

A Comparative Analysis of the Variation of 4G and 5G Signal Strength in Abuja, Nigeria

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Abstract: The aim of this work was to examine a study on the comparative study of the 4G and 5G networks' signal strength variation in Abuja, Nigeria. The research adopted an experimental research method by measuring the 4G and 5G network signal strength in Abuja in a location in the Galadimawa area of Abuja using 4G- and 5G-signal-enabled phones with the Netmonitor signal strength application. The measurement was conducted on three consecutive days, from December 19 to 21, 2025, and from 7:00 am to 6:00 pm. The results show that there was a variation in the signal strength of both the 4G and 5G networks at one point or another on each day throughout the study period, with some variations occurring even hourly, though the signal strength of both the 4G and 5G networks was higher in the morning and evening periods compared to the signal strength in the afternoon on three days. This could be a result of higher atmospheric disturbances in the day as well as increased user density, vehicular movement, and physical obstructions. The results also show that even though the 4G and 5G network signals experienced fluctuations at some points on each of the days, the 5G signal strength in the study area is stronger than the 4G signal strength, which demonstrates the improved performance and reliability of the 5G network within the study area. From the results, it was concluded that 5G network signal strength in Abuja is stronger than 4G network signal strength, though both are being affected by atmospheric conditions and other environmental factors and physical factors. It was recommended that this similar research work be carried out in other cities of Nigeria where the 5G network is currently in use, as was done in Abuja in this research. This study would help network service providers to improve the quality of their network coverage and strength in the future and in other cities.

Keywords: Abuja, Attenuation, 4G, 5G, Noise temperature, Signal fluctuations.

1.0 Introduction

Wireless telecommunications, which is a form of communication technology that enables the use of mobile phones for conveying voice and data signals from one end to another, is significantly contributing to the development of ICT and global sustainable development. These contributions are based on its ease and speed of deployment, reduced disruption to the physical environment, and other factors (Sunday et al., 2020). Telecommunication is the transmission of information of any nature by wire, radio, optical, or electromagnetic systems. A mobile phone is the signal strength received by a mobile phone from a cellular network (on the downlink). Depending on various factors, such as proximity to a tower and any obstructions such as buildings, trees, rocks, etc., this signal strength will vary, as it was observed that despite the availability of different GSM network service providers in Nigeria, many parts of the country still experience poor network service (Sa'adu et al., 2019). Mobile wireless communication in Nigeria has evolved over the years. From the analog-based technology of 1G (first generation) to the digital wireless systems of 2G (second generation), 3G (third generation), and the most recent and current 4G (fourth generation) (Cosmas et al., 2021), we now have 5G already in operation.

The increasing demand for multiple data and high speeds in our world today confirms the important role that modern technology plays in our daily lives. It provides the subscriber with a seamless experience for various applications such as streaming high-quality content and enabling effective remote work, which demonstrates the urgent need to build an advanced and effective communications infrastructure to meet these evolving requirements. Also, the significant surge in broadband data usage and smartphone adoption presents a pivotal factor in advancing mobile network development in recent years. However, with the persistent growth in user numbers, achieving optimization becomes challenging, underscoring the importance of evaluating network performance (Eyceyurt and Josko, 2020 and Mahdi et al., 2024).

The signal throughput, both downlink and uplink, is an important key performance indicator in mobile networks. It represents the speed or rate at which data is transferred between the user's device and the network (DL) or from the user's device to the network (UL). Throughput is an important factor in determining the Quality of Service (QoS) provided to users. Meeting or exceeding expected productivity levels is critical to maintaining high service quality and maintaining subscriber satisfaction (Raida et al., 2018). The work by Rekoputra et al. (2023) examined the performance of the 5G network in the Industry 4.0 Implementation Center (NTUST), focusing on parameters such as network speed, latency, jitter, and packet loss rate. To conduct this analysis, advanced measurement equipment was employed, which allows for up to 100 users in a virtual environment. The study emphasized the importance of the technology used in the wireless network, such as Wi-Fi 6 and Ethernet, for enabling a smart factory environment. Also, Lyczkowski et al. (2020) presented a measurement-based performance comparison between a private Long-Term Evolution (LTE) network and an IEEE 802.11b/g/n network deployed in an automotive factory. But in spite of some related works being done within and outside Nigeria on 4G and 5G networks, the comparative study on the network signal strength in Abuja had not been done; this necessitated this work, taking into consideration the importance of quality network signal to various sectors of Nigeria.

