



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

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Portable 5G Demonstrator (Release B)

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Version History

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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.

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.

Table 1 Relevant deliverables

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).

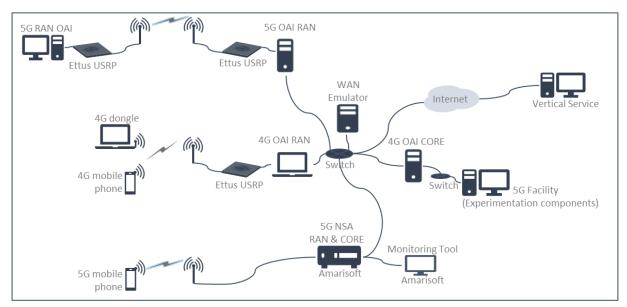


Figure 1 Physical diagram of the Portable Demonstrator

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.

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	4G Evolved Packet Core
5GC	 CPU) Amarisoft EPC & 5GC (Athens Platform) 	5G New Core
Transport Network Emulator	•	
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

Table 2 Infrastructure layer components of the Portable Demonstrator

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 Classic¹. 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.

	Mobile Core Product	Radio Access Products	UE	
	OAI vEPC	OAI eNodeB	Commercial 4G	
Phase 1	Athonet EPC	OAI eNodeB	Commercial 4G/4G Dongle	
	N/A	OAI gNodeB	OAI nr-UE/SDR ETTUS	
Phase 2	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			

Table 3 Portable 5G Demonstrator Technology roadmap

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 i9proceesors, 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.

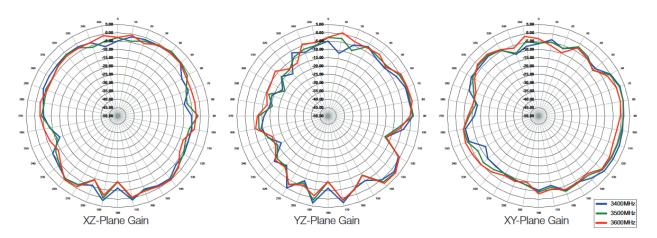


Figure 3 Antennas gain plots on 3.5GHz²

The ETTUS USRPs are synchronized with the Octoclock-G Clock Distribution Module³, 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).

