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Revisiting 5G quality of service in Bangkok metropolitan region: BTS Skytrain station areas

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ABSTRACT

This article compares two of the leading mobile network operators (MNOs) in Thailand's telecom market in terms of the service quality of Thailand's fifth generation (5G) networks. The following three factors: download speed, upload speed, and latency, which are frequently considered to be indicators of the quality of Internet networks, were examined. The researchers employed the test results to determine the quality of service (QoS) that was achieved by comparing newly collected data to data that had previously been examined utilizing the same format and application in the middle of May 2021. The average download speed decreased from 196.4 Mbps in 2021 to 140.4 Mbps in 2023, while the average upload speed dropped from 62.6 Mbps in 2021 to 52.0 Mbps in 2023. Furthermore, the average latency increased from 14.9 ms in 2021 to 23.3 ms in 2023. These results show a considerably enhanced service although the test region in this study only comprised BTS stations. Furthermore, this was the case even though the test area in this study only encompassed a small percentage of the total population.

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1. INTRODUCTION

The fifth generation (5G) of mobile telecommunications is currently the most prevalent type of technology used in the field of telecommunications. It can provide high speed, higher bandwidth, high stability of connections, and extremely low latency compared to fourth generation (4G) [1]. At present, the deployment of 5G, which has become popular in many countries, including several nations in the ASEAN region as well as Thailand, has taken place. The introduction of this novel technology in Thailand was an important turning point in the country's long and successful history of telecommunications. In the first quarter of 2020, one of the leading mobile network operators (MNOs) in the Thai telecommunications industry, which was also the first winner of the frequency spectrum auction, made the official launch of 5G services. This was followed by the launch of 5G services by the second winner of the frequency spectrum auction a few months later [2], [3]. Following the conclusion of the auction for the use of the frequency spectrum, the following events took place in the frequency bands shown: n3 (1800 MHz), n28 (700 MHz), n41 (2600 MHz), and n258 (26 GHz) [4]. It was anticipated that by the end of this year, Thailand would have 5G coverage for more than 85% of the country's population, while the percentage of 5G devices would expand to 15% and the number of 5G subscribers would be over 10 million by the end of 2022 [5]. These improvements are all due to the advancement of 5G in Thailand.

The rollout of 5G services began in various places throughout the world around the year 2020. This new technology enables compatibility between 5G and older technologies, such as LTE and 3G [6], [7]. It does so by supporting both the stand-alone (SA) and non-standalone (NSA) topologies of 5G [8], [9]. In general, it is anticipated that 5G will theoretically deliver significant efficiencies in comparison to 4G (see Figure 1). Since it is capable of supporting a peak data rate of 20 Gbps for the downlink and 10 Gbps for the uplink, respectively [3], while the goals for the data rate are, for example, 100 Mbps and 50 Mbps for the downlink and the uplink, respectively. Furthermore, it may be able to support a peak data rate of 20 Gbps for the downlink and 10 Gbps for the uplink. However, in Thailand, there is no official report on the quality of service (QoS), although it is influenced by a number of performance measures [10]. This means that there is no credible institution that can be relied upon to compile the necessary information. The three most common service measurements of quality are the download (DL) speed, the upload (UL) speed, and the latency [11]. They require interaction between the user terminal and the base transceiver station (BTS), which are correspondingly configured for downloading and uploading data [11], [12]. In general, download links are typically designed to function at a faster rate than upload links. Megabits per second (Mbps) are used to measure them. The download and upload rates that are theoretically possible with 5G are 10 Gbps and 1 Gbps, respectively [13]. Both download and upload links, as well as latency are essential because they are the critical variables for the next generation of networks and applications (for example, self-driving cars and telesurgery) [11], [14], [15]. It is possible for future technologies to lessen their impact, but it will never be eliminated [15], [16]. Therefore, this element needs to be kept relatively consistent and below a predetermined limit [11], [17], otherwise, interactive communication (such as voice over internet protocol (VoIP), video telephony, and online gaming) might not work since the latency would be too high. It is generally considered to be beneficial for communications if the latency value is less than 150 milliseconds [11], [17]. In the past, the multinational corporation Opensignal would publish its reports once a year about the QoS parameters spanning both DL and UL. However, each time the report has been published, it has been regarded with skepticism due to the fact that its methodology has been called into question, and some of the QoS values have appeared to be lower than the findings that have been tested by end-users in Thailand [3]. As a result, the present investigation was carried out in order to determine whether or not the findings from this study linked with the DL and UL speeds, as well as latency, are compatible with the report that was provided by Opensignal or whether they differ in certain respects.

