Exploring 5G Data Rates: An Analysis of Thailand's Iconic Landmarks - The Grand Palace and Wat Arun

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Abstract—**The recent deployment of 5G New Radio (NR) technology promises to transform the possibility of mobile networks around the world. In many Asian countries, including Thailand, video content, both on-demand and live, dominates the online content market. It's not uncommon for tourists and content creators to create such content at tourist destinations, then immediately upload them to the social media platforms like YouTube, Instagram, and Tiktok. As video content takes up a lot of transmission bandwidth in the uplink direction, this provides a new challenge for any Mobile Network Operator (MNO) as many User Equipment (UE) compete with each other for the limited uplink bandwidth available at the base station serving the tourist destination. In this paper, the performance of the 5G network of two Thai MNO at two of the most popular tourist destinations in Bangkok, Thailand, will be evaluated. The results showed that the 5G quality of service (QoS) at these two landmarks was significantly lower than the typical performance at BTS Skytrain stations located in the business districts. Additionally, even though these two landmarks are located close to each other, there was a significant difference in 5G QoS between the two.**

Keywords—5G New Radio, Radio Access Network, Wireless Network, Thailand, Tourism

I. INTRODUCTION

After the COVID-19 pandemic declined, the tourism industries in Thailand started to recover as Thailand's National Communicable Disease Committee announced that from July 1st, 2022, Thailand will return to normal and measure against the pandemic would be scrapped [1]. As a result, the number of foreign visitors, including tourists, skyrocketed to 11.5 million at the end of December 2022 [2]. Additionally, after the reopening of many countries, including China, it is expected that the number of foreign visitors will reach at least 25 million by 2023 [3][4].

While there are various types of activities that the tourists enjoy during their visit, one of the most popular activities this year [5][6], which is part of Thai cultural tourism, is visiting Thai historical sites and iconic landmarks such as the Grand Palace and Wat Arun [7] (See Fig. 1), then dressing up in Thai traditional outfit for a photo shooting (See Fig. 2). Among these tourists are digital content creators and influencers (e.g., YouTubers and TikTokers), who mainly use the mobile network for their content creation needs such as live streaming and uploading their content to social media platforms. To these people, mobile networks are an essential infrastructure for their job.

Previously, there were many studies regarding the quality of service (QoS) of 4G Long-Term Evolution (LTE) and 5G New Radio (NR) mobile networks (including the evaluation of main QoS metrics such as downlink (DL) and uplink (UL) performance) provided by MNO in Bangkok as well as nationwide, throughout Thailand [8][9][10][11][12][13]. However, these researches mainly focus on the network performance near the business districts and BTS Skytrain stations. They did not cover the major tourist destinations. Particularly, the Grand Palace and Wat Arun, which are two of Thailand's most iconic landmarks, and are popular among foreign visitors. Therefore, it is important to investigate the downlink and uplink performance of Thai 5G mobile networks, among two MNOs, in these areas to see whether they can provide good quality of service to the tourists or not. The results will also be compared to the benchmark [10] and can be utilized by Thai MNOs to improve their quality of service, especially in the area that serves famous tourist destinations. The results in this paper may also be used as a case study for future work focusing on other famous landmarks or tourist destinations in other countries.

Fig. 1.   Two of the top places in Bangkok (a) The Grand Palace (b) Wat Arun

Fig. 2.   The tourists with traditional Thai costumes, adopted from [7].

II. BACKGROUND

A. Overview of 4G

In Thailand, the plan for the 4G deployment in 2009 was delayed for about 7 years. In 2013, the 4G LTE technology was tested in the pilot stage before being rolled out to the public in Q4/2015 [10][14]. The delay in the deployment worked in the favor of Thailand as the base station equipment at that point had evolved significantly, supporting many technologies that greatly improve the cell capacity and data rates such as 256QAM downlink modulation (DL 256QAM), 64QAM uplink modulation (UL 64QAM), 4X4 MIMO, and Carrier Aggregation (CA). Three frequency bands were deployed during the initial stage: LTE Band 1 (2100 MHz), LTE Band 3 (1800 MHz), and LTE Band 8 (900 MHz). This is later followed by the introduction of Time Division Duplex LTE (TDD-LTE) in 2018 on the LTE Band 40 (2300 MHz).