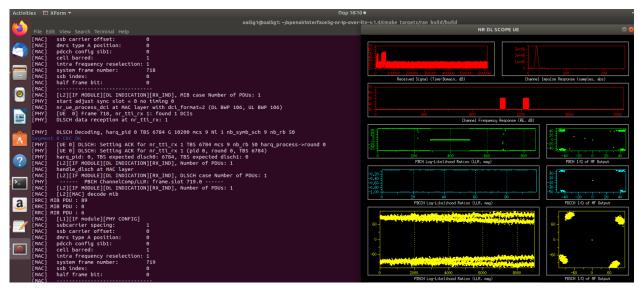


Figure 4 5G-NR OAI Scope monitors detection of 5G NR physical channels

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/

Activiti	ies 🖻] Terminal 🔻	Пер 16:11 •	
100			oal5g1@oal5g1:~/openairinterface5g-nr-ip-over-lte-v.1.4/cmake_targets/ran_build/build	
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			File Edit View Search Terminal Help	
			16:10:31.547100960: LEGACY_MAC_INFO log pdcch config sib1: 0	
			16:10:31.547101143: LEGACY MAC INFO log cell barred: 1	
			16:10:31.547101487: LEGACY MAC INFO log intra frequency reselection: 1	
			16:10:31.547101716: LEGACY_MAC_INFO log system frame number: 575	
			16:10:31.547101960: LEGACY_MAC_INFO log ssb index: 0	
			16:10:31.547102137: LEGACY_MAC_INFO log half frame bit: 0	
			16:10:31.547102372: LEGACY_MAC_INFO log	
Sec. 1			16:10:31.547102583: LEGACY_MAC_INFO log [L2][IF MODULE][DL INDICATION][RX_IND], MIB case Number of PDUs: 1	
			16:10:31.547102990: LEGACY_PHY_INFO log start adjust sync slot = 0 no timing 0	
			16:10:31.557122141: LEGACY_PHY_INFO log PBCH ChannelComp/LLR: frame.slot 576.0	
			16:10:31.557162101: LEGACY_MAC_INFO log [L2][IF MODULE][DL INDICATION][RX_IND], Number of PDUs: 1	
-			16:10:31.557162432: LEGACY_MAC_INFO log [L2][MAC] decode mib	
			16:10:31.557174586: LEGACY_MAC_INFO log [L1][IF module][PHY CONFIG] 16:10:31.557174548: LEGACY_MAC_INFO log subcarrier snarion: 1	
A			16:10:31.557174748: LEGACY_MAC_INFO log subcarrier spacing: 1 16:10:31.557175157: LEGACY_MAC_INFO log ssb carrier offset: 0	
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			16:10:31.557176072: LEGACY MAC INFO log intra frequency reselection: 1	
-	[RRC]		16:10:31.557176259: LEGACY MAC_INFO log system frame number: 576	
2_	[RRC]		16:10:31.557176461: LEGACY MAC INFO log ssb index: 0	
			16:10:31.557176636: LEGACY MAC INFO log half frame bit: 0	
			16:10:31.557176806: LEGACY MAC INFO log	
a			16:10:31.557176942: LEGACY_MAC_INFO log [L2][IF MODULE][DL INDICATION][RX_IND], MIB case Number of PDUs: 1	
<u> </u>			16:10:31.557177324: LEGACY_PHY_INFO log start adjust sync slot = 0 no timing 0	
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			16:10:31.567138890: LEGACY_MAC_INFO log [L2][MAC] decode mib	
			16:10:31.567159866: LEGACY_MAC_INFO log [L1][IF module][PHY CONFIG]	
			16:10:31.567160148: LEGACY_MAC_INFO log subcarrier spacing: 1	
			16:10:31.567160690: LEGACY_MAC_INFO log ssb carrier offset: 0	
			16:10:31.567169983: LEGACY_MAC_INFO log dwrs type A position: 0	
			16:10:31.567161150: LEGACY_MAC_INFO log pdcch config sib1: 0 16:10:31.567161373: LEGACY MAC INFO log cell barred: 1	
			10:10:31.507/10:1375: LEGACY_MAC_INFO log (LET Darred: 1 10:10:31.507/10:169: LEGACY MAC INFO log (Intra frequency reselection: 1	
			16:10:31.357/161019; LEGACY_MAC_INFO log system frame number: 577	
			16:10:31:567102051: LEGACY MAC INFO log system frame number: 6	
			16:10:31.56712216: LEGACY MAC INFO log half frame bit: 0	
			16:10:31.557132414: LEGACY MAC INFO log	

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.

