NITOS testbed: a heterogeneous environment for 5G and beyond experimentation

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Abstract

In this position paper, we focus on the NITOS testbed and the experimentally driven 5G activities around the established experimentation ecosystem it provides. NITOS is a highly heterogeneous testbed located in the premises of University of Thessaly, Greece. The testbed provides remote access to experimenters from around the globe, allowing repeatable experimentation with cutting edge resources. In this position paper, we cover some of the main contributions with frameworks for experimentation in Cloud-based Radio Access Networks, Multi-access Edge Computing, Spectrum Coordination, as well as frameworks for orchestrating different software functions as VNFs.

1. Introduction

NITOS testbed [1] is a heterogeneous testbed, located in the premises of University of Thessaly, in Greece. The testbed facilitates access to open source and highly configurable equipment, allowing for innovations through the experimental evaluation of protocols and ideas in a real world environment. The technologies supported currently span a high variety of the existing protocols for wireless and wired communications, with a special focus to 5G technologies. The experimental ecosystem is consisting of several wireless and wired networking components, coupled with powerful nodes and a cloud-computing infrastructure. The key equipment components in NITOS are the following:

Figure 1: NITOS indoor (left) and outdoor (center) deployments. A programmable LTE-A base station is available in one of the testbed deployments

- Over 100 nodes equipped with IEEE 802.11 a/b/g/e/n/ac compatible equipment, and using open source drivers. The nodes feature multiple wireless interfaces, and are high-end computers, with quad-core Intel Core i5 and Core i7 processing capabilities, 4/8 GBs of RAM and SSD disks.
- Commercial off-the-shelf (COTS) LTE testbed, consisting of a highly programmable LTE macrocell, multiple femtocells, an experimenter configurable EPC network and multiple User Equipment (UE).
- Open Source LTE equipment, running over commodity Software Defined Radio (SDR) equipment, by the adoption of the OpenAirInterface (www.openairinterface.org) [2] platform. The platform is allowing multiple configurations and setups, and allows the experimenter to create a highly customizable LTE network using the testbed. OpenAirInterface can be set to operate as either a femtocell or UE, whereas its accompanying core network is provided (OpenAirCN).
- A Software Defined Radio (SDR) 5G testbed, consisting of 10 USRPs N210, 16 USRPs B210, 4 USRPs X310, 2 USRPs N310 and 4 ExMIMO2 FPGA boards.
- A millimeter wave testbed, operating in the V-band (60GHz) based on six nodes provided by Blu Wireless. The platforms support high data-rate point-to-point setups, with beam steering capabilities of 90 degrees.
- The nodes are interconnected through 5 OpenFlow hardware switches, sliced using the FlowVisor framework, allowing multiple experimenters control the traffic generated from their experiments with their OpenFlow controller.
- A Cloud Computing testbed, consisting of 96 Cores, 286 GB RAM and 10 TBs of hardware storage. For the provisioning of the cloud, OpenStack is used.
- Multiple WSN clusters, supporting the IEEE 802.15.4 stack, or a WiFi mesh setup, gathering measurements such as temperature, luminosity, air quality, radiation emission, etc.

The equipment is distributed across three different testbed locations (indoor, outdoor and office setup), and can be combined with each other for creating a very rich experimentation environment. The nodes are running any of the major UNIX based distributions.

2. NITOS tools for 5G experimentation

In this section, we provide some of the experimental contributions of the testbed team, with ready to deploy frameworks around 5G experimentation in the testbed. All the contributions can be effortlessly deployed as VNFs over the testbed.