2.0 Brief about 4G and 5G networks

Fourth-generation (4G) wireless is the broadband mobile communication that supersedes 3G (third-generation wireless) and is the predecessor of 5G (fifth-generation wireless). 4G succeeds the third generation (3G) standards and provides ultra-broadband Internet access, which opens the door to high-definition mobile TV, video conferencing, and cloud

computing. 4G users get speeds of up to 100 Mbps, while 3G only promised a peak speed of 14 Mbps. 5G is the fifth generation of cellular technology. 5G is designed to increase speed, reduce latency, and improve the flexibility of wireless services. One important feature of 5G is that 5G networks run on the same radio frequencies as their predecessors, 3G, 4G, and 4G LTE networks, which previously served most mobile. 5G is equipped to handle the requirements of new technologies like next-generation smartphones that need 5G coverage.

2.1 Some differences between 4G and 5G networks are (ITU (2019)):

- i. The latency in 5G networks is around 1-10 ms, which enables real-time applications, such as remote surgery, autonomous vehicles, and smart city infrastructure, whereas 4G networks exhibit latency ranging from around 50-100 ms.
- ii. The 5G network exhibits significantly faster data transfer rates compared to the 4G network, with peak speeds reaching up to 20 Gbps, whereas 4G networks have peak speeds of up to 100 Mbps, with 1 Gbps achievable in ideal conditions.
- iii. 5G networks have a significantly higher capacity, supporting up to 1 million device connections per km², whereas 4G networks are limited to approximately 1000 devices per km², making 5G more suitable for massive IoT deployments, smart cities, and industrial automation.
- iv. The 5G network operates on higher frequency bands, including millimeter wave (mmWave) spectrum in addition to sub-6 GHz frequencies, whereas 4G networks primarily operate on sub-3 GHz frequencies.
- v. The 5G network architecture is designed to be decentralized, leveraging cloud-native and software-defined principles, enabling edge computing, reducing latency, and improving overall network performance. In comparison, 4G networks employ a centralized, IP-based architecture.
- vi. 5G networks incorporate enhanced security features, such as robust encryption and authentication mechanisms, to protect against cyber threats and data breaches, addressing the vulnerabilities and encryption limitations present in 4G networks.

3.0 Research methodology

The materials used for the research work were one 4G signal-enabled smartphone and one 5G signal-enabled smart phone, Netmonitor application, a computer, MS Excel software, and a stopwatch. The experimental setup was made in Galadimawa town of Abuja, and the experiment location remained the same throughout the three-day measurement period of December 19 to December 21, 2025. The research which made use of experimental research method, as the measurement of the 4G and 5G network signal strength was conducted on three consecutive days from December 19 – 21, 2025, and from 7:00 am to 6:00 pm. The analysis of the data was done using Excel software, and the results were represented in tabular and graphical forms. Results interpretations were done based on the tabular presentations and graphical trends of each of the two networks (4G and 5G).

4.0. Results and Discussion

Table 1.0 shows the data of the hourly measurements of 4G and 5G signal strength, recorded in the Galadimawa area of Abuja Municipal Area Council (AMAC), Abuja, over the period of December 19–21, 2025. The results obtained reveal notable variations in signal strength across different times of the day and between the two generations of mobile communication technology. It was observed from the result that the 4G signal strength was higher in the morning and evening compared to the afternoon period. From 7:00 am, the signal strength started decreasing from -103 dBm until around 9:00 am, when it increased a little, and

started oscillating in almost every hour but remained relatively low until 4:00 pm, when it started increasing again from -106 dBm to -105 dBm to -103 dBm at 6:00 pm. In the same way, the signal strength of the 5G network on day 1 displayed a similar trend as the signal strength was higher in the morning and evening when compared with the noon signal strength. It can be observed that the signal strength in the early morning period (7:00 am) was -87 dBm, after which the signal strength started reducing. The signal strength decreased from -87 dBm at 7:00 am to -97 dBm at 8:00 am, then decreased to -96 dBm at 9:00 am, then increased to -93 dBm at 10:00 am. The 5G signal was at its lowest level at 3:00 pm when the signal strength was -103 dBm. In the case of 4G, the signal was weakest at 3:00 pm on day 1. In all, it can be observed from the result that the signal strength of both 4G and 5G network signals experienced variations in almost every hour irrespective of whether it was an upward or downward change. But despite the general variation in the two, during midday and early afternoon, increased human activities and higher subscriber usage are likely to contribute to congestion within the network, leading to signal degradation and reduced quality of service of the 4G signal network. Consequently, users may experience slower data rates, increased latency, and occasional service interruptions during these periods. However, despite this reduction, the 5G signal remains relatively stronger and more stable than its 4G counterpart at all times of measurement. The consistent superiority of 5G signal strength over 4G across all time intervals can be attributed to several technological advancements inherent in fifth-generation mobile networks.