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[PHY] [UE 0] Canno 017 as the set of a construction of the set of	a a 😦	16:40:43.503941 IP 10.0.1.1. 16:40:43.513852 IP 10.0.1.1.			
File Edit View Search Terminal Help		16:40:43.533949 IP 10.0.1.1.			
[PHY] DLSCH [3] 12.0-13.0 sec 80.4 KBytes 659 Kbits/sec 7.278 ms 0/	56 (0%)	16:48:43.554069 IP 10.0.1.1.			
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	56 (8%)	16:40:43.593871 IP 10.0.1.1.			
[PHY] [UE 0[3] 14.0-15.0 sec 80.4 KBytes 659 Kbits/sec 7.042 ms 0/ [PHY] harg [3] 15.0-16.0 sec 80.4 KBytes 659 Kbits/sec 7.170 ms 0/	56 (0%)	16:40:43.603905 IP 10.0.1.1. 16:40:43.623954 IP 10.0.1.1.			
[MAC] [12][[3] 10.0-17.0 sec 81.8 KBytes 670 Kbits/sec 7.340 Ms 0/	57 (0%)	16:40:43.643933 IP 10.0.1.1.			
Fueci Landi 3 17.0-18.0 Sec 80.4 KBytes 059 KDits/sec 0.990 MS 0/	56 (0%) 56 (0%)	16:40:43.663940 IP 10.0.1.1.			
[MAC] [L2][[3] 10 0 20 0 rec 90 4 VPuter 650 Vhite/rec 7 202 mr 0/	56 (0%)	16:48:43.673864 IP 10.0.1.1			
[PHY][3] 19.0-2010 sec 80.4 KBytes 059 Kbtts/sec 7.327 ms 0/ [MAC] [L2][[3] 20.0-21.0 sec 80.4 KBytes 659 Kbits/sec 7.327 ms 0/	56 (0%)	16:40:43.693845 IP 10.0.1.1. 16:40:43.713930 IP 10.0.1.1.			
[MAC] [12][[3] 21.0-22.0 sec 81.8 KBytes 670 Kbits/sec 7.078 Ms 0/	57 (0%)	16:40:43.733955 IP 10.0.1.1.			
FORT MTR POLE 3] 22.0-23.0 Sec 79.0 KBytes 647 Kbits/sec 7.070 MS 6/	55 (0%)	16:40:43.753992 IP 10.0.1.1.			
[RRC] MIB PDU[3] 23.0-24.0 sec 80.4 KBytes 659 Kbits/sec 7.151 ms 0/ [RRC] MIB PDU[3] 24.0-25.0 sec 80.4 KBytes 659 Kbits/sec 7.230 ms 0/	56 (0%) 56 (0%)	16:40:43.763899 IP 10.0.1.1.			
[RRC] HID FUEL 33 OF A 36 A FOR A KOWART (FO WHITE TAKE TAKE TAKE	56 (0%)	16:40:43.783971 IP 10.0.1.1			
[MAC] [L1][3] 25.0-20.0 Sec 80.4 KBytes 059 KDt(5/Sec 7.309 HS 0/ [MAC] subcal 3] 26.0-27.0 Sec 80.4 KBytes 659 Kblts/sec 7.355 HS 1/	57 (1.8%)	16:40:43.803939 IP 10.0.1.1. 16:40:43.823823 IP 10.0.1.1.			
[Mar] ssh [3] 27.0-28.0 Sec 80.4 KBytes 659 Kbits/Sec 7.157 MS 0/	56 (0%)	16:40:43.843997 IP 10.6.1.1.			
[Mari dmrs [3] 28.0-29.0 sec 80.4 KBytes 659 Kbits/sec 7.270 ms 0/	56 (0%)	16:40:43.854016 IP 10.0.1.1.			
[MAC] pdcchi 31 20 0 10 0 cd 4 Mbytes 050 White sec 0.00 ms	56 (0%) 56 (0%)	16:40:43.873950 IP 10.0.1.1.			
[MAC] cell [3] 30.0-31.0 sec 80.4 KBytes 039 Kbtts/sec 7.049 Hs 0/ [MAC] intra[3] 31.0-32.0 sec 80.4 KBytes 659 Kbtts/sec 7.142 Hs 0/	56 (0%)	16:40:43.893872 IP 10.0.1.1.			
FMAC1 evetal 3] 32.0-33.0 Sec 80.4 KBytes 659 KDits/sec 7.250 MS 0/	56 (0%)	16:40:43.914013 IP 10.0.1.1. 16:40:43.923946 IP 10.0.1.1.			
[Mar] ssh 1[3] 33.0-34.0 sec 80.4 KBytes 659 Kbits/sec 7.323 MS 0/	56 (0%)	16:40:43.943982 IP 10.0.1.1.			
[MAC] half 3] 34.0-35.0 sec 81.8 KBytes 670 Kbits/sec 7.083 ms 0/	57 (0%)	16:40:43.963926 IP 10.0.1.1.			
[MAC]		16:40:43.983988 IP 10.0.1.1.			
<pre>[MAC] [L2][IF MODULE][DL INDICATION][RX_IND], MIB case Number of PDUs: 1 [PHY] start adjust sync slot = 0 no timing 0</pre>		16:40:44.004076 IP 10.0.1.1. 16:40:44.013978 IP 10.0.1.1.			
[MAC] nr ue process dci at MAC laver with dci format=2 (DL BWP 106, UL BWP 10	16)	16:40:44.033949 IP 10.0.1.1.			
[PHY] [UE 0] Frame 918, nr ttl rx 1: found 1 DCIs		16:40:44.053981 IP 10.0.1.1.			
[PHY] DLSCH data reception at nr_tti_rx: 1		16:40:44.073869 IP 10.0.1.1.			
[DIN] DICCU Decadles, have aid a TOC (704 C 10000 are 2 ML + above) and and		16:40:44.083897 IP 10.0.1.1.			
[PHY] DLSCH Decoding, harq_pid 0 TBS 6784 G 10200 mcs 9 Nl 1 nb_symb_sch 9 nl Segment 0 CRC 0K	J_10 50	16:40:44.103993 IP 10.0.1.1. 16:40:44.123938 IP 10.0.1.1.			
[PHY] [UE 0] DLSCH: Setting ACK for nr_tti_rx 1 TBS 6784 mcs 9 nb_rb 50 harg	process->round 0	16:46:44.143935 IP 10.0.1.1.			
[PHY] [UE 0] DLSCH: Setting ACK for nr_tti_rx 1 (pid 0, round 0, TBS 6784)		16:40:44.163965 IP 10.0.1.1.	.52126 > oai5g2.5001: UDP,	length 1470	
[PHY] harq_pid: 0, TBS expected dlsch0: 6784, TBS expected dlsch1: 0		16:48:44.173868 IP 10.0.1.1			
[MAC] [L2][IF MODULE][DL INDICATION][RX_IND], Number of PDUs: 1 [MAC] handle dlsch at MAC layer		16:40:44.194015 IP 10.0.1.1. 16:40:44.213906 IP 10.0.1.1.			
[MAC] [L2][IF MODULE][DL INDICATION][RX IND], DLSCH case Number of PDUs: 1		16:40:44.233930 IP 10.0.1.1.			
[PHY] PBCH ChannelComp/LLR: frame.slot 919.0		16:40:44.243971 IP 10.0.1.1.			
[PHY] [UE 8] frame 919, nr_tti_rx 8, Error decoding PBCH!		16:48:44.264026 IP 10.0.1.1.			
[PHY] start adjust sync slot = 0 no timing 0 [DHV] DECH Changelown (LLD: frame slot 020 0		16:40:44.283872 IP 10.0.1.1.			
[PHY] PBCH ChannelComp/LLR: frame.slot 920.0 [PHY] [UE 0] frame 920, nr_tti_rx 0, Error decoding PBCHI		16:40:44.304016 IP 10.0.1.1. 16:40:44.323942 IP 10.0.1.1.			
[PHY] start adjust sync slot = 0 no timing 0		16:40:44.333985 IP 10.0.1.1.			
[PHY] PBCH ChannelComp/LLR: frame.slot 921.0		16:40:44.354028 IP 10.0.1.1.	.52126 > oai5g2.5001: UDP,	length 1470	
[PHY] [UE 0] frame 921, nr_ttl_rx 0, Error decoding PBCH!		16:40:44.373786 IP 10.0.1.1.			
[PHY] start adjust sync slot = 0 no timing 0		16:40:44.393937 IP 10.0.1.1	.52126 > 0a15g2.5001: UDP,	length 1470	
		U:			10

