Data in Brief
Open access
Article template

DATA ARTICLE TEMPLATE V.19 (DECEMBER 2024)

ARTICLE INFORMATION

Article title

Drive-Test-Based LTE Handover Dataset for Cellular Mobility Studies in Urban Bangladesh

Authors

M M Sadman Shafi*, K M Istiaque, Shafayet Sadik Sowad, Mohammad T. Kawser.

Affiliations

Department of Electrical and Electronic Engineering, Islamic University of Technology, Board Bazar, Gazipur 1704, Bangladesh

Corresponding author's email address and Twitter handle

E-mail: sadmanshafi@iut-dhaka.edu

Keywords

mobility management; handover optimization; radio access network; signal quality; LTE measurement data; network performance evaluation; real-world dataset; wireless communication

Abstract

This paper presents a high-resolution Long Term Evolution (LTE) mobility dataset collected through controlled drive testing in a densely deployed urban cellular network. The dataset captures real-world radio conditions, Layer 3 measurement reports, and handover statistics using professional-grade tools, including XCAL-M software and Samsung Exynos-based user equipment. The data collection process involved multiple drive test sessions under varying traffic and mobility conditions, resulting in timestamped records of key radio parameters such as RSRP, RSRQ, CINR, and Cell IDs. The dataset is organized into raw, processed, and supplementary folders containing DRM log files, measurement reports, and event statistics—facilitating transparency, reproducibility, and further research. A preprocessing pipeline was applied to ensure the dataset is machine learning-ready, with focus on cleaning, interpolation, and handover labeling strategies. This publicly available dataset aims to support advanced studies in cellular mobility, network performance analysis, and data-driven handover modeling.

SPECIFICATIONS TABLE

Subject	Electrical Engineering
Specific subject area	Telecommunication, LTE Networks, Wireless Communication, Cellular Communication
Type of data	.csv (raw and processed datasets), .txt (measurement reports, event statistics), .drm (XCAL-M binary log files)

Data collection	Data were collected via structured drive tests conducted in Dhaka, Bangladesh using XCAL-M (Accuver) drive test software, Samsung Galaxy S10 (Exynos), and an Arduino Uno with Neo-7M GPS module. Measurements were recorded during peak evening hours across a 13 km urban route and include Layer 3 signaling events, signal strengths, UE velocity, and handover logs. Preprocessing included cleaning, filtering, interpolation, and time-to-trigger (TTT) handling for ML-readiness.
Data source location	Country: Bangladesh City: Dhaka Route: Le Meridien (Uttara) to BRAC University campus
Data accessibility	Repository name: Mendeley Data Data identification number: 10.17632/n2pvmtyn2j.1 Direct URL to data: https://data.mendeley.com/datasets/n2pvmtyn2j/1
Related research article	None

1. VALUE OF THE DATA

• This dataset is one of the first publicly available LTE mobility datasets collected from real network environments in Bangladesh, where such granular handover-related data has not been documented or shared before. This enhances its value as a novel resource for researchers focused on region-specific network performance and optimization.

• The dataset incorporates User Equipment (UE) speed information alongside RSRP, RSRQ, and neighbor cell parameters, making it suitable for mobility-aware analysis and modeling of handover scenarios. This enables better understanding of handover dynamics under varying velocity conditions, which is critical in vehicular and high-mobility use cases.

• Two separate datasets are being published: one presenting the raw field measurements and the other offering a cleaned, machine learning (ML)-ready version. The processed dataset includes time-aligned interpolation, filtering and handover event handling (e.g., Time to Trigger logic), making it ideal for ML-based prediction and optimization tasks.

• The dataset includes a wide range of diagnostic information such as event triggers, discrete radio measurement reports, and dynamic radio management (DRM) statistics. This structure allows flexible reusability, letting users tailor the dataset to simulate or test mobility management solutions according to their specific needs.

• By making both raw and processed versions available, the dataset supports a full research lifecycle—from baseline analysis and visualization to developing and validating algorithms for handover decision-making, anomaly detection, or QoS optimization.

2. BACKGROUND

This dataset was compiled to improve LTE handover mechanisms in Bangladesh's mobile environments. It supports machine learning models for handover prediction, QoS evaluation, and coverage optimization, addressing the lack of public datasets from the region. It is the first public dataset from a Bangladeshi LTE network, providing timestamped, field-collected measurements of serving and neighbor cell parameters with handover events. Data were collected via drive tests, capturing radio conditions during mobility across geographical zones. Prior studies, like one from Nigeria's Sabon Gari Market, offered LTE insights but lacked handover structuring [1]. An Austrian highway dataset focused on data rates, omitting raw RRC measurements or UE speed [2]. A Nigerian LTE assessment lacked timestamped granularity or machine learning formats [3]. A 2G dataset captured RF parameters but excluded newer metrics [4]. As Bangladesh's first LTE dataset, it includes UE velocity for handover analysis, raw logs with RSRP, RSRQ, and timestamps [5], and a preprocessed machine learning-ready version with interpolated features and TTT handling [6]. It provides high granularity and a broad feature set for LTE mobility research in South Asia.

3. DATA DESCRIPTION

3.1 Dataset Overview

The dataset is structured into multiple directories to support different stages of analysis, from raw signal capture to machine learning-ready formats. Each folder serves a distinct purpose—ranging from unprocessed CSV logs to preprocessed datasets, Layer 3 signaling messages, and original binary logs. This modular organization ensures transparency, reproducibility, and ease of access for researchers seeking to validate or extend LTE handover studies. An overview of the dataset folder structure is provided in **Table 1.**

Table 1.
Overview of Dataset Folder

Folder	**Description**
Parent Dataset	Raw CSVs from drive tests (3 sets)
Processed Dataset	Cleaned, interpolated, ML-ready CSVs
Measurement Reports	Layer 3 logs (per file)
Event Statistics	Handover attempts, outcomes, timestamps
DRM Files	Original .drm logs for full reconstruction

The raw datasets consist of Dataset_1 with 7 files containing 11 columns and a total of 1,480 data points, Dataset_2 with 2 files containing 14 columns and 1,521 data points, and Dataset_3 with 3 files also containing 14 columns and 1,072 data points. After processing, Dataset_1 was reduced to 922 data points while retaining 11 columns, Dataset_2 to 592 data points with 14 columns, and Dataset_3 to 641 data points with 14 columns.

To provide a clearer understanding of the dataset's structure and features, we present both the raw and processed views of the collected data. The column names and target variable used across the datasets are summarized in **Table 2**. The raw data files, collected over three drive test sessions, are described in **Table 3**, which shows the number of columns and total data points across multiple CSV files. The processed dataset, which has been cleaned, filtered, and interpolated for machine learning applications, is presented in **Table 4**. Each processed dataset is available in two versions: version 1 includes preprocessing with a 320 ms time-to-trigger constraint, while version 2 is generated without applying this constraint. The number of handover events observed in parent dataset, total distance traveled, and average distance per handover instance for each day of testing are outlined in **Table 5**.

