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RESEARCH ARTICLE OPEN ACCESS

Comparative Analysis of 4G and 5G Network Speeds Across Adailiya, Kaifan, and Yarmouk in Kuwait

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ABSTRACT
This study provides a comprehensive evaluation of the outdoor performance of 4G and 5G networks across the neighborhoods of Adailiya, Kaifan, and Yarmouk in Kuwait. The analysis focuses on key performance metrics, including **ping (latency)**, **jitter (latency variation)**, **download speeds**, and **upload speeds**. Field tests conducted in various outdoor locations reveal that 5G significantly outperforms 4G in all measured parameters. Average download speeds on 5G reached up to 444 Mbps, while 4G managed 50 Mbps. Similarly, upload speeds were markedly higher on 5G, averaging 53 Mbps compared to 31 Mbps on 4G. Furthermore, 5G networks demonstrated substantial improvements in latency and jitter, ensuring a more stable and responsive connection. These findings underscore the transformative potential of 5G for enhancing outdoor connectivity in residential areas and highlight the need for further infrastructure development to ensure consistent coverage and performance.
Keywords: 4G, 5G, outdoor network performance, latency, jitter, download speed, upload speed, Kuwait, Adailiya, Kaifan, Yarmouk, telecommunications.

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I. Introduction

1.1 Background

The rollout of 5G technology promises unprecedented advancements in mobile network performance, offering significantly higher speeds and lower latency compared to 4G. This study investigates the comparative performance of 4G and 5G networks in three key residential neighborhoods of Kuwait: Adailiya, Kaifan, and Yarmouk. Understanding the performance of these networks, especially in outdoor settings, is crucial for optimizing user experience and guiding infrastructure investments.

1.2 Problem Statement

Despite the widespread deployment of 5G, its performance in specific residential areas has not been thoroughly examined. This study aims to address this gap by providing a detailed comparison of 4G and 5G network performance across different outdoor locations in Adailiya, Kaifan, and Yarmouk.

1.3 Research Objectives

- To evaluate the outdoor performance of 4G and 5G networks in terms of **ping**, **jitter**, **download speeds**, and **upload speeds**.
- To identify performance variations across different blocks within each neighborhood.
- To provide recommendations for improving 5G infrastructure based on the findings.

1.4 Significance of the Study

This research provides critical insights into the current state of 5G deployment in Kuwait's residential areas. It offers valuable data for telecom operators and policymakers to enhance network quality and ensure better connectivity for residents.

II. Literature Review

2.1 Evolution of Mobile Network Technologies

Mobile networks have evolved significantly over the past few decades. 4G networks, introduced in the late 2000s, provided a major leap in data transmission capabilities, supporting high-definition video streaming and faster internet browsing. The advent of 5G, however, marks a new era, promising even higher speeds and lower latency, which are essential for emerging applications such as autonomous vehicles, virtual reality, and the Internet of Things (IoT).

2.2 A Comparison between 4G and 5G

The Evolution of 5G network has boosted the telecom industry with the promising unprecedented speed, reduced latency and enhanced connectivity. Unlike 4G, 5G is better no only in terms of speeds but also lower latency and higher bandwidth, which leads to latest innovation in the era of mobile communication. For the users, 5G provide enhanced

Quality of Services (QOS) integrated with energy efficiency and sustainability.

2.3 Performance Metrics: Latency and Jitter

Latency (ping) is the time it takes for data to travel from the user's device to the server and back. Lower latency is crucial for real-time applications such as online gaming and video calls. **Jitter** refers to the variability in ping over time, which can cause disruptions in data streams, impacting the quality of service. 5G is expected to significantly reduce both latency and jitter, providing a more stable and responsive connection compared to 4G.

2.4 Impact of Environmental Factors on Network Performance

The performance of mobile networks is influenced by various environmental factors, including building materials, topography, and weather conditions. While 5G offers enhanced capabilities, its higher frequency bands are more susceptible to interference, which can impact performance, especially in indoor and densely built-up areas.

III. Methodology

3.1 Research Design

This study adopts a quantitative research design, employing field measurements to assess the performance of 4G and 5G networks in Adailiya, Kaifan, and Yarmouk.