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

← → ሮ ŵ											🖾 🕁	👱 🛝 🖽 🛛 🥹 🧰 🛑 🛆 🕯
Amarisoft LTE Web GUI 2019-11-27	O	🗎 Logs: 4067	E MME	🚮 Stats								
URL Add server Load file	Export	UL/DL	Layer	* UE	ID	· Cell ID		Ŧ	Info		* Level * Clear Filter	Click on a row to see it's content here.
🛶 🥥 🔯 🐠 🐳	×	Time origin: 00:	00:00:00	Group UE ID:								
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📑 MME 🥝 🗲 🖸		Time	Diff	ENB	MME			SFN	RNTI	Info	Message	
IMS		17:46:14.211	+25.048	*	NAS	291				EMM	Service request()	
i i Live		17:46:27.003	+12.792		NAS	291				ESM	PDN disconnect request	
@ gnb0.log 🥥 @ mme.log					NAS	291				ESM	Deactivate EPS bearer context	
e mine.log		17:46:27.083	+0.080	*	NAS	291				ESM	Deactivate EPS bearer context	
		17:46:30.203	+3.120		NAS	291				ESM	PDN connectivity request 0	
					NAS	291				ESM	Activate default EPS bearer co	
		17:46:30.283	+0.080		NAS	291				ESM	Activate default EPS bearer co	
		17:47:07.643	+37.360		NAS	291				ESM	PDN disconnect request	
					NAS	291				ESM	Deactivate EPS bearer context	
		17:47:07.724	+0.081		NAS	291				ESM	Deactivate EPS bearer context	
		17:47:07.882	+0.158		NAS	291				EMM	Detach request	
		17:47:12.236	+4.354	S1AP							Connecting to 127.0.1.100:364	
		17:47:13.563	+1.327	S1AP							Connected to 127.0.1.100:364	
				S1AP 📦							127.0.1.100:36412 S1 setup re	
		17:47:14.555	+0.992	S1AP (#							127.0.1.100:36412 S1 setup re	
		17:47:17.798	+3.243	PHY			1	324.4		PRACH	H sequence_index=40 ta=1 snr=	
				MAC		1	1				Allocating new UE	
		17:47:17.799	+0.001 🧔	MAC			1				RAR: rapid=40 ()	
				PHY			1	324.9	0×5	PDSCH	H harq=si type=2 rb_start=0 I_cr	
				PHY			1	324.9	0×5	PDCCH	H cce_index=0/8 L=4 dci=1a()	
		17:47:17.809	+0.010	PHY		1	1	325.5	0×3d	PUSCH	H harq=7 type=0 rb_start=3 l_crt	
				MAC		1	1				LCID:0 len=6 PAD: len=2	
				RRC		1	1			CCCH	RRC Connection Request	
			4	RRC		1	1			CCCH	RRC Connection Setup	
				PHY		1	1	325.9	0x3d	PHICH	group=3 seq=0 hi=1	

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 SDR⁴, 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 functions⁵. 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.

