5Genesis

5TH GENERATION END-TO-END NETWORK, EXPERIMENTATION, SYSTEM INTEGRATION, AND SHOWCASING

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Portable 5G Demonstrator (Release B)

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LIST OF ACRONYMS

Acronym	Meaning
5G PPP	5G Infrastructure Public Private Partnership
5G-IA	The 5G Infrastructure Public Private Partnership
eNB	eNodeB, evolved NodeB, LTE eq. of base station
EU	European Union
EPC	Evolved Packet Core
gNB	gNodeB, 5G NR, next generation NR eq. of base station
GPP	General Purpose Processor
HetNet	Heterogeneous Network
H-RAN	Heterogeneous RAN
ICIC	Inter-Cell Interference Coordination
ICMP	Internet Control Message protocol
IDS	Intrusion Detection System
IOT	Internet of Things
KPI	Key Performance Indicator
LPWA	Low Power Wide Area
LTE	Long-Term Evolution
LTE-A	Long-Term Evolution - Advanced
MANO	NFV MANagement and Organisation
MME	Mobility Management Entity
mMTC	Massive Machine Type Communications-5G Generic Service
NBI	North Bound Interface
NFV	Network Function Virtualisation
NFVI	Network Function Virtualisation Infrastructure
NSA	Non standalone
NSMF	Network Slice Management Function
NR	New Radio
OAI	Open Air Interface
OSA	OpenAirInterface Software Aliance
OAM	Operations, Administration & Management
OF	OpenFlow
ONAP	Open networking Automation Platform
OSM	Open Source MANO
RAN	Radio Access Network
RRH	Remote Radio Head
RRM	Radio Resource management
RU	Radio Unit
SDN	Software Defined Network
SDR	Software Defined Radio
SFP	Small form-factor pluggable
UE	User Equipment

Executive Summary

This document presents the 5GENESIS portable demonstrator, i.e., a portable platform that is used in the 5GENESIS project for participating in exhibitions/demo events and, also, to provide vertical sectors with a full 5G reference testbed for on-site testing. The main content of the document refers to the description of the integration activities conducted during the period up to M18 of the project.

As it is explained in the document, the development of the 5GENESIS portable demonstrator targets a compact physical layout to guarantee portability. However, the developments are not limited to a monolithic approach. Multiple building blocks have been integrated in a modular way to enhance the variety of test cases and experiments that the 5GENESIS portable demonstrator can support. In that sense, both open source software solutions (such as the Open Air Interface (OAI), provided by EURECOM, over Ettus USRPs) and commercial off-the-shelf products (such as the Amarisoft products) have been adopted.

All the activities reported in this document abide by the need to meet a major objective of the project, i.e., to realize the 5GENESIS reference architecture (released from WP2 of the project). In this context, the reader can find infrastructure level integrations as well as installations and configurations of the 5GENESIS facility layer, i.e., the set of tools (released from WP5 of the project) that are being developed to enable automated experimentation, slice management, and performance monitoring. From the infrastructure perspective, research-oriented set ups for 4G and 5G technologies have been integrated, while a 5G NSA solution is also available for performance testing from verticals.

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1. Introduction

1.1. Purpose of the Document

This document is the second document dedicated to the work performed in WP4 for the realization of the 5GENESIS portable demonstrator. The document serves as a reference point for the current status of the conducted integration activities, as well as a comprehensive descriptor of the functional and infrastructure components of the demonstrator. We note that the work reported in this document is linked to the activities of WP7 of the project (especially the dissemination and demonstration tasks) and as such, it can complement any participation is related events.

In the table below, the documents that have been released in the context of the 5GENESIS project are provided, including the relevance level with this document.

Table 1 Relevant deliverables

ID	Document title	Relevance
D2.1 [1]	Requirements of the Facility	The document sets the ground for the first set of requirements, related to the features that the platform should support and the Use Cases that should be tested.
D2.2 [2]	5GENESIS Overall Facility Design and Specifications	The 5GENESIS facility architecture is defined in this document. The list of functional components to be deployed in each testbed is defined.
D2.3 [3]	Initial planning of tests and experimentation	Testing and experimentation specifications that influence the testbed definition, operation and maintenance are defined.
D4.16 [4]	The Portable 5G Demonstrator	D4.16 is the initial deliverable of the 5GENESIS Portable demonstrator. In D4.16, the focus was mainly on the description of the technologies and the different components that was available for the integration of the 5GENESIS portable demonstrator. Here, in D4.17, the focus is on well-integrated setups and on the evolution of the developments for the portable demonstrator. Also, since D4.17 is a public deliverable, effort has been allocated to avoid strong correlation with the content in its predecessor (treated as confidential).
D5.1 [5]	System level tests and verifications	This document provides guidelines, tests and software for the realization of the 5GENESIS facility coordination layer components.

1.2. Structure of the Document

The document is composed of four sections where the second one includes the core technical aspects of the document. It includes a comprehensive overview of the 5GENESIS demonstrator, and separate subsections have been assigned to i) mobile network technologies i.e., the RAN and core set ups, ii) the transport network and how it is emulated in the context of the demonstrator, and iii) the network management and control tools used to support experimentation and testing. The third section refers to the activities conducted for the evolution of the demonstrator so far, while the fourth section includes the conclusions.

1.3. Target Audience

This document targets primarily the 5GENESIS consortium in order to be used as a reference document for the planning of WP5 and WP6 activities, but also aims at external non-5GENESIS-related people, either from other 5G-PPP projects or from the research community and the ICT industry. The document may help appreciate design decisions for the deployment of 5G components and evaluate the adoption and deployment progress of the 5G infrastructure. The deliverable will help that interested audience to:

- Be informed on the latest 5G developments of the portable demonstrator
- Understand the requirements and risks for each deployed component within the portable demonstrator
- Facilitate technology selection and design decisions for their components
- Understand the limitations and restrictions in technology deployment and usage.

2. PORTABLE DEMONSTRATOR OVERVIEW

2.1. Target Deployment Overview

The Portable Demonstrator of the 5GENESIS project provides a mobile end-to-end platform for demonstration purposes in exhibitions and various events, as well as a fully functional tool that enables on-site testing and experimentation for vertical industries. The main principle of the development process for the 5GENESIS Portable Demonstrator refers to a compact and mobile platform that integrates all the necessary components for experimentation over a 5G mobile network.

To facilitate its portability and the feature of "on-site testing", the 5GENESIS Portable Demonstrator is realized with small form factor PC cases and laptops, while all the software and tools are onboarded in order to be self-contained and autonomous. However, the potential of connecting the infrastructure part of the 5GENESIS Portable Demonstrator with other facilities is under study. This potential could enable new demonstration scenarios not foreseen so far.

Figure 1 depicts the physical components of the Portable 5G Demonstrator. It is noted that the diagram in Figure 1 includes the full set of physical components that are currently active for the development process, meaning that it shows commercial nodes, auxiliary PCs/monitors, as well as the nodes where open source or project specific software is installed (e.g., OAI, WAN emulator etc).

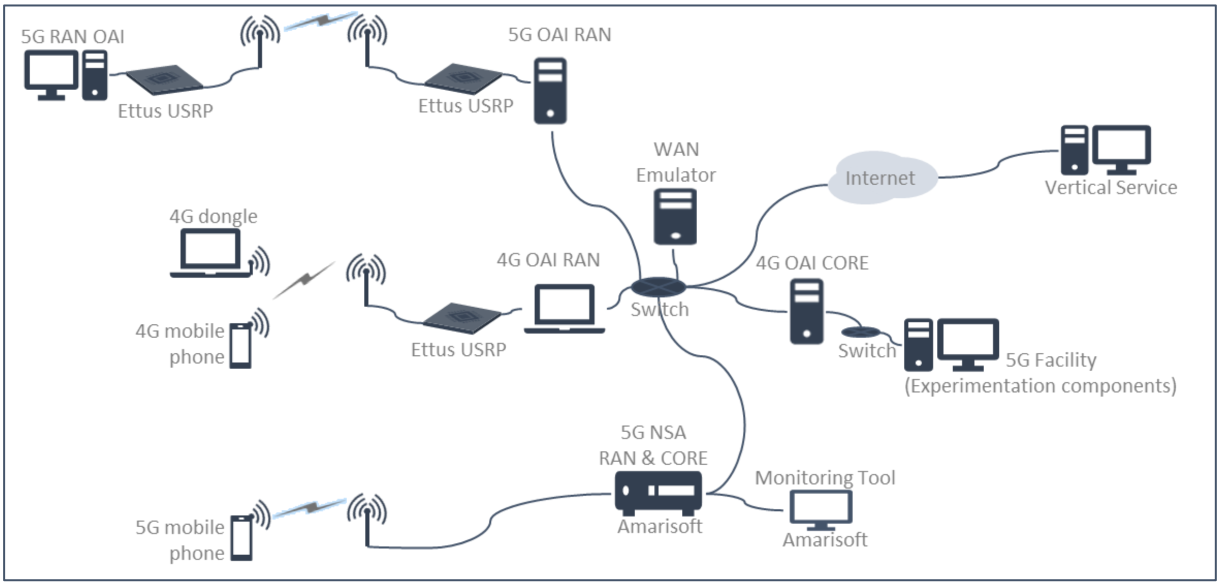

Figure 1 Physical diagram of the Portable Demonstrator

In terms of the functional components as of 5GENESIS Facility Release B (please refer to WP5 D5.1), the features of the Portable Demonstrator are:

- 5G NR radio front-end (eNB/gNB) and user equipment (UE), based on open source SDR and software components by ECM, as well as Commercial Off-The-Self (COTS) solutions (especially for commercial 5G mobile phones);
- 4G and 5G NG core functions, including both open source implementation by ECM (OAI) and commercial solutions (Amarisoft);
- Coordinator layer components (w.r.t. the 5GENESIS reference Architecture) on top of NFV/SDN MANO stack.