3.2 Diversity in Kuwait

The primary focus of this study is to compare 4G and 5G network speeds in residential areas of Kuwait, known for their diverse landscapes. Kuwait is divided into six governorates, and this analysis focuses on the Capital Governorate, Al Asimah (Kuwait City). Specifically, it examines the districts of Adailiya, Kaifan, and Yarmouk. These areas provide a range of urban environments for testing network performance. As of 2022, Adailiya, with its four blocks, has a population of approximately 21,996, while Kaifan consists of seven blocks and a population of about 28,919. Yarmouk, with four blocks, had a population of around 24,634 in 2018. The study aims to highlight differences in 4G and 5G network speeds across these districts, considering variations in population density and urban infrastructure.

3.3 Sampling of Locations

Measurements were taken from strategically selected outdoor locations across each neighborhood, including residential blocks, public spaces, and main roads. This approach ensures a representative assessment of network performance in typical outdoor settings.

3.4 Data Collection Tools

The study utilized the Ookla Speed test application to measure the following metrics:

- **Ping (ms)**
- **Jitter (ms)**
- **Download Speed (Mbps)**
- **Upload Speed (Mbps)**

3.5 Procedure

Tests were conducted during different times of the day, including peak and off-peak hours, to capture a comprehensive picture of network performance. Each block was tested multiple times to ensure data accuracy and reliability.

IV. Results

4.1 Adailiya

Outdoor Performance:

The data collected on three different blocks (Block 1, 3 and 4) on three different dates were sampled and analyzed. The samples were collected on the dates of 17/3/23, 13/4/24 and 16/4/24 and the average of the data is shown in tab 4,5,6. The Upload and download speeds are measured in Mbps (Megabytes per second) and for the case of ping and jitter it is measured in ms (Milli Seconds). The averaged data for the complete area (Block 1,3 and 4) of Adailiya is published in Tab 1, and the results are explained in detail as follows

- **Ping (ms):** On average, 4G had a download latency of 1964 ms, which was reduced to 425 ms with 5G. For uploads, 4G averaged 1574 ms, while 5G reduced this to 703 ms.
- **Jitter (ms):** On average, during downloading 4G experienced a jitter of 98 ms, which was reduced to 77 ms with 5G. For uploads, 4G averaged 98 ms of jitter, while 5G reduced this to 71 ms.
- **Download Speed (Mbps):** 4G averaged 54 Mbps; 5G reached 467 Mbps.
- **Upload Speed (Mbps):** 4G showed 29 Mbps; 5G averaged 65 Mbps.

AVERAGE				
	5G		4G	
	Down	Up	Down	Up
Adailiya	467	65	54	29
	Ping			
	425	703	1964	1574
	Jitter			
	71	77	98	98

Tab 1 Average data collected on the different blocks of Adailiya on Speed, Ping and Jitter.

4.2 Kaifan

Outdoor Performance:

The data collected on three different blocks (Block 1, 4 and 7) on three different dates were sampled and analyzed. The samples were collected on the dates of 17/3/23, 13/4/24 and 15/4/24 and the average of the data is shown in tab 7,8,9. The Upload and download speeds are measured in Mbps (Megabytes per second) and for the case of ping and jitter it is measured in ms (Milli Seconds). The averaged data for the complete area (Block 1,4 and 7) of Kaifan is published in Tab 2, and the results are explained in detail as follows

- **Ping (ms):** On average, 4G had a download latency of 1933 ms, which was reduced to 594 ms with 5G. For uploads, 4G averaged 1778 ms, while 5G reduced this to 606 ms.
- **Jitter (ms):** On average, during downloading 4G experienced a jitter of 111 ms, which was reduced to 84 ms with 5G. For uploads, 4G averaged 99 ms of jitter, while 5G reduced this to 76 ms.
- **Download Speed (Mbps):** 4G averaged 67 Mbps; 5G reached 534 Mbps.
- **Upload Speed (Mbps):** 4G showed 29 Mbps; 5G averaged 67 Mbps.