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)

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

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")

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

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

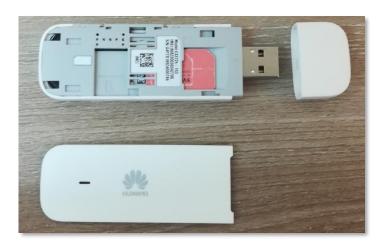


Figure 10 The LTE dongle used in the 4G set up

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.

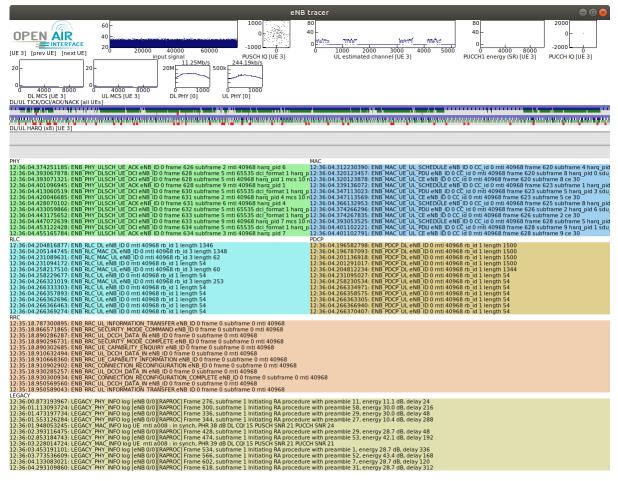


Figure 12 The T-tracer results as retrieved from the eNB

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.

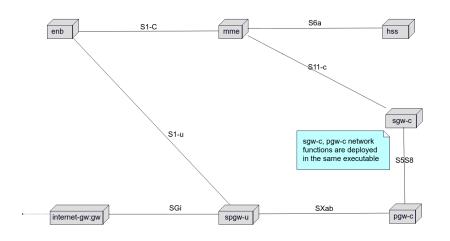


Figure 13 The components and the interfaces of the setup as provided by OAI

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

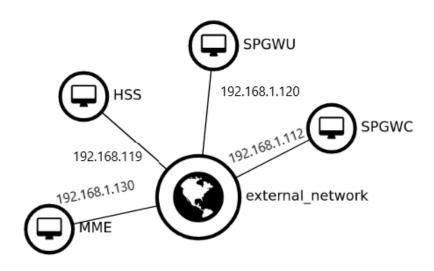


Figure 14 The integrated network topology with the IPs used

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.