In summary, the results demonstrate that while 4G coverage in Galadimawa, AMAC, is relatively weak and operates near the lower threshold of acceptable service quality, 5G provides noticeably stronger and more reliable signal strength throughout the day. The findings highlight the growing relevance of 5G deployment in urban Abuja as a means of enhancing network capacity, improving user experience, and supporting the increasing demand for high-speed mobile data services.

Table 1: Recorded data of hourly 4G and 5G signal strength in the study area on day 1 (December 19, 2025)

S/N	Time	4G Signal Strength (dBm)	5G Signal Strength (dBm)
1	7:00 am	-103	-87
2	8:00 am	-105	-90
3	9:00 am	-110	-96
4	10:00 am	-101	-93
5	11:00 am	-110	-98
6	12:00pm	-109	-96
7	1:00 pm	-111	-97
8	2:00 pm	-110	-92
9	3:00 pm	-113	-103
10	4:00 pm	-106	-94
11	5:00 pm	-105	-86
12	6:00 pm	-103	-85

Table 2 represents the hourly 4G and 5G signal strength, recorded in the study area within Abuja Municipal Area Council (AMAC) on Day 2 (December 20, 2025) of the experiment. On day 2, the signal strength of 4G and 5G signals also exhibited hourly variations. From 7:00 am, the signal strength of the 4G network changed from -101 dBm to -99 dBm to -104 dBm to -106 dBm to -98 dBm.... In the same way, the signal strength of the 5G changed from -79 dBm at 7:00 am to -78 dBm at 8:00 am to -82 dBm at 9:00 am to -85 dBm at 10:00 am. This means that both 4G and 5G experienced variations or fluctuations irrespective of

the narrow or wider nature of it. Again, it can be seen from the result that the signal strength of both 4G and 5G networks was higher in the evening time when the temperature is low, and the number of disturbances in the atmosphere might be reducing too. In a general view, the 4G signal strength values recorded on Day 2 range from -98 dBm to -106 dBm, indicating a weak but relatively stable signal environment. The strongest 4G signals are observed during the early morning and late evening hours, particularly at 8:00 am, 11:00 am, 5:00 pm, and 6:00 pm, where values approach -98 dBm to -99 dBm. Despite these fluctuations, the variation in 4G signal strength on Day 2 is narrower compared to Day 1, indicating a more consistent network performance throughout the day. For the 5G network, the 5G signal strength measurements on Day 2 range from -73 dBm to -92 dBm, reflecting moderate to strong signal conditions across most of the observation period. The strongest 5G signals are recorded in the early morning and early evening, particularly at 8:00 am (-78 dBm) and 6:00 pm (-73 dBm), indicating excellent reception quality during these periods. The weakest 5G signal (-92 dBm) occurs around 1:00 pm, coinciding with peak daytime activity.

Table 2: Recorded data of hourly 4G and 5G signal strength in the study area on day 2 (December 20, 2025)

S/N	Time	4G Signal Strength (dBm)	5G Signal Strength (dBm)
1	7:00 am	-101	-79
2	8:00 am	-99	-78
3	9:00 am	-104	-82
4	10:00 am	-106	-85
5	11:00 am	-98	-91
6	12:00pm	-100	-90
7	1:00 pm	-102	-92
8	2:00 pm	-103	-81
9	3:00 pm	-102	-83
10	4:00 pm	-101	-82
11	5:00 pm	-99	-82
12	6:00 pm	-98	-73

Table 3 represents the hourly measurements of 4G and 5G signal strength, recorded on Day 3 (December 21, 2025). Just like on Day 1 and Day 2, the 4G network signal strength experienced an hourly variation at some points while remaining stable at some points. The signal strength was -106 dBm at 7:00 am and then decreased to -110 dBm at 8:00 am and 9:00 am and then experienced an improvement at 10:00 am when the signal became -103 dBm, and after this began to decrease again at 11:00 am and 12:00 pm, and it continues. In the same way, 5G signal strength experienced variations or fluctuations almost hourly, just like the 4G network. But irrespective of the nature of the change, it is observed that the signal strength received by the 5G network users was better in the morning and evening and lower in the noon period.

