5GOpen@TheBeacon: The 5G Testbed

João Francisco Nunes Pinheiro*, Carlos F. M. e Silva*, Johann Marquez-Barja*,
*University of Antwerp, IDLab, imec, Antwerp, Belgium,
emails: {joaofrancisco.nunespinheiro, carlos.moreiraesilva, johann.marquez-barja}@uantwerpen.be

***Abstract*—5G communications presents new and exciting functionalities by taking a big leap in performance when compared with the previous generations of mobile communications. The openness provided by the different interfaces supported by the OpenRAN paradigm enable the development of intelligent controllers that are able to scale and optimize the network, while the decentralization and softwarization of components allow hybrid deployments that can combine multiple vendor solutions, which are able to unlock the full potential of 5G, required to fulfill a wide range of use cases. With this in mind, this paper presents 5GOpen@TheBeacon, a 5G testbed aimed at development, experimentation, integration, and innovation for this technology and related functionalities.**

***Index Terms*—5G, Experimentation, Testbed, OpenRAN.**

I. Introduction

5[th] Generation (5G) experimentation has been a desire for long in order to tweak performance and implement innovative functions and algorithms for boosting functionalities on this new era of mobile communications.

Leveraged by the OpenRAN [1] model, 5G mobile communications define a set of open interfaces to enable efficient communication among its elements. Moreover, the model also takes advantage of the *softwarization* of certain components to breakdown the 5G stack into several Network Functions (NFs) that enable decentralized/hybrid deployments among multiple vendors; as the full potential of 5G can only be unlocked by the intensive research and experimentation (which lacks in comercial solutions).

In this manner, herein we present 5GOpen@TheBeacon, a 5G testbed located in the center of Antwerp, Belgium, tailored for research, development, integration, and validation of innovative solutions suited for boosting this emerging technology.

II. Overall Capabilities

Although the 5G paradigm favors openess by allowing softwarized and modular deployments [1], the use of commercial solutions usually implies closed source and/or proprietary software, which in its turn tends to be very restrictive. This leads to limitations of both implementation and testing cases of different functionalities, such as innovative scheduling algorithms.

In contrast, our testbed aims to perform 5G deployment/development, validation, integration and testing in both office and open environments by making use of open source solutions[2], such as OpenAirInterface (OAI)[3], Open5GS[4], Free5GC[5], srsRAN[6] and FlexRIC[7], to deploy a full End-to-End (E2E) 5G network, thus enabling the experimentation of different solutions in the whole 5G chain, from the core network to the Radio Access Network (RAN), and RAN Intelligent Controller (RIC) (see table I).

TABLE I
5GOpen@TheBeacon's solutions for the 5G chain.

Core network	RAN	RIC
OPEN AIR INTERFACE		FlexRIC
Open5GS	srsRAN	dRAX™ Accelleran
free5GC		

As said before, our testbed enables data collection, development, and testing of various solutions on top of the integration between different 5G software vendors, allowing the interoperability validation, as supported by 5G and OpenRAN [2].

III. Hardware

For development and testing, Virtual Machines (VMs) are available on virtualization servers. Those servers are also equipped with Universal Software Radio Peripherals (USRPs) x310 available. Particularly, the hardware may be enumerated as follows: 1) Proxmox enabled servers with a variety of guest Operating Systems (OSs) available; 2) 1x GPU per server to dedicate to one VM for Artificial Intelligence (AI)/Machine Learning (ML) purposes; 3) 128 GB of RAM for VM allocation; 4) 2x Intel Xeon E5-2620 CPUs (8 cores, 16 threads); and 5) 1x USRP X310 over 10 GB link to passthrough to the VMs. This virtualization environment provides the users a cloud-like environment to deploy different applications, such as core network, RICs, x/rApps, and simulated RAN environments.

For the over-the-air deployments, General Purpose Computing Units (GPCUs) are used as gNBs and have the following hardware specifications: 1) Intel i7-11700K processor with 8 cores; 2) 64 GB RAM; 3) RTX 3060 GPU for AI/ML algorithms development, training, and testing; 4) USRP B210 over USB3 interface; and 5) 2x 10 GB SFP links for use with different Radio Heads (RHs). The experiments which involve over-the-air transmission require the testbed users to have the appropriate spectrum licenses, if the desired use falls outside of the testbed's test license, which covers 50 MHz of 5G New Radio (NR) band 77.

[1]https://o-ran.org
[2]The exception is Accelleran's dRAX, https://accelleran.com/drax
[3]https://openairinterface.org
[4]https://open5gs.org
[5]https://www.free5gc.org/
[6]https://www.srslte.com/
[7]https://gitlab.eurecom.fr/mosaic5g/flexric

For User Equipment (UE) testing, we have Intel NUCs connected to Quectel RM500Q 5G modules, with Subscriber Identity Module (SIM) cards pre-programmed to be used with specific test Public Land Mobile Network (PLMN)-IDs, which are the network identifiers tied to our testbed equipment. The hardware is the following: 1) 1x RM500Q module with a pre-programmed SIM card; 2) 32 GB of RAM; and 3) Intel i7-10710U (6 cores, 12 threads). Finally, the hardware of both GPCU and UE is represented in fig. 1.