	TEXT: IMSI:	208931234561019
	IMSI UNAUTHENTICATED:	0
PN CON		
	In use: APN:	1 default openair4G[[]ur
	APN: APN AMBR Bitrate Uplink:	
	APN AMBR Bitrate Downlink:	100000
ON CON	NECTION:	
	PDN type:	IPV4
	PAA IPv4:	12.1.1.2
	SGW FTEID S5S8 CP: PGW FTEID S5S8 CP:	Interface type=S5_S8_SGW_GTP_C, TEID=1, IPv4=172.58.58.102 Interface type=S5_S8_PGW_GTP_C, TEID=1, IPv4=172.58.58.101
	Default EBI:	s
		67297
S BEA	RER:	
	EBI:	
	TFT:	TODO tft
	SGW FTEID S5S8 UP: PGW FTEID S5S8 UP:	null_fteid Interface type=S5_S8_PGW_GTP_U, TEID=1, IPv4=192.168.1.120
	Bearer QOS:	MBR UL=0, MBR DL=0, GBR UL=0, GBR DL=0, PCI=0, PL=0, PVI=0, QCI=0
	PDR ID UL:	1
	PDR ID DL:	
	PRECEDENCE:	
	FAR ID UL:	
W CON	TEXT	
IN CON	IMSI:	208931234561019
	IMSI UNAUTHENTICATED:	0
N CON	TEXT:	
	In use:	1
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	APN AMBR Bitrate Uplink:	50000
	APN AMBR Bitrate Downlink: NECTION:	100000
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	PAA IPv4:	12.1.1.2
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	PGW FTEID S5S8 CP:	Interface type=S5_S8_PGW_GTP_C, TEID=1, IPv4=172.58.58.101
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S BEA		01291
	EBI:	
	TFT:	TODO tft
	SGW FTEID S5S8 UP:	null_fteid
	PGW FTEID S5S8 UP:	Interface type=S5_S8_PGW_GTP_U, TEID=1, IPv4=192.168.1.120 MBR UL=0, MBR DL=0, GBR UL=0, GBR DL=0, PCI=0, PL=0, PVI=0, QCI=0
	Bearer QOS: PDR ID UL:	MBR UL=0, MBR DL=0, GBR UL=0, GBR DL=0, PCI=0, PL=0, PVI=0, QCI=0
	PDR ID DL:	2
	PRECEDENCE:	0
	FAR ID UL:	1
	FAR ID DL:	2
	gwu:~\$ sudo spgwu -c /usr/local/etc/c	ai/spgw_u.conf
t.ipv4.	conf.all.forwarding = 1	
t.ipv4. t.ipv4.	conf.all.send_redirects = 0	
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t.ipv4 t.ipv4 t.ipv4 t.ipv4 t.ipv4 t.ipv4 t.ipv4 t.ipv4 t.ipv4 SEID 90000000	<pre>conf.all.send_redirects = 0 conf.default.send_redirects = 0 conf.all.accept_redirects = 0 conf.default.accept_redirects = 0 conf.pdn.send_redirects = 0 conf.pdn.accept_redirects = 0 itch Packet Detection Rule list order</pre>	ed by established sessions: tion create outer hdr tun id rmv outer hdr tun id UE IPv4 >COR none GTPU_UDP_IPV4:0000000112.1.1.2 ed by established sessions:
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t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i sEID 00000000	<pre>conf.all.send_redirects = 0 conf.default.send_redirects = 0 conf.all.accept_redirects = 0 conf.default.accept_redirects = 0 conf.pdn.send_redirects = 0 conf.pdn.accept_redirects = 0 itch Packet Detection Rule list order</pre>	ed by established sessions: tion create outer hdr tun id rmv outer hdr tun id UE IPv4 >COR none CTPU_UDP_IPv4:00000001 12.1.1.2 ed by established sessions: tion create outer hdr tun id rmv outer hdr tun id UE IPv4
t.ipv4. t.ipv4. t.ipv4. t.ipv4. t.ipv4. t.ipv4. t.ipv4. sEID 00000000 PFCP sw SEID 00000000	<pre>conf.all.send_redirects = 0 conf.default.send_redirects = 0 conf.default.accept_redirects = 0 conf.default.accept_redirects = 0 conf.pdn.accept_redirects = 0 conf.pdn.accept_redirects = 0 itch Packet Detection Rule list order</pre>	ed by established sessions: tion create outer hdr tun td rmv outer hdr tun td UE IPv4 >COR none CTPU_UDP_IPV4:00000001 12.1.1.2 ed by established sessions: tion create outer hdr tun td rmv outer hdr tun td UE IPv4 >COR none CTPU_UDP_IPV4:00000001 12.1.1.2
t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i t.ipv4.i sEID 00000000 PFCP sw SEID 00000000	<pre>conf.all.send_redirects = 0 conf.default.send_redirects = 0 conf.default.accept_redirects = 0 conf.default.accept_redirects = 0 conf.pdn.accept_redirects = 0 conf.pdn.accept_redirects = 0 itch Packet Detection Rule list order</pre>	ed by established sessions: tion create outer hdr tun id rmv outer hdr tun id UE IPv4 >COR none CTPU_UDP_IPV4:00000001 12.1.1.2 ed by established sessions: tion create outer hdr tun id rmv outer hdr tun id UE IPv4

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 v2.2.2⁶ 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/

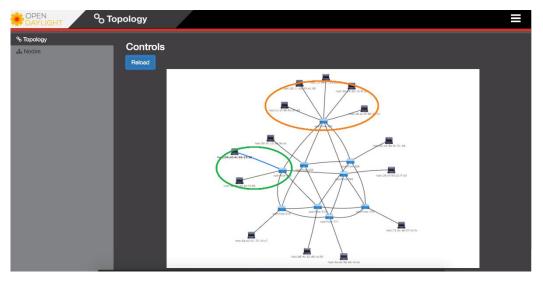


Figure 16 An example of Torus Topology in Mininet with ODL as external SDN Controller.

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)	
<pre>[4] local 10.30.0.200 port 5001 connected with 10.30.0.202 port 33 [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 505 [4] 0.0-10.0 sec 451 MBytes 377 Mbits/sec ^Csh-3.2iperf -s -u</pre>	
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 328[ID] IntervalTransferBandwidthJitterDatagrams	
[3] 0.0-10.0 sec 358 MBytes 301 Mbits/sec 0.048 ms 764/256 (0.3%)	407
[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.