2.2. Platform Infrastructure Layer

Table 2 includes the technical characteristics of the physical components that comprise the 5GENESIS Portable Demonstrator.

Table 2 Infrastructure layer components of the Portable Demonstrator

Component	Product/Technology	Mode of Implementation
LTE and 5G-NR UEs	• 5G NR UE: Dell G5 5587, i9-8950HK & USRP N310 (National Instruments) • Samsung A90 5G • 4G UE: Commercial LTE mobile phones and dongles	4G and 5G UEs
eNB/gNB	• OAI gNB: Dell G5 5587, i9-8950HK & USRP N310 (National Instruments) • Amarisoft Callbox eNB & gNB (Amari Callbox Classic) • OAI eNB: Dell Inspiron 5570 (i7-8550U CPU) & USRP B210	LTE and 5G-NR Base Stations
10GbE Adapter Module between OAI based host PCs and SDRs	• 2xThunderbolt-3 10GbE Adapter Module (Sonnet)	Provides 10GbE Ethernet connectivity between the gNB/5G UE SDRs and the respective Openair Interface PC hosts
EPC	• OAI vEPC: Dell Vostro 3470 (i7-8700 CPU) • Amarisoft EPC & 5GC (Athens Platform)	4G Evolved Packet Core
5GC		5G New Core
Transport Network Emulator	Intel NUC 6i7KYK	
Switch	Generic Top-of-the-Rack Switch	
Traffic Generators for performance / benchmarking / monitoring	• iPerf • Ping • Speedtest	Testing and Measurement
Router	• Cisco RV180	Router for external connectivity

2.2.1. Mobile Network Technology

The 4G and 5G RAN and Core open source solutions provided by ECM (OAI software) have been integrated in the Portable 5G Demonstrator and will continue to be updated as more functionalities become gradually available in the course of 5GENESIS. The inclusion of an open source solution in the Portable Demonstrator serves mainly for showcasing its significant efficiency in RAN and Core design from both innovation and cost perspectives to appropriate target audiences, given that there is a trend towards open interfaces. It is also an approach that allows for the full integration of the management and coordination layer of the 5GENESIS reference architecture, i.e., the layers that enable the run of automated and controlled tests. As an alternative solution for demonstration purposes with commercial 5G COTS UEs, the Portable 5G Demonstrator adopts the Amarisoft Callbox Classic[1]. All the approaches are described in the following subsections, while the roadmap for the three integration cycles of the project (phases) is summarized in Table 3.

Table 3 Portable 5G Demonstrator Technology roadmap

	Mobile Core Product	Radio Access Products	UE
Phase 1	OAI vEPC	OAI eNodeB	Commercial 4G
	Athonet EPC	OAI eNodeB	Commercial 4G/4G Dongle
Phase 2	N/A	OAI gNodeB	OAI nr-UE/SDR ETTUS
	Commercial EPC/5GC (Amarisoft Athens Platform Solution)	Commercial eNodeB/gNodeB (Amarisoft Athens Platform Solution)	Commercial 5G UE (Amarisoft Athens Platform)
Phase 3	To be decided	OAI gNodeB	Commercial 5G/OAI nr-UE
	Commercial Solution adopted by Athens Platform		

2.2.1.1. 5G NR setup

The 5GENESIS Portable Demonstrator has integrated the 5G RAN open source solution provided by ECM. The setup has been implemented bearing high processing power and portability in mind, satisfying the Portable Demonstrator's requirements. ECM's OAI application implements the NR features at the gNB and UE side (the so-called nrUE component in OAI) in compliance to the Rel.15 Standards. It also provides utilities for debugging, monitoring and demonstration purposes. In this context, the 5GENESIS Portable Demonstrator shall continue integrating the OAI software extensions that will be made gradually available throughout the different phases of the 5GENESIS project.

The OAI gNB and OAI nrUE software runs on top of two lap tops with overclocked i9-proceesors, in order to support the high processing requirements of the OAI software. The

[1] https://www.amarisoft.com/app/uploads/2019/09/Amari_Callbox_classic.pdf

software implements the whole chain of signal processing functions of the 5G-NR protocol stack, ranging from the physical to the higher layers of the RAN protocol stack.

The ETTUS USRPs N300 convert the RF signal to and from baseband using analog filtering, digital up and down conversion circuits. They feed the signal through 10GbE SFPs, which are required to support the sampling rates of 5G-NR (61.44Ms/s and 122.88Ms/s, depending on the 5G configuration). The laptops are connected to the USRPs with 10GbE-Thunderbolt3 adapters, capable of supporting the required rates.

Figure 2 5G NR Setup of the Portable Demonstrator

The connection between the two USRPs takes place either over-the-air or wire with proper attenuators to protect the radio frequency units. The supported bandwidths are 40, 80 and 100 MHz (106, 217 and 273 PRBs respectively) and the frequency band of operation is 3.5GHz. When transmitting over-the-air in areas with assigned license, the USRPs shall utilize a set of omnidirectional antennas, while the proper transmission and reception gains of the SDRs will be configured through the OAI application.

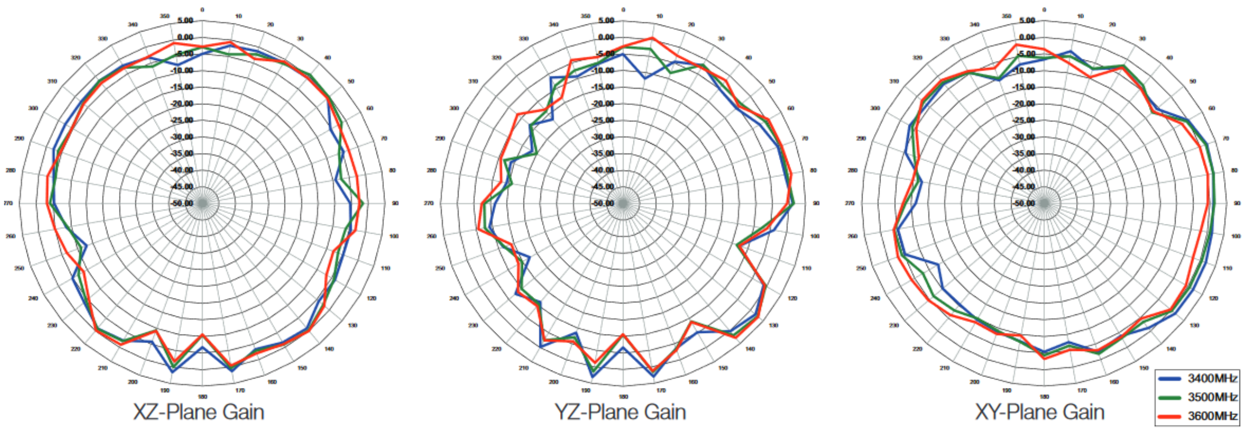

Figure 3 Antennas gain plots on 3.5GHz[2]

The ETTUS USRPs are synchronized with the Octoclock-G Clock Distribution Module[3], providing 8 pulse per second and 10MHz reference signals for time and frequency synchronization. The reference signals of the Octoclock-G are generated either by an internal GPS-disciplined, oven-controlled crystal oscillator or an external source.

The OAI gNB and OAI nrUE laptop hosts have been configured with Ubuntu 18.04 LTS and 5.0.0.25-low-latency kernel version.

5G RAN monitoring takes place using the *T-Tracer* and *XForms* utilities. The figure below depicts the XForms application running in the nrUE laptop, providing information on the received signal (both control and data channels at the physical layer).

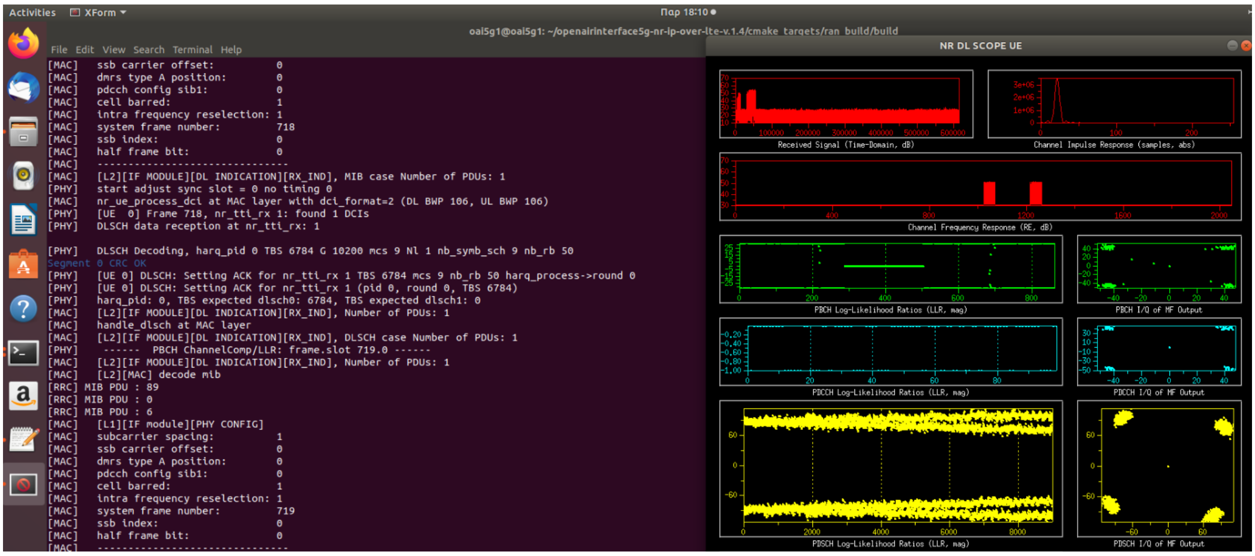

Figure 4 5G-NR OAI Scope monitors detection of 5G NR physical channels

On the other hand, the T-tracer utility (Figure 5) includes the *textlog tracer* that provides timestamped logs for metrics defined by the user.