AVERAGE				
Kaifan	5G		4G	
	Down	Up	Down	Up
	534	67	69	29
	Ping			
	594	606	1933	1778
	Jitter			
	84	76	111	99

Tab 2 Average data collected on the different blocks of Kaifan on Speed, Ping and Jitter.

4.3 Yarmouk

Outdoor Performance:

The data collected on three different blocks (Block 1, 2 and 4) on three different dates were sampled and analyzed. The samples were collected on the dates of 11/11/23, 18/11/23 and 22/11/23 and the average of the data is shown in tab 10,11,12. The Upload and download speeds are measured in Mbps (Megabytes per second) and for the case of ping and jitter it is measured in ms (Milli Seconds). The averaged data for the complete area (Block 1,2 and 4) of Yarmouk is published in Tab 3, and the results are explained in detail as follows

- **Ping (ms):** On average, 4G had a download latency of 2112 ms, which was reduced to 944 ms with 5G. For uploads, 4G averaged 260 ms, while for 5G it is 843 ms.
- **Jitter (ms):** On average, during downloading 4G experienced a jitter of 119 ms, which was reduced to 89 ms with 5G. For uploads, 4G averaged 60 ms of jitter, while for 5G it is 83 ms.
- **Download Speed (Mbps):** 4G averaged 27 Mbps; 5G reached 332 Mbps.
- **Upload Speed (Mbps):** 4G showed 37 Mbps; 5G averaged 27 Mbps.

AVERAGE				
Yarmouk	5G		4G	
	Down	Up	Down	Up
	332	27	27	37
	Ping			
	944	843	2112	260
	Jitter			
	89	83	119	60

Tab 3 Average data collected on the different blocks of Yarmouk on Speed, Ping and Jitter.

V. Discussion

5.1 Performance Differences: Ping and Jitter

The data indicate that 5G offers a significant reduction in both **ping** and **jitter** compared to 4G, enhancing the overall stability and responsiveness of the network. Adailiya exhibited the best performance due to its proximity to 5G infrastructure, while older infrastructure in Kaifan and Yarmouk contributed to slightly higher latency and jitter. Fig 1 shows the ping comparison separately for 4G and 5G with regards to their download and upload conditions. The areas are also highlighted in three different colors for easy identification. Similarly, Fig2 shows the Jitter comparison separately for 4G and 5G with regards to their download and upload conditions.

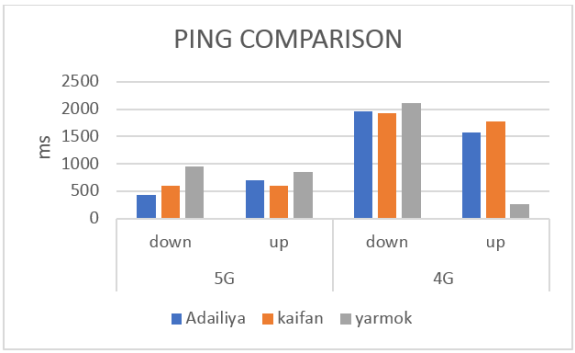

Fig1 Average Ping comparison in three different areas

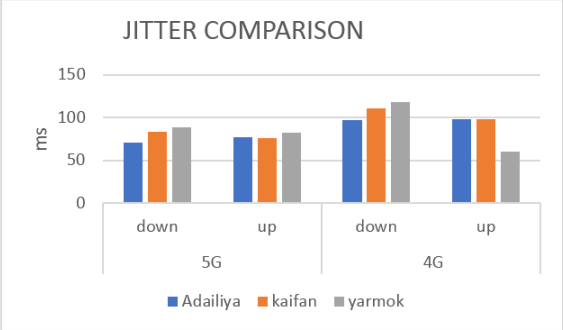

Fig2 Average Jitter comparison in three areas

5.2 Download and Upload Speed Comparison

5G demonstrated a marked increase in both **download** and **upload speeds** in all three neighborhoods. Kaifan showed the highest speeds, suggesting a well-established 5G infrastructure. While Adailiya and Yarmouk also saw substantial improvements over 4G, their performance lagged behind, possibly due to fewer 5G base stations. Fig 3 clearly illustrates the speed performance area wise.

