Campus Quality of Services Analysis of Mobile Wireless Communications Network Signal among Providers in Malaysia

Murizah Kassim[1], Zulfadhli Hisam[2], Mohd Nazri Ismail[3]
Institute for Big Data Analytics and Artificial Intelligence (IBDAAI)Universiti Teknologi MARA
40450 Shah Alam, Selangor, Malaysia[1]
School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia[1, 2]
Faculty of Science and Defence Technology, National Defence University of Malaysia, Kuala Lumpur, Malaysia[3]

***Abstract*—Wireless communication is very important in this generation where todays 5G internet connection is still unconfirmed and 4G communication is still needed. Network in Malaysia has been supported by many telecommunication companies and the Quality of Services is still poor supported especially in the campus area. This research presents a performance analysis of Quality of Services for 4G wireless Communication among Providers supported in a campus area in Malaysia. A 4G Nemo Outdoor wireless analyzer was used to collect the Reference Signal Received Power (RSRP) signal data based on the identified campus road maps. Digi and U-Mobile Network was identified and compared as two telecommunications providers in the testing. The identified road maps were analyzed along the routes while testing signals are collected while driving. It is identified that Digi supports better for the Mobile broadband network which shows an excellent of 1% and good connections of 29 % and 0% signal loss in the drive areas. RSRP signal for U-Mobile shows there is 8% signal loss and the connections provided only at the Mid-Cell for 43% and Cell Edge connections for 48%. This concludes that the 4G signal strength in the campus area having average signal strength, but some medium signal strength is also identified based on the road locations. This research is significant for QoS of supports mobile network in a campus area.**

***Keywords*—Quality of services; 4G/LTE; mobile network; wireless communication; RSRP; campus network**

I. Introduction

Wireless communications have enabled the connection of billions of people to the Internet which they benefit from today's digital economy. A mobile phone is one of today's wireless communication devices where it allows people to use their devices and communicate everywhere in the world. It is identified that every sector of the economy now relies upon wireless technologies such as in banking, agriculture, transportation, healthcare, education, and many more [1]. Todays, the development of 4G to 6G services, mobile network, high-speed data, wireless sensor network and broadband services have become the most important sources of mobile communications operation services [2, 3]. Population changes using mobile phone data has been investigates and the social networking sites use and college students' academic performance on testing for an inverted U-shaped relationship using automated mobile app usage data also has been analyzed[4]. 5G is a robust wireless communications networks but 5G is still in the stage of testing in Malaysia. Performance Analysis of Mobile Broadband Networks with 5G Trends and planning of antenna for future 5g energy harvesting in Malaysia has been done[5, 6]. Many applications and systems today like artificial intelligence and the Internet of Things need higher bandwidth to achieve QoS in communications either in wireless broadband or wireless sensor network [7, 8]. The advantage of using the wireless network is the costing is inexpensive compared to a wired network. A wireless network is using Radio Frequency (RF) for transmitting and receiving data by using the wave. The internet can be achieved on two platforms which are connections through coverage mobile data plan subscribed to the telecommunication by using the smartphone. Secondly are the broadband connections devices for the installation of network in a most permanent building. The problem of mobile data for broadband providers needs updates checking for QoS. Some connections are identified as loss and slow. Thus, identify routes or areas of the supported broadband needs manually testing by using certain software to inspect all places without the reference map of routes. The other problems of data transmissions are noise.

This research described the performance analysis that has been done for QoS for 4G Wireless Communication among Providers which was tested in a campus area. A Nemo Outdoor tools and software has been used as the platform to analyze the transmission data 4G while driving test along the identified route maps in a campus network is identified for data collections. The Reference Signal Received Power (RSRP) performance of the 4G signal strength is presented to show the QoS for both providers in supporting coverage in the campus network.

