Conducting Time-synchronized Measurements in 5G Campus Networks

Simon Raffeck*, Stefan Geißler*, Tobias Hoßfeld*
*Chair of Communication Networks, University of Würzburg, Würzburg, Germany,
*{simon.raffeck, stefan.geissler, tobias.hossfeld}@uni-wuerzburg.de,

***Abstract*—Every generation of mobile networks promises significant improvements in efficiency, performance, and reliability. With the introduction of 5G and the rollout of application specific campus deployments, this promise hinges on optimized dimensioning and configuration. To this end, we present our 5G campus testbed that enables time-synchronous measurements using both physical and virtual UEs. We highlight design choices and present selected results from ongoing research.**

I. 5G Campus Testbed

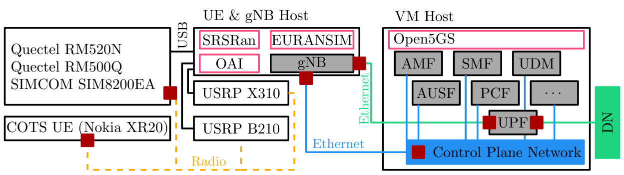

Fig. 1. 5G network setup; control plane (blue), data plane (green), radio (orange); red squared show measurement points.

The testbed to capture both control and data plane traffic in a 5G campus network is shown in Figure 1. We deploy Open5Gs in individual VMs, each hosted on the same host (2xAMD EPYC 7402 24-Core, 1TB Memory, 10G Ethernet). Running the VMs on the same server, enables us to leverage the same hardware clock, ensuring synchronized timestamps in the captured traffic traces. Therefore, we capture traffic on the bare-metal server instead of individual VMs.

For the radio access network, we deploy both virtual and physical UEs as well as gNBs. By using different USB-connected 5G modules, commercial, and virtual UEs, we cover a wide range of client devices. We deploy two state-of-the-art open-source gNB implementations,SRSRan and OpenAirInterface, using the USRP B210 and X310 as the radio unit. UERANSIM [1] is used emulate both virtual UEs and a gNB.

In the testbed, both the USB-connected 5G modules and the gNB is hosted on the same bare-metal server, allowing the synchronization of UE egress and gNB egress traffic traces. Similarily, all core functions are hosted on the same bare-metal server, allowing the synchronization of signaling messages.

This setup enables the evaluation of throughput, delay, and channel quality metrics (e.g. RSSI). In [2], we evaluated the one-way-delay of the radio channel for varying gNB configurations. In [3], we developed a model of the radio channel to predict the traffic pattern at the gNB egress, based on gNB configuration and validated our model using both simulations and measurements from the testbed.

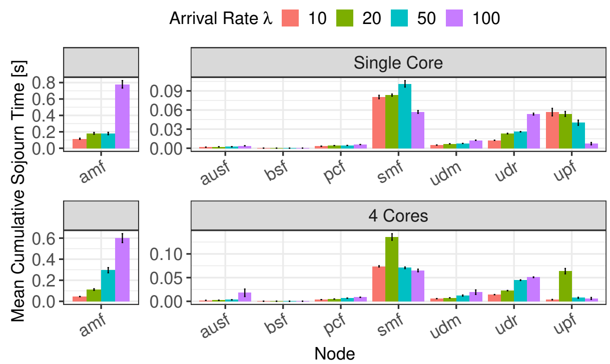

Fig. 2. Mean cumulative sojourn time for each UE on NFs within the 5G core under varrying degrees of load and with different VM settings.

II. Preliminary Results

Figure 2 shows preliminary results on the sojourn times observed during UE attachment. We generate a stream of new UEs using UERANSIM with rates between 10 and 100 new arrivals per second and measure the cumulative sojourn time of each involved core function, as the sum of all sojourn times observed for each individual signaling message. Each function is involved in processing multiple signaling messages for each attachment procedure. The data shows that a significant fraction of time is used by the AMF. The time scales with load, where 100 arrivals per second lead to severe queueing at the AMF. Other core functions exhibit, relatively to the AMF, low cumulative sojourn times, that even fall with increased load, as the AMF becomes the bottleneck. Finally, scaling the available CPU resources appears to have varying impact on the involved core functions depending on the load. More measurements are required, to full quantify this observation.

Moving forward, we will further investigate both radio and core performance in both signaling and data plane, leveraging the powerful and flexible testbed described above.

References

[1] A. Güngör. Ueransim. [Online]. Available: https://github.com/aligungr/UERANSIM

[2] S. Raffeck, S. G. Grøsvik, S. Lange, T. Hossfeld, T. Zinner, and S. Geissler, "Parameterizing 5G New Radio: A Comparative Measurement Study on Throughput and Delay," in *International Conference on Network and Service Management (CNSM)*. IEEE, 2024.

[3] S. Raffeck, S. G. Grøsvik, L. A. Becker, S. Lange, S. Geissler, T. Zinner, W. Kellerer, and T. Hossfeld, "A Discrete-Time Model of the 5G New Radio Uplink Channel," in *36th International Teletraffic Congress (ITC 36)*. IEEE, 2025.