5G European Validation platform for Extensive trials

Deliverable D2.2
Site facilities planning

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List of Acronyms and Abbreviations

3GPP	Third Generation Partnership Project
5G	Fifth Generation
AGV	Automated Guided Vehicle
API	Application Programming Interface
ARCEP	Autorité de Régulation des Communications Electroniques et des Postes
BBU	Base Band Unit
CA	Carrier Aggregation
CEE	Cloud Execution (Ericsson) Environment
CIC	Cloud Infrastructure Controller
CP	Control Plane
CPRI	Common Public Radio Interface
C-RAN	Cloud Radio Access Network
CU	Cloud Unit
DU	Digital Unit
E2E	End-to-End
eMBB	Enhanced Mobile Broad Band
EPC	Evolved Packet Core
E-UTRAN	Evolved Terrestrial Radio Access Network
FDD	Frequency Division Duplex
HSR	High Speed Rail
HSS	Home Subscriber Server
HW	HardWare
IaaS	Interface as a Service
IoT	Internet of Thing
IRU	Indoor Radio Unit
KPI	Key Performance Indicator
LAN	Local Access Network
LIDAR	LIght Detection And Ranging
LTE	Long-Term Evolution
MANO	Management and Orchestration
MCR	Mobile Cloud Robotics
MEC	Mobile Edge Computing
MIMO	Multiple Input Multiple Output
MME	Mobility Management Entity
mMTC	massive Mobile Type Communication
NB-IoT	Narrow Band – Internet of Things
NFV	Network Function Virtualization
NFVM	NFV Manager
NFVO	NFV Orchestrator
NFVI PoP	NFV Infrastructure Point of Presence
NR	New Radio
NSA	Non Stand-Alone
NSD	Network Service Descriptor
OAI	Open Air Interface
ODL	OpenDayLight
QoS	Quality of Service
RAN	Radio Access Network
RAU	Radio Access Unit
RD	Radio Dot
RRC	Radio Resource Control
RRH	Remote Radio Head
RRU	Remote Radio Unit
SA	StandAlone
SDN	Software Defined Network
SDR	Software Defined Radio
SW	SoftWare
TaaS	Testing as a Service
TDD	Time Division Duplexing
UC	Use case
UE	User Equipment
uRLLC	Ultra-Reliable Low-Latency Communications
USRP	Universal Software Radio Peripheral
vCPU	Virtual Central Processing Units
vEPC	virtual Evolved Packet Core
vEPG	virtual Evolved Packet Gateway
VIM	Virtualized Infrastructure Manager

VM	Virtual Machine
VNF	Virtual Network Function
VNF-FGD	VNF Forwarding Graph Descriptor
VNIC	Virtual Network Interface Controller
VPN	Virtual Private Network
WAN	Wireless Access Network

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Executive Summary

The present deliverable describes the planning of each site facility deployment at least until April 2019. It also gives some perspectives of updates that will occur after this date. April 2019 has been put at the first objective since it corresponds to the initial access to the site facility for vertical hosting. Attached to this deliverable, we have inserted an Excel file, with one sheet per site facility, giving the dates of availability for each component/equipment that compose the integrated site facility. These components are referred via index number in the Excel sheet, showing their date of availability. Then, in the document, a brief description of each component is done as well as its methodology of implementation, testing and validation. More attention is paid about the site facility integration. Indeed, since some site facilities are composed of several integrated platforms regarding the use case they want to host, each integrated platform is detailed about the components they are composed of, the KPI they plan to achieve and the methodology of integration they plan to apply.

The content of this document is complementary to the 5G EVE deliverable D2.1 [1], which describes more in details the various site facilities. We just refer or take inputs coming from [1] to give information about the site facilities architectures and components that integrate the platforms. Therefore, reading first [1] is a prerequisite to better understand this document.

1 Introduction

The objective of this document is to provide a roadmap for 5G EVE platform implementation (in terms of components) over particular European site facility composing this platform. Then, planning for each integrated platform is given as well as an overview of the different tests leading to the components' validation. The global validation procedure for the E2E transmission allowing to host the verticals is explained.

For each site facility, the objective is to have a view of its roadmap through the main functionalities, and updates that will be implemented in order to be able to host the initial access to participating vertical industries for non-interworking use cases in April 2019. At this moment, the APIs and test tools will be not yet available. Then, the integration of common tools developed in the project framework will be done progressively.