B. Overview of 5G Deployment in Thailand

Realizing the growing need for mobile data service, the National Broadcasting and Telecommunications Commission (NBTC) and MNOs carried out a 5G field test in late 2019 as well as early 2020. This was quickly followed by the frequency spectrum auction in February 2020, where four frequency bands were up for the auction: n3 (1800 MHz), n28 (700 MHz), n41 (2600 MHz), and n258 (26 GHz). The roll-out of the 5G network started on the same day that the auction had concluded on the n41 Band. In the early stage, two of the winners of the n41 band opted to deploy their 5G network using 64T64R Massive MIMO equipment for huge capacity and high throughput thanks to the beam-forming technology. After NBTC ordered TV channels and wireless microphone users to move out of the 700 MHz spectrum, the network was finally allowed to start commercializing its 5G on the n28 band in early 2021, providing the basic coverage layer. As for the n258 band, MNO had already carried out the internal test, but due to the high price of User Equipment (UE), has not started the deployment on this frequency band yet. As of the time of conducting this research, 5G in Thailand has more than 85% population coverage nationwide.

C. Data Rate

Two of the most well-known QoS parameters that are used to present 5G network performance provided by MNOs are the data rate called, download (DL) and upload (UL) speeds [15][16]. For general users who use 4G/5G services, the higher means the better, therefore they are very familiar these two parameters. In general, DL are usually faster than UL, since users mostly use download function from 4G/5G services (e.g., watching YouTube/Netflix). However, there are a few kinds of users, such as, content creators, YouTubers and TikTokers that require high data speed for uploading their contents.

D. Related Research Works

There are many relevant researches and studies involving the field test of mobile networks that had been conducted in the past. Volk and Sterle [17] conducted field test experiments regarding the use of 5G for the public protection and disaster relief (PPDR) sector in Slovenia. Additionally, Volk et al. [18] conducted the field test of the 5G application as a backhaul of the PPDR system in Germany. Richter and Reimers [19] proposed techniques to integrate the terrestrial broadcast with the 5G NR, then conducted the field test in Germany. Zeng et. al. [20] conducted a test in China, then reported on the flexibility, versatility, and efficiency of 5G NR multicast and broadcast, which is to be supported in the 3GPP Release-17. Arunruangsirilert et al. [21] evaluated the live streaming performance of 5G SA, 5G NSA, and LTE networks in Thailand, with 5G SA showing better performance. Additionally, they conducted the field test on the performance of UL-MIMO [22], which is to be supported along with 5G SA deployment, on the Japanese Urban Train, with UL-MIMO-enabled UE demonstrating about 20% better performance. Mohamed et al. [23] compared the indoor performance of 5G NSA and SA networks, finding that 5G SA performed slightly better than 5G NSA.

In terms of data rate or throughput, Jahdhami et al. [24] conducted the drive tests in Ibra City, Oman, presenting the quality of service (QoS) results for 3G/4G technologies provided by two mobile network operators (MNOs). Similarly, Putra and Widyasmoro [25] conducted drive tests for QoS analysis of 5G in two zones in Indonesia, where the results also included both DL and UL throughput. Table ?? summarized the throughput and data rates of the mobile networks from the previous findings mentioned in Section II. These works involved the field test results from a wider area of the country, which can be used to cross-check the result in this paper, and also be used as the reference to reveal whether the 5G QoS around the landmark area needed to be improved or not.

III. METHODOLOGY AND TOOLS

Unlike the previous works, which involved the mobility field test [23][24][25], this study was focused on the DL and UL performance of the 5G NR as well as the legacy 4G LTE networks from two MNOs when the UE is at rest in the location of two famous and iconic landmarks of Bangkok, the Grand Palace, and Wat Arun, both of which located on the opposite side of the Chao Phraya River (see Fig. 3). The displacement between these two locations is approximately 700 meters. The tools used for the measurements were two smartphones, 4G [26] and 5G [27] model, from the same manufacturers. The smartphones were chosen from the compatibility list provided by MNOs to ensure that all network features are supported. Both of the smartphones have the chipset and RF modem from Mediatek and support Dual SIM Dual Standby (DSDS). The 4G smartphone has the Helio G85 RF modem, while the 5G smartphone has the Dimensity 920 RF modem. Four SIM cards from two MNOs, hereafter refers to as MNO-X and MNO-Y, were prepared for the experiment. Three commercially-available network performance measurement applications, consisting of nPerf, Opensignal, and Ookla Speedtest [10], were installed on both smartphones to be used in the field test. Eleven and eight test spots covering all of the main attractions within the Grand Palace and Wat Arun, respectively, were selected for the throughput data gathering.

