Poster: Commercial 5G Performance: A V2X Experiment

Raphaël Frank and Faisal Hawlader
Interdisciplinary Centre for Security, Reliability and Trust (SnT)
University of Luxembourg, 29 Avenue J.F Kennedy, L-1855 Luxembourg
firstname.lastname@uni.lu

***Abstract*—This poster paper presents the results of a 4G/5G measurements campaign conducted in Luxembourg City in August 2021. We test the performance of both network technologies while stationary and on the move. We report the results for download and upload throughputs, as well as the Round-trip Time (RTT). We briefly discuss the results in the context of Vehicle-to-Everything (V2X) applications.**

***Index Terms*—Vehicular Communications, Experimental Research, Mobile Networks, 5G**

I. Introduction

Commercial 5G networks are currently being rolled out all over the world. First measurement campaigns have recently been performed with mixed results [1], [2]. In this short paper we present preliminary results of a 4G/5G measurement campaign performed in Luxembourg City.

The recently launched 5G network offers connectivity at the Low- (700 MHz) and Mid-band (3.6 GHz). It is worth mentioning that no millimeter Wave (mmWave) is deployed in Luxembourg due to an ongoing public debate on health concerns. The tested 4G network makes use of the most recent LTE Advanced standard that relies on Carrier Aggregation to achieve high data rates. Our measurements show that the current 5G deployment only offers a marginal performance improvement over the 4G network. A denser deployment combined with dedicated infrastructure will most likely increase the performance significantly over the next few years.

II. Experimental Setup

We use the *iPerf3* utility to measure the download and upload throughput, and *ping* to record the Round-trip Time (RTT). The test setup is depicted in Fig. 1. We use a public *iperf3* server located in Paris and run the client on a laptop located in a vehicle. The laptop is connected via USB to a Realme 8 5G Smartphone running Android 11 and equipped with a MediaTek Dimensity 700 chip that we used as 5G modem. The smartphone was located inside the vehicle at the front of the windshield for all experiments.

Two experiments have been conducted: (1) Stationary and (2) Mobile measurements. The experiment map including the locations of the tests and base stations is depicted in Fig. 2.

All tests have been conducted in August 2021 under dry and clear weather conditions.

[1] https://bit.ly/3COv8ds

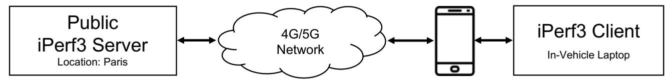


Fig. 1: Experimental setup.

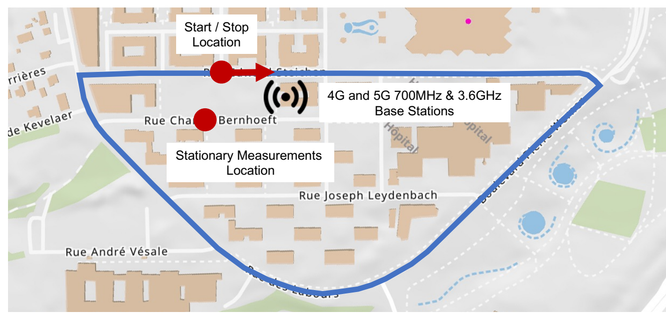
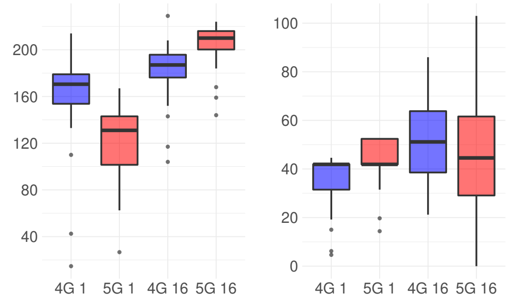


Fig. 2: Test site in the Kirchberg area of Luxembourg City[1].

III. Results

A. Stationary Measurements

First, we investigated the upper bound performance while stationary. The car was parked at the side of the road in line of sight with the base station at a distance of approximately 115 meters. We ran download and upload measurements for 1 and 16 TCP streams to test the impact of parallel connections. We set the interval to one second and run the test for a total of 50 seconds. The results can be seen in Fig. 3. We can see that the download performance of 4G is comparable to that of 5G, and it even beats 5G for a single TCP stream. The reason is probably due to the usage of the LTE Advanced Carrier Aggregation, which combines multiple frequency blocks to increase the data rate. Also, the upload speed is similar. We suspect that the data rate is throttled by the network operator based on traffic demand and link quality, which would also explain the wider spread for the parallel uploads. It is worth mentioning that the parallel downloads generate a high number of packet re-transmissions, peaking at 9.170 for 5G and 2.507 for 4G. Finally, the mean RTT (ping 64 bytes) for 5G is 46 ms and 42 ms for 4G. Those high values are probably due to the fact that both technologies share the same base station infrastructure. We note that similar results have been reported in previous studies [1], [2].