[2] https://gr.mouser.com/datasheet/2/238/ant-lte-mon-1659497.pdf

[3] https://www.ettus.com/all-products/octoclock-g/

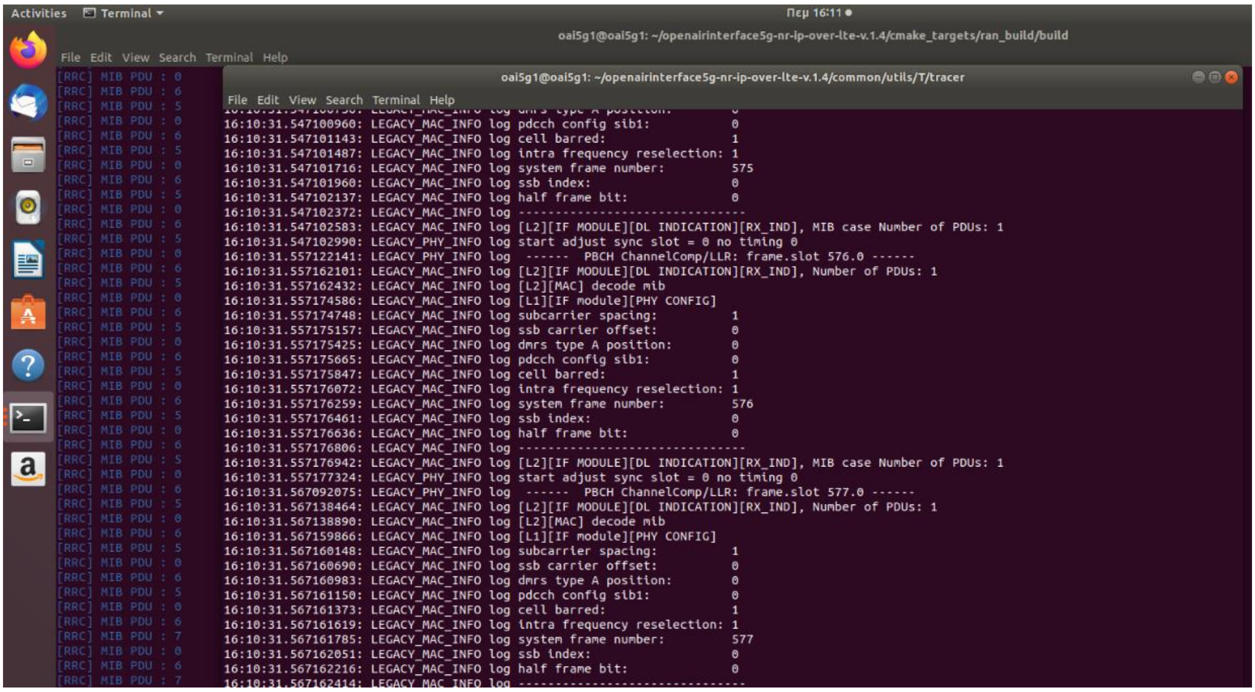

Figure 5 OAI Textlog T-tracer timestamped logs on the OAI gNB and nrUE

As of Release B of the Portable Demonstrator, there have been IP-based connectivity tests between the OAI gNB and the OAI nr-UE, using iperf and ping utilities (Figure 6). For the realization of these tests, a special mode (noS1) has been integrated in OAI, as an intermediate step until the complete NSA developments in OAI become available. The noS1 mode allows to preconfigure the required parameters for data-plane communications (Data radio bearer, PDCP and RLC entities, IP interfaces) and establish an IP communication link between the gNB and the nrUE, without having an actual RRC Connection establishment and UE attachment to the core network.

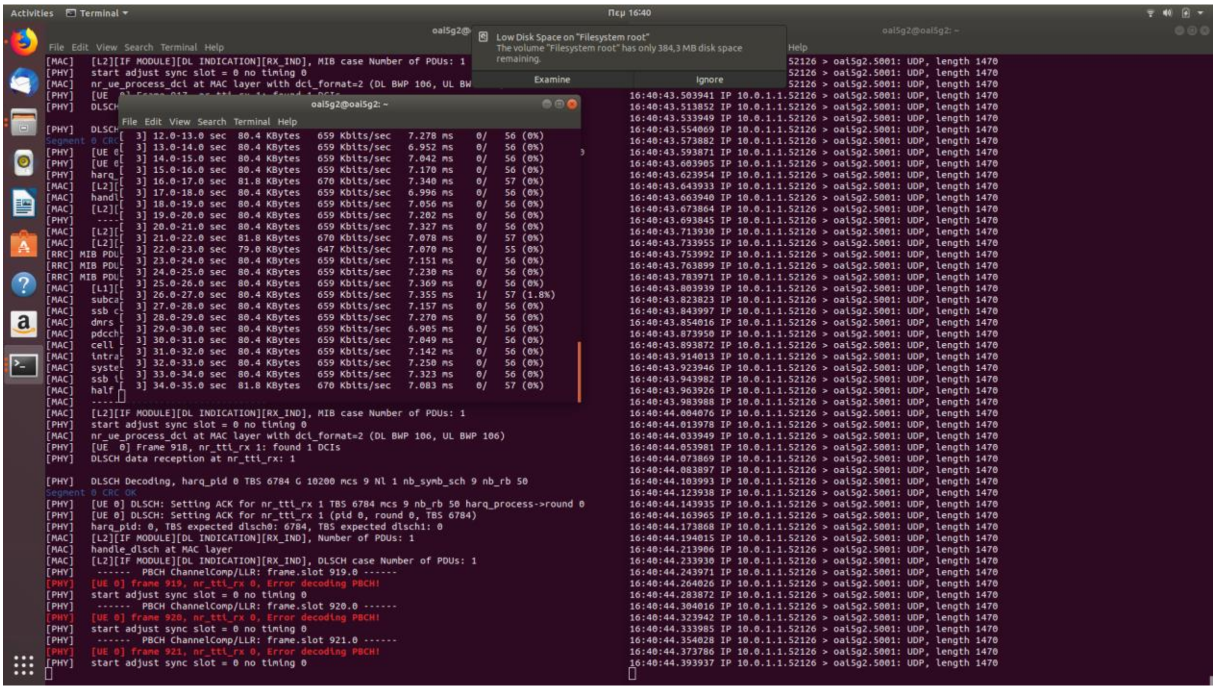

Figure 6 Ping and iperf tests between OAI gNB and OAI nr-UE

2.2.1.2. 5G NSA setup

As already mentioned, a key principle of the 5GENESIS portable demonstrator is to examine multiple set-ups in a modular way to enhance the variety of test cases and experiments that the 5GENESIS portable demonstrator can support. The Amarisoft Callbox Classic is one of the commercial solutions deployed in the Athens Platform and provides the capability of demonstrating a complete 5G NSA implementation. On top of this implementation 5GENESIS-specific features are being added to enable slice management and automated experimentation capabilities. In addition, the currently available web interface for monitoring the parameters of the system, is being enriched with Grafana and Prometheus tools.

Figure 7 Amarisoft Callbox Classic and Samsung A90 5G

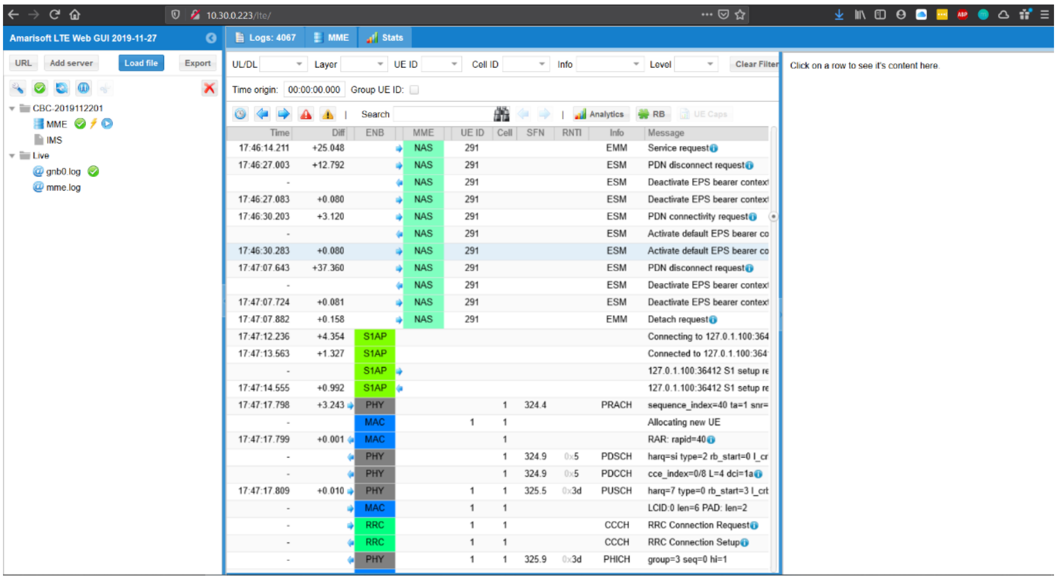

Figure 8 Amarisoft Web Interface

2.2.1.3. End-to-End 4G set up

RAN features

The 4G RAN of the Portable Demonstrator is implemented with the open-source OpenAirInterface RAN (OAI-RAN) solution, provided from Eurecom. The 4G eNB component consists of an ETTUS USRP B210 SDR[4], with VERT 900 antennas attached, connected via USB3.0 to an Intel Core i7-8550U CPU @ 1.80GHz x 4 Dell laptop, deploying OAI RAN functions[5]. All functions are running on Ubuntu 18.04 operating system with Linux 4.15.0-72 low latency kernel. The eNB node uses a physical interface through which it is connected to the OAI EPC.