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

Table 6 Management and Orchestration Layer components

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

*	Virtual Machine Manager	- + >
File Edit View Help		
🖳 🗏 Open 🕨 📗 🕑 🔹		
Name	* (CPU usage
▼ QEMUWM		
Earning Rational SM		
Romal M		
Diming Diming		humm

Figure 19 MANO Layer VMs

Open Source	=			∋ PortableVIMs - 😫 PortableOSM
S MANO	=		κ. 	
MAIN NAVIGATION	PortableVIMs Overview			Home > Projects > PortableVIMs
者 Home	Project Name:	PortableVIMs		
PROJECT			0	0
Cverview	Created:	15-01-2020 13:56:49	NS packages	VNF packages
	Modified:	15-01-2020 13:56:49	Open list 🧿	Open list 🕤
Packages				opernate
NS Packages			0	0
VNF Packages				
Solution Templates			NS Instances	VNF Instances
A Instances			Open list 🕤	Open list 🧿
- NS Instances				
VNF Instances				
🗁 PDU Instances				
NetSlice Instances				
SDN Controllers				
VIM Accounts	OSM			Open Source MANO
			0.014	



rtual Machine View Send Key	Katana5M on	UNCYM	- +
tree warring agent here with			
) I 🕑 • 🖄			
katanasm#katanasm:"∕slice-manager\$ kat	and use add of use icon		
5b29c76c-38d5-442c-b807-313df4c7529b	and the data is the group		
katanasm@katanasm:"/slice-nanager\$ kat	ana vim ls		
VIN IB	CREATED AT	YPE	
56dZ4e9d-2064-40d8-aad3-7e484c42e331	2020-01-15 11:11:48	penxtack	
5b29c76c-38d5-442c-b807-313df4c7529b	2020-01-20 12:23:29	penstack	
katanasn€katanasn:"∕slice-nanager\$ kat	ana nfuo add -f nfuo, jsoi		
c0eaf 390-7433-4e61-a31f-ed204b4fZa89			
katanasn@katanasn("/slice-nanager\$ kat			
HFV0_ID	CREATED AT	YPE	
d87a6fee-3cee-497e-a332-dccb19e68b37	2020-01-16 11:20:31	Sn	
c0eaf390-7d33-4e61-a31f-ed204b4fZa89	2020-01-20 12:23:50	SH	
katanasm9katanasm:"/slice-nanager\$ kat 6bff1615-30f0-4603-af90-dc35bc052261			
katanasm≅katanasm∶"∕slice-manager\$ kat			
SLICE_ID	CREATED AT	TATUS	
5fe4f1ed-af94-4144-a213-1fc72bdf2fdb	2020-01-16 11:47:36	lacement	
171688c0-4659-42fd-8f52-5d3b728ed3e4 ea7891a2-61eb-4c9c-be69-51cfae8846f6	2020-01-16 13:06:26 2020-01-16 13:10:46	laceest	
	2020-01-16 13:10:46	lacencut	
be4bd4b8-7136-4cf2-bbcd-f92efebf65e0 2a327daa-1391-47a9-a10b-3a91ec2adf58	2020-01-16 13:23:28	lacencut	
2c5c0115-bcc2-4f07-9aac-adc4a63f8c6b	2020-01-16 13:29:49	laceneut	
bd0e70f2-14ad-41a9-bc31-723c216891d3	2020-01-20 09:01:34	lacement	
011cb384-3d3d-4b76-a10e-4cebe2b9c27b	2020-01-20 09:05:46	lacenent	
35451220-405b-4e4f-a231-4c57ee49b423	2020-01-20 09:00:47	lacenent	
b60becaf-138c-14a1-a186-986411525cc9	2020-01-20 09:10:44	lacenent	
655f d187-b5e7-4b9c-aea0-002c2e3137e0	2020-01-20 09:16:25	lacencut	
b7ebfa94-1Bac-40b4-ac5e-a6342eaae42c	2020-01-20 09:22:56	lacement	
a985edec-911a-47b1-ab11-3fdedf1a8e97	2020-01-20 09:45:19	lacement	
43b9c628-3616-48e9-b616-5Fe74b6472ac	2020-01-20 09:46:49	lacement	
419433b4-4063-4aF6-ab00-F9391d010b9d	2020-01-20 09:54:09	lacement	
7e1c490d-5369-41c1-8869-ee85f0e5f191	2020-01-20 09:56:30	lacement	
05bcae9c-bfa1-1e1f-b378-0c303bab3b3e	2020-01-20 09:58:30	lacenent	
0b9%l2a0-4cca-4fac-bb1f-16119d2c9477	2020-01-20 10:13:36	lacement	
81c7dfc7-03cd-48eb-94b7-27ca57e99143	2020-01-20 10:20:42	lacenent	
900c8c7f-b9c1-4c63-b6e9-20f967af3f6c	2020-01-20 10:25:33	laceneat	
14eScf?1-811c-4dcd-9dbc-42500659f?46	2020-01-20 10:41:17	laceneut	
6bff1615-38f8-4603-af98-dc35be852261	2020-01-20 12:24:03	lacenent	
katanasn@katanasm:"/slice-nanager\$			