Even if the focus is mainly done about the site facility status until April 2019, the perspectives of site facility upgrades are envisaged after April 2019 as well. Indeed, since these improvements are dependent on the equipment providers, the roadmap should be refined over the medium term.

Figure 1 recalls the global WP2 roadmap in a macro view with the different deliverables and milestones. Among the milestones, MS5 that occurs in April 2019, corresponds to the initial access to site facilities whereas MS8, end of 2019, to the moment where the site facilities will be interconnected and equipped to the main tools for integrating external verticals, leading to the first version of E2E site facility. This first version will be followed by the second one (MS9 in April 2020) and the third one (MS10 end 2020) with various improvements that will follow the main specifications of 3GPP R16 release. The last version will describe the final 5G Validation platform facilities achieved by 5GEVE project. Therefore, we propose a regular evolution of this deliverable every 6 months from the first delivery of the platforms at the end of April 2019. The various versions of deliverable will highlight the main site facilities evolution that will compose the E2E facility.

For each site, we propose to map the main deadlines about components delivery on the calendar. We refer in a specific Excel sheet per site facility, the availability of the site facilities components/equipment by giving in this main word document their main functionality, their date of availability and how they will be tested and validated in the integrated framework. Then, a specific section about the integrated platform is detailed for each site facility, given the combination of the different components that will compose it. A description of the main objectives of each integrated platform is carried out, giving the main KPIs that are expected.

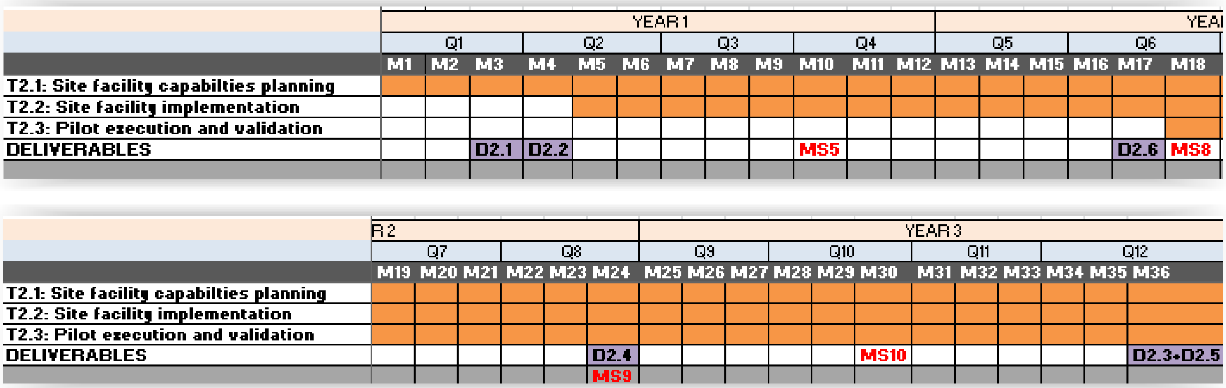


Figure 1: Global WP2 planning

An “inventory” of each 5G EVE site facility is given in [2] through the presentation of the detailed planning of availability of the main components of each site. The components availability table [2] is also the basis for the regular monitoring of the site facility implementation. It will be also updated during the project. Each planning is also searchable in APPENDIXES until December 2019. Each component is referred by an index number that is reported in the document to give information about it.

We move follow the same organization for each site facility for the detailed components/equipment reporting. The attached excel file inventories the planning of each site facility through its main components.

1.1 Structure of the document

The main structure of this deliverable is as follows; Chapter 2 contains the planning of the Greek site facility, Chapter 3 contains the planning of the Italian site facility, Chapter 4 contains the planning of the Spanish site facility, Chapter 5 contains the planning of the French site facility. Finally, Chapter 6 makes a conclusion and recommendation.

2 Greek site facility planning

2.1 Introduction

As described in detail in D2.1 [1], the Greek site will consist of platforms and components of Ericsson and Nokia in terms of the access and core networks. The RAN will consist of different nodes from Ericsson GR and Nokia GR while the core network will consist of vEPCs from Ericsson and Nokia.

For the Ericsson case, a distributed cloud infrastructure will be used to enable the service of AGV.

The cloud management system will consist of the service and resource orchestrators. The control system will be responsible to control the VNFs lifecycle and the traffic to the underlying data plane. The monitoring management system will be responsible to collect data on metrics, topology and the resources in order to monitor the KPIs and adapt them to the needs of the project.