II. Related Work

There are many types of performance analysis of the wireless network of 4G. Multiple-input and multiple-output (MIMO) is one technique for performance analysis for 4G Wireless. One research has presented that MIMO and orthogonal frequency division multiplexing (OFDM) were used for supported high data rate and high performance in different channel conditions [9]. Many methods have shown the use of different applications of voice and data connection

in the 4G wireless network. 4G analysis performance also used MADM algorithms which are integrated into three types of network situations. The network is WLAN, UMTS, and WiMAX [10]. Some references identified that the performance analysis for 4G wireless communication had three possible architecture types which are multimode devices, overlay networks, overlay networks, and common access protocol. The multimode device can access services in a different wireless network. The multimode device can improve call and expand effective coverage areas [11]. Conventional mobility management schemes tend to hit the core network with increased signaling load when the cell size is shrinking and the user mobility speed increases. A survey has been done for the idle mode mobility management and then proposes a new architecture, namely predictive mobility management (PrMM) to mitigate the identified challenges [12]. Malaysia has many telecommunications providers' services for wireless communication such as 4G/LTE. The famous providers in Malaysia are Celcom, Digi, Maxis, U-Mobile, and many more. These providers are much designated for the wireless network for the 4G services. 4G services are identified as the promise of a higher platform of a wireless network in the world although 5G has been implemented not all countries are ready and supported on the platform [13]. The fourth generation was upgraded from the three-generation 3G network. The different and the important of upgrading from the 3G to 4G network are the specifications on the coverage of speed and the costing to the consumers. The Table I shows the DIGI data features and Table II shows the U-Mobile data features on the download speed, upload speed, and latency between 3G and 4G of Digi and U-MOBILE network [14].

The keys of the 4G infrastructures are accessing information connected to a wide range of information and services, and receiving a large volume of information, data, pictures, voice, and video [15]. 4G is using the Orthogonal Frequency Division Multiplexing (OFDM) [16]. Besides, the advantages of using the 4G have advantages of supporting a higher speed that can reach up to 100Mbps. Using 4G with higher speed can do many things such as playing online games, watching high-definition video streaming, VOIP and can get interactive TV [17, 18]. The 4G there have 5 important ways and factors of making the 4G are Orthogonal Frequency Division Multiplexing (OFDM), Mobile WiMAX, Ultra Mobile Broadband (UMB), multiple-input multiple-output (MIMO), and Long-Term Evolution (LTE) [19]. It is mentioned that Mobile broadband (MBB) is one of the critical goals in fifth generation (5G) networks due to rising data demand. MBB provides very high-speed internet access with seamless connections. Existing MBB, including third-generation (3G) and fourth-generation (4G) networks, also requires monitoring to ensure good network performance [20]. Fig. 1 shows the Long-term Evolution or LTE are the norm for mobile device wireless broadband and Global Mobile Communication System (GSM) information terminals. Using LTE can improve the information network's ability and speed focus applied in Malaysia[21]. Using LTE can enhance the capacity and speed of the data network. LTE characteristic are the bandwidths are can improve from 1.4 MHz until 20 MHz, LTE also supports the frequency division duplexing (FDD) and the time division duplexing (TDD)[18]. Additionally, the LTE can support the voice and data to the cell towers with older network technology such as CDMA2 2000 that are family of 3G mobile technology that can be sending voice, data, and signaling data besides mobile phone and cell sites [22].

TABLE I. DIGI DATA FEATURES

Feature	3G	4G
Download speed (Mb/s)	1.4	7.7
Upload speed (Mb/s)	0.3	3.4
Latency (ms)	657	45

TABLE II. U-MOBILE DATA FEATURES

Feature	3G	4G
Download speed (Mb/s)	1.7	13.3
Upload speed (Mb/s)	0.4	3.4
Latency (ms)	630	31

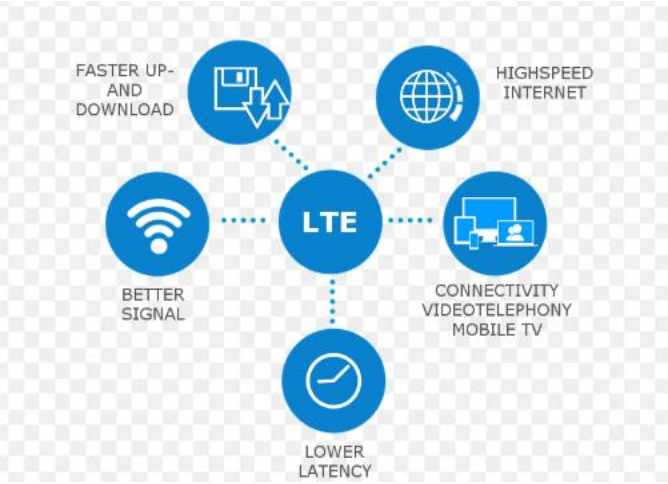

Fig. 1. Network Concept of Long-Term Evolution (LTE).