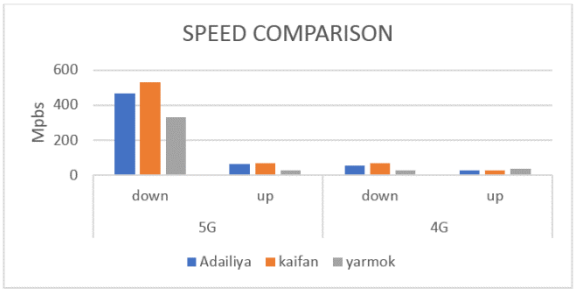

Fig3 Average 4G/5G Download and Upload speed comparison in three areas

5.3 Impact of Environmental Factors

The study reveals that environmental factors such as building density and the age of infrastructure can impact 5G performance. In Yarmouk, where buildings are older and more densely packed, there was a noticeable decline in performance compared to Kaifan and Adailiya.

5.4 Implications for Telecom Providers

Telecom operators should prioritize infrastructure upgrades in neighborhoods like Adailiya and Yarmouk to ensure consistent 5G performance. Deploying additional base stations or small cells can help mitigate performance issues related to signal interference and network congestion.

VI. Conclusion

This research highlights the superior performance of 5G over 4G in outdoor settings across Adailiya, Kaifan, and Yarmouk. While 5G offers significant improvements in speed and stability, infrastructure limitations in older neighborhoods pose challenges to achieving uniform performance. Targeted investments in 5G infrastructure will be necessary to fully realize the potential of this technology in Kuwait's residential areas.

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8. Appendix

8.1 Adailiya

8.1.1 Block 1

Adailiya	5G		4G	
Block 1	Down	Up	Down	Up
	440	74	63	38
	Ping			
	285	655	1775	1242
	Jitter			
	61	75	93	95

Tab 4 Average of data collected for block 1 on different dates

8.1.2 Block 3

Adailiya	5G		4G	
Block 3	Down	Up	Down	Up
	604	73	61	24
	Ping			
	690	440	1243	1756
	Jitter			
	85	68	92	101

Tab 5 Average of data collected for block 3 on different dates

8.1.3 Block 4

Adailiya	5G		4G	
Block 4	Down	Up	Down	Up
	356	49	38	24
	Ping			
	302	1014	2876	1724
	Jitter			
	67	89	108	97

Tab 6 Average of data collected for block 4 on different dates

8.2 Kaifan

8.2.1 Block 1

kaifan	5G		4G	
Block 1	Down	Up	Down	Up
	590	41	91	22
	Ping			
	676	756	1673	2002
	Jitter			
	88	84	91	101

Tab 7 Average of data collected for block 1 on different dates

8.2.2 Block 4

kaifan	5G		4G	
Block 4	Down	Up	Down	Up
	569	104	76	33
	Ping			
	486	242	1639	1425
	Jitter			
	79	58	97	97

Tab 8 Average of data collected for block 4 on different dates

8.2.3 Block 7

kaifan	5G		4G	
Block 7	Down	Up	Down	Up
	442	57	39	30
	Ping			

	618	819	2487	1908
	Jitter			
	84	88	144	99

Tab 9 Average of data collected for block 7 on different dates

8.3 Yarmouk

8.3.1 Block 1

Yarmouk	5G		4G	
Block 1	Down	Up	Down	Up
	183	11	6	15
	Ping			
	976	1545	2466	384
	Jitter			
	92	100	124	78

Tab 10 Average of data collected for block 1 on different dates

8.3.2 Block 2

Yarmouk	5G		4G	
Block 2	Down	Up	Down	Up
	515	38	44	48
	Ping			
	723	534	2104	146
	Jitter			
	86	77	116	48

Tab 11 Average of data collected for block 2 on different dates

8.3.2 Block 4

Yarmouk	5G		4G	
Block 4	Down	Up	Down	Up
	298	33	30	47
	Ping			
	1133	449	1766	250
	Jitter			
	89	72	116	54

Tab 12 Average of data collected for block 4 on different dates