Figure 9 The end-to-end 4G set up

The 4G UEs are implemented with Commercial-off-the-Shelf (COTS) mobile phones and dongles (Figure 10). The UE is registered to the OAI EPC using (U)SIM cards provided by Sysmocom. The cards have been configured /programmed using pySim-prog, a command line utility that is used to modify identities and private key data in SIM cards. A list of the available COTS UEs used in our implementation, and the adopted frequencies for transmission are outlined below, in Table 4 and

Table 5, respectively.

Table 4 UE features used in the end-to-end 4G setup

UEs	Features
1 x Huawei E3372 (USB Dongle)	Cat4 (DL: 150 Mbps/UL: 50 Mbps at 20 MHz), LTE FDD Bands: 800/900/1800/2100/2600
1 x Samsung Galaxy S4	Cat3 compatible Smart Phones (100/50)
1 x Samsung Galaxy Note 3	Cat4 compatible Smart Phones (150/50)

[4] The version of software driver for the USRP used is 3.13.1.

[5] The code is taken from Eurecom's "openairinterface5g" repo (master branch, commit "7af84127")

Table 5 eNB parameters for the end-to-end 4G setup

eNB parameters	Values
LTE Band	7
Downlink Frequency (MHz)	2685
Uplink Frequency (MHz)	2565
Downlink NRB	25

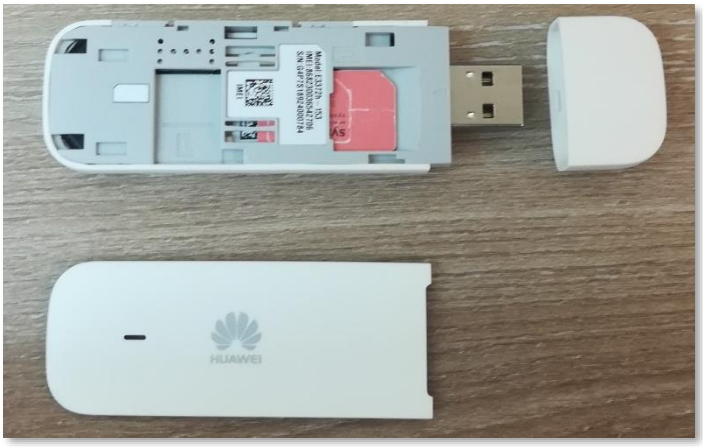

Figure 10 The LTE dongle used in the 4G set up

UE attachment

To attach a UE in the network, we first have to set our network's APN on the device. In the case of the Huawei dongle, we configure the APN from the dongle's portal. The portal can be accessed when the USB is attached to the machine. Otherwise, if an LTE smart phone is used, then the APN can be added from the phone settings. When the APN is set, the device scans for LTE networks nearby, and then the user decides to which networks she/he wants to be connected. The figure provided below depicts the dongle's portal results when the device connects to our network.

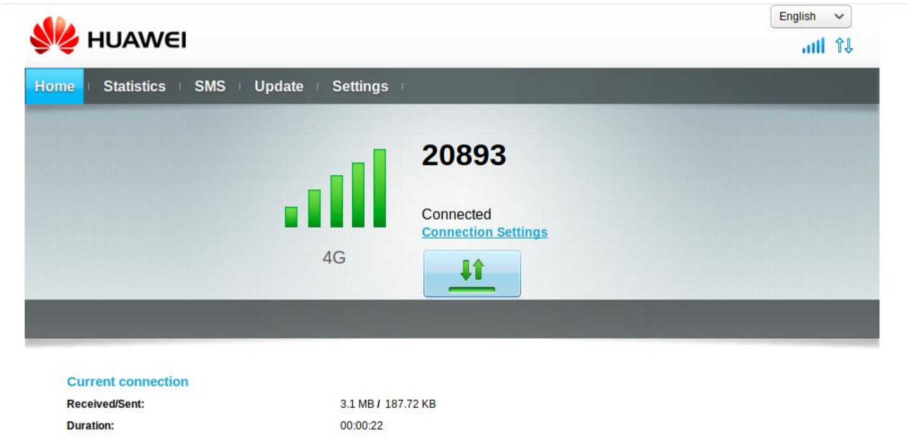

Figure 11 The established connection from the LTE Dongle in the 4G setup

RAN Monitoring

The OAI T-Tracer has been used for monitoring purposes. The figure below depicts T-Tracer results from the eNB, providing information on the received signal, uplink and downlink channels, as well as the packets of the network layers transmitted and received.

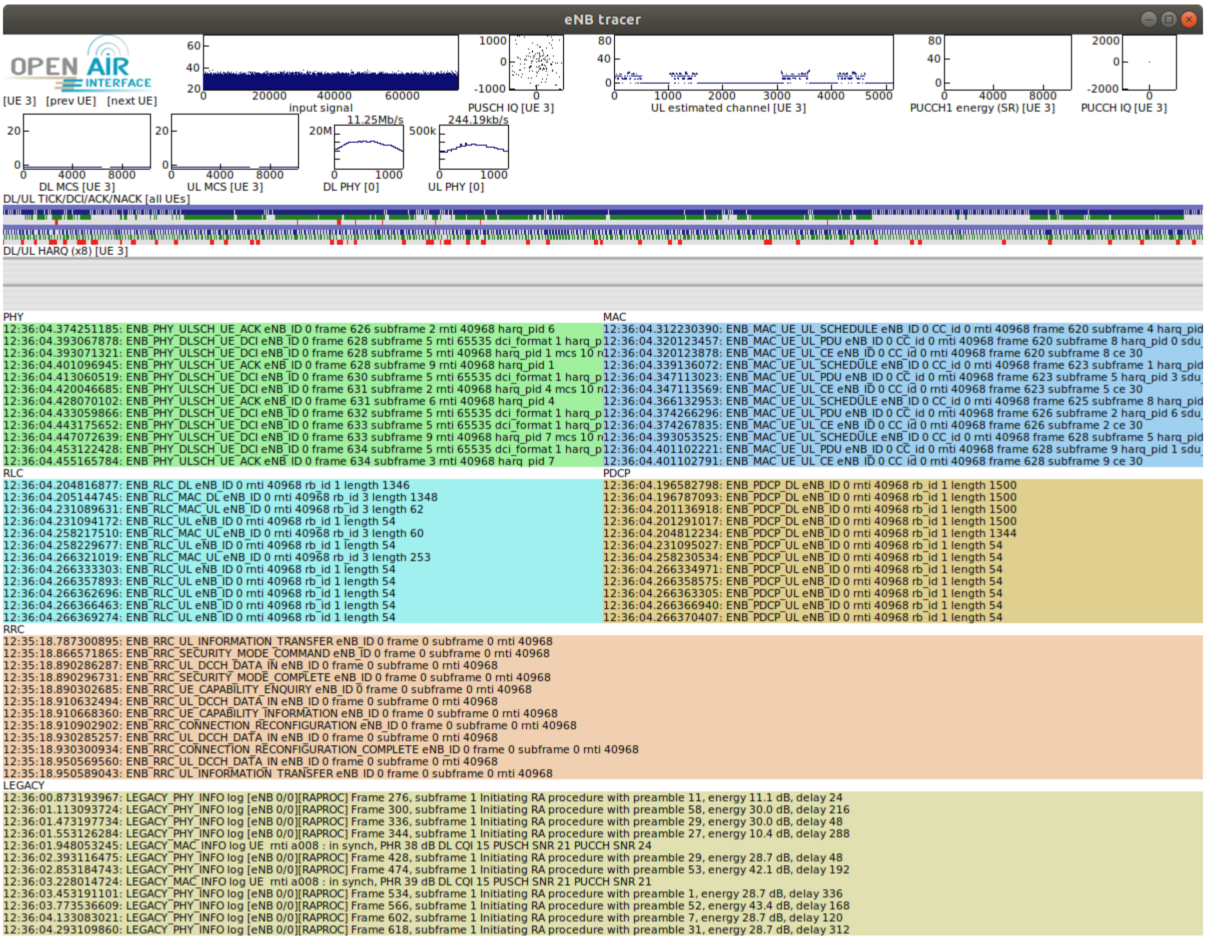

Figure 12 The T-tracer results as retrieved from the eNB

Features of the Mobile Core Network

The Mobile Core Network of the Portable Demonstrator is integrated by the open-source Eurecom's OAI Core Network solution. The code is implementing all basic functions of the LTE core components (MME, HSS, SPGW). OAI Core Network solution is divided in two projects:

- openair-cn, implementing HSS and MME functions
- openair-cn-cups, implementing the separation of user and control plane functions of SPGW (SPGWU, SPGWC)

OAI implements the core network components and respective interfaces, as shown in the figure below.