III. PROPOSED METHOD

A. Research Flow

Fig. 2 shows the research flowchart of the process. There are a few steps that need to follow in collecting the data by using the Nemo Outdoor

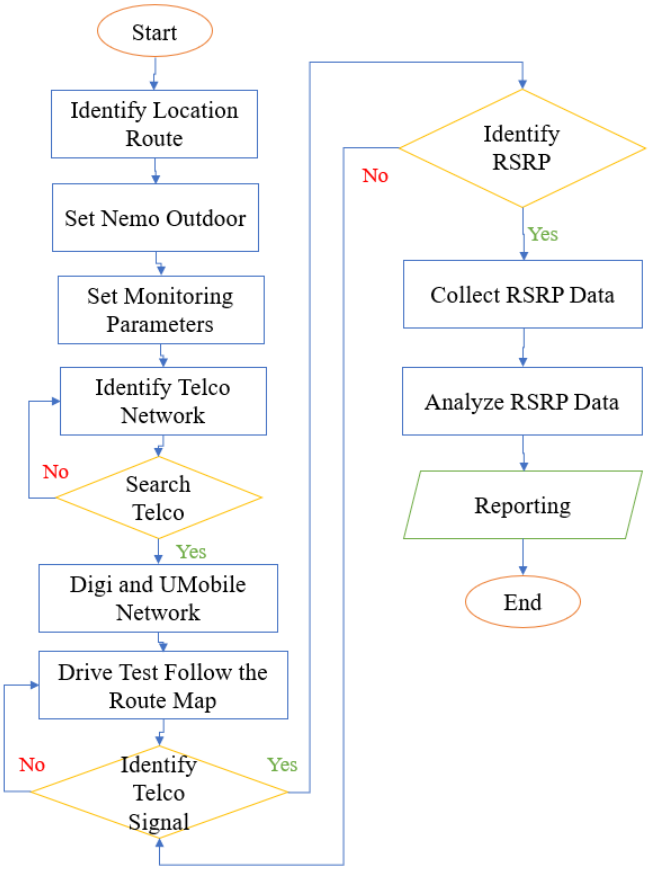

Fig. 2. Research Flowchart.

First, the task of checking or selecting the type of telecommunication network that can be identified around the campus area in Shah Alam is defined. Digi and U-Mobile were chosen based on the pre-trial where both signals gave the highest output in the communications signal. Next, the Nemo outdoor device and software is set for mapping signal is configured. After the configurations are justified and pretesting, the Nemo outdoor devices are to be ON while driving test followed by the route maps was tested. Data collections on the signal strength from Digi and U-Mobile have been set according to its frequencies on the Nemo Outdoor device. IF there are errors occurred then the driving test must be done again until the signal is collected successfully. During the drive test process, the data collection on the signal must be in real-time captured smoothly by time. Lastly, the result of the data collections is smoothly continued to be extracted from the Nemo software. Data is analyzed based on the defined wanted graph.

B. Campus Route Map

The location of the route maps is defined to search for the RSRP Signal strength where setting is to be done on the Nemo outdoor. The Nemo Outdoor software then will open the maps to know the location of selected area for signal data collection. A Campus area has been selected which analysis on the data is important to present the reliability for students' connections in the campus who subscribed to the mobile data plan.

1) Nemo monitoring tools: The process of collecting the data is by drive testing which driver needs to ride the vehicle by following or marking the maps to get the data network signal and strength for RSRP. RSRP can be identified on the Long-Term Evolution (LTE) and 4G network. The admin for the data collector needs to insert a type of SIM card networks such as Digi or U-mobile into the smartphone of the Nemo Outdoor. This process is easier for data collection for each type of network, and it is read from the smartphone. Next, after the Handy Nemo software is activated from the admin or driver smartphone who drives the car according to routes of the campus map. The route of the campus maps also is mapping to the Nemo software. However, the route also can be created by the driver while driving the car. Table III shows the parameters for the used Nemo Outdoor analyzer.