Simply put, the 4G signal strength recorded on Day 3 ranges from -103 dBm to -113 dBm, reflecting weak to very weak coverage conditions throughout most of the day. The weakest 4G signal (-113 dBm) occurs at 12:00 pm, indicating significant signal attenuation during the midday period. Several other low values, particularly -110 dBm, are observed during the morning and early afternoon hours, suggesting persistent challenges in maintaining reliable 4G coverage in the study area. This pattern implies that network congestion and environmental interference during peak activity hours may substantially affect 4G

performance. In comparison, the 5G signal strength values on Day 3 range from -85 dBm to -105 dBm, indicating generally moderate signal quality with noticeable temporal variation. The strongest 5G signals are observed during the early morning and evening periods, particularly at 7:00 am and 6:00 pm, where values of approximately -85 dBm are recorded. The weakest 5G signal (-105 dBm) occurs at 3:00 pm, coinciding with the period of highest daytime activity and network usage. Despite this decline, 5G signal strength remains comparable to or stronger than 4G at most time intervals, underscoring its relative robustness.

Table 3: Recorded data of hourly 4G and 5G signal strength in the study area on day 3 (December 21, 2025)

S/N	Time	4G Signal Strength (dBm)	5G Signal Strength (dBm)
1	7:00 am	-106	-85
2	8:00 am	-110	-88
3	9:00 am	-110	-94
4	10:00 am	-103	-98
5	11:00 am	-110	-101
6	12:00pm	-113	-98
7	1:00 pm	-107	-99
8	2:00 pm	-107	-86
9	3:00 pm	-109	-105
10	4:00 pm	-107	-87
11	5:00 pm	-105	-87
12	6:00 pm	-104	-85

Figure 1 shows the hourly variation of 4G signal strength measured over three consecutive days in the study area within Abuja. The graph presents signal strength values against time from 7:00 am to 6:00 pm, enabling a comparative assessment of temporal trends and day-to-day consistency in 4G network performance. Across the three days (December 19–21, 2025), the graph shows a declining trend in signal strength from the early morning towards midday and early afternoon, followed by a gradual improvement during the late afternoon and evening hours. The weakest signal levels are generally observed between 11:00 am and 3:00 am, a period typically associated with increased network usage, higher human activity, high temperature (which can increase noise signal), overheating of devices, and greater environmental interference in urban settings. This trend suggests that network congestion and signal attenuation are more pronounced during peak hours, leading to reduced 4G performance. A comparison among the three days reveals that Day 2 exhibits relatively stronger and more stable 4G signal strength compared to Days 1 and 3, as shown in the line graph of Day 2 signal strength. The fluctuations on Day 2 are less severe, indicating more consistent network conditions. In contrast, Day 3 shows the greatest level of signal degradation, with several measurements falling below -110 dBm, particularly around midday. This may be attributed to variations in atmospheric conditions, user density, or temporary network load changes during the measurement period. Overall, Figure 1 highlights the temporal variability and limited robustness of the 4G network in the study area. The weak signal levels experienced across all three days, though not always, suggest the need for network optimization and the deployment of more advanced technologies to enhance coverage, quality of service, and capacity in urban environments like Abuja.