Table 2.
Dataset Columns

Features	Timestamp
	Longitude
	Latitude
	Speed (km/h)
	Serving Cell ID
	Serving Cell RSRP
	Serving Cell RSRQ
	Serving Cell CINR-1
	Serving Cell CINR-2
	Serving Cell CINR
	Neighbour Cell ID
	Neighbour Cell RSRP
	Neighbour Cell RSRQ
Target Variable	Handover Trigger

Table 3.
Parent Dataset

Dataset Folder	Dataset Names	Number of Columns	Data Points
Dataset_1	File 1	11	132
	File 2	11	320
	File 3	11	74
	File 4	11	46
	File 5	11	243
	File 6	11	11
	File 7	11	654
Dataset_2	File 1	14	723
	File 2	14	798
Dataset_3	File 1	14	160
	File 2	14	339
	File 3	14	573

Table 4.
Processed Dataset

Dataset Names	Number of Columns	Data Points
Dataset_1_ver_1	11	922
Dataset_1_ver_2	11	922
Dataset_2_ver_1	14	592
Dataset_2_ver_2	14	592
Dataset_3_ver_1	14	641
Dataset_3_ver_2	14	641

Table 5.
Handover Instances with respect to travelled distance

Time Period	Handover Count	Total Distance Travelled (km)	Distance Travelled per Handover in meter
Day 1	129	26.21	203
Day 2	95	25.54	268
Day 3	107	27.28	254

Descriptive statistics for each dataset are provided in **Tables 6**, **7**, and **8**, which correspond to Dataset_1, Dataset_2, and Dataset_3, respectively. These statistics include signal strength parameters such as RSRP, RSRQ, and CINR for both serving and neighboring cells, as well as UE speed where applicable. This layered presentation ensures transparency in both the raw collection process and the structured post-processing steps.

Table 6.
Descriptive statistics of Dataset_1

Statistic	Serving Cell RSRP	Serving Cell RSRQ	Serving Cell CINR	NeighCell RSRP	NeighCell RSRQ
Count	922	922	922	922	922
Mean	47.04	12.41	-2.02	45.65	9.25
Std	13.04	7.23	10.81	11.62	7.74
Min	13	0	-30	1	0
Max	78	51	31.5	77	45

Table 7.
Descriptive statistics of Dataset_2

Statistic	Speed (km/h)	Serving Cell RSRP	Serving Cell RSRQ	Serving Cell CINR	NeighCell RSRP	NeighCell RSRQ
Count	592	592	592	592	592	592
Mean	3.33	52.13	11.19	-1.35	50.30	7.79
Std	3.98	9.31	6.05	5.86	9.12	6.03
Min	0	21	0	-15	22	0
Max	14.49	76	24	25	76	24

Table 8.
Descriptive statistics of Dataset_3

Statistic	Speed (km/h)	Serving Cell RSRP	Serving Cell RSRQ	Serving Cell CINR	NeighCell RSRP	NeighCell RSRQ
Count	641	641	641	641	641	641
Mean	23.45	52.19	11.82	-1.06	51.05	7.69
Std	14.61	10.67	7.06	8.31	10.08	6.28
Min	0	19	0	-30	18	0
Max	63	78	31	25	80	46

3.2 Quantitative Analysis of Dataset

To understand the relationships between key signal parameters, correlation matrices were computed for each of the three datasets. These matrices help identify potential linear dependencies between features such as RSRP, RSRQ, CINR, and UE velocity, which are critical for modeling handover decisions. The correlation patterns are visualized in **Fig. 1** for Dataset_1, **Fig. 2** for Dataset_2, and **Fig. 3** for Dataset_3. These visualizations assist in feature selection and preprocessing for machine learning tasks by highlighting strongly correlated or independent variables.