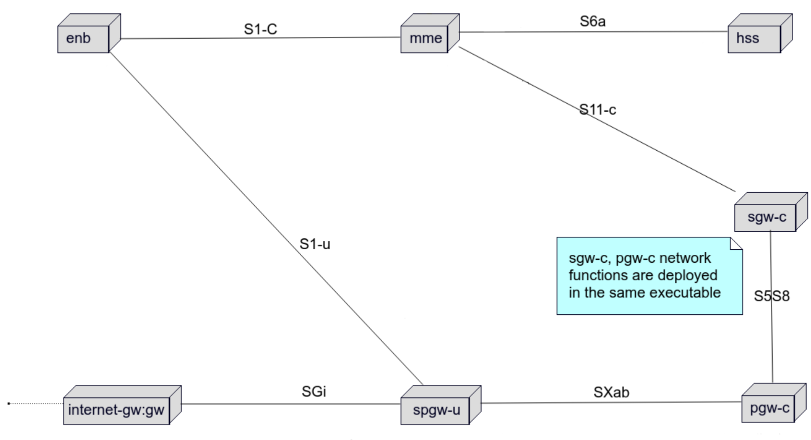

Figure 13 The components and the interfaces of the setup as provided by OAI

The MME, SPGWC, SPGWU and HSS communicate with each other via the following interfaces:

- MME and SGWC via S11-c
- MME and HSS via S6-a
- SGWC with PGWC via S5/S8
- SPGWU with PGWC via SXab
- SPGWU with eNB via S1-u
- SPGWU uses the SGi interface for internet connectivity

The hardware and software specifications of the OAI EPC deployment are detailed below:

- Dell Vostro 3470 (Intel i7-8700 CPU @ 3.20 GHz x 12 , 16 GB RAM, 1TB Disk storage)
- CentOS Linux 7

In the Portable Demonstrator, in order to follow the principles of Network Slicing concept, every core component is thought as a separate VNF. As a result, all core components are deployed on different virtual machines. To accomplish this task, we use Openstack as NFV Infrastructure at out Dell host machine. The following guest VMs were established:

- HSS
    - Ubuntu 18.04.03 LTS
    - Linux Kernel 4.15.0-74-generic
    - 1 VCPU, 2GB RAM, 20 GB Disk
    - openair-cn master branch (commit “d1d0e45”)
- MME
    - Ubuntu 18.04.03 LTS
    - Linux Kernel 4.15.0-74-generic
    - 2 VCPU, 4GB RAM, 40 GB Disk
    - openair-cn master branch (commit “d1d0e45”)
- SPGWC
    - Ubuntu 18.04.02 LTS
    - Linux Kernel 4.15.0-74-generic
    - 2 VCPU, 4GB RAM, 40 GB Disk
    - openair-cn-cups develop branch (commit “ec7a30c”)
- SPGWU
    - Ubuntu 18.04.02 LTS
    - Linux Kernel 4.15.0-74-generic
    - 2 VCPU, 4GB RAM, 40 GB Disk
    - openair-cn-cups develop branch (commit “ec7a30c”)

Core virtual machines have one network interface each, in order to communicate with every other component. This interface is connected to the external network, provided by a physical router, giving our host machine internet access. Core LTE interfaces (S11, S6-a etc), are using the components' external addresses to communicate. Interface S5/S8 is implemented by defining a couple of virtual network interfaces in SPGWC VM. The figure below depicts the network topology of the core network.

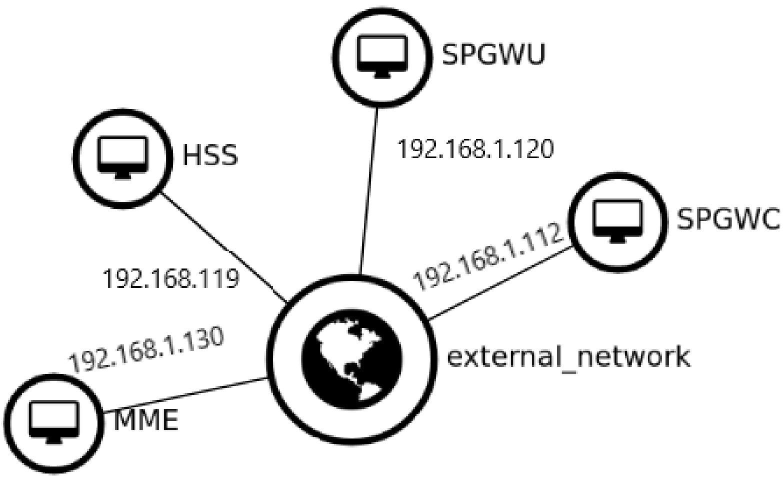

Figure 14 The integrated network topology with the IPs used

A screenshot of the console, depicting the data flow in the core network, having all the core network components up and running, is provided in Figure 15.

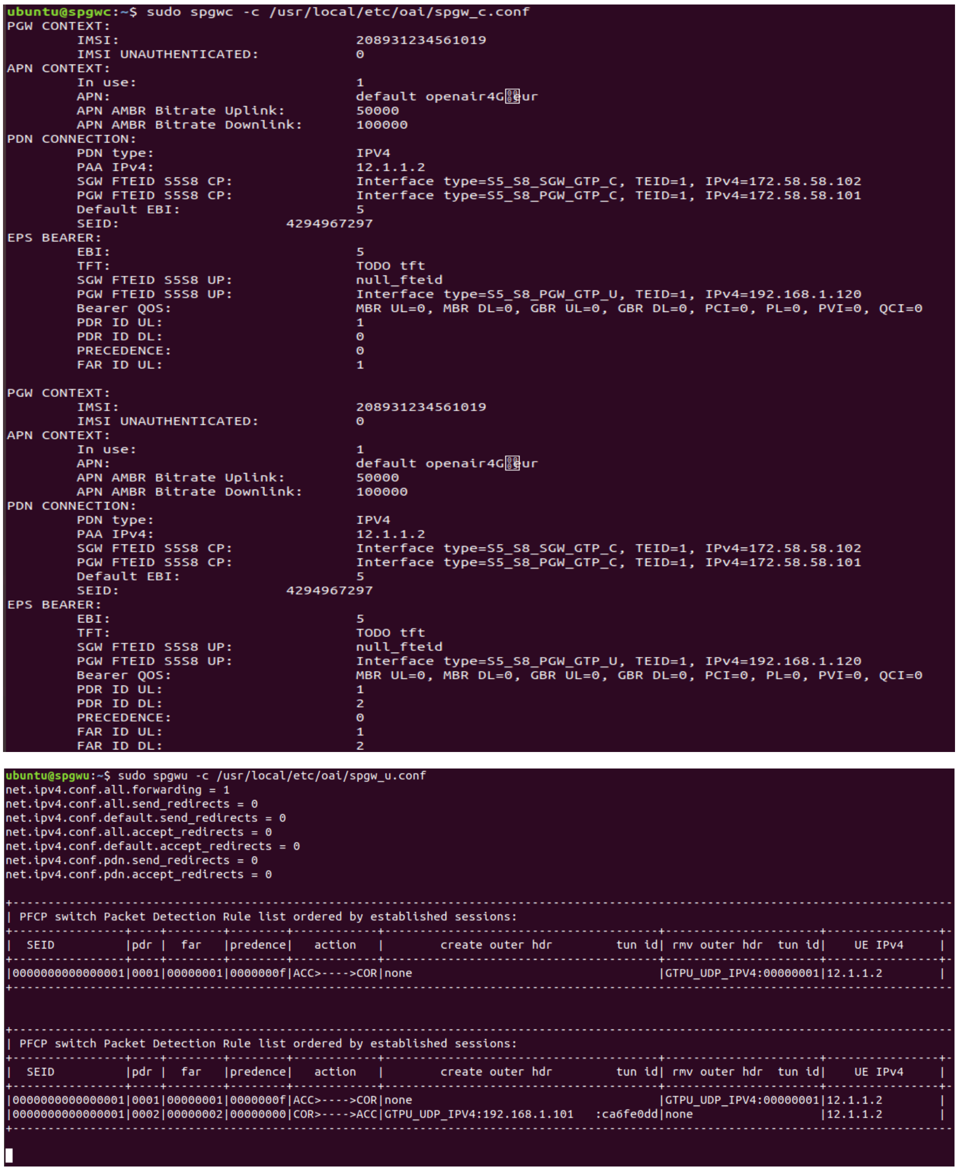

Figure 15 Console screenshots depicting the data flow in the core network

2.2.2. Transport Network

The Portable 5G Demonstrator includes a WAN Emulator based on Mininet v2.2.2[6] for emulating the transport network. The WAN emulator is utilized for demonstrating SDN capabilities and allowing the deployment of various WAN topologies within a single node. The following figure depicts an example topology implemented with Mininet and OpenDayLight as the SDN controller:

[6] Mininet Emulator: http://mininet.org/

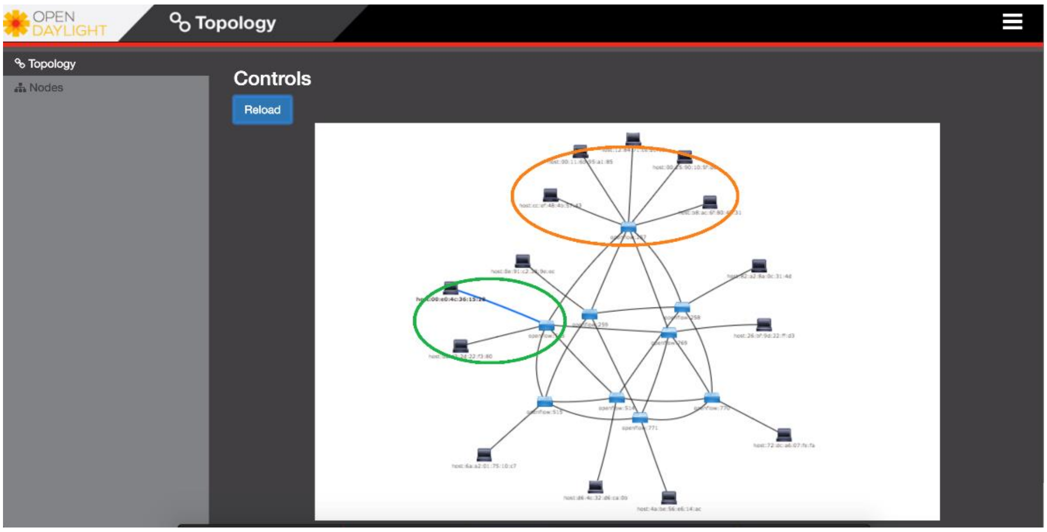

Figure 16 An example of Torus Topology in Mininet with ODL as external SDN Controller.

The physical machine (Intel NUC6i7KYK) runs Ubuntu Server and has three network interfaces. Two of them are assigned to Mininet in order to provide communication with external hosts and the third one is the Management interface.

Figure 17 demonstrates network traffic between Mininet hosts and physical machines deployed. The terminal depicts the physical host, acting as iperf server while responding to requests made by the Mininet host and another physical hosts. It is also possible to conduct iperf measurements between two virtual Mininet hosts, as shown in Figure 18.

```
sudo
sh-3.2# iperf -s -c
iperf: option requires an argument -- c
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size:  128 KByte (default)
------------------------------------------------------------
[  4] local 10.30.0.200 port 5001 connected with 10.30.0.202 port 33955
[ ID] Interval       Transfer     Bandwidth
[  4]  0.0-10.1 sec   416 MBytes   346 Mbits/sec
[  4] local 10.30.0.200 port 5001 connected with 10.30.0.11 port 50539
[  4]  0.0-10.0 sec   451 MBytes   377 Mbits/sec
^Csh-3.2iperf -s -u
------------------------------------------------------------
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size:  192 KByte (default)
------------------------------------------------------------
[  3] local 10.30.0.200 port 5001 connected with 10.30.0.11 port 32803
[ ID] Interval       Transfer     Bandwidth        Jitter   Lost/Total
Datagrams
[  3]  0.0-10.0 sec   358 MBytes   301 Mbits/sec   0.048 ms  764/256407
 (0.3%)
[  3]  0.0-10.0 sec  4 datagrams received out-of-order
```

Figure 17: Traffic passing through Mininet

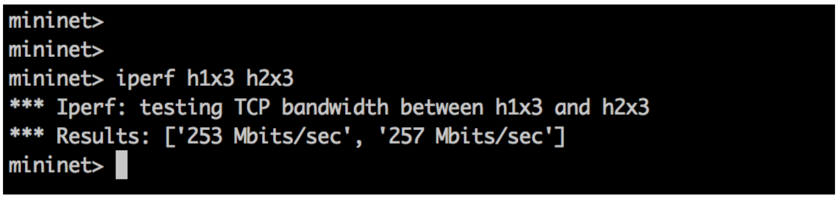

Figure 18 Mininet Console

2.3. Management and Orchestration Layer

The Management and Orchestration layer of the portable demonstrator is responsible for the following actions:

- Creation of virtual network instances upon the physical network by using the resources and the functionality of the infrastructure layer.
- Mapping of network functions to virtualized network instances so that they build a service chain with the association of network function and virtualization layer.
- Maintaining communication between service/application, coordination layer and the network slicing framework to manage the lifecycle of virtual network instances and dynamically adapt or scale the virtualized resources according to the changing experimental context.

Table 6 Management and Orchestration Layer components

Component	Product/Technology
Katana Slice Manager	Release A implementation of the 5Genesis reference architecture Slice Manager implementation (WP3 component)
NFV MANO OSM	OSM[7] is an open source MANO aligned with the ETSI framework for NFV. OSM is an orchestration and management system which manages life-cycle, and configuration aspects of the hosted VNFs that are deployed on the wide number of supported NFV Infrastructure (NFVI) platforms. These MANO capabilities are critical to implement the sophisticated services expected by the 5G communication systems and utilize the underline management systems and tools. For the purpose of the 5GENESIS platform, the deployed OSM is of release 5 and is already integrated with the Element management systems and monitoring tools as well as the Virtualization Infrastructure Managers (Openstack).
Prometheus	Prometheus servers deployed in hierarchical mode are collecting aggregated time series data from a large number of subordinated servers and can be used to take measurements from any device on the platform by creating custom exporters that use the SNMP protocol

[7] OSM, https://osm.etsi.org/

Grafana	Used for the visualization and analytics of the Prometheus metrics and supports a lot of presentation dashboards.
iPerf	Network Performance tool supporting modeling and replay of network traffic

Regarding the above technologies of the MANO Layer, the below hardware and software was used:

Host PC:

- Dell Vostro 3470
- CPU: Intel Core i7-8700 3.2GHz
- OS: Ubuntu 16.04.06 LTS

In the host pc, 3 Virtual Machines (VMs) was created via the Virtual Machine Manager for hosting all the MANO Layer's and Coordination Layer's components. The software and hardware that was selected and used in the 3 VMs, in listed below. Also a set of figures is provided depicting the actual instances of the VMs (Figure 19), the OSM (Figure 20) and the Slice Manager (Figure 21).

VM for Katana Slice Manager:

- OS: Ubuntu 16.04.06 LTS
- Hardware: 2 vCPUs, 4GB RAM, 60GB Storage

VM for OSMv5:

- OS: Ubuntu 16.04.06 LTS
- Hardware: 2 vCPUs, 4GB RAM, 60GB Storage

VM for Coordination Layer, Prometheus, iPerf and Grafana:

- OS: Windows 10 Pro x64
- Hardware: 2 vCPUs, 2GB RAM, 50GB Storage

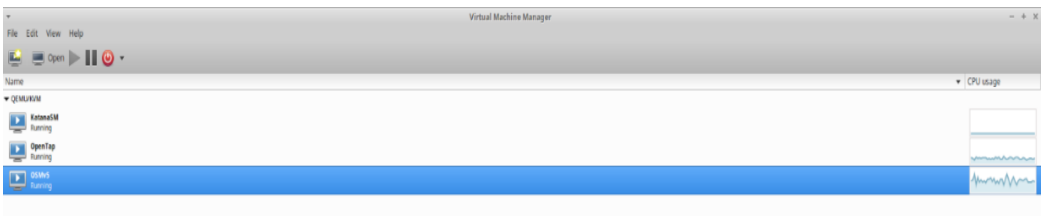

Figure 19 MANO Layer VMs

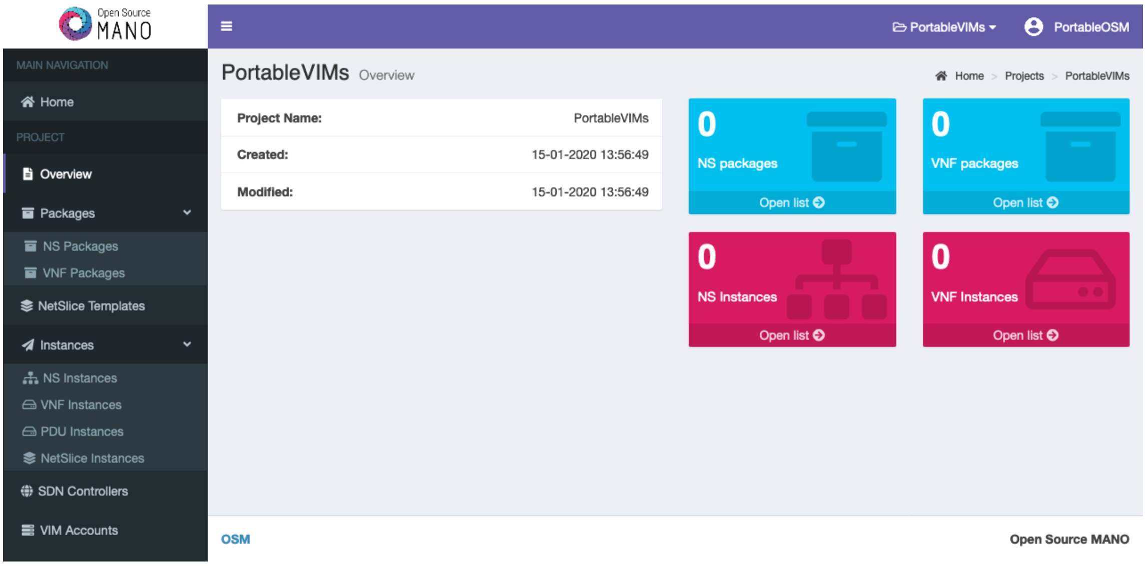

Figure 20 NFV MANO OSM

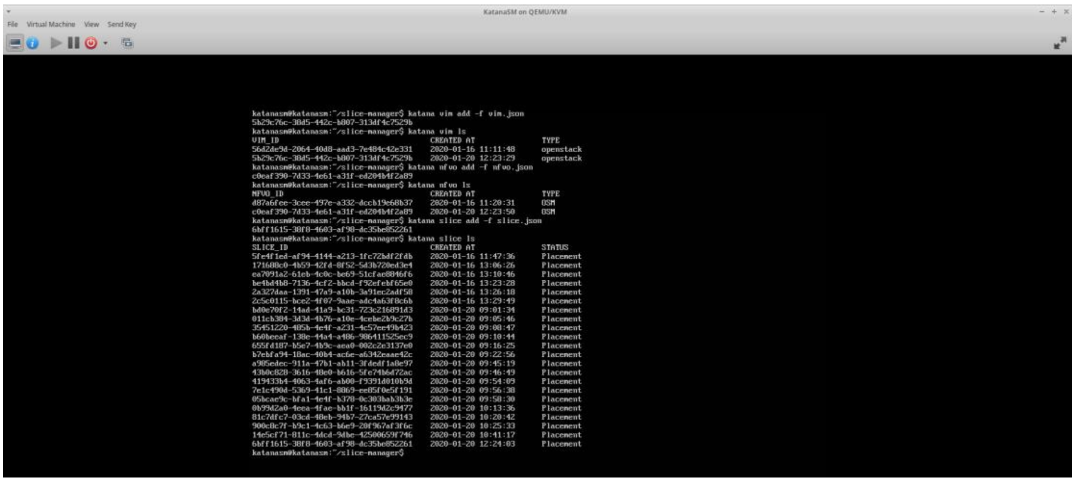

Figure 21 Katana Slice Manager

2.4. Coordination Layer

The Coordination Layer is common for all 5GENESIS platforms as defined in WP2 towards forming a Pan-European 5G Experimental Facility and this homogeneity applies also to the portable 5G demonstrator as well. The software components of the coordination layer are solely instantiated at each platform, i.e. an instance of them runs autonomously and independently at each platform, although their functional and architectural features remain the same, creating the basis towards a common 5GENESIS facility across the foreseen sites.

In order for the Portable Demonstrator to be self-contained, the Coordination Layer has also been included, providing the set of functionalities that would allow demonstrations of real-life tests to interested vertical industries and experimenters.

More details on the architectural components and functionalities of the coordination layer will be provided in WP3 and the corresponding deliverables. Regarding the activities of integrating the Coordination Layer in the portable demonstrator, the components depicted in the following table were installed in a single VM (one of the 3 VMs mentioned above, at Section 2.3)

Table 7 the coordination layer components

Component	Description
5GENESIS Portal	Release A implementation of the 5GENESIS reference architecture. 5GENESIS Portal implementation (WP3 component)
Experiment Life Cycle Management	Release A implementation of the 5Genesis reference architecture ELCM implementation (WP3 component)
Keysight OpenTAP	Keysight's TAP commercial-off-the-self testing automation tool is used to implement the experiment life cycle management activities that are triggered by the vertical's requests through the portal or the open API.
Results Repository / InfluxDB	InfluxDB is the open-source storage engine provided within the InfluxData framework, and handles in particular time series data and is used to store all monitoring events and metrics that are necessary for the generation of the end-reports and KPIs validation.

The Figures below show an overall presentation of the Coordination Layer starting from the Portal/ELCM interaction through testing, analyzing, storing and displaying data.

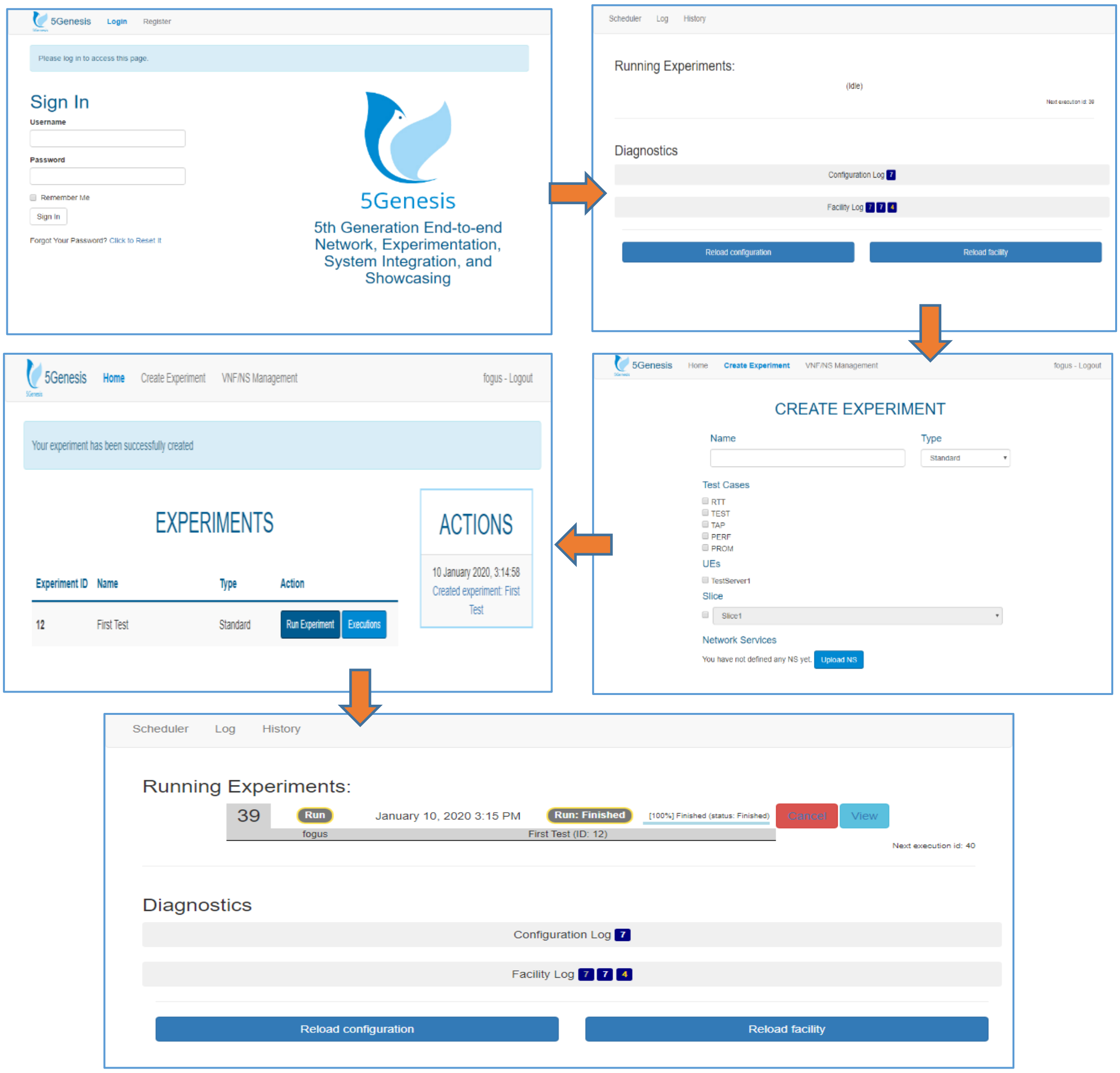

Figure 22 Set of screens depicting the steps for setting an experiment in the Portable Demonstrator

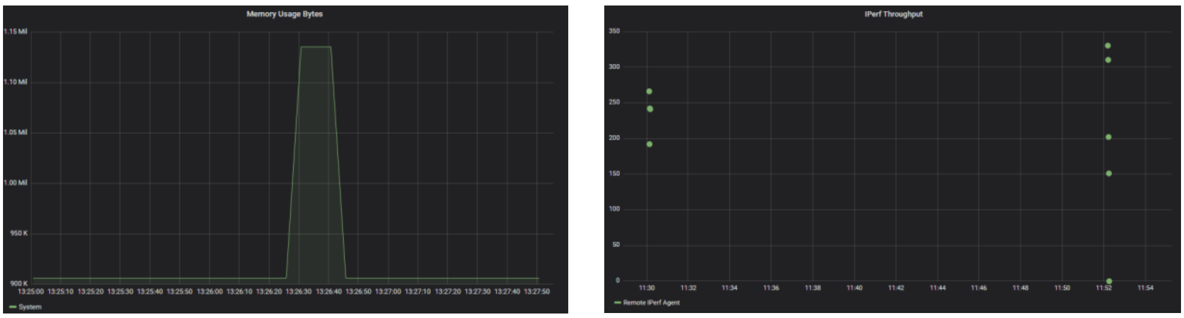

Figure 23 Memory usage and Throughput screens from the Grafana component

3. Portable Demonstrator Evolution

3.1. Instantiation of the 5GENESIS Architecture

The 5GENESIS portable demonstrator follows the general functional architecture of 5GENESIS, as defined in Deliverable D2.2 [2].

The figure below visualizes the per-phase instantiation of the 5GENESIS architectural blueprint in the 5GENESIS Portable demonstrator. It shows the functional blocks implemented and integrated in Phases 1 & 2, as well as the functionalities that will be integrated in Phase 3.