With regard to the pertinent literature or earlier studies, they can be displayed as shown in Table 1 [3], [4], [8], [18]-[31]. The evaluation of updated 5G performance in Bangkok, Thailand, has not been carried out previously, despite the fact that there are a number of tasks linked with 5G performance evaluation. Therefore, for the purpose of evaluating the efficacy of 5G technology in the Bangkok metropolitan region using stationary tests [3], the areas surrounding BTS stations were chosen. This is because each station serves between 15,000 and 20,000 passengers on a daily basis. In contrast to [3], only the Opensignal application was used for this study because the purpose of this research was to compare the results to those found in the Opensignal reports [32], [33].

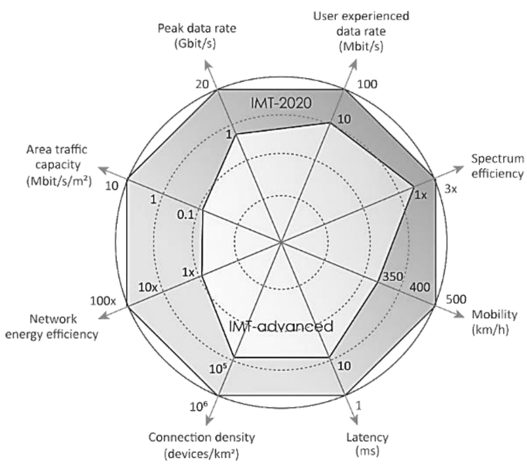


Figure 1. Key capabilities of 5G, adopted from the same source as presented in [3]

Table 1. Literature reviews, adopted from [3]

Ref.	Quality value of related services							Network		Test mode			Tools	Country/note
	Throughput	Download speed	Upload speed	Latency	Jitter	Loss	Other parameters	4G	5G	Stay in place	Mobility	N/A		
[3]	-	✓	✓	✓	-	✓	-	-	✓	✓	-	-	Speedtest	Thai (11 BTS stations)
[4]	-	✓	✓	-	-	-	-	✓	✓	-	✓	-	nPerf, Opensignal, Speedtest	Thailand (Wat Arun)
[8]	-	✓	✓	✓	✓	✓	MOS	✓	-	✓	-	-	MIQ application with crowdsourcing	Thailand (Nationwide)
[20]	✓	✓	-	✓	-	-	-	-	✓	✓	✓	-	Microsoft Azure server	USA (in 3 cities)
[21]	-	✓	✓	-	-	-	-	-	✓	-	-	✓	speedtest.cn	105 cities in China
[22]	-	✓	-	✓	-	-	Signal strength, page display success ratio and vMOS	✓	-	-	-	✓	Huawei proprietary tools	Malaysia (Rural areas in 3 States)
[23]	✓	-	-	-	-	-	-	-	✓	✓	-	-	Huawei equipment	Indonesia
[24]	✓	-	-	✓	-	-	RSSI	-	✓	✓	-	-	Surveillance task outline	UK and Northern Ireland (Backcountry)
[25]	-	-	-	✓	-	-	RSRP	-	✓	-	✓	-	Not specified	Republic of Finland
[26]	✓	-	-	-	-	-	RSRP, SNR	-	✓	✓	✓	-	iPerf	Japanese
[27]	✓	✓	✓	-	-	-	-	-	✓	✓	✓	-	Not specified	Japanese
[28]	✓	✓	✓	✓	-	✓	-	✓	✓	-	✓	-	Python scripts and PC on the car	Republic of Finland
[29]	✓	✓	✓	✓	-	✓	-	✓	✓	-	✓	-	Not specified	Jakarta, Indonesia
[30]	-	✓	✓	✓	-	-	-	✓	✓	-	-	✓	Not specified	Jakarta, Indonesia
[31]	-	-	✓	✓	✓	-	SNR, BER	✓	-	✓	-	-	Mobile Phone	Melaka, Malaysia
[32]	-	-	✓	✓	✓	-	-	✓	✓	-	-	✓	Not specified	Indonesia
[33]	-	-	✓	-	-	-	-	-	✓	-	✓	-	Teleoperated driving	Indonesia