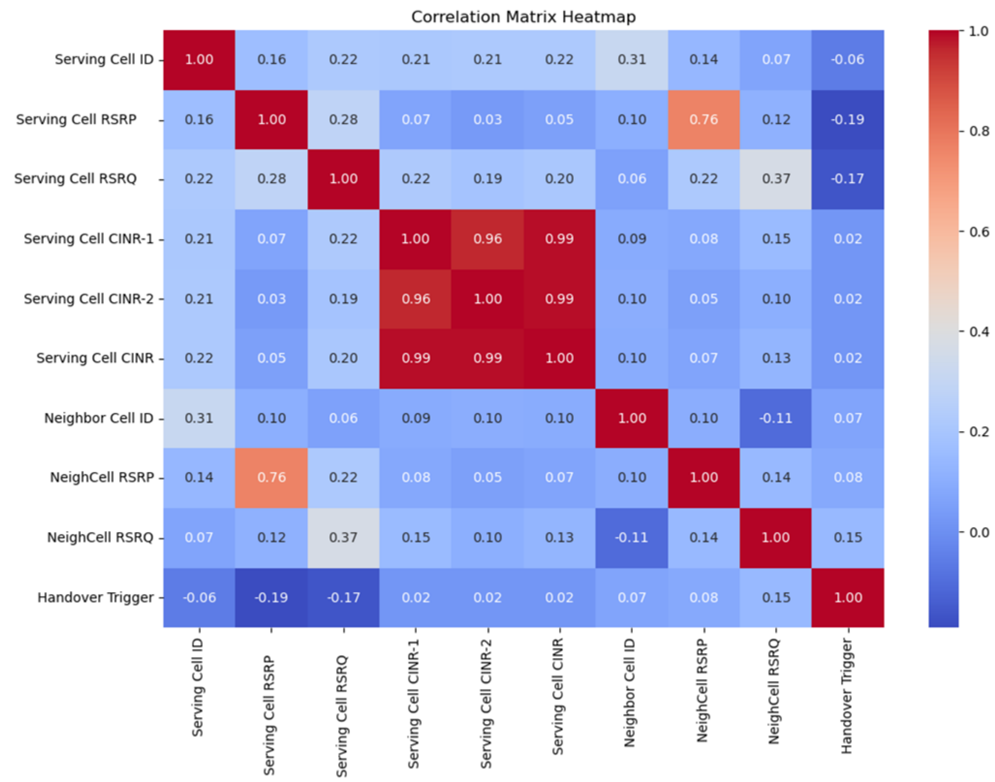


Fig. 1. Correlation Matrix of Dataset_1

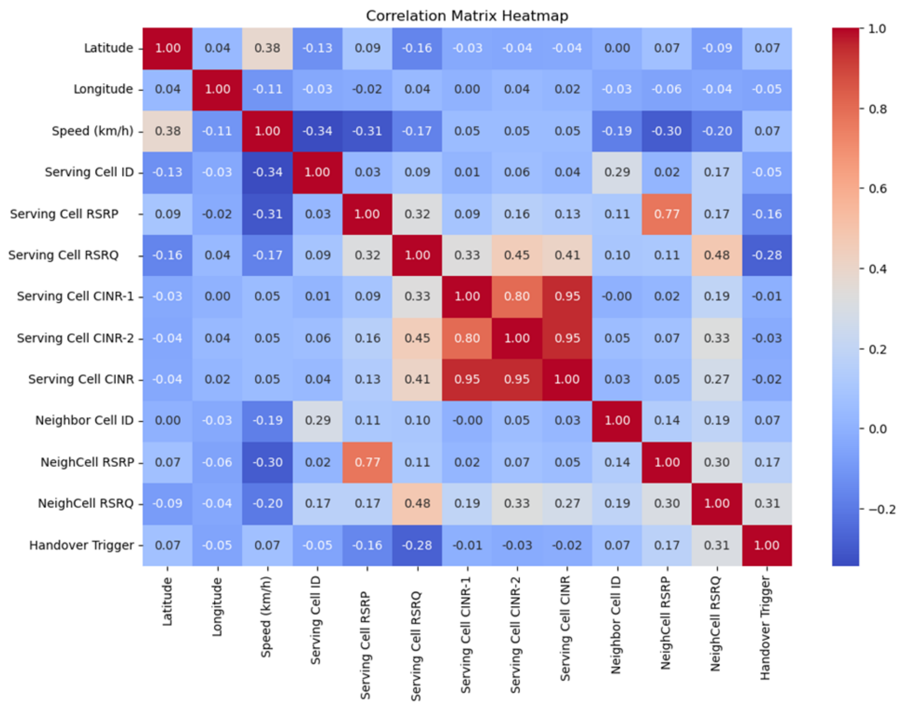


Fig. 2. Correlation Matrix of Dataset_2

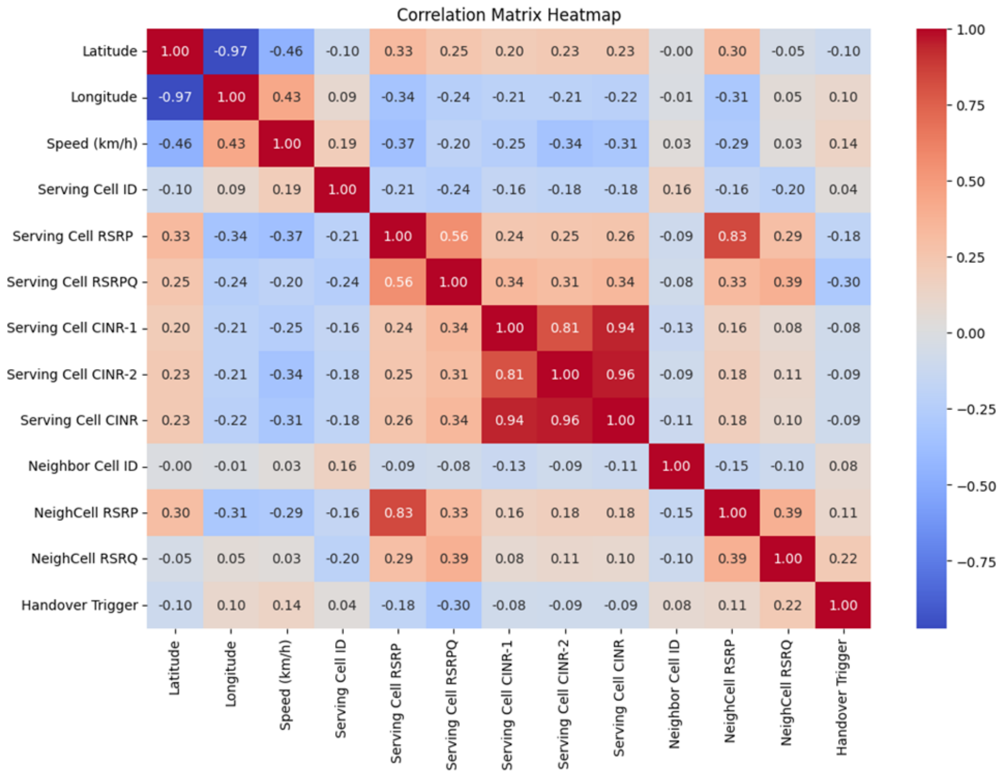
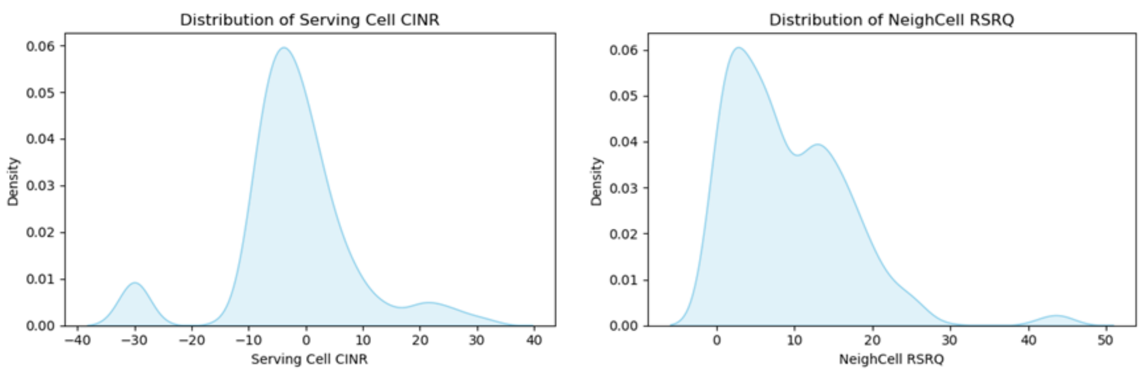


Fig. 3. Correlation Matrix of Dataset_3

Additionally, the overall distribution of key network parameters, including RSRP, RSRQ, CINR, and UE speed in Dataset_1, is visualized in **Fig. 4**, providing insight into the signal environment and mobility conditions under which the data were collected.