TABLE III. DESCRIPTION OF NEMO OUTDOOR DEVICES

Type of Devices	Description
Laptop	• To open the software of the Nemo Outdoor • To extract or transfer the data collect from the smartphone (Handy Nemo software)
Smartphone	• Known as Handy Nemo devices in collecting the data network
Dongle (Outdoor Measurement)	• The license to open the software of Nemo Outdoor • To measure the measurement collection data
Dongle (Outdoor Playback)	• The license to open the software of Nemo Outdoor • To measure the data playback of the route

Fig. 3 shows the handy Nemo Outdoor software with a specified setting and Fig. 4 shows the identified maps for data collections on the Digi network and U-mobile 4G network signals which have been linked to the laptop interface platform. Fig. 5 shows the Nemo Outdoor playback and measurement for the data signal collections.

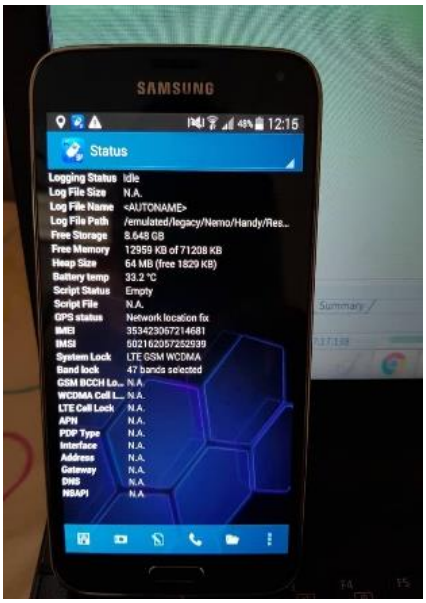

Fig. 3. Handy Nemo Software.

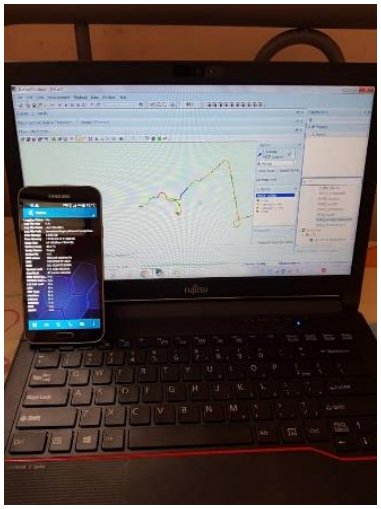

Fig. 4. Interface of Maps to PC or Mobile.

Fig. 5. Outdoor Playback & Measurement.

2) Digi and U-Mobile network: The Digi and U-Mobile network has been identified for analysis based on the best pretesting signals achieved compared to the other providers. The references for checking the quality and strength of the 4G network have been established. The performance analysis has measured the RSRP for both Digi and U-Mobile network. RSRP is the average Resource Elements (RE) power that carries cell-specific Reference Signals (RS) across the whole bandwidth. Thus, RSRP is measured only in the RS symbols. RSRP is the average of one RS resource element received. Fig. 6 and Fig. 7 shows the driving test followed the route of maps of in the campus area for both networks.

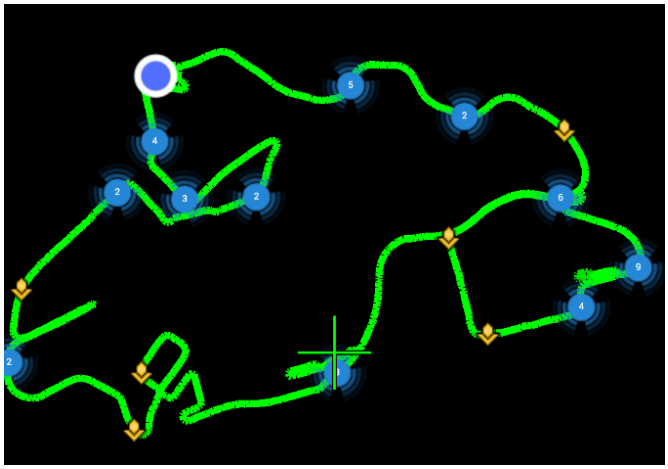

Fig. 6. Digi 4G Network Map.