The most important contribution of this study is that it offers recent data, which were gathered from actual field tests by utilizing trustworthy methods and technologies. In fact, this study also made use of data and methods from [1], [34]. However, this study shows the updated results from tests in 2023 about 5G performance in the main locations in the Bangkok metropolitan region, Thailand, and it has been found that the results are worse than the results obtained in 2021. Additionally, the results of this study are better than the results reported by Opensignal [33].

2. METHOD

In contrast to many other previous studies, that came before it, this study focussed on the DL, UL, and latency efficiency of the 5G networks that were provided by two MNOs. The areas surrounding BTS Skytrain station areas were selected for this study in accordance with [3], [34]. In 2023), this study used an Android 5G smartphone that that had a Mediatek MT6833P Dimensity 810 chipset and an Octa-core (2×2.4 GHz Cortex-A76 and 6×2.0 GHz Cortex-A55) CPU [4]. It was supported by a dual sim dual standby (DSDS), whereas the android smartphone that was used in 2021 was ta smartphone that had a Kirin 990 5G chipset and an Octa-core (2×Cortex-A76-based 2.86 GHz+2×Cortex-A76-based 2.36 GHz+4×Cortex-A55-based 1.95 GHz) CPU [3]. It was also supported DSDS. However, the study conducted in 2023 involved the use of a smartphone of a different brand and model than the one employed in the previous study. This was necessitated by the unavailability (end of life) of the one used in the earlier study. Nevertheless, this second study thoughtfully considered and addressed any potential effects arising from differences in chipsets or processors [35]. Both smartphones, of course, came equipped with the Opensignal speed test application installed on them [3]. In a manner analogous to [1], [34], the BTS Skytrain stations pass through the most important commercial districts and residential areas in the Bangkok metropolitan region (see Figure 2). There are around 200,000 passengers daily in total.