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)

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.

Table 7 the coordination layer components

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

5Genesis Login Register		Scheduler Log History
Please log in to access this page.		Running Experiments:
Sign In Jsename		(de) Netrestrict 12
		Configuration Log 2
Sign in 5th Gene Forget Your Passwoort? Click to Reset It Network, System	Genesis eration End-to-end Experimentation, Integration, and howcasing	Factify Log 💽 🖉 🗖
5Genesis Home Create Experiment VNF/NS Management	fogus - Loqout	SGenesis Hone Cruste Experiment Will ANS Management Repus-Logout
	iugus - Luguur	CREATE EXPERIMENT
Your experiment has been successfully created		Name Type Standard •
EXPERIMENTS	ACTIONS	Test Cases RTT TEST PEST PERT PERT UES
Experiment ID Name Type Action 12 First Test Standard Run Experiment Execution	10 January 2020, 3:14:58 Created experiment: First Test	ItelSever1 Silce Sicc1
		Network Services You have not defined any HS yets Ligand HS
Scheduler Log History	,	
Running Experiments: 39 Run fogus		un: Finished (100%) Finished (status: Finished) View at (ID: 12) Ned execution id: 40
Diagnostics	0	
		ation Log 7
	uration	

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

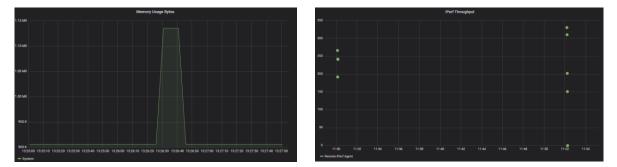


Figure 23 Memory usage and Throughput screens from the Grafana component

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.

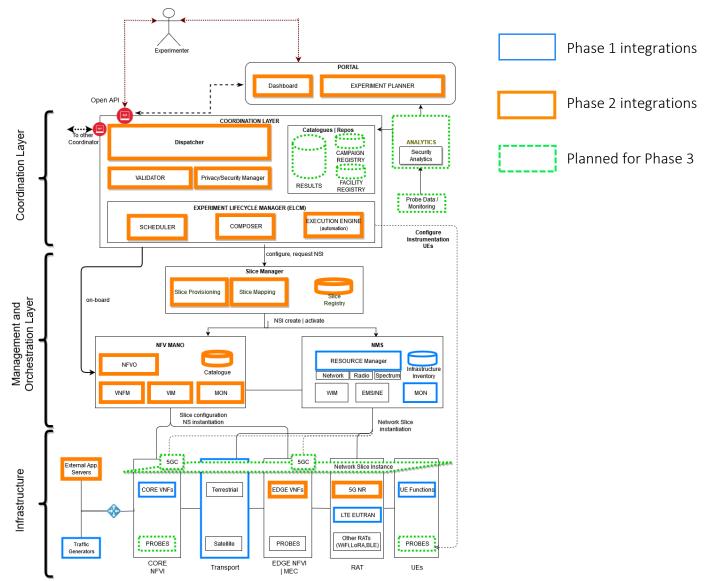


Figure 24 Instantiation of the 5GENESIS Architecture during integration cycle 2 (phase 2)

3.1.1. 4G Deployment Configurations

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

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	ΝΑ	
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	

Table 8	8 The 4G	deploymen	t configurations
TUDIC		acployment	c configurations

3.1.2. 5G Deployment Configurations

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

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	ΝΑ		
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	ΝΑ		
Core Network	NA	Amarisoft	To be defined		
RAN	OAI NR	Amarisoft gNB (SDR)	To be defined		
UE	ΟΑΙ	Samsung A90 5G	To be defined		
Relevant Use Cases	To be defined	To be defined	To be defined		

Table 9	The 5G	deployment	configurations
Tuble 5	1110.00	acproyment	. comparations

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 OAIcompliant (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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