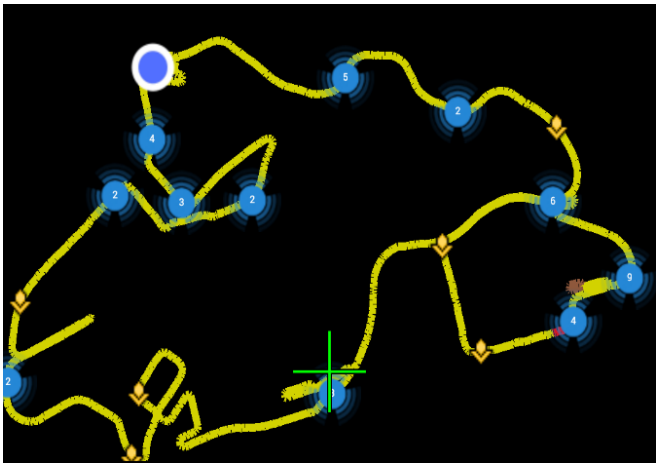

Fig. 7. U-Mobile 4G Network Map.

The Handy Nemo Outdoor has collected the data of each sector in the campus area in Shah Alam by following the routes map. The reading data on strength of the signal by the 4G network of Digi and U-Mobile are collected. The person in charge or driver needs to understand the condition of strength RSRP either it is Excellent, Good, Mid Cell, and Cell Edge while driving. Table IV shows the RF condition for the 4G signal strength. Additional quality can be measure by Reference Signal Received Quality (*RSRQ)*, but it is not measured in this research.

TABLE IV. RADIO FREQUENCY (RF) CONDITION 4G SIGNAL STRENGTH

RF Condition	RSRP (dBm)	RSRQ (dB)
Excellent	>= -80	>= -10
Good	-80 to -90	-10 to -15
Mid Cell/ Medium	-90 to -100	-15 to -20
Cell Edge	<= -100	< -20

3) LTE signals strength: RSRP is the average power received from a single Reference signal, and its typical range is around -44dbm (good) until -140dbm (bad) and the RSRQ is indicating the quality of the received signal, and its range is typical -19.5dB (bad) to -3dB (good).

- Identification of providers Signal

The identification of providers signal has been tested by using the Nemo Outdoor Software. This process needs to be done separately where the providers' signals will automatically be identified by the Nemo software. If the signals are undefined in the area the system will record as No Signal. Along the way while driving testing if the signal is changing the providers the system will record as Change Cells of network identification.

- RSRP Signal Strength

Nemo Outdoor Software is a multifunction for taking any data on wireless communication. The RSRP signal strength of the 4G network has been collected when the process identifies the provider's signal. The person in charge of the driving test needs to identify the signal strength of RSRP data collection. Some instructions must be followed to ensure the collection data signal strength of RSRP.

4) Data Collection RSRP: Two approaches can be done in collecting the data signals. First is the signal data can be request from the Research and Development team of each provider, but normallly this approach is hard where data is confidential for outsiders. The second approach is where researchers must collect themselves the data based on the targetted area. Thus, Nemo Outdoor device and software is one of the most usable devices for data collections. Nemo outdoor provided data collections for RSRP strength of the 4G network. Few steps to be followed by the Nemo outdoor users for data collections in order the signal to be collected correctly without failed for data analyzing. The steps of setting up Nemo needs to be explored more where connections to the end devices like smartphone, laptop, and dongle of Nemo's license must be correct and properly running.

The research gaps have been identified such as the Performance, Speed, Frequency of 4G Network and RSRP Signal strength has been compared and identified in analyzing the performance of Campus Quality of Services Analysis of Mobile Wireless Communications Network Signal among Providers in Malaysia.

IV. Result and Analysis

A. RSRP Signal Strength

Fig. 8 and Fig. 9 show the data collection of Digi 4G Network and U-mobile 4G Network strength which is the RSRP signal for about an hour. The graph shows the condition strength of both networks was the same, but it has different condition strength between each time in minutes. Result explained that most signals of LTE were greater than -100dbm, that means some of the area in the campus area have faced bad 4G/LTE signal of LTE.

