets for advanced knowledge discovery.



**Figure 3:** Three-Tier Architecture of KayusQoS

### 2.3 Data Collection

The data collection phase constituted the cornerstone of this study, as the quality of any knowledge discovery framework is inherently tied to the quality of its input data. In this research, data was collected through a dual-source approach:

1. Primary Data obtained directly through the KayusQoS Android application, which was specifically developed for this study.
2. Secondary Data obtained from the Nigerian Communications Commission (NCC) Quality of Service (QoS) reports, which served as a regulatory benchmark.

### 2.4 Flowchart of KayusQoS Data Capture

**Table 3:** Collected dataset summary

Operator	Calls	Valid	Geo-tagged
MTN	736	736	100%
Airtel	736	736	100%
GLO	736	736	100%
9Mobile	736	736	100%
<b>Total</b>	<b>2944</b>	<b>2944</b>	<b>100%</b>



Figure 4: Flowchart of KayusQoS for Capturing Data

### 3. Results and Discussion

#### 3.1 Benchmarking

The collected dataset was preprocessed to remove inconsistencies and ensure data integrity. Five Key Performance Indicators were computed for each operator based on Nigerian Communications Commission definitions. KayusQoS achieved 100% automation and geo-tagging, collecting 2,944 valid records. Preprocessing ensured clean data ready for mining. This full automation highlights the frameworks efficiency in capturing real-time, geo-tagged data without manual intervention addressing the limitations of traditional drive-test systems that are costly and labour intensive (Ozovehe & Usman, 2015)



Figure 5: Screenshots of KayusQoS Application

Table 4: QoS performance results of GSM operators

Operator	Call Success Rate (%)	Setup Call Rate (%)	Drop Handover Rate (%)	Success Received Strength (dBm)	Signal Retainability Rate (%)
MTN	98.4	1.2	96.8	-73	98.1
Airtel	97.6	1.5	95.4	-75	97.2
GLO	93.8	2.9	91.2	-82	94.0
9Mobile	94.5	2.4	92.0	-80	94.6
NCC Benchmark	≥98	≤2	≥95	≥-85	≥98

Benchmarking against regulatory thresholds indicates that MTN fully complied with all Nigerian Communications Commission Quality of Service benchmarks, suggesting robust network optimization and coverage. Airtel met most benchmarks but recorded slight shortfalls in Retainability Rate, which may reflect moderate infrastructure investments compared to MTN. GLO and 9Mobile failed to meet multiple benchmark thresholds, indicating degraded Quality of Service in some locations, potentially due to signal interference or coverage gaps as noted for data-driven tools like KayusQoS to identify patterns for proactive optimization (Joseph & Ojo, 2023)

The results demonstrated noticeable variation in QoS performance among GSM operators in Nasarawa State. MTN consistently recorded superior performance across all indicators, suggesting better network optimization and coverage. Airtel showed relatively stable performance with minor deficiencies, while GLO and 9Mobile exhibited higher call drop rates and lower handover success rates, aligning with broader challenges in Nigerian GSM networks such as large data volumes and complex patterns that require knowledge discovery techniques. The ability of the KayusQoS framework to automatically capture, compute and geo-tag Quality of Service metrics confirms its suitability as a low-cost alternative to traditional drive-test systems. By eliminating the need for specialized hardware and manual intervention, KayusQoS enables scalable and frequent monitoring, supporting proactive network optimization and regulatory oversight.

#### 4. Conclusion

This study presented KayusQoS, a mobile-driven software framework for automated Quality of Service data collection and knowledge discovery in Nigerian GSM networks. Using a total of 2,944 call records collected across selected locations in Nasarawa State, the framework was validated through real-world deployment and benchmarking against Nigerian Communications Commission standards. KayusQoS provides a practical, validated, low-cost alternative to traditional drive-test methods. The study recommends that The Nigerian Communications Commission (NCC) can use the developed framework for independent, low-cost QoS monitoring to enforce standards more effectively. Also, worthy of recommending is the high predictive accuracy of the models which demonstrated that the routine drive tests can be supplemented or partially replaced by data-driven forecasting, reducing costs and enabling proactive network optimization

#### References

- Ali, A., Ahmad, I. and Rehman, A. 2022. Data mining applications in telecommunication industry: A review. *Journal of King Saud University - Computer and Information Sciences*, 34(6): 2785–2796. <https://doi.org/10.1016/j.jksuci.2022.03.012>
- Fayyad, U., Piatetsky-Shapiro, G. and Smyth, P. 1996. From data mining to knowledge discovery in databases. *AI Magazine*, 17(3): 37–54. <https://doi.org/10.1609/aimag.v17i3.1230>
- Garg, VK. (2007). *Wireless communications and networking*. Morgan Kaufmann.
- GSMA. 2025. *The mobile economy Sub-Saharan Africa 2025*. GSMA Intelligence. <https://www.gsma.com/mobileeconomy/sub-saharan-africa>
- Han, J., Kamber, M. and Pei, J. 2022. *Data mining: Concepts and techniques (4th ed.)*. Morgan Kaufmann.
- Hevner, AR., March, ST., Park, J. and Ram, S. 2004. Design science in information systems research. *MIS Quarterly*, 28(1): 75–105. <https://doi.org/10.2307/25148625>
- Imran, M., Katranaras, E., Seyedebrahimi, M. and Di-Bernardo, M. 2019. New vertical handover prediction schemes for LTE-WLAN heterogeneous networks. *PLoS ONE*, 14(4): Article e0216964. <https://doi.org/10.1371/journal.pone.0216964>
- Ian, P. 2020. GSM network architecture and elements. *Electronics Notes*. <https://www.electronics-notes.com/articles/connectivity/2g-gsm/network-architecture.php>
- Joseph, A. and Ojo, FK. 2023. Assessment of quality of service in Nigerian GSM networks. *Nigerian Journal of Technology*, 42(1): 45–56.

Mehmood, Y., Khan, A. and Ahmad, F. 2023. A survey of mobile crowdsensing and crowdsourcing strategies for smart mobile communication networks. *Computers & Electrical Engineering*, 106: Article 108578. <https://doi.org/10.1016/j.compeleceng.2023.108578>

Nigerian Communications Commission. 2024. Industry statistics: Subscriber data. <https://www.ncc.gov.ng/stakeholder/statistics-reports/industry-information/subscriber-statistics>

Nigerian Communications Commission. 2025. Quality of Service KPIs and benchmarks. <https://www.ncc.gov.ng/industry/regulations-guidelines/quality-service-qos>

Oughton, E.J. and Frias, Z. 2023. Estimating digital infrastructure investment needs to achieve universal broadband. *IMF Working Papers*, 2023(027). International Monetary Fund. <https://doi.org/10.5089/9798400233623.001>

Ozovehe, A.J. and Usman, A.D. 2015. Performance analysis of GSM networks in Minna metropolis of Nigeria. *Nigerian Journal of Technology*, 34(2): 359–367. <https://doi.org/10.4314/njt.v34i2.21>

Witten, I.H., Frank, E., Hall, M.A. and Pal, C.J. 2017. *Data mining: Practical machine learning tools and techniques* (4th ed.). Morgan Kaufmann.