Measuring the Effects of Guaranteed Bit Rate on 5G Cell Resource Allocation and Throughput

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***Abstract*—5G networks support prioritization of traffic via Guaranteed Bit Rate (GBR), enabling predictable performance for sensitive applications. However, allocating guaranteed resources to GBR clients may negatively impact the overall cell performance. In this work, we present a measurement methodology to investigate the influence of GBR-enabled User Equipments (UEs) on the net bit rate available to other users within a 5G cell. Our experimental lab setup uses a private indoor 5G cell and a fully passive measurement methodology to assess cell utilization under varying signal quality conditions. Results show how GBR allocation under degraded signal conditions can cause significant bit rate reductions for other UEs. Our initial findings highlight the trade-offs introduced by GBR in 5G networks and emphasize the need for careful resource planning in mixed-priority environments.**

***Index Terms*—Guaranteed Bit Rate, 5G, Network Parametrization, Passive Network Measurements**

I. Introduction and Background

While 5G is designed to supply a vast number of users at the same time, provide high data rates and high Quality of Service (QoS) to the users, a high network utilization influences the overall network performance. [1] presents a long-term performance measurement study in commercial 5G non-standalone networks in Rome, Italy. They utilized a measurement setup consisting of mobile devices communicating in 5G non-standalone networks of different providers for assessing performance indicators like throughput and latency, and a Spectrum Scanner for obtaining information about the network. Over the course of their study, they reported a decrease of radio conditions (i.e. decreased SINR), transport block size and ultimately a decrease of throughput and increase of latency. They expect these effects to be conditioned by several factors like higher network utilization and higher interference due to a higher density of physical serving cells. The paper highlights the importance of more detailed investigations of network performance. As examined in detail in [2], the performance and QoS achievable at a specific User Equipment (UE), highly deviates based on its positioning in relation to the serving cell. This is again expected to be conditioned by factors like interference and beamforming, but also by the path loss, which increases with higher frequencies [2], [3]. Specifically applications which require a high throughput like e.g. video streaming are highly affected by the fluctuation of throughput in 5G networks, as outlined in [4]. 5G offers the possibility to configure scheduling scenarios like assigning a Guaranteed Bit Rate (GBR) to individual network users through network slicing [5], [6], which could aid applications that require a high throughput. However, configuring a UE with a GBR could drastically influence the QoS available to other users within a certain cell. In this paper we document our investigations of the influence of a UE communicating with a GBR on the overall communication within a 5G cell. The paper is structured as follows: section II details the research objective. In section III we introduce our measurement setup and in section IV results are presented. Section V concludes the paper.

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II. Research Objective

As the physical resources of a specific provider are limited by the bandwidth available to that provider, they need to be split among all the devices connected to and communicating within a certain communication cell. The usable net bit rate offered to a user is determined by how well the physical resources assigned to that user are utilized, i.e. by the used coding and modulation scheme. Hence, the available net bit rate is ultimately determined by the UE's signal quality. If fair scheduling is configured within a cell, i.e. all UEs are configured with the same prioritization configuration, we expect the net bit rate available to an individual UE to be approximately linearly dependent on the number of communicating UEs, considering a certain signal quality at that UE. However, if the prioritization configuration deviates from fair scheduling, e.g. one of the communicating clients is configured to have a GBR, we expect this communication to highly influence the net bit rate available to the rest of the communicating clients within the same cell. This is expected, because the quantity of physical resources needed to achieve the GBR highly depends on the signal quality of that UE. Our study aims to investigate the influence of an individual UE configured and communicating with a GBR on the overall communication within a 5G cell in the context of changing signal quality.

Table I
5G NETWORK CONFIGURATION

Parameter	Value
Mode of Operation	5G Stand Alone
Frequency Band	n78
Duplex Mode	Time Division Duplex (TDD)
Bandwidth	80 MHz
MIMO Configuration	4x4 MIMO
TDD Frame Configuration	Frame Configuration 2
Special Subframe Configuration	SSC 6

III. MEASUREMENT SETUP

To investigate aforementioned interdependencies, we utilized several measurements in a lab environment with a private 5G indoor cell. To this end, the 5G network was operating in frequency band n78 (Time Division Duplex, TDD), with 4x4 MIMO, and 80MHz total bandwidth. TDD was configured with frame configuration 2 and special subframe configuration 6 [7]. The 5G network configuration used is summarized in Table I.