TABLE I.   RELATED WORKS REFERRING TO DL AND UL SPEEDS

Technology	DL (Mbps)	UL (Mbps)	Remark	Ref
4G	17.78	14.59	Nationwide	[10]
5G	240.3	87.3	Bangkok	[11]
	156.4	25.5	AIS/Nationwide	[12]
	100.4	10.9	True/Nationwide	
	143.3	25.8	AIS/Nationwide	[13]
	78.7	18.6	True/Nationwide	

The field tests at Grand Palace were conducted on March 15, 2023, and April 8, 2023, while the tests at Wat Arun were conducted on March 14, 2023, and March 26, 2023. For each selected test point in Grand Palace, two trials of the experiment were performed, while three trials were performed at each test spot within Wat Arun, which ultimately yield a total of 66 and 72 data records from the Grand Palace and Wat Arun, respectively. The results are presented in Section IV.

IV. RESUTS AND ANALYSIS

After conducting the field tests, the gathered data were considered if there were outliers. The data were calculated for average values before presenting as shown in Fig. 4. From the figure, it can be described as follows:

- For overall, the DL speeds from 5G are higher than the UL speeds from the same technology obviously.
- Mostly, 5G shows higher speeds than 4G, particularly cases of DL speeds.
- For 4G, in the Grand Palace, the DL speeds from both MNOs are higher than the UL speeds, whereas, the UL speeds in Wat Arun are slightly higher than the DL speeds.
- All speeds from each location both 5G and 4G from MNO-X are higher than from MNO-Y, except the case of 4G DL speed in the Grand Palace.

However, there are interesting issues from Fig. 4 as follows:

- H1: the average 5G UL speed from MNO-X and MNO-Y in the Grand Palace are the same or not
- H2: the average 5G UL speed from MNO-X and MNO-Y in Wat Arun are the same or not
- H3: the average 4G UL speed from MNO-X and MNO-Y in the Grand Palace are the same or not
- H4: the average 4G UL speed from MNO-X and MNO-Y in Wat Arun are the same or not
- H5: the average 5G UL speed and 4G UL speed from MNO-X in the Grand Palace are the same or not
- H6: the average 5G UL speed and 4G UL speeds from MNO-Y in the Grand Palace are the same or not
- H7: the average 5G UL speed and 4G UL speed from MNO-X in Wat Arun are the same or not

- H8: the average 5G UL speed and 4G UL speed from MNO-Y in Wat Arun are the same or not

Furthermore, one can observe that a few cases of 4G, UL speed are a little bit higher that DL speeds, therefore, these hypotheses are also considered, as follows:

- H9: the average 4G DL and UL speeds from MNO-X in the Grand Palace are the same or not
- H10: the average 4G DL and UL speeds from MNO-Y in the Grand Palace are the same or not
- H11: the average 4G download and UL speeds from MNO-X in Wat Arun are the same or not
- H12: the average 4G download and UL speeds from MNO-Y in Wat Arun are the same or not

The above-mentioned hypotheses were analyzed using t-test. Then the analyzed results are shown in Table II.

V. DISCUSSION AND CONCLUSION

Overall, the results of this study are similar to those presented in [11] and slightly superior to the findings in [12-13]. However, upon analyzing the results in the previous section, it is evident that the p-values for H7 and H8 are 0.070 and 0.118, respectively. This implies that there is no significant difference in UL speeds between 4G and 5G networks provided by MNO-X in Wat Arun. Similarly, MNO-Y in the Grand Palace offers comparable UL speeds. Furthermore, the p-value of 0.574 for H9 demonstrates that both DL and UL speeds provided by MNO-X's 4G network exhibit the same average speed as those in the Grand Palace. This similarity can also be observed in H12, where MNO-Y's 4G network in Wat Arun provides similar speeds.
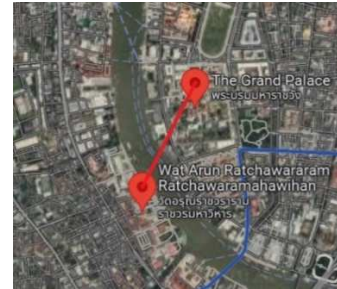