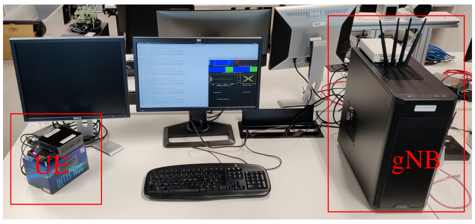

Fig. 1. GPCU connected to USRP acting as gNB and UE (Intel NUC with a Quectel RM500Q 5G module).

IV. Architecture

Fig. 2 represents the current architecture of the testbed. Starting from the top, we have the virtualization servers that provide a cloud-like environment for the experiments. Here we are able to deploy any virtualized resource, from different core functions to RAN controllers. One other use of this resource is to develop and pre-test configurations for over-the-air experimentation, thus reducing troubleshoot time when running complex experiments.

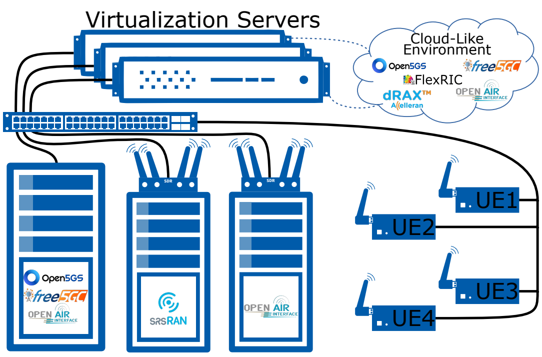

Fig. 2. 5GOpen@TheBeacon's architecture.

Although 5G core functions are designed to run as Virtual NFs (VNFs) [3], on bottom left of our architecture we have designated a bare-metal machine for core deployment. This improves performance when running over-the-air experiments that require many connected UE and gNBs. It also adds on development capabilities by enabling the deployment of intelligent algorithms that could potentially enhance 5G core performance.

On the bottom left of our architecture, we have the over-the-air setup that makes use of the GPCUs as gNBs and Intel NUCs with 5G modems as UE. This enables a real life deployment of a E2E 5G network, with a mix of general purpose (USRPs and GPCUs) and targeted hardware (5G modems). The GPCUs can double as gNBs and Multi-access Edge Computing (MEC) hardware, which allows experimenters to deploy intelligent algorithms directly on the gNBs for better performance.

Moreover, both setups (virtualized and non-virtualized) are interconnected, enabling hybrid experimentation with the possibility of cloud, MEC, and bare-metal experimentation.

V. Integration Status and Performance

As stated before, multiple developments of the different 5G functions for both core network and RAN are being integrated into our setup, which is shown in table II.

TABLE II
Core network-RAN integration.

		Core network	
		OpenAirInterface	Open5GS
RAN	OpenAirInterface	Working	Working
	srsRAN	Queued	Queued

Regarding the integration of a RIC, current efforts (*in progress*) are aimed at using dRAX with both working solutions shown in table II, which is a closed source platform, but still OpenRAN compatible, allowing for intelligent deployments and execution of x/rApps.

Finally, the performance status of the testbed is shown in table III.

TABLE III
Core network-RAN performance.

	OAI (core + RAN)	Open5GS core + OAI RAN
Latency	20 ms	15 ms
UL thr.	20 Mbps	20 Mbps
DL thr.	130 Mbps	150 Mbps
Coverage	Up to 90 m with out-of-box OpenAirInterface configuration	

VI. Conclusions and Future Work

The current paper presented the 5GOpen@TheBeacon, a 5G testbed aimed at experimentation, development, and integration of different solutions for the core network, RAN, and RIC that target the optimization of the network.

Future works for the testbed include: 1) Further exploration of the OpenRAN interfaces for better control and data acquisition, and validation of different equipment, such as different commercial phones and radios; 2) Continuous testing and adaptation of testbed's configuration, targeting the 3GPP's performance requirements; 3) Last but not least, the integration with IDLab's Smart Highway Testbed[8], allowing researchers to test real-life scenarios involving 5G vehicular communications.

References

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[2] O.-R. Alliance, "O-RAN: Towards an open and smart RAN," O-RAN Alliance, White Paper, Oct. 2018.

[3] 3GPP, "System architecture for the 5G system (5GS)," 3rd Generation Partnership Project (3GPP), Technical Specification (TS) 23.501, Mar. 2021, version 17.0.0.

[8]https://www.uantwerpen.be/en/research-groups/idlab/infrastructure/smart-highway