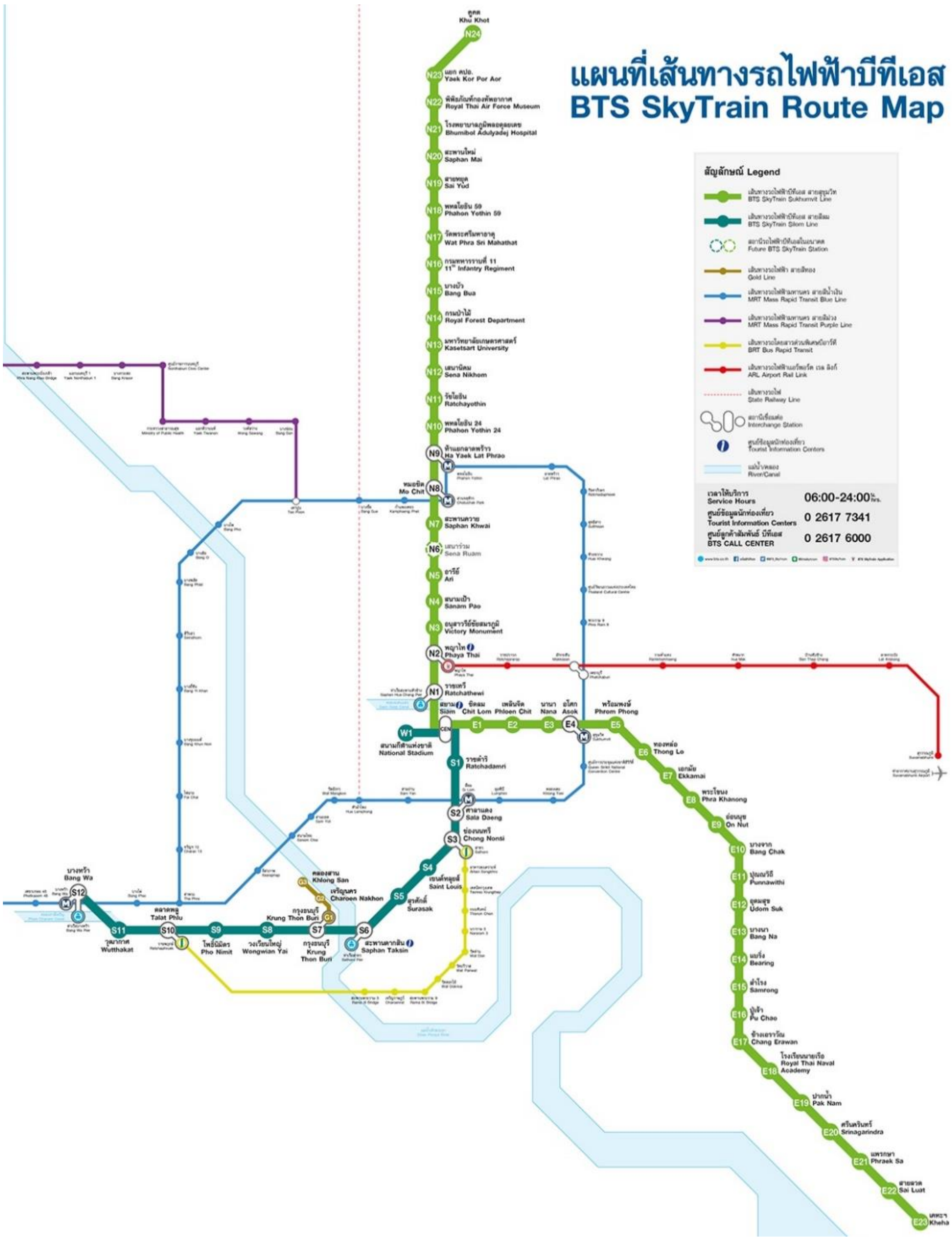
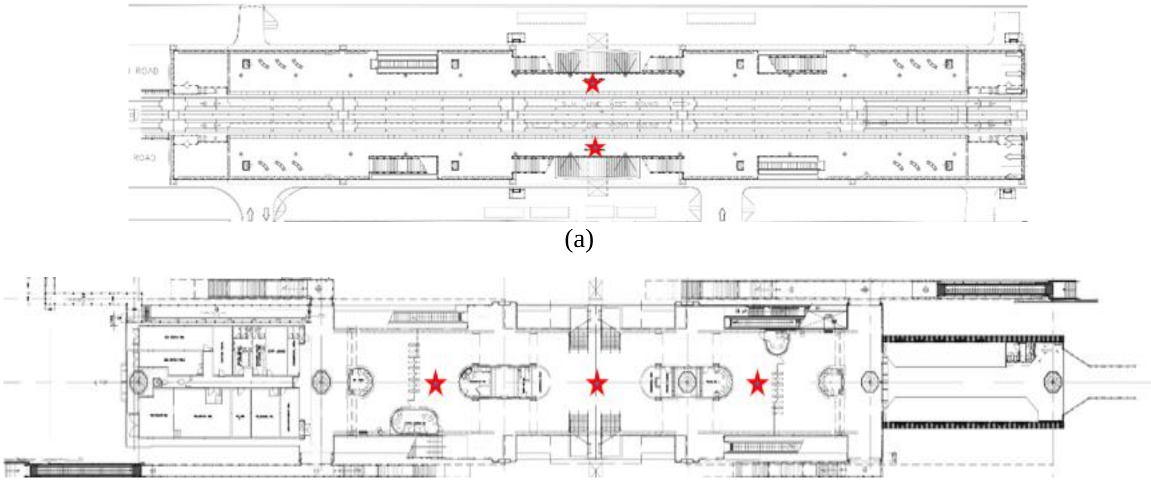


Figure 2. BTS routes in green and light green, adopted from the same source as illustrated in [3]

For the purpose of data collection, stationary tests were carried out at two test points on the platform level (see Figure 3(a)) and three test points on the concourse level (see Figure 3(b)) of each BTS Skytrain station, utilizing 5G unlimited packages from two MNOs that were the first and second winners from the frequency spectrum auction. These tests were carried out within approximately two weeks between March and April 2023, while the older data for comparison were measured by randomly selecting data from the data set that was gathered in May 2021. On this second visit a total of sixty BTS Skytrain stations were revisited. In addition, the findings from the Opensignal reports were also incorporated [34], [35]. Table 2 provides further information regarding the method and instruments used. However, the results measured by using the Opensignal application do not show the technology used (for example, 4G (LTE), 5G (SA), or 5G (NSA)) while performing the field tests. Because of this, a second application known as the nPerf Speed Test application as utilized in [34] was applied in this study as well as a check at each test point before or after conducting each test session using the Opensignal application as utilized in [3]. This was similar to the research conducted in 2021. In the following section, the results of a random selection from 2021, the results of the second visit, and the findings from the Opensignal reports and related results are compared and reported.