We had four UEs communicate within that cell, as depicted in Figure 1. Those UEs aimed to use a specified bit rate, configured and executed by iPerf3. Three of the UEs were stationary, with no specific prioritization configuration. For the fourth UE we alternated the prioritization configuration, as described below. For this UE we also changed the position throughout the measurement process, to alter the signal quality. We qualitatively determined these positions by repeated bit rate measurements and ultimately chose positions with significantly differing achievable bit rates. We tracked the actually achieved bit rate in a one second interval and also observed the utilization of the cells physical resources in a one second interval by a fully passive measurement method [8]. While this method only yields an estimate of the actual utilization of the cells physical resources, it does not introduce any measurement traffic. Hence, it can be expected to have zero influence on the communication and resource allocation within the cell. Being utterly independent of the communication, and vice versa, renders this method ideal for our study case. Our study setup was designed as follows: In a first step we investigated the aforementioned linear dependency of the net bit rate on the number of communicating clients at a certain signal quality level. To do so, we first determined the maximum net bit rate achievable by a mobile UE at specific signal quality levels.

This was done by conducting experimental iPerf measurements at certain positions and tracking the bit rate utilized by iPerf in a one second interval. The arithmetic mean of the bit rate at each signal quality level was used as a reference value for the respective quality levels. We utilized the same experimental measurement procedure on three stationary clients communicating within the same cell, to obtain reference maximum bit rates for those UEs as well. However, for the stationary clients we did not change position, hence their signal quality was anticipated to stay on a similar level for all subsequent measurements. We then proceeded with letting

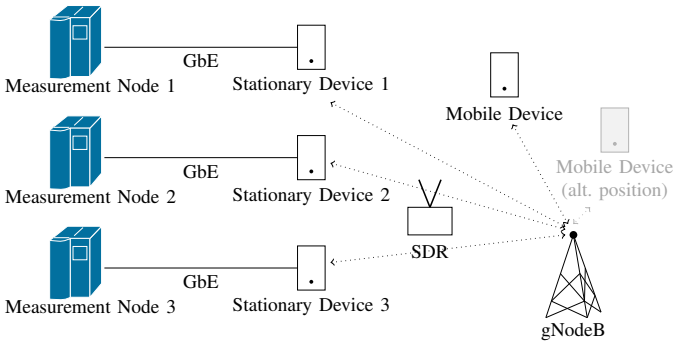

Figure 1. Measurement setup

all UEs communicate concurrently and again determined the maximum bit rate achievable by the individual clients. This experiment was repeated for all pre-defined signal quality levels of the mobile UE. In the second stage of our study, we configured the mobile UE with a GBR. We repeated the measurements that included the mobile device, to investigate the influence of the GBR at different signal quality levels on the overall communication within our private 5G cell.

IV. DATA ANALYSIS

Our initial tests of the individual client's respective maximum downlink bit rate coherently showed a maximum possible downlink bit rate of approximately 950MBit/s. However, as depicted in Figure 1, the stationary devices were connected to a 5G measurement node via Gigabit Ethernet (GbE). Hence, their respective maximum bit rate is not only limited by the 5G connection, but also influenced by the GbE connection between the client and the measurement node. As the mobile device is connected solely to the 5G cell, it is safe to assume that the maximum downlink bit rate of this device is solely determined by the 5G connection. In Figure 2 we present the results of our measurement.

For the stationary devices, we summed up their respective bit rates, to bypass the possible limitation by the GbE connection. As introduced in section II we expect the available physical resources of the 5G cell to be distributed among the communicating UEs. This ulitmately reduces the bit rate available to the UEs, hence renders the 5G cell the limiting factor in our measurement setup.

We then normalized the combined bit rate and the bit rate of the mobile device with respect to their respective maximum value during our measurement interval. In Figure 2 (top) it can be seen, that with guaranteed bit rate at the mobile device the actual bit rate at that device stays relatively constant while the combined bit rate of the stationary clients decreases. In Figure 2 (bottom) a measurement without GBR activated is shown. Here, the combined bit rate changes only slightly, while the bit rate at the mobile device decreases drastically. Next to the bit rates, Figure 2 shows the utilization of the 5G cell we used. The utilization remains constant around 70%,