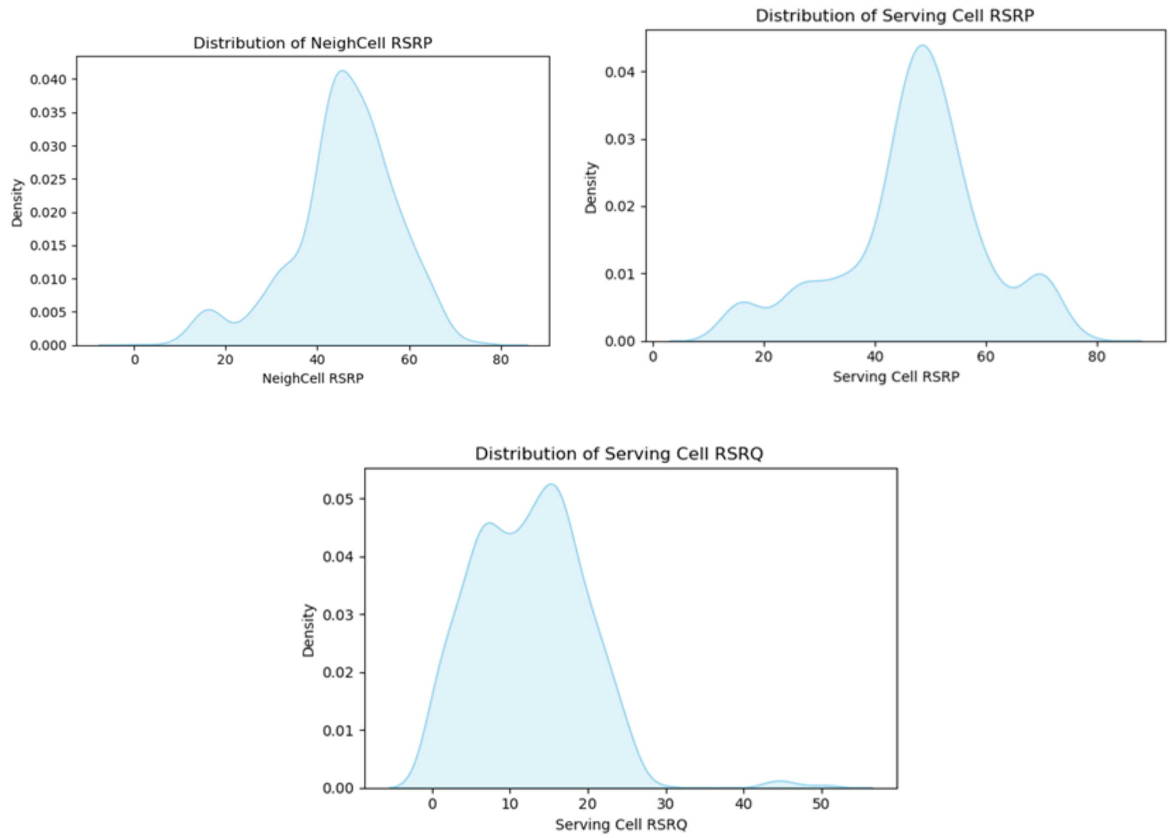


Fig.4. Distribution of network parameters of Dataset_1

LTE Measurement Report Quantization Ranges

In LTE networks, the Reference Signal Received Power (RSRP) and Reference Signal Received Quality (RSRQ) values reported by the User Equipment (UE) are quantized before being sent in measurement reports. These quantized values are represented by integer values according to 3GPP specifications [7].

The tables below illustrate the quantization mappings used for RSRP and RSRQ in the Measurement Reports included in our dataset. Understanding these mappings is essential for interpreting the raw Layer 3 signaling messages (e.g., MeasReport) extracted using XCAL-M software.

In LTE networks, signal quality metrics such as RSRP and RSRQ are quantized before being reported in Layer 3 measurement messages. The integer values assigned to these metrics follow specific mapping schemes defined by 3GPP standards. The quantization mapping for RSRP values is shown in **Table 9**, while the corresponding mapping for RSRQ values is presented in **Table 10**. These mappings are essential for interpreting the raw measurement reports contained in the dataset.

Table 9.
RSRP Quantization Range

RSRP-Range IE Value	RSRP Value
0	RSRP < -140 dBm
1	-140 dBm ≤ RSRP < -139 dBm
2	-139 dBm ≤ RSRP < -138 dBm
3	-138 dBm ≤ RSRP < -137 dBm
...	...
95	-46 dBm ≤ RSRP < -45 dBm
96	-45 dBm ≤ RSRP < -44 dBm
97	-44 dBm ≤ RSRP

Table 10.
RSRQ Quantization Range

RSRQ-Range IE Value	RSRQ Value
0	RSRQ < -19.5 dB
1	-19.5 dB ≤ RSRQ < -19 dB
2	-19 dB ≤ RSRQ < -18.5 dB
3	-18.5 dB ≤ RSRQ < -18 dB
...	...
32	-4 dB ≤ RSRQ < -3.5 dB
33	-3.5 dB ≤ RSRQ < -3 dB
34	-3 dB ≤ RSRQ

4. EXPERIMENTAL DESIGN, MATERIALS AND METHODS

Long Term Evolution (LTE) is a fully packet-switched system comprising the Evolved Packet Core (EPC), eNodeB, and User Equipment (UE), designed under the System Architecture Evolution (SAE) to support seamless mobility and low-latency communication [8]. Together with the Evolved Universal Terrestrial Radio Access Network (EUTRAN), it forms the Evolved Packet System (EPS) [9].

To assess real-world mobility performance, drive tests are categorized as Single Site Verification (SSV), Multiple Site Verification (MSV), or Operator Benchmarking [3]. Our study conducted an MSV drive test as it was performed across a cluster of LTE cells along a 7 km urban route in Dhaka, characterized by frequent inter-cell handovers. The goal was to collect a mobility-aware dataset for machine learning-based handover prediction and optimization, reflecting LTE's focus on efficient mobility within dense urban deployments [10].

This section encompasses details about the drive test location, time period, required equipment, software set up and data extraction methods. The overall drive test setup, including hardware and software components, is illustrated in **Fig. 5**.

4.1 Equipment Used in the Drive Test

- XCAL-M software
- Samsung device with Exynos SoC chipset
- Laptop
- Android-based mobile phone
- Arduino Uno
- Neo-7M GPS module
- Vehicle

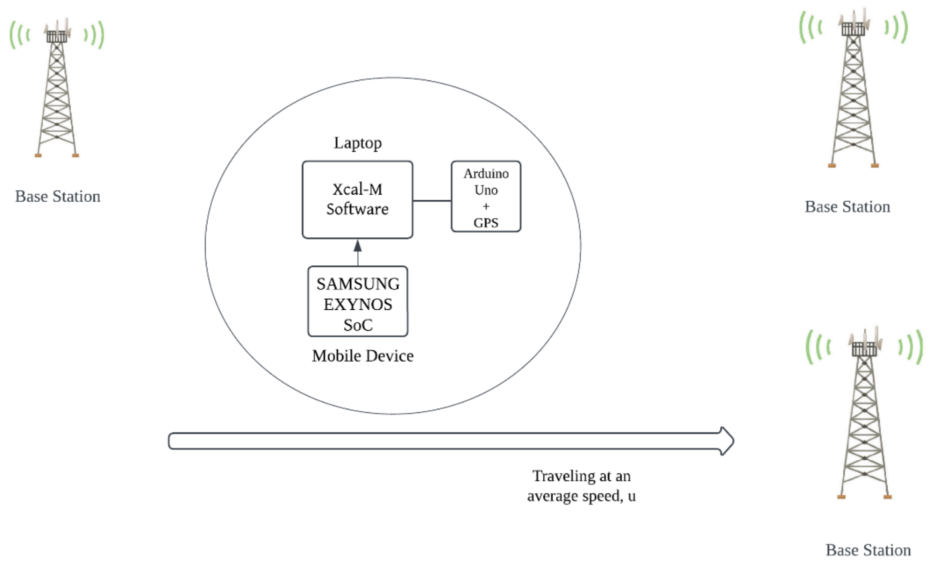


Fig.5. Schematic Diagram of Drive Test

4.2 Location of the Drive Test

To select an appropriate location for the drive test, we utilized the publicly available cell ID database from the **OpenCellID** website, which provides approximate geolocations of cellular base stations. This database includes information for multiple Radio Access Technologies (RATs), namely GSM, UMTS, and LTE. For the purpose of this study, which focuses on LTE handover behavior, we specifically filtered and targeted LTE eNodeBs [11]. We selected a region within Dhaka, Bangladesh characterized by a high density of LTE base stations to ensure frequent inter-cell handover events, which are critical for evaluating handover decision algorithms and mobility management performance.