(a) DL (Mbps)

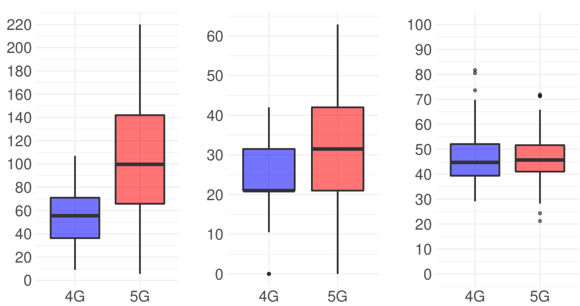
(b) UL (Mbps)

Fig. 3: Stationary test results.

B. Mobile Measurements

Next, we conducted measurements while driving. The track is depicted in Fig. 2 and has a length of approximately 1.7 km. The average speed of one loop was around 36 km/h.

The performance comparison is depicted in Fig.4. We observe an average download throughput of 55 Mbps for 4G, which is much lower than observed in stationary tests. On the other hand, 5G provides a decent performance with an average throughput of 105 Mbps, which indicates that 5G seems to be more robust to mobility. Again, we observe a similar performance for upload and RTT.



(a) DL (Mbps)

(b) UL (Mbps)

(c) RTT (ms)

Fig. 4: Mobile test results for 1 UL/DL TCP stream and 64 bytes RTT.

Finally, in Fig. 5 we plot download, upload and RTT over time. We can see in the second half of the run the download performance for 4G and 5G are more or less the same. This is most probably due to the fallback from 5G to 4G in this area which is highly obstructed by buildings. The upload plot confirms our suspicion that the data rate is throttled as it displays very regular values. Finally, we observe periodic peaks in the RTT of 4G. More investigations are needed to explain this phenomenon.

While driving one loop, we downloaded 1.87 Gbytes and uploaded 631 Mbytes using the 5G network. For 4G we downloaded 1.01 Gbytes and uploaded 411 Mbytes.

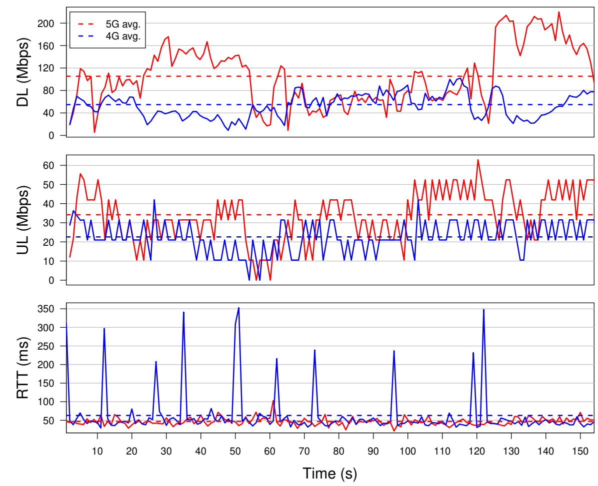


Fig. 5: Performance comparison over time.

IV. Discussion

What do those numbers mean in the context of V2X applications? The short answer is that this performance is insufficient for safety critical and high data rate applications. A commercial mobile network is usually not designed to serve specific V2X needs. We expect that network operators will progressively upgrade their core network to support such applications by building dedicated 5G infrastructure, including edge computing nodes. On the other hand, the Cellular-V2X (C-V2X) standard allows vehicles to communicate directly, thereby avoiding the high latency induced by the backbone network. The ultra-high data rates will only be achieved using mmWave technology, which however is not well suited for high mobility applications [1] and requires a dense deployment which will most likely only be possible in urban environments.

V. Conclusion

The 5G technology has been widely publicized as a major leap forward. So far however the improvement over the latest 4G standard is only marginal. We expect however that the performance will significantly increase once denser networks with dedicated infrastructure will be deployed. The highest performance will only be achieved with the deployment of the mmWave technology.

Acknowledgments

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References

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