B. Digi and U-Mobile RSRP Performance Analysis

The performance analysis for 4G/LTE signal strength is presented for both networks. The process of analyzing the collecting data which refers to the LTE signal strength is referred to Table IV. Result presents the 4G network signal strength based on the data referred to the reading of RSRP. The RF condition of the strongest signal was divided into four categories. First, Excellent that range is below and equal to -80dbm. Second, Good range from -80dbm until -90dbm. Third, Mid Cell range from -90dbm until -100dbm, and lastly cell edge was above -100dbm it shows that the signal strength was weak in those areas. Fig. 10 shows a five (5) hour data collection and Fig. 11 shows the best of RSRP signal strength that can be concluded that it has a few places that have a good 4G/LTE signal strength. The places that have the good signal strength of LTE were at the resident places which are the colleges, faculty, and cafeteria.

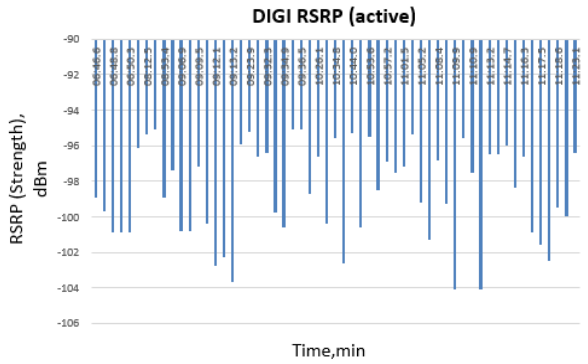

Fig. 8. RSRP Signal for Digi 4G Network.

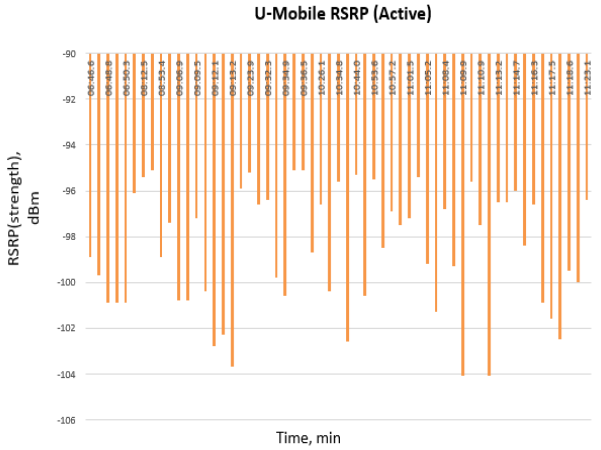

Fig. 9. RSRP Signal for U-Mobile 4G Network.

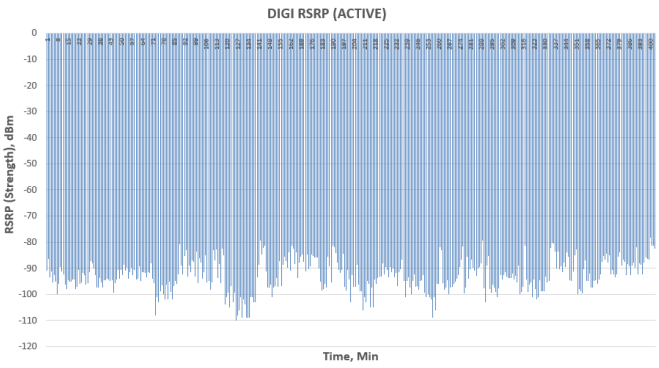

Fig. 10. Digi 4G/LTE Signal Strength Network.

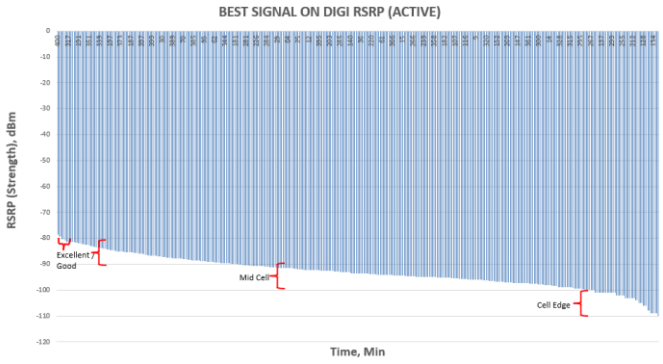

Fig. 11. Best Digi 4G/LTE Signal Strength Network.