The drive test route spanned approximately 13 kilometers, beginning at Le Meridien Dhaka (Uttara) and concluding at the BRAC University campus. This route includes variations in user mobility patterns such as stationary periods, pedestrian speeds, and vehicular movement under mixed traffic conditions. The measurements were collected using the Grameenphone LTE network, one of the largest mobile network operators in Bangladesh.

It is important to note that, due to the specific selection of the test area the use of a single Mobile Network Operator (MNO), the results obtained from this drive test may not be fully representative of broader network conditions across the city. Additionally, the findings may not generalize to other network operators with differing infrastructure deployments, frequency bands, or mobility management strategies. The Cell ID mapping from **OpenCellID** and the corresponding drive test route on Google Maps are shown in **Fig. 6**.

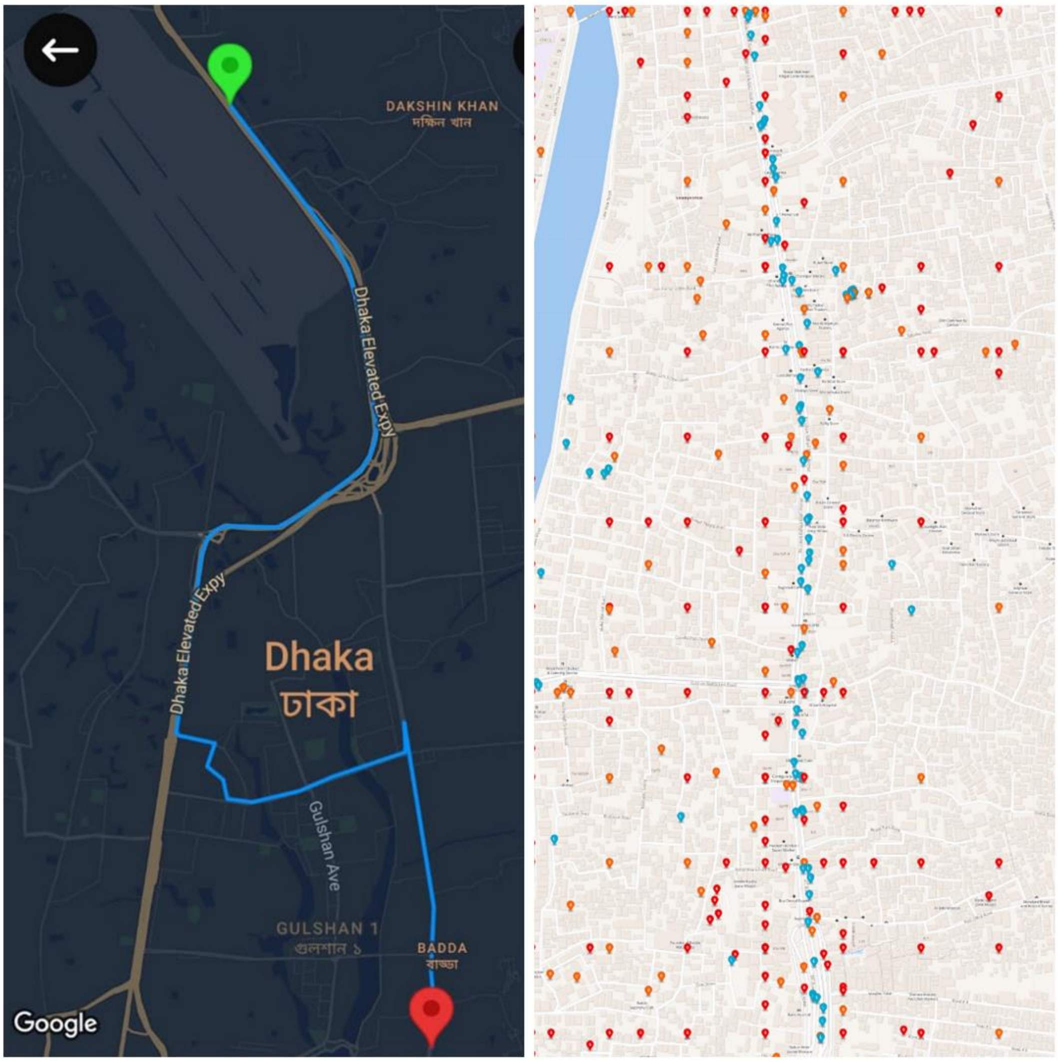


Fig.6. Drive Test Route on Google Maps (Left) and Cell ID Database from OpenCellID (Right).

4.3 Time Period

The drive test was conducted over three separate days: October 15, November 6, and November 16, with measurements recorded during the evening hours between 16:00 and 22:00 (local time). On each day, the test route—spanning from Le Meridien Dhaka (Uttara) to BRAC University and back—was traversed in two complete rounds, with a 30-minute interval between each outbound and return trip. The time window was deliberately chosen to coincide with evening peak hours, a period characterized by high user density and network load, which can significantly influence radio resource management and handover dynamics. The selected route lies in one of the busiest corridors of Dhaka city, commonly subject to vehicular congestion and traffic delays. Such conditions introduced non-uniform mobility patterns (e.g., stop-and-go movement), which in turn affect radio measurements, particularly those related to handover triggering, RSRP fluctuation, and SINR degradation due to prolonged exposure to edge-of-cell conditions.

Traffic-induced delays allowed for denser spatial sampling of radio conditions, especially near cell edges. The short, repeatedly traversed route led to multiple encounters with the same LTE cell IDs under varying conditions, enhancing the dataset's temporal diversity. This redundancy improves the robustness and generalizability of machine learning models for handover prediction.

The network infrastructure in the area remained operationally static during the measurement period; that is, no observable commissioning or decommissioning of LTE eNodeBs took place. Therefore, temporal variations in collected Key Performance Indicators (KPIs) [12] are attributed primarily to changes in user mobility and traffic conditions, rather than alterations in network topology or configuration. The average ambient temperature and relative humidity during the test periods were approximately 29°C and 72%, respectively—values typical of Dhaka's tropical climate in the post-monsoon season.

4.4 Software Set Up

For the execution of the drive test, we employed XCAL-M, a professional-grade drive test software developed by Accuver, installed on a laptop and interfaced with a Samsung Galaxy S10 device powered by the Exynos chipset. This setup enabled the collection of detailed Layer 1 to Layer 3 signaling information, radio frequency (RF) metrics, and protocol-level data essential for in-depth analysis of mobility and handover performance in LTE networks. The mobile device was connected via diagnostic mode to ensure direct access to chipset-level KPIs.