(a)

(b)

Figure 3. Test points at; (a) platform level and (b) concourse level

Table 2. Measurement tools

Item	Detail	
	2021	2023
Number of stations	61	60
Test date and time	May 10-15, 2021 8:00 am-6:00 pm	March 20-April 7, 2023 9:00 am-1:00 pm
Number of mobile networks	2	2
Smartphone-5G chipset	Kirin 990	MediaTek Dimensity 810
Test package	Unlimited from 2 providers	Unlimited from 2 providers
Number of applications used to test	4	2
Number of test points per station	4	5
Number of data records used for this study	244	296

Note:
- four stations have a different layout compared to the other stations, thus there were was only four test points in these particular stations.
- station N6 was temporarily closed during the second visit.

3. RESULTS, ANALYSIS, AND DISCUSSION

The results of the second visit and data gathering for the new data in 2023 and the random selection of the data from the old data set collected in 2021 [34]. Both set of the data were processed in order to remove the outliers, while the results contained in the two Opensignal reports presented in 2021 and 2023, respectively, were applied [34], [35]. The findings obtained from these three different sources are then presented and discussed in subsections 3.1 to 3.3.

3.1. Download speed results

The DL speeds shown in Figure 4 can be described as follows:
- Overall, the DL speeds provided by MNO1 show a higher performance than the speeds provided by MNO2, both in 2021 and 2023.
- The average DL speed provided by MNO1 decreased dramatically from almost 310 Mbps in 2021 to 166 Mbps approximately in 2023.
- The average DL speed provided by MNO2 increased from almost 85.3 Mbps in 2021 to 144.6 Mbps in 2023. This means that the performance of MNO2 improved significantly.

– The average DL speed from the two major MNOs that were measured in this study decreased from 196.4 Mbps in 2021 to 140.4 Mbps in 2023.
– The average DL speed from the two major MNOs, that were obtained from the Opensignal reports [34], [35] decreased from 196.4 Mbps in 2021 to 140.4 Mbps in 2023.
– One can see that the results from this study are consistent with the reports from Opensignal, since the average DL speeds from the studies in 2023 decreased when compared with the average speeds measured in 2021.
– However, overall, the average DL speeds measured by the team of authors show better results when compared with the results from the Opensignal reports [34], [35].