Fig. 12 shows that some areas in the campus have a bad result of the signal strength of LTE or 4G network for U-mobile network. Some are having loss signal. Fig. 13 shows the best identified signal strength and most of the result from the signal strength in the campus area was only medium-range and cell edge signal strength. This is due to result shows the strength was mostly over and above from the -90dbm until -100dbm an above. Table V presents the comparison of Digi and U-Mobile RSRP identified form the research. It is identified that Digi supports better for the Mobile broadband network which shows an excellent of 1% and good connections of 29% and 0% signal loss in the drive areas. RSRP signal for U-Mobile shows there is 8% signal loss and the connections provided only at the Mid-Cell for 43% and Cell Edge connections for 48%.

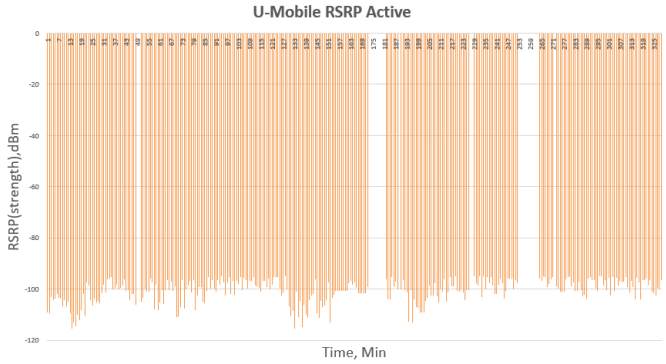

Fig. 12. U-Mobile 4G/LTE Signal Strength Network.

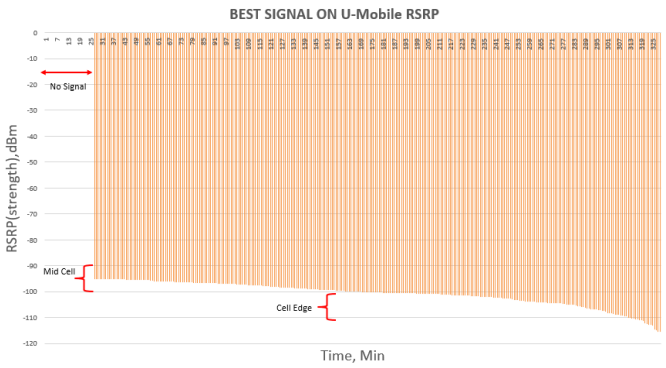

Fig. 13. Best U-Mobile 4G/LTE Signal Strength Network.

TABLE V. DIGI AND U-MOBILE COMPARISON PERCENTAGE OF RSRP

RSRP Strength	Digi	U-Mobile
Excellent	1%	0%
Good	29%	0%
Mid-Cell	59%	43%
Cell Edge	10%	48%
No Signal	0%	8%

DiGi comes top for Download Speed Experience which presents DiGi users experienced the fastest overall mobile download speeds in Malaysia. This result has supported the Mobile Network Experience Report that presents 17.6 Mbps on average of 8% (1.3 Mbps) faster than Maxis's users, 37.5%-40.4% faster than U Mobile and Unifi users, and almost 84% faster than those on Celcom broadband mobile network [23].

V. CONCLUSION

This research has successfully analyzed the Quality of Services for 4G Wireless Network Communications among Providers in a campus network. Two main providers were analyzed which is Digi and U-Mobile which are most identified signal in the campus network. The transmission data of the LTE or 4G signal strength is identified which shows how the transmission data was done using the Nemo Outdoor. The transmission of signal strength of 4G has shown a different strength in each different place in the campus between the providers. Research also identified that data collection to analyse the problem of the quality and the performance of the signal strength that needs to improve. The used of NEMO Outdoor is a good platform for company telecommunication to get the signal and quality strength of the 4G network which is easy to detect and analyze the place that has the low 4G network signal strength. Future research recommendation is to try to make a network that can detect more different types of data analysed.

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