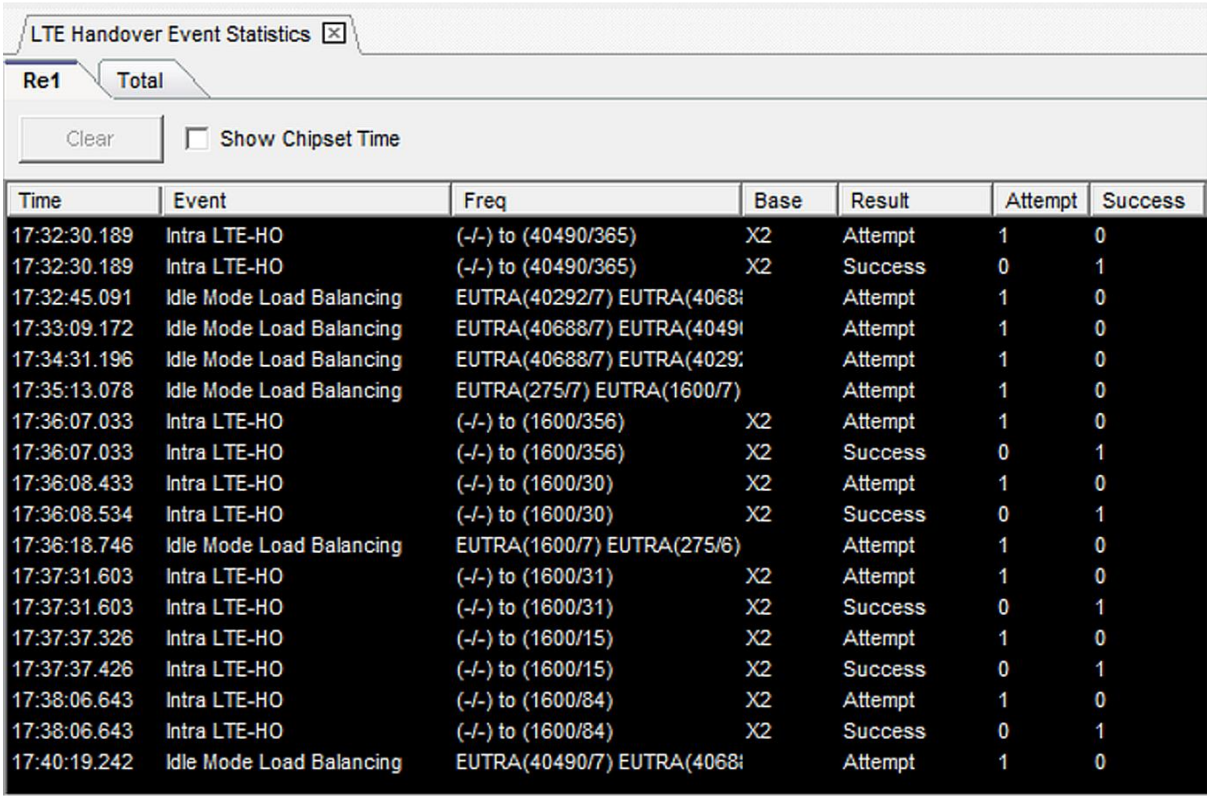
In addition, we integrated an Arduino Uno microcontroller with a Neo-7M GPS module to continuously log the user equipment's geolocation (Latitude and Longitude) and UE velocity. This auxiliary setup ensured accurate tracking of mobility patterns, enabling correlation between user movement and observed network behavior.

Compared to Android-based applications such as G-NetTrack Pro, which typically record measurements at one-second intervals due to OS-level constraints, XCAL-M offers millisecond-level granularity, making it substantially more suitable for fine-grained temporal and spatial analysis of handover events and transient radio conditions [13].

The Samsung S10 device, serving as the user equipment (UE), was placed inside a private test vehicle, and the entire system was configured for real-time data acquisition as the vehicle traversed the defined route. Throughout the drive, XCAL-M continuously captured network performance metrics and handover signaling messages, synchronized with precise GPS coordinates and time stamps.

4.5 Data Extraction from XCAL-M

Following the completion of the drive test, network performance data was extracted using the built-in post-processing capabilities of XCAL-M. To analyze mobility and handover-related events, we navigated to the “Layer3 KPI” module, selected “LTE”, and then accessed the “LTE Handover Event Statistics” window. This interface provided detailed handover metrics, including the number of handover attempts, successful handovers, and corresponding event types along with precise timestamps, enabling temporal correlation with user movement and signal conditions. The statistics are visualized in **Fig. 7**.



Time	Event	Freq	Base	Result	Attempt	Success
17:32:30.189	Intra LTE-HO	(-/-) to (40490/365)	X2	Attempt	1	0
17:32:30.189	Intra LTE-HO	(-/-) to (40490/365)	X2	Success	0	1
17:32:45.091	Idle Mode Load Balancing	EUTRA(40292/7) EUTRA(4068		Attempt	1	0
17:33:09.172	Idle Mode Load Balancing	EUTRA(40688/7) EUTRA(4049		Attempt	1	0
17:34:31.196	Idle Mode Load Balancing	EUTRA(40688/7) EUTRA(4029		Attempt	1	0
17:35:13.078	Idle Mode Load Balancing	EUTRA(275/7) EUTRA(1600/7)		Attempt	1	0
17:36:07.033	Intra LTE-HO	(-/-) to (1600/356)	X2	Attempt	1	0
17:36:07.033	Intra LTE-HO	(-/-) to (1600/356)	X2	Success	0	1
17:36:08.433	Intra LTE-HO	(-/-) to (1600/30)	X2	Attempt	1	0
17:36:08.534	Intra LTE-HO	(-/-) to (1600/30)	X2	Success	0	1
17:36:18.746	Idle Mode Load Balancing	EUTRA(1600/7) EUTRA(275/6)		Attempt	1	0
17:37:31.603	Intra LTE-HO	(-/-) to (1600/31)	X2	Attempt	1	0
17:37:31.603	Intra LTE-HO	(-/-) to (1600/31)	X2	Success	0	1
17:37:37.326	Intra LTE-HO	(-/-) to (1600/15)	X2	Attempt	1	0
17:37:37.426	Intra LTE-HO	(-/-) to (1600/15)	X2	Success	0	1
17:38:06.643	Intra LTE-HO	(-/-) to (1600/84)	X2	Attempt	1	0
17:38:06.643	Intra LTE-HO	(-/-) to (1600/84)	X2	Success	0	1
17:40:19.242	Idle Mode Load Balancing	EUTRA(40490/7) EUTRA(4068		Attempt	1	0

Fig.7. LTE Handover Event Statistics from X-CAL M Software

For extracting information on serving cell parameters, we utilized the “Call Statistics” option, selected the “LTE Summary Table”, and further filtered the data by choosing the “Serving Cell” view. This yielded essential serving cell identifiers, including the Physical Cell ID (PCI) and Carrier-to-Interference-plus-Noise Ratio (CINR). LTE Summary Table is visualized in **Fig. 8**.