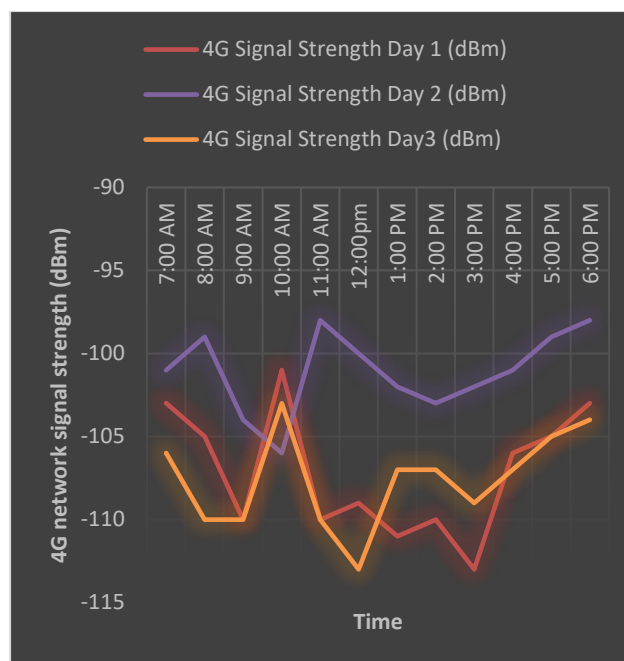


Fig. 1: Graphical representation of hourly 4G signal strength on the three days

Figure 2 shows the hourly variation of 5G network signal strength measured over three consecutive days. Abuja from December 19–21, 2025. The graph depicts signal strength values plotted against time from 7:00 am to 6:00 pm daily. The graph shows that there was a variation in the three days' signal strength, in which relatively stronger signals were recorded during the early morning and evening periods, and weaker signals occurred around the afternoon period. It was also observed that the period between 12:00 pm and 3:00 pm consistently shows a reduction in signal strength across all three days. This noon period is the peak activity period in urban environments, where increased user density, vehicular movement, and physical obstructions contribute to higher signal attenuation and network load in addition to increased noise temperature and higher speed of particles in the atmosphere due to increased kinetic energy as a result of increased atmospheric temperature. Nevertheless, even during these peak periods or at noon on the days of the experiment, the 5G signal remains within acceptable operational limits, indicating superior capacity handling compared to earlier-generation networks.

Comparing the 5G signal strength in the three days, the analysis reveals that Day shows the strongest and most stable 5G signal performance, with higher signal levels and fewer fluctuations throughout the day. Also, the signal strength on Day 1 shows moderate variability, while the signal strength on Day 2 displayed a pronounced or highly noticeable signal degradation, especially during the mid-afternoon period. These differences on various days in the study period could be as a result of variations in atmospheric conditions, localised interference, or transient changes in network configuration and user behavior of the network. In all, it can be observed that 5G network deployment in Abuja is playing a critical role in enhancing network performance, supporting high data rate services, and meeting the growing communication demands of urban areas.

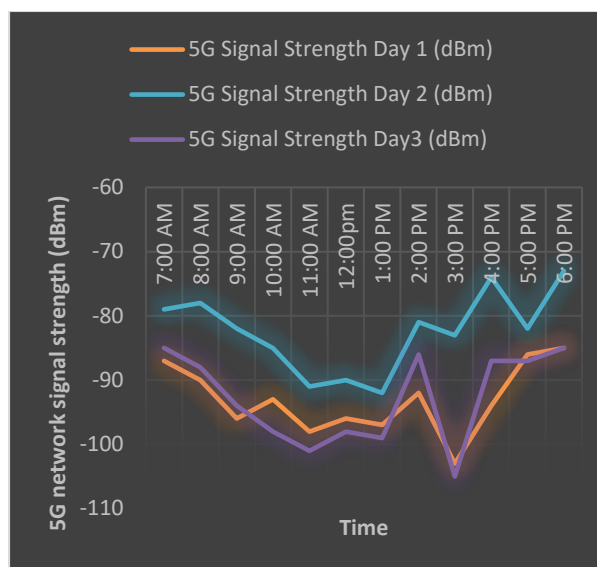


Fig. 2: Graphical representation of hourly 5G signal strength on the three days

In addition, though both 4G and 5G network signals in this study location throughout the study period exhibit variations between the morning, afternoon, and evening, and sometimes hourly, which indicates that the signal reception from both networks by the users is not stable but affected by various factors, especially atmospheric components, the overall observation from the figures (fig. 1 and 2) is that 5G network signal strength remains consistently stronger than 4G network signal strength throughout the study period of three days, with most values falling within the moderate to good signal range. This demonstrates the improved performance and reliability of the 5G network within the study area. However, in spite of this general strongness in the 5G strength, noticeable temporal variations were observed, which highlights the influence of daily network usage patterns and atmospheric factors on 5G signal propagation.

5.0 Conclusion

The analysis of the study on the comparative analysis of the 4G and 5G networks' signal strength variation in Abuja, Nigeria, has been done. The research made use of an experimental research method, which involved the measurement of the 4G and 5G network signal strength in the area, thus making the data used in this work primary data. The result of the three days of experimental work shows that there was a variation in the signal strength of both the 4G and 5G networks at one point or another on each day throughout the study period, with some occurring even hourly. The results also showed that the signal strength of both 4G and 5G networks was higher in the morning and evening compared to the signal strength in the afternoon on three days. This could be a result of higher atmospheric disturbances in the day as well as increased user density, vehicular movement, and physical obstructions. Further analysis revealed that even though the 4G and 5G network signals experienced fluctuations at some points on each of the days, the 5G signal strength in the study area is stronger than the 4G signal strength. This demonstrates the improved performance and reliability of the 5G network within the study area. From the results, it can be concluded that 5G network signal strength in Abuja, the study area, is stronger than 4G network signal, though both are being affected by atmospheric conditions and other environmental factors and physical factors leading to the signal fluctuations at some points of the day. This study would help network service providers to improve the quality of their network coverage and strength in the future and in other cities.

6.0 Recommendation

This research work was carried out in Abuja, north-central Nigeria. We recommend that similar research work be done in other cities of Nigeria where the 5G network is currently in use.

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