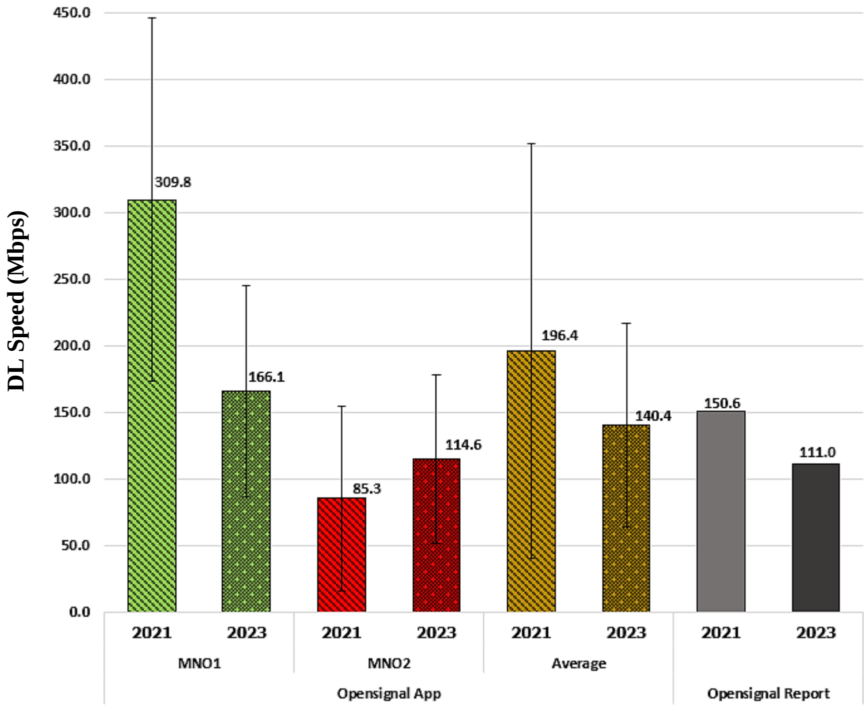


Figure 4. The results of DL speeds

3.2. UL speed results

The UL speeds shown in Figure 5 can be described as follows:
– Overall, the UL speeds provided by MNO1 show a better performance than the speeds provided by MNO2, both in 2021 and 2023.
– The average UL speed provided by MNO1 declined from 83.5 Mbps in 2021 to 71.5 Mbps approximately in 2023.
– The average UL speed provided by MNO2 decreased from almost 42 Mbps in 2021 to 33 Mbps approximately in 2023.
– The average UL speed from two major MNOs that were measured in this study decreased from 62.6 Mbps in 2021 to 52 Mbps in 2023.
– The average UL speed from two major MNOs that were obtained from the Opensignal reports [32], [33] declined slightly from 25.0 Mbps in 2021 to 22.2 Mbps in 2023.
– One can see that the results from this study are consistent with the Opensignal reports, since the average UL speeds from the studies in 2023 decreased when compared with the average speed measured in 2021.
– However, overall, the average UL speeds measured by the team of authors show higher UL speeds compared with the results from the Opensignal reports [32], [33].

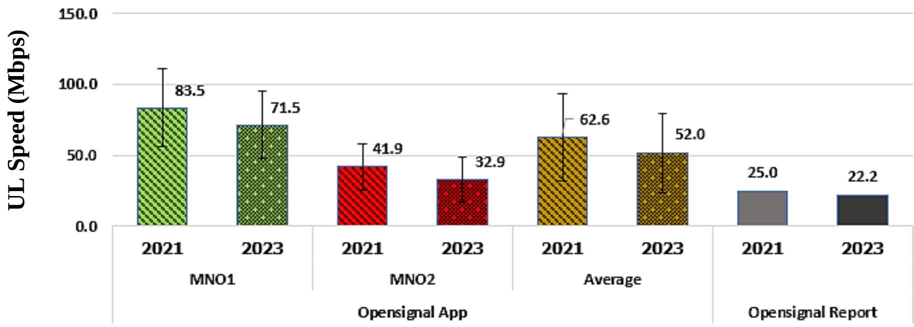


Figure 5. The results of UL speeds

3.3. Latency results

There is no report on latency in the Opensignal reports [32], [33], therefore, only the data measured in 2023 and the selected data measured in 2021 are compared in Figure 6, which can be described as follows:

- In 2021 the average latency of 17.3 ms provided by MNO1 showed a worse performance than the average latency of 12.5 ms provided by MNO2.
- However, in 2023 the average latency of 22.7 ms provided by MNO1 shows a better performance than the average latency of 23.9 ms provided by MNO2.
- The average latency of 14.9 ms from two MNOs in 2021 waslower than the average latency of 23.3 ms from MNOs in 2023. This means that the 5G networks measured in 2023 showed less efficiency than the average latency measured in 2021.
- Overall, the trends in the latency results for both MNOs are consistent they are lower when compared to the previous latencies measured in 2021.

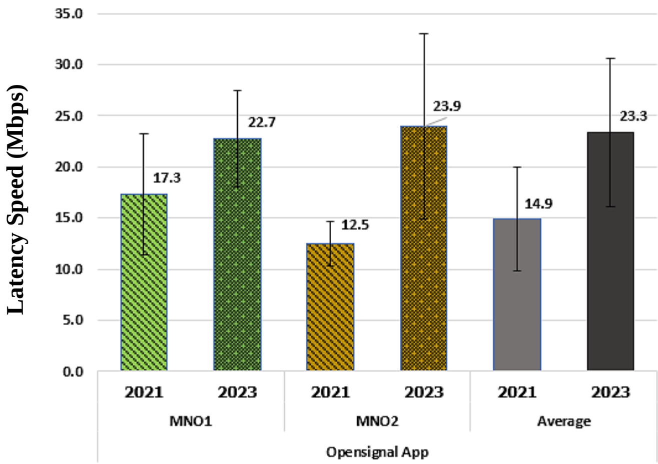


Figure 6. The results on latency

3.4. Technological analysis

During the field testing in 2021 and 2023, the nPerf Speed Test program was utilized, and the results relating to the technologies used at each test point were gathered. Table 3 is the appropriate place to present them. Table 3 presents a technological analysis:

- In 2021, the average speeds (DL and UL) provided by MNO1 were higher than MNO2 because the percentage of MNO1 (69.3%) provided a higher number of 5G channels (5G NSA) when compared to the percentage of MNO2 (61.9%).
- In 2023, the percentage of MNO1 provided a higher percentage of 5G channels (92.9%) than MNO2 (91.6%). However, it is questionable whether the percentages of 5G NSA in 2023 were higher than the percentages in 2021 but the average data rates measured in 2023 were lower than the data rates measured in 2021.

Table 3. Comparison of the results associated with the technology used in each test session from nPerf

Year	Operator	Service system			Estimation of 5G coverage areas
		5G (NSA)	4G (LTE)	Total	
2021	MNO1	169	75	244	169/244×100%=69.3%
	MNO2	151	93	244	151/244×100%=61.9%
2023	MNO1	275	21	296	275/296×100%=92.9%
	MNO2	271	25	296	271/296×100%=91.6%

3.5. Statistical analysis

An additional analysis of the results was performed using t-tests, following [4]. The results from each MNO measured in 2021 and 2023 were compared using the six hypotheses and only the new data between two MNOs measured in 2023 were compared using additional hypotheses. A comparison between the old data from the two MNOs was ignored, since it was clear that with regard to the overall data rates in 2021, MNO1 showed a better performance than MNO2. All the hypotheses are presented as follows:

- H1: the average 5G DL speed provided by MNO1 measured in 2023 and the DL speed measured in 2021 are the same or not.
- H2: the average 5G DL speed provided by MNO2 measured in 2023 and the DL speed measured in 2021 are the same or not.
- H3: the average 5G UL speed provided by MNO1 measured in 2023 and the UL speed measured in 2021 are the same or not.
- H4: the average 5G UL speed provided by MNO2 measured in 2023 and the UL speed measured in 2021 are the same or not.
- H5: the average 5G latency provided by MNO1 measured in 2023 and the latency measured in 2021 are the same or not.
- H6: the average 5G latency provided by MNO2 measured in 2023 and the latency measured in 2021 are the same or not.
- H7: the average 5G DL speed provided by MNO1 and the DL speed provided by MNO2 measured in 2023 are the same or not.
- H8: the average 5G UL speed provided by MNO1 and the UL speed provided by MNO2 measured in 2023 are the same or not.
- H9: the average 5G latency provided by MNO1 and the latency provided by MNO2 measured in 2023 are the same or not.

As shown in Table 4, one can see that all the hypotheses show significant differences. Therefore, the results of the analysis can be used to confirm that theyare reliable Figures 4 to 6.

Table 4. An analysis of the results from the hypotheses tests

Hypothesis	p-values	Meaning
H1	<0.001	The average 5G DL speed from MNO1 measured in 2023 was significantly worse than the DL speed measured in 2021.
H2	<0.001	The average 5G DL speed from MNO2 measured in 2023 was significantly worse than the DL speed measured in 2021.
H3	<0.001	The average 5G UL speed from MNO1 measured in 2023 was significantly worse than the UL speed measured in 2021.
H4	<0.001	The average 5G UL speed from MNO2 measured in 2023 was significantly worse than the UL speed measured in 2021.
H5	<0.001	The average 5G latency from MNO1 measured in 2023 was significantly worse than the latency measured in 2021.
H6	<0.001	The average 5G latency from MNO2 measured in 2023 was significantly worse than the latency measured in 2021.
H7	<0.001	The average 5G DL speed from MNO1 measured in 2023 was significantly better than the DL speed from MNO2.
H8	<0.001	The average 5G UL speed from MNO1 measured in 2023 was significantly better than the UL speed from MNO2.
H9	0.044	The average 5G latency speed from MNO1 measured in 2023 was significantly worse than the latency speed from MNO2.