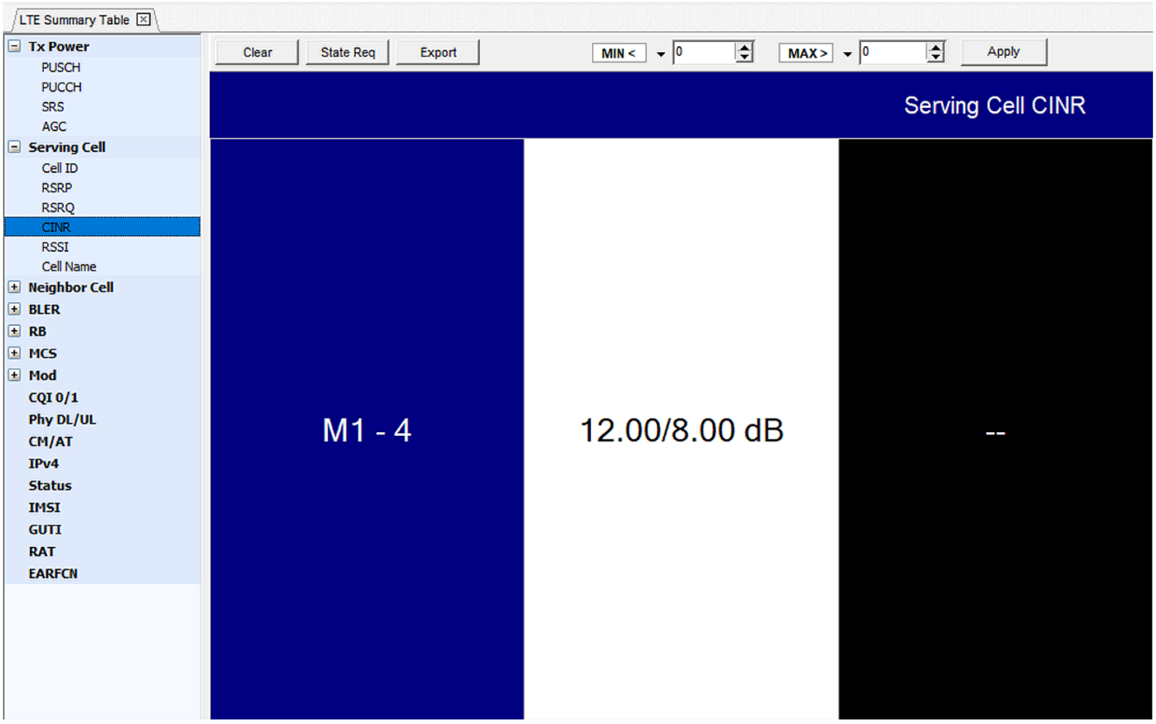


Fig.8. LTE Summary Table from X-CAL M Software

To obtain detailed radio measurement data, we accessed the "Message" tab, selected "Signaling Message", and filtered for "Measurement Report" messages. These messages included Serving Cell RSRP, RSRQ, and corresponding Neighbor Cell RSRP, RSRQ, along with Neighbor Cell IDs, all timestamped for precise temporal alignment. Measurement reports play a crucial role in LTE networks, as they are fundamental to the handover decision-making process, enabling the eNodeB to evaluate surrounding cell conditions and initiate mobility procedures based on preconfigured event thresholds. A visualization of LTE Signaling Message is given in **Fig. 9.**

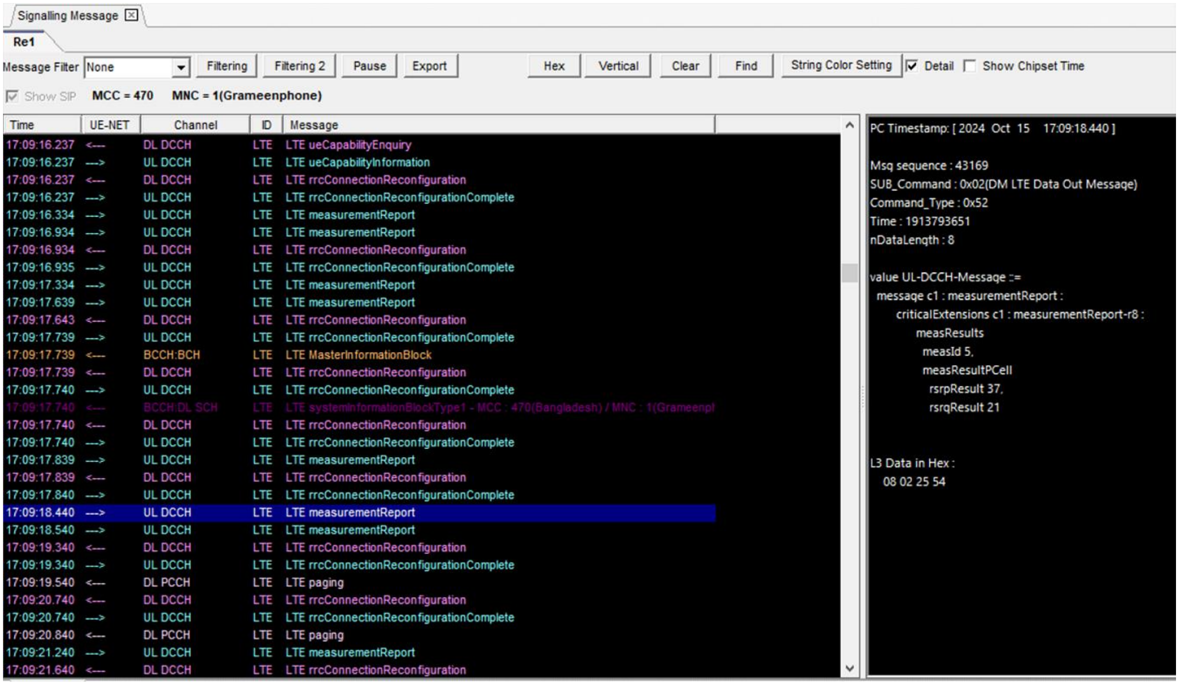


Fig.9. LTE Signaling Message from X-CAL M Software

In LTE, Reference Signal Received Power (RSRP) and Reference Signal Received Quality (RSRQ) are critical physical layer metrics reported by the User Equipment (UE) in Layer 3 Measurement Reports, which are governed by the MeasConfig Information Element (IE). The S-Measure field within MeasConfig defines the RSRP threshold below which the UE initiates neighbor cell measurements. If S-Measure = 0, the UE is configured to perform neighbor measurements continuously, regardless of the serving cell's RSRP level.

RSRP and RSRQ thresholds are quantized using RSRP-Range and RSRQ-Range IEs, respectively. The RSRP-Range IE supports integer values from 0 to 97, each corresponding to a 1 dB interval from below -140 dBm up to and beyond -44 dBm. The RSRQ-Range IE spans 0 to 34, mapping to standard RSRQ intervals. These quantized values appear in the Measurement Report under the signaling messages tab in XCAL-M software.