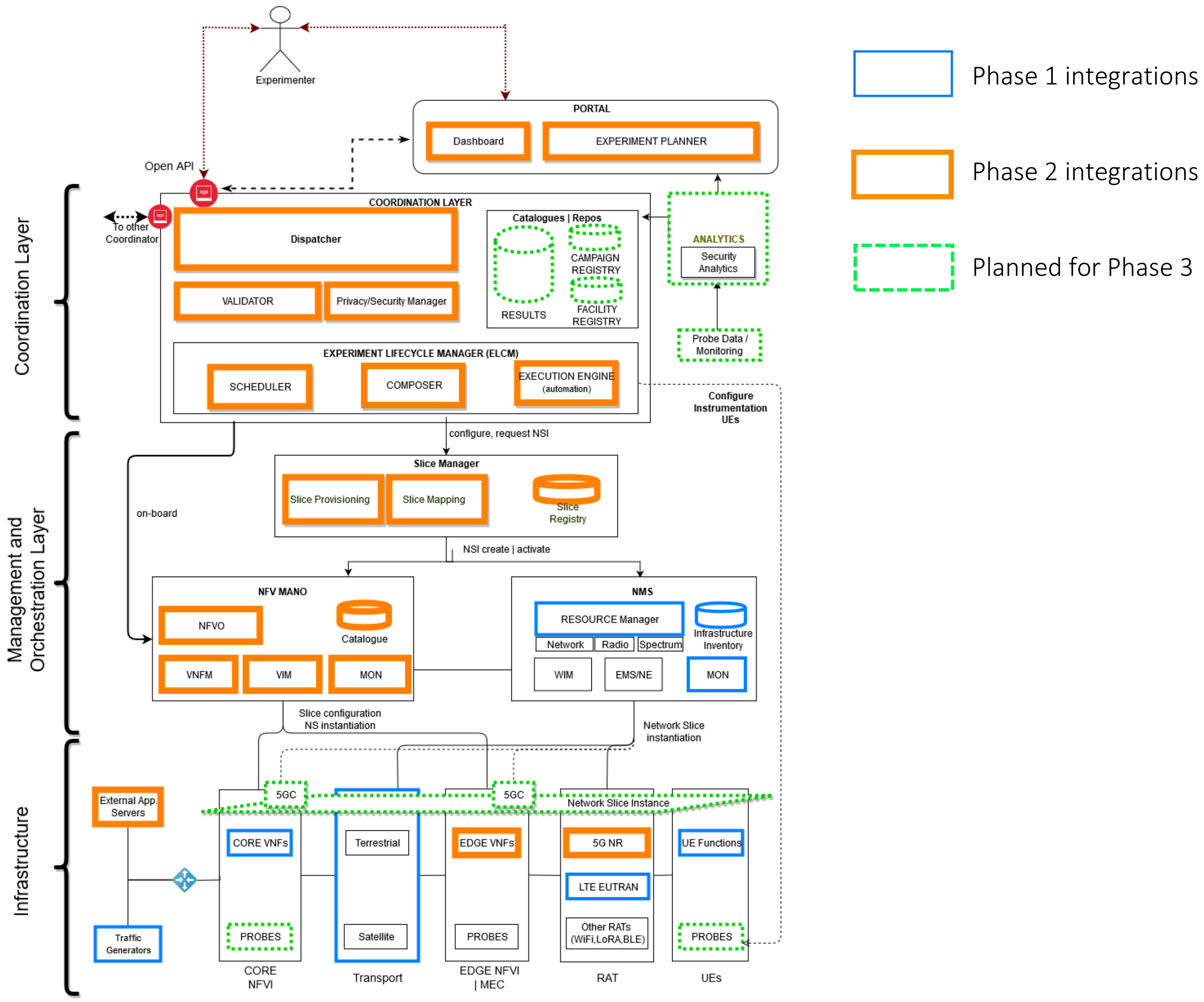

Figure 24 Instantiation of the 5GENESIS Architecture during integration cycle 2 (phase 2)

3.1.1. 4G Deployment Configurations

The table below (Table 8) presents the currently supported deployment configurations based on 4G technologies.

Table 8 The 4G deployment configurations

Deployment Parameters	Products/Technologies Options
ID	DEMO.E2E4G
Description	Opensource E2E deployment of experimentation environment with 4G infrastructure
Core Cloud	YES - Openstack
Edge Cloud	NA
# Edge Locations	NA
WAN/Network	SDN
Slice Manager	YES - Katana
MANO	OSM v6
NMS	eNB EMS
Monitoring	Prometheus
3GPP Technology	4G LTE+
3GPP Option	NA
Non-3GPP Technology	NA
Core Network	OAI vEPC
RAN	OAI eNB
UE	COTS Cat.12 (600/300) / Huawei LTE Dongle
Relevant Use Cases	To be defined

3.1.2. 5G Deployment Configurations

The table below (Table 9) presents the currently supported deployment configurations based on 5G technologies.

Table 9 The 5G deployment configurations

Deployment Parameters	Products/Technologies Options		
ID	DEMO.5GNR	DEMO.5Gcots	DEMO.E2E5G
Description	5GNR setup	5GNSA setup	Opensource/Commercial E2E experimentation environment with 5G infrastructure
Core Cloud	NA	NA	To be defined
Edge Cloud	NA	NA	To be defined
# Edge Locations	NA	NA	NA
WAN/Network	NA	NA	To be added
Slice Manager	NA	To be added	To be added
MANO	NA	NA	To be added
NMS	NA	NA	To be defined
Monitoring	NA	To be added	To be defined
3GPP Technology	5G	5G	5G
3GPP Option	noS1	NSA	NSA/SA
Non-3GPP Technology	NA	NA	NA
Core Network	NA	Amarisoft	To be defined
RAN	OAI NR	Amarisoft gNB (SDR)	To be defined
UE	OAI	Samsung A90 5G	To be defined
Relevant Use Cases	To be defined	To be defined	To be defined

3.2. Phase 1 Accomplishments

During the first integration cycle, specific actions have been taken towards a well-packaging of the components to serve a set of experiments that will convey easily the 5G performance capabilities to non-expert audience. Mainly, the following activities have been performed:

- The major infrastructure for the wireless part was prepared. It is composed of OAI-compliant (Open Air Interface Compliant) SDR hardware and general-purpose computers/servers that will host 5G RAN and core functionalities at the next phases. .
- The first release of e2e monitoring tool has been integrated, providing RAN monitoring during the first integration phase.
- The first release of the transport network emulator has been integrated, providing the capability of emulating complex WAN topologies.
- NFVI infrastructure is in place based on INTEL NUC computing devices, together with the necessary cloud computing platform (Openstack) and OSM on top of it.

In summary, Figure 24 indicates in blue the components that have been chained to provide a first round of proof of concept experiments.

3.3. Phase 2 Accomplishments

During the second integration cycle, specific actions have been taken capitalizing on the integrations made during the first integration cycle. Mainly, the following activities have been performed:

- Integration of the coordination layer components and pass the tests defined in project level for all the 5GENESIS platforms.
- Integration of three setups for the infrastructure part of the demonstrator, using open source (research oriented) components as well as commercial ones.

In summary, Figure 24 indicates in orange the components that have been chained to provide the second release of the 5GENESIS portable demonstrator. As can be observed in Figure 24, the major infrastructure part of the demonstrator was implemented, including also the Release A components of the coordination layer (Portal, ELCM, Slice Manager, Monitoring).

3.4. Next Milestones

A constant updating of the demonstrator is performed after the implementation freezing for releasing the 5GENESIS portable demonstrator after the second integration cycle of the project. The target is to reflect in each release of the demonstrator the evolutions not only of the 5GENESIS Portable Demonstrator, but also of the whole project, incorporating the most recent (and relevant) technical advances and project outcomes.

The current roadmap regarding the migration from 4G to 5G Mobile Network during 5GENESIS consists of the last phase (Phase 3), where the target is the integration of the 5G

Standalone Architecture (SA) infrastructure, assuming that the necessary 5G network components have reached a mature operational level and are ready for integration.

The next steps in the integration process include the following milestones:

- Define the test cases for a second set of experiments and perform the first set of tests (providing input to the next Deliverable of WP6, i.e., D6.2)
- Finalize the components that will compose the portable part of the demonstrator, as well as the interfacing among the components (please, refer to Figure 24 where the targeted components for phase 3 are highlighted in green).

In addition to the technical milestones listed above, operation and maintenance actions are important to signify the readiness of the 5GENESIS platforms. As such, the operation and maintenance are actions planned in WP level. Also, for the phase 3 of the project, a continuous action for the 5GENESIS portable demonstrator is to support the dissemination strategy as it is examined in WP7 and formalized in WP7 deliverables.

4. CONCLUSIONS

This document presented the second release of the 5GENESIS portable demonstrator, as well as the activities conducted for the evolution of the demonstrator towards its final implementation.

During this second integration cycle of the project, the infrastructure part of the demonstrator was implemented, following a modular approach that resulted to three setups, namely, the end-to-end 4G set up, the 5G NR set up, and the 5G NSA set up. Also, the integration of the Release A components of the coordination layer (Portal, ELCM, Slice Manager, Monitoring) was completed successfully.

Based on the integrations reported in this document, extensive tests will be performed to ensure that all the newly integrated services and components work as expected. Also, the setups will be used for dissemination purposes in the context of the WP7 tasks that include demonstration activities.

This document will be followed by the D4.18 Deliverable, describing the Release C of the 5GENESIS portable demonstrator, in December 2020.

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[1] 5GENESIS Consortium, "Deliverable D2.1 Requirements of the Facility", 2018

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[3] 5GENESIS Consortium, "Deliverable D2.3 Initial planning of tests and experimentation", 2018

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