Remark: it is significant at p-value < 0.05 for 95% confidence interval.

3.6. Discussion

According to the results obtained from the field tests within the BTS Skytrain station areas in Bangkok and the analysis as presented in subsections 3.1-3.6, there were many interesting issues. However, those issues needed to be discussed, as follows:

- With regard to Figures 4 to 6, the DL and UL speeds measured in 2023 were lower than the DL and UL speeds measured in 2021, while the latencies assessed in 2023 were higher than the latencies measured in 2021 [3], [34]. This means that the recent 5G networks provided a lower performance than in 2021.
- The cause of the lower speeds may be the higher number of 5G subscribers and the 5G user equipment (UEs), while the licenses to allow users to access the full capacity of 5G might have been limited. Furthermore, business and/or marketing reasons explain the reasons for the reduced 5G performance since the MNOs had to invest in and deploy new 5G equipment and systems to replace the old equipment and systems in order to support 5G users or subscribers.
- Overall, the average 5G performance assessed by the auditors was higher than the performance shown in the Opensignal report.
- The results for 5G speeds from this study are consistent with the Opensignal reports. The overall DL and UL speeds in 2023 tends to decrease significantly when compared to the previous results in 2021. This may a result of the increasing number of 5G users at present. However, it is inconsistent with the DL speeds provided by MNO2, since its 5G DL performance has improved.
- Table 3 shows that although the coverage areas of 5G networks in 2023 in Bangkok are higher than in 2021, they cannot guarantee a better 5G performance.
- This study covers the BTS Skytrain station areas in the Bangkok metropolitan region only for the period of time the studies were conducted; therefore, the results from this study are not representative of the 5G performance for the whole of Bangkok or Thailand.
- The smartphones used for the field tests in 2021 and the one used in 2023 are not the same brand and model becauseof a limited budget and because the same brand and model as in 2021 were not available at that time, while the smartphones used in 2023 were personal phones that were available in at that time. The power of the chipsets may be different [35] and this issue could be investigated in depth in a future work.
- In revisiting the BTS Skytrain stations, the number of test points increased from one point to two points at the platform level of all stations, except for four stations that had different floor plans. The additional test points may have impacted the 5G performance since the platform level is approximately 12 meters higher than the ground level. Therefore, this issue should be investigated in depth in the future.
- Previously, there were three major MNOs, but two of them have merged together, and only one smartphone was used in the field tests because of budget limitations. Thus, only two major MNOs were evaluated in this study.
- The method using stationary mode for 5G performance evaluation in this study might be applied to other routes of railway systems in the Bangkok metropolitan region. Furthermore, it could be applied in other countries to evaluate and/or verify whether 5G performances are consistent with the Opensignal reports or other reports.
- This study was performed using stationary tests only; mobility tests should be an option for a future study. Some QoS parameters, such as loss and jitter, have not been considered in this study, therefore, these methods and parameters should be considered in any future studies.
- This study was mainly based on the Opensignal application, while one interesting feature of the nPerf Speed Test application was also applied. In the future, other applications (e.g., the Speedtest application by Ookla) should be considered.

4. CONCLUSION

This study which looked at three QoS parameters-DL speed, UL speed, and latency-and it was found that the performance of 5G in the field is very different from how it works in theory. According to this study, there was a significant decline in 5G performance from the major MNOs between 2021 and 2023. A larger number of 5G subscribers and 5G UEs, as well as business and/or marketing considerations, are possible explanations for the degraded performance of 5G.

When compared to the 2021 evaluation, the DL speed in 2023 was just 140.4 Mbps, down from 196.4 Mbps. In 2023, the UL speed was measured at 52.0 Mbps, down from 62.6 Mbps in 2021. However, by 2023, the delay had risen to 23.3 ms, up from 14.9 ms in 2021. The field test results match those from Opensignal. Although Opensignal's published values for DL and UL are lower than those found in this investigation, the aggregate results can be used to confirm that the speeds shown here are substantially faster. However, future research should consider other network metrics (e.g., jitter and loss), apps (e.g., Speedtest), and methodologies (e.g., mobility tests).

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