4.6 Data Preprocessing

The objective of applying machine learning (ML) to the drive test dataset is to model and predict handover decisions based on real-world LTE mobility patterns. In this context, the handover serves as the target variable, while the number of handovers is used as the primary performance metric, with a focus on minimizing unnecessary handovers and ping-pong events [14] through reinforcement learning-based optimization to enhance network stability and efficiency. To prepare the dataset for ML models, a series of preprocessing steps were applied: missing RSRP and RSRQ values were interpolated manually based on serving cell IDs and timestamp continuity, data segments with hardware anomalies were excluded, and all non-LTE measurements were filtered out. Furthermore, the concept of Time-to-Trigger (TTT)—a standardized delay (set as 320 ms in our study) before a handover is executed—was incorporated. While raw handover labels were derived directly from Cell ID transitions in the Event Statistics log, the refined dataset assigns a handover label to those datapoints that contribute to a handover decision within the TTT window, thereby capturing the pre-handover context necessary for accurate model training.

LIMITATIONS

The dataset provides valuable insights into LTE handover behavior in real-world conditions but has several limitations. On the first day, GPS hardware was unavailable, resulting in missing latitude, longitude, and speed data. In later days, GPS data were collected from inside a vehicle, leading to potential positional inaccuracies due to weak satellite reception. Speed measurements, derived from basic GPS modules, were influenced by hardware limitations and frequent traffic congestion, affecting velocity reliability. The dataset also lacks throughput data, which limits analysis of performance during handovers. Additionally, data were collected from a single operator in specific urban and suburban areas of Bangladesh, reducing generalizability. Rare handover types, such as inter-frequency and inter-RAT handovers, are underrepresented due to network configuration and test scope.

ETHICS STATEMENT

The authors confirm that they have read and followed the ethical requirements for publication in Data in Brief. The current work does not involve human subjects, animal experiments, or any data collected from social media platforms.

CRediT AUTHOR STATEMENT

M.M. Sadman Shafi: Conceptualization, Methodology, Software, Formal analysis, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing.
K M Istiaque: Conceptualization, Validation, Resources, Visualization, Data Curation, Writing - Review & Editing.
Shafayet Sadik Sowad: Formal analysis, Software, Validation, Resources, Data Curation.
Mohammad T. Kawser: Supervision, Project administration.

ACKNOWLEDGEMENTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

DECLARATION OF COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the authors used ChatGPT to assist in improving the readability and language of the manuscript. After using this tool, the authors carefully reviewed and edited the content as needed and take full responsibility for the content of the published article.

REFERENCES

[1] S.A. Garba, F.U. Ambursa, Y.S. Baguda, M.A. Shehu, Exploring wireless connectivity and network performance: A dataset of 4G LTE user equipment measurements, *Sci. World J.* 18 (2024) 558–566. https://doi.org/10.4314/swj.v18i4.4.

[2] K. Hamid Bilal, A. Mustafa, A. Mugdam Jaheldeen, A.A. Babiker, N. Mustafa, Handover Drive Test, *Int. J. Eng. Appl. Manag. Sci. Paradigms* 22 (2015).

[3] S.D. Yusuf, S.I. Isa, B.J. Kwaha, Analysis of 4G/LTE Network Performance in North-Central Nigeria: A Comprehensive Drive Test Approach, *J. Eng. Res. Rep.* 26 (2024) 105–122. https://doi.org/10.9734/jerr/2024/v26i91267.

[4] S. Farthofer, M. Herlich, C. Maier, S. Pochaba, J. Lackner, P. Dorfinger, An Open Mobile Communications Drive Test Data Set and its Use for Machine Learning, *IEEE Open J. Commun. Soc.* (2022). https://doi.org/10.1109/OJCOMS.2022.1234567.

[5] F. Afroz, R. Subramanian, R. Heidary, K. Sandrasegaran, S. Ahmed, SINR, RSRP, RSSI and RSRQ Measurements in Long Term Evolution Networks, *Int. J. Wirel. Mob. Netw.* 7 (2015) 113–123. https://doi.org/10.5121/ijwmn.2015.7409.

[6] F.M. Chang, H.L. Wang, S.Y. Hu, S.J. Kao, An efficient handover mechanism by adopting direction prediction and adaptive time-to-trigger in LTE networks, in: B. Murgante, et al. (Eds.), Comput. Sci. Appl. – ICCSA 2013, Lect. Notes Comput. Sci., vol. 7975, Springer, Berlin, Heidelberg, 2013, pp. 226–240. https://doi.org/10.1007/978-3-642-39640-3_20.

[7] ETSI, TS 126 192 V18.0.0, Adaptive Multi-Rate Wideband Plus (AMR-WB+) speech codec; Floating-point speech codec specification, 2023. https://www.etsi.org/deliver/etsi_ts/126100_126199/126192/18.00.00_60/ts_126192v180000p.pdf (accessed 15 July 2025).

[8] NXP Semiconductors, LTE in Public Safety and the Transition to Mission Critical Voice, White Paper, 2017. https://www.nxp.com/docs/en/white-paper/LTEPTCLOVWWP.pdf (accessed 15 July 2025).

[9] Radisys Corporation, Evolved Universal Terrestrial Radio Access (E-UTRAN): A Technical Overview, White Paper, 2012. http://go.radisys.com/rs/radisys/images/paper-lte-eutran.pdf (accessed 15 July 2025).

[10] [10] R. Ahmad, A Comprehensive Study of LTE Handover Performance, Bachelor's Honors Thesis, Pace University, 2014. https://digitalcommons.pace.edu/cgi/viewcontent.cgi?article=1286&context=honorscollege_theses (accessed 15 July 2025).

[11] M. Malekzadeh, F. Rezaiee, Impact of inter-enodeb handover parameters on performance optimization of LTE networks, *Indones. J. Electr. Eng. Comput. Sci.* 9 (2018) 212–220. https://doi.org/10.11591/ijeecs.v9.i1.pp212-220.

[12] Z. Shakir, A.Y. Mjhool, A. Al-Thaedan, A. Al-Sabbagh, R. Alsabah, Key performance indicators analysis for 4G-LTE cellular networks based on real measurements, *Int. J. Inf. Technol. (Singapore)* 15 (2023) 1347–1355. https://doi.org/10.1007/s41870-023-01210-0.

[13] S. Manas Kala, M. Mishra, A. Biju, V. Sathya, T. Amano, T. Higashino, et al., Architecture, Performance, and Usability of Mobile Cellular Network Monitoring Applications for Data-driven Analysis, *IEEE Access*, n.d. https://doi.org/10.1109/ACCESS.2024.DOI.

[14] D. Zidic, T. Mastelic, I. Nizetic Kosovic, M. Cagalj, J. Lorincz, Analyses of ping-pong handovers in real 4G telecommunication networks, *Comput. Netw.* 227 (2023). https://doi.org/10.1016/j.comnet.2023.109699.