2.1 Convergence of multiple heterogeneous access technologies in the Cloud

Cloud-RAN based architectures are widely considered a fundamental part of 5G networks. Therefore, in the upcoming standards for 5G RAN, disaggregating the RAN functionality between a Central Unit (CU) and multiple Distributed Units (DUs) is considered, addressing the splitting of the 5G protocol stack at the higher OSI layer 2 [3]. This split is expected to bring numerous advantages to mobile network operators, as through the isolation of the stack from the Packet Data Convergence Protocol layer and upwards, the CU will be able to act as the Cloud-based convergence point among multiple heterogeneous technologies in the provisioned networks and hence able to serve multiple heterogeneous DUs. Moreover, data rate requirements for this type of split are not very demanding, thus allowing IP-based transferring of data from the DU to CU and vice-versa. Based on these concepts, we proposed, implemented and evaluated a protocol for a Cloud-RAN based architecture allowing the selection and dynamic switching of different heterogeneous networks in the RAN. The basis for this contribution is the open source OpenAirInterface platform, appropriately extended in order to support data plane splitting of the LTE functionality, and the subsequent data injection to WiFi networks. Experimental results from the benchmarking and proof-of-concept evaluations of the framework will be presented in the workshop, whereas the complete contributions can be found in [4].

2.2 Multi-access Edge Computing in the Cloud-RAN

Multi-access Edge Computing (MEC) has been proposed as the means to drastically minimize the service access latency, by bringing computational resources and services closer to the wireless network edge. Edge resources are planned for extended usage in the upcoming 5G networks, as they are able to meet stiff latency demands required from services being developed around this ecosystem (e.g. VR, e-Health, Industry 4.0, etc.). At the same time, 5G networks redefine the operation of traditional base station units, by disaggregating them and operating part of them in the Cloud, thus creating Cloud-RANs. These Cloud-RANs can also be heterogeneous, allowing users to access the network through multiple wireless technologies. In this concept, we have blended the novel disaggregated and heterogeneous base station architecture with the MEC concept, and proposed the deployment of the edge computing services even closer to the network edge. During the workshop, we will present a prototype implementation based on an open source platform that allows services to be executed close or over the machines hosting the radio access services for the network access. By exploiting features for integrating heterogeneous radio resources in the cell, we create a switching technology for the MEC side of the network that selects the technology through which each client of the network is served. Experimental results show significant performance improvements in terms of latency even for legacy technologies (e.g. LTE), as well as for adaptive video streaming [5].

2.3 Orchestration Infrastructure

The orchestration software that is running in the testbed is acting as the “glue” between the developed software frameworks and the physical infrastructure of the testbed. Network Functions Virtualization Management and Orchestration (NFV-MANO) provides a standardized approach on the management and effortless deployment of (virtual) services. Although NFV-MANO initially focused on the deployment of services over datacenters, the introduction of fully softwarized network architectures even for the wireless part creates fertile ground for the re-conception of the manner through which the underlying hardware is managed. As all of our prior contributions in the testbed are software based, the NFV-MANO architecture can be employed for the efficient orchestration of the frameworks in the testbed. NITOS has adopted the Open Source MANO framework for provisioning virtual services on top of the virtualized wireless equipment. Through extensions to the Virtual Infrastructure Manager service for the testbed, we are able to establish and manage virtualized wireless network interfaces, hosted on the generic networking nodes of the testbed [6]. The extensions are introduced transparently and as an optional feature to the existing operation of the orchestrator, in order to allow the portability of network services and network functions to instances that do not implement our extensions. With our contributions, we manage to deploy virtual functions internetworked over wireless links, as well as maintain the traditional NFV MANO deployment process.

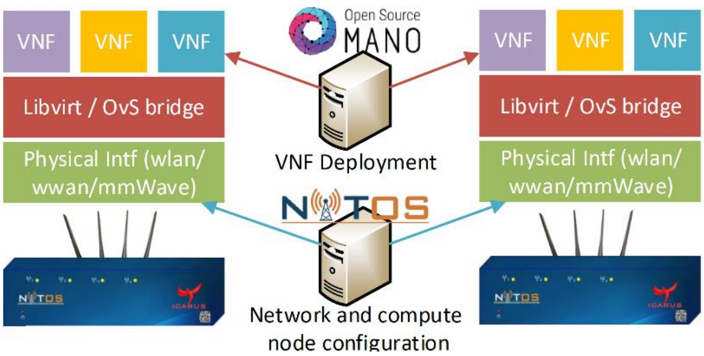

Figure 2: VNF instantiation on a NITOS node: each VNF is bridged to the underlying physical wireless network (WiFi/LTE/mmWave), configured through the NITOS testbed tools.

References:

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