At a first stage, three use cases will be executed over the Greek site facility. They will utilize existing OTE facilities in combination with existing and new Ericsson GR and Nokia GR components and platforms, while WINGS will also contribute and advance its Smart city and Utilities platforms for the corresponding use cases. At this stage of deployment (April 2019), some proprietary components will be used by both vendors to enable the respective use cases that they are driving (i.e. Industry 4.0 for Ericsson and Smart City for Nokia), as well as to enable the execution of the utilities use case. In the following stages, the interconnection of equipment between the vendors will take place, enabled by OTE overlaid components. Hence, it operates as one unified facility capable of supporting multiple use cases. In the following sections, the currently foreseeable timelines regarding the availability of the different components and platform functionalities are presented, based on the available roadmaps.

2.1.1 Industry 4.0 – AGV use case oriented architecture

As explained in detail in D1.1 [3] and D2.1 **Error! Reference source not found.**, the Greek site facility will be partially comprised of Ericsson equipment, functionalities and platforms. More specifically, RAN and core Ericsson equipment will be used to upgrade the Greek site facility as well as management functionality while Ericsson software and relevant platforms will be utilized to support the industry 4.0 use case in supporting AGV functionality in an emulated manufacturing environment.

Realistic Mobile Cloud Robotics (MCR) scenarios are enabled through the replacement of traditional robots with new ones connected to the cloud. These new robots only include low-level controls, sensors, and actuators and having their intelligence residing in the cloud means that they have access to almost unlimited computing power. Altogether, they are more flexible, more usable and more affordable to own and operate. The connection between MCR systems and the cloud is provided through the mobile network and will benefit from the expected 4G and 5G extremely low latency connections. All these equipment, functionalities and platforms are presented in the following sub-sections based on the currently known timelines for product releases.

2.1.2 Utilities use case – Smart grid fault detection & management

The Utilities use case will be supported by the CATARACT platform developed by WINGS. CATARACT leverages on commercial and on more novel sensors, standardized communication technologies, analytics and artificial intelligence, visualization and customizable dashboards enabling the following functionalities i) embedded intelligence for smart behaviour for smart sensors that offers identification of critical events, self-adaptation of measurement and transmission profiles and energy management; and ii) embedded and cloud-based intelligence (based on analytics and artificial intelligence) for smart grid fault detection and management that enables prediction of critical events and data correlation for identification of complex events.

The CATARACT platform will be deployed in the Greek site facility and the main focus will be placed on demonstrating fault management scenarios for distributed electricity generation in smart grids, which will be supported by the following added value services:

- Online monitoring of the consumed energy at the desired granularity
- Prediction of demand and supply-demand matching
- Detection of abnormalities and corresponding remediation actions

The CATARACT platform functionalities and components are described in detail in Section 2.2.6.4.

2.1.3 Smart city use case – Safety / Health / Home - Mobility

As explained in detail in D1.1 [3] and D2.1 **Error! Reference source not found.**, one of the Greek site facility use cases that will be implemented with equipment by Nokia GR is in the vertical of E-Health and is the "Connected Ambulance". This is a key use case of the project that highlights the 5G network characteristics and carries significant impact in the Smart City framework.

The scope of the "Connected Ambulance" use case will be to convert the ambulance into a communication hub that will be used to transmit the patient vital data, video and audio signals both from the accident scene as well as while the ambulance is on route to the hospital. Additionally, time permitting, augmented reality scenarios may also be deployed. 5G connectivity is required to properly support this use case, due to the massive capacity, reliability and low latency features needed for HD video transmission for e.g. remote diagnostic as well as the reliability and low latency needed for patient monitoring and some basic control. For the HD video transmission, a general latency requirement is sufficient, but reliable communication is required if the diagnosis is based on combined information and involves remote care action (e.g. doctor guiding actions at the ambulance), especially when mobility is introduced.

The "Connected Ambulance" use case will be implemented using Nokia equipment, functionalities and platforms. More specifically, RAN and core Nokia equipment will be used to upgrade the Greek site facility as well as management and orchestration functionality while the Nokia IoT platform (see Section 2.2.6.2) will be utilized to support the e-Health smart ambulance use case.

The Nokia IoT platform is a platform that provides horizontal services for all IoT applications and verticals. It is a horizontal platform that can connect to any IoT enabled device. This platform is flexible enough to support multiple deployment and business models including private, public cloud, private cloud, SaaS and transactional. It provides service providers, enterprises and governments with a standards-based platform for securely managing any device, protocol or application. All these equipment, functionalities and platforms are presented in the following sub-sections based on the currently known timelines for product releases.

Part of the Smart city use case pilot that will take place in the Athens site facility will focus on issues of i) Safety and environment, ii) Health monitoring and forecasting and iii) Smart mobility and smart homes, as described in detail in [1]. These pilots will be enabled by the WINGS Cloud-based IoT platform named STARLIT (**s**mar**t** living pl**a**tform powered by a**r**tificia**l** **i**ntelligence and robus**t** IoT connectivity).

The STARLIT platform is a WINGS proprietary end-to-end solution offering a combination of services for smart home, smart health and smart navigation and comprises functions for learning, forecasting and system self-management. The rich set of (enhanced city and smart home) services offered by STARLIT includes dynamic creation of smart city dashboard applications; visualisation of real-time and historical data, as well as predictions on information of interest about the city; proactive customized recommendations for city life improvement; self-healing/repairing of the system. The above are realized through i) WINGS' proprietary algorithms, which are based on advanced artificial intelligence (AI) mechanisms, i.e., machine learning algorithms and predictive analytics (supervised, unsupervised, reinforcement, deep learning); ii) cloud and IoT technologies, exploiting various sensors and actuators, (e.g., temperature, humidity, luminosity, lighting, motion) and several programmable IoT boards (e.g. Raspberry Pi, Arduino) and iii) end-user applications for automated indoor environment adaptation, remote health monitoring and forecasting and smart mobility. The STARLIT platform functionalities and components are described in detail in Section 2.2.6.3

2.2 Planning

As pointed out in the joined Excel file [2] and referred to in Appendix A, the main development/deployment components are specified. More details are given in the following where:

- "E" refers to Ericsson;
- "N" refers to Nokia;
- "O" refers to OTE;
- "W" refers to WINGS;
- Aggregation of mixed references ("E" + "N" + …) is related to multiple owners.

In addition, the planning for the Greek site facility is given in APPENDIX A.

2.2.1 Network infrastructure

2.2.1.1 Equipment

Ref#E1 will be available at **M10**. It corresponds to the devices (AGVs) and their control management. The control functions are distributed partially on a remote cloud and partly on the AGV. The lower level functions, controlling sensors, and actuators, are located on the AGV, while the rest resides in a powerful remote cloud. The benefit of this choice is mainly the enhancement of flexibility, exploiting the computation power of the cloud. The vehicle controller supervises the communication with the AGV system management, controls the next step movement and handles sensors and actuators. It takes care of stopping the AGV in presence of a very close obstacle to avoid an immediate collision. It collects the LIDAR information to be sent to the AGV system management and then to the main control system for navigation and collision avoidance purposes. Collision avoidance should make use of cameras and LIDAR sensors fusion to determine the change of trajectory to avoid an obstacle. A detailed presentation of the AGVs as well as their control management functionality has been given in Section 2.1.1 of D2.1 **Error! Reference source not found.**.

Ref#N1 will be available at **M9**. It corresponds to High density 1000BASE-T switch which will be interconnecting the main NFV rack with site routers and radio. The general networking architecture of the Nokia core solution and the corresponding data paths in the network are depicted in Figure 2.

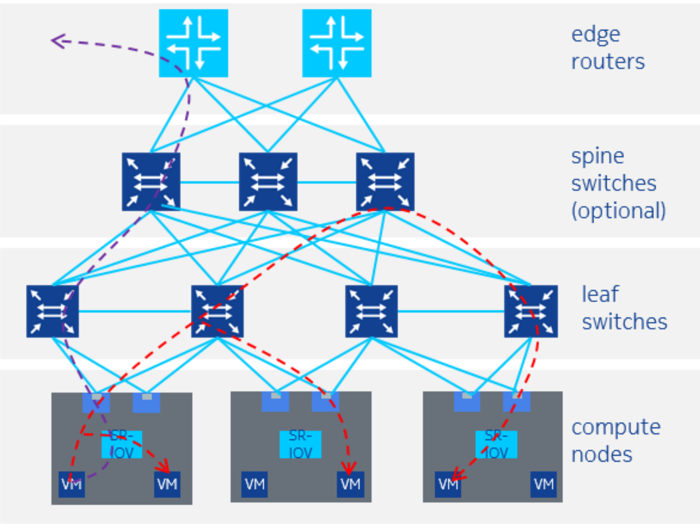


Figure 2: General network architecture of the Nokia core & in-network data paths

Ref#O5 refers to the HW necessary for hosting OTE’s Athonet platform (see Section 2.2.6.1). The computational resources of OTE’s testbed will consist of two servers Dell R630 servers which will be used for hosting the vEPC provided by Ericsson and the other one to host OpenStack and Open Source MANO for instantiating and implementing the applications of the verticals through the Open-Air Interface infrastructure.

2.2.1.2 RAN components

Ref#E2 includes the Radio Access Network equipment that will be available at **M9**. The HW comprises the baseband node and one or more radio units depending on the manufacturing or warehouse coverage area. The software includes the components needed to operate the 3GPP wireless system including LTE and 5G. These components have been described in detail in D2.1 **Error! Reference source not found.**, however some key points are also mentioned here for the sake of completeness and to facilitate understanding.

The baseband unit is common across different radio configurations, it provides the baseband processing resources for the encoding and decoding of the uplink and downlink radio signals, the radio control processing, the radio network synchronization, the IP and the O&M interface for the Ericsson Radio System. Warehouse cellular coverage to enable the AGVs service will be provided by deploying Ericsson’s indoor Radio Dot System (RDS) solution. This is a high performance distributed active radio antenna system based on a centralized RAN architecture. A simplified diagram is shown in Figure 3.

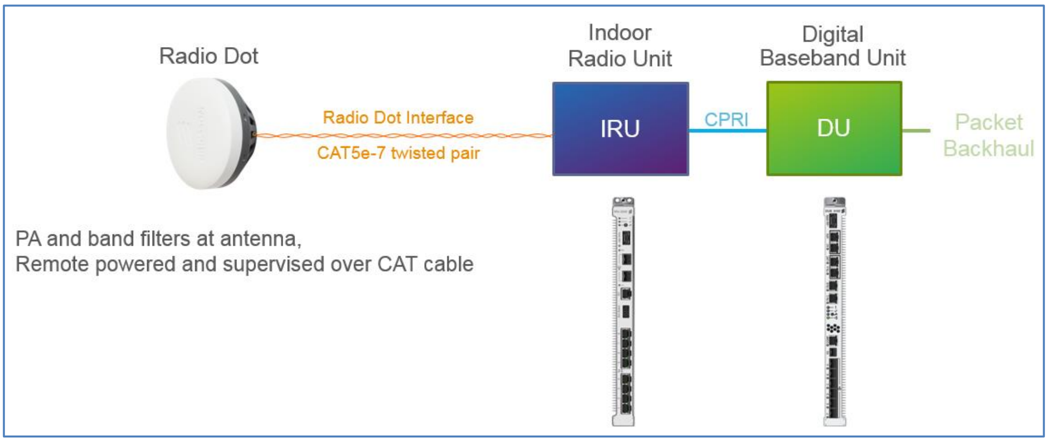


Figure 3: Radio DoT architecture optimized for medium to large scale indoor deployments

The Ericsson RDS consists of 3 key components:

A. Radio Dot (RD): It contains the power amplifier and filters for the frequency band(s). RDs are power fed from the Indoor Radio Unit (IRU) over up to 200 m LAN cabling. It is designed for deployment in an indoor environment, in single, dual-band and 5G variants. Using one Radio Dot and LTE 20 MHz spectrum capacity the following peak throughput can be delivered:

- 200 Mbps using MIMO 2x2 system (CAT4 device)
- 400 Mbps using MIMO 4x4 system (CAT9 device)

The baseband processing for the uplink and downlink of LTE and NR is provided by the baseband unit 6630. The RDS centralized baseband architecture enables coordination across the covered area.

B. Indoor Radio Unit (IRU): The IRU provides the power and control for the RDs. It generates the RD interface on 8x RJ45 ports and connects to the Dots over standard enterprise LAN cables.

C. Digital Unit (DU) or Baseband: The Baseband connects to the IRUs over the CPRI interface. The Baseband runs the 4G+ SW features. It supports key coordination features for running small cells in large multi-antenna indoor environments. Features include Combined Cell, Carrier Aggregation, Lean Carrier, Uplink Comp. The Baseband provides synchronization and transport security functionality and aggregates the radio traffic onto a common backhaul connection.

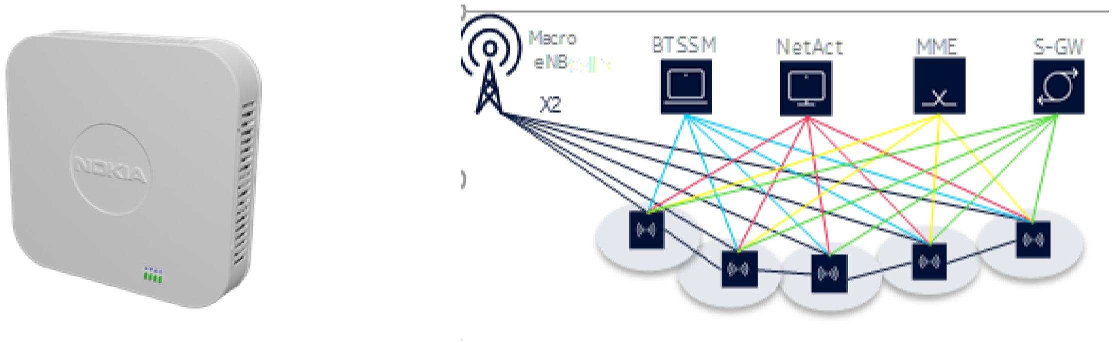
The provided RAN system is fully compliant to 3GPP R15. The first phase of RAN SW/HW deployment will comprise functionality compliant to LTE Advanced Pro technology included up to 3GPP R14 specifications.

Ref#E5 includes the Radio Access Network equipment that will be available at **M17** (November 2019). The initial RDS architecture is also in line with the radio network architecture of 5G. It can coexist with pure 5G NR radio by including additional RDs optimized for 5G NR compatible with 3GPP R15 specifications. Complementing the 4G Dot, RD4479 is a single band 5G RD with four Rx/Tx antenna branches will be used on a second phase to provide NR coverage offering peak downlink speed up to 2 Gbps. 5G NR RD delivers speeds up to 2Gbps and supports the new 5G mid-band 3-6GHz (n78 compatible). It fully reuses the currently installed architecture for 4G+ RD with the ease of installation and flexibility and functional parity with the macro network. A second baseband 6630 will be needed for the 5G/NR RDs.

Ref#N2 will be available at **M9** and it will consist of Multi-Band FDD LTE Small Cells as depicted in Figure 4a. The proposed solution is a fully 3GPP eNB compliant small cell solution using Nokia's Flexi Zone platform. Key benefits of the proposed solution are as follows:

- Uniform user experience across the network through tight integration and feature parity with the macro network
- Total cost of ownership (TCO) benefits due to macro parity, common NetAct OSS with macro, complemented with heterogeneous network features
- Unrivalled small cell baseband capacity in the market
- Optional integrated 802.11ac Wi-Fi and Licensed-Assisted Access (LAA)
- Enabled for evolution to Zone architecture for extremely high small cell cluster capacity and Multi-access Edge Computing (MEC) for local breakout additional services such as augmented reality
- Smoothly and securely deploy and operate indoor small cells in its existing network

Nokia Flexi Zone small cells BTS support standard 3GPP interfaces (S1, X2) which enables easy integration with the legacy mobile network also in a multivendor environment. An indicative small cell architecture including the relevant interfaces is depicted in Figure 4b.



a) b)

Figure 4: a) Nokia Indoor Multi-Band FDD LTE small cell, b) Nokia small cells main architecture and interfaces

Nokia small cell solution uses the same software and supports the same features as the macro network thus leveraging the field experience and Inter-operability tests. Flexi Zone solution will result in the tight integration of office small cells with the macro network. It will also offer the cost and performance benefits through macro feature parity and common OSS. Flexi Zone Small Cell future-proof product family and its most innovative small cell architecture provide new capabilities and versatile approach to address the varying deployment needs and business cases.

Ref#N11 refers to the upgrades that will enable support of 5G NR technology and will be available at **M17**. 5G and the growing Internet of Things (IoT) will demand a much wider range of communication services. Additionally, new network capabilities will be needed to run increasingly diverse use cases. Nokia AirScale is the new way to build such a network without having the need to replace huge chunks of existing installed infrastructure since it evolves from the existing Nokia Flexi network proposed in the previous phase. With AirScale it is possible to deploy 5G service on existing LTE bands, as well as new bands, such as mmWave. Nokia Airscale is a radio access network with the hardware and software to prepare the way for IoT and 5G connectivity. Nokia Airscale Radio Access includes the following elements (also depicted in Figure 5):

- Nokia AirScale Base Station comprising a single, dual and triple band radio unit and indoor and outdoor system modules
- Nokia AirScale Active Antennas (Compact Active Antennas as well as massive MIMO Adaptive Antennas)
- Nokia Airscale Cloud RAN
- Nokia Airscale WiFi