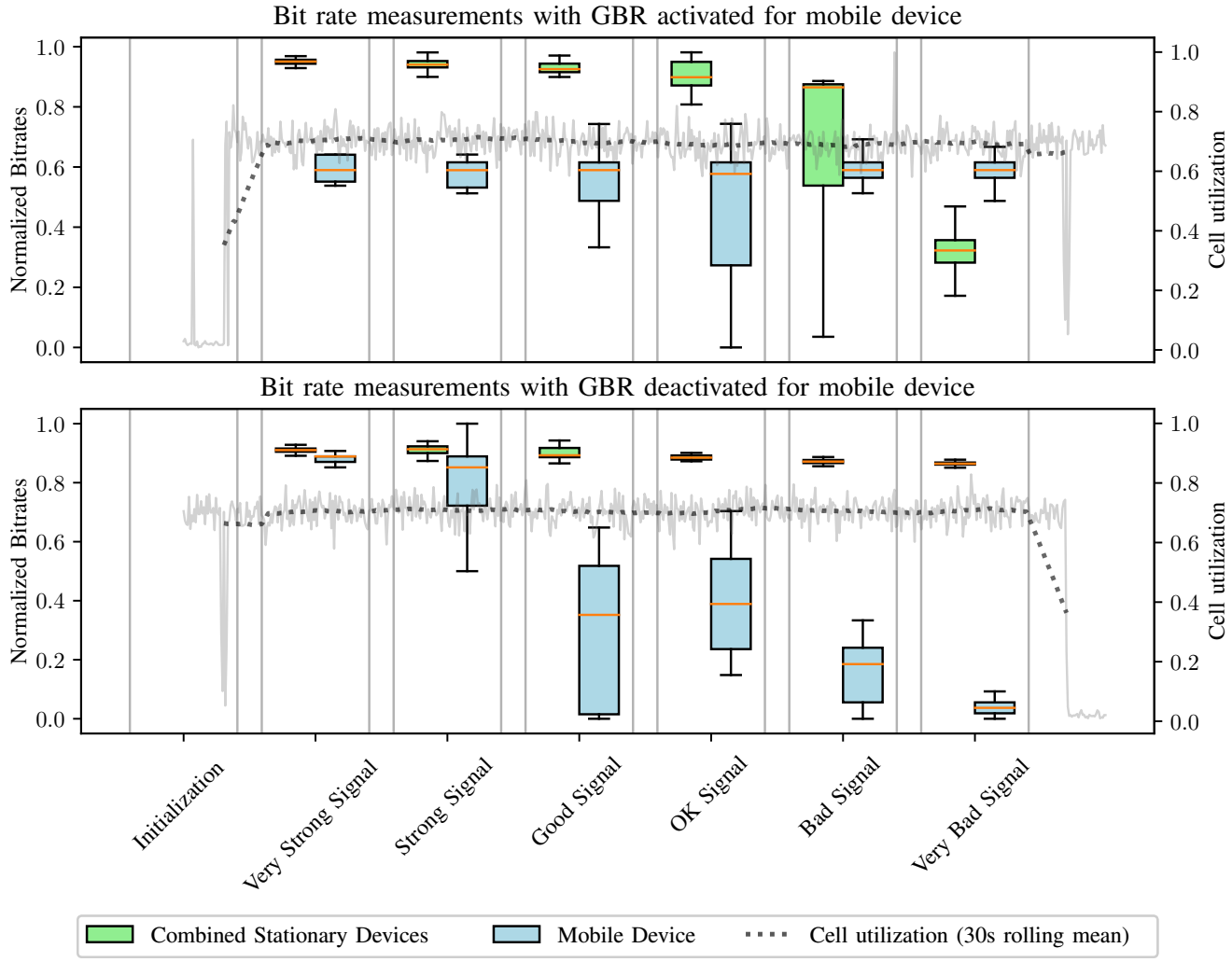

Figure 2. Bit rate tests with decreasing signal quality at the mobile device.

which corresponds to a fully utilized downlink in the given cell configuration (see Table I).

V. Conclusion

This work presents an experimental lab setup and measurement methodology including an initial investigation of the effects of Guaranteed Bit Rate (GBR) configurations on the overall communication performance within a 5G cell. Our initial experimental results show that GBR-enabled UEs can significantly reduce the available bit rate for other users, especially under degraded signal conditions. These findings highlight the importance of considering both signal quality dynamics and scheduling fairness when deploying GBR in mixed-priority environments.

Furthermore, we demonstrate that a fully passive and non-intrusive measurement methodology can effectively capture resource utilization dynamics without affecting network behavior. This makes the proposed setup a practical and scalable approach for evaluating traffic prioritization strategies and resource allocation in both experimental and operational 5G environments.

VI. Further Research

While our initial results demonstrate the impact of GBR-enabled UEs on cell-wide throughput degradation, several aspects remain open for further investigation. In addition to bit rate, latency is an increasingly critical key performance indicator (KPI), especially for real-time applications such as telemedicine or industrial control. Future measurement campaigns will explore how GBR affects end-to-end latency under varying network loads and radio conditions.

Moreover, our current measurements were conducted in a controlled lab environment using a private 5G cell setup. A next step is to validate the observed effects in real-world operational 5G networks with live traffic situations. This could help assess the applicability of our findings under more complex and dynamic network conditions.

Our proposed measurement setup, being lightweight and non-intrusive, is well-suited for such extensions.

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