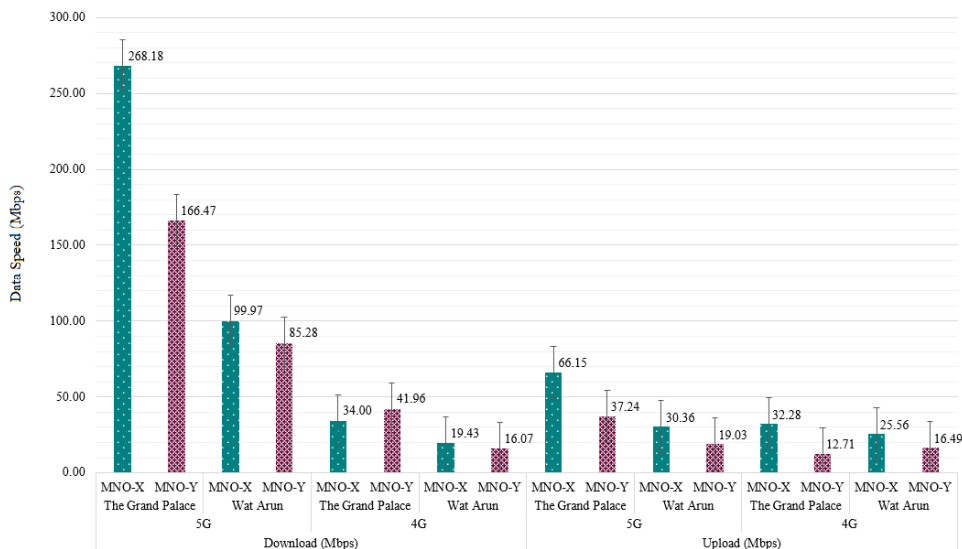Fig. 3.   The Grand Palace and Wat Arun located be Chao Phraya River

Fig. 4.   The resluts from the field tests in The Grand Palace and Wat Arun

TABLE II.   ANALYZED RESULTS FROM HYPOTHESIS TESTS

Hypothesis	p-values	Remarks
H1	<0.001	Significant (MNO-X > MNO-Y; 5G@The Grand Palace)
H2	<0.001	Significant (MNO-X > MNO-Y; 5G@Wat Arun)
H3	<0.001	Significant (MNO-X > MNO-Y; 4G@The Grand Palace)
H4	<0.001	Significant (MNO-X > MNO-Y; 4G@Wat Arun)
H5	<0.001	Significant (5G-UL > 4G-UL; MNO-X@The Grand Palace)
H6	<0.001	Significant (5G-UL > 4G-UL; MNO-Y@The Grand Palace)
H7	0.070	Insignificant (5G-UL > 4G-UL; MNO-X@Wat Arum)
H8	0.118	Insignificant (5G-UL > 4G-UL; MNO-Y@The Grand Palace)
H9	0.574	Insignificant (4G-UL > 4G-DL; MNO-X@The Grand Palace)
H10	<0.001	Significant (4G-UL > 4G-DL; MNO-X@ The Grand Palace)
H11	0.003	Significant (4G-UL > 4G-DL; MNO-Y@Wat Arun)
H12	0.915	Insignificant (4G-UL > 4G-DL; MNO-Y @Wat Arun)

Remark: p-value of <0.05 is significant with 95% confidential interval

From this study, which conducted field tests between two palaces located on opposite sides of the river with a displacement of less than one kilometer, it has been observed that the Quality of Service (QoS) provided by 5G Mobile Network Operators (MNOs) in these two locations is significantly lower than the speeds presented in [15]. However, the overall data speeds from MNO-X are higher than those from MNO-Y. Focusing specifically on the two places examined in this study, the DL and UL speeds in Wat Arun are notably worse than those in the Grand Palace. From a tourist's perspective, Wat Arun is one of the most renowned tourist destinations in Thailand and is easier to reach compared to the Grand Palace due to its lower entrance cost. Furthermore, Wat Arun serves as a significant location for digital content creators who live and upload video streaming content. Therefore, it is imperative for the operators to improve the QoS of 5G in Wat Arun to match the level provided at the Grand Palace. This improvement would enable digital content creators to contribute to the promotion of tourism in this area. One of the key contributions of this study is that it can serve as an example for other countries considering improvements in their telecom infrastructure to promote tourism.

Additionally, future work can consider conducting this study with data speeds from the Grand Palace as well as evaluating other QoS parameters such as latency and jitter. Furthermore, it would be beneficial to examine other landmarks, places, or cities for a more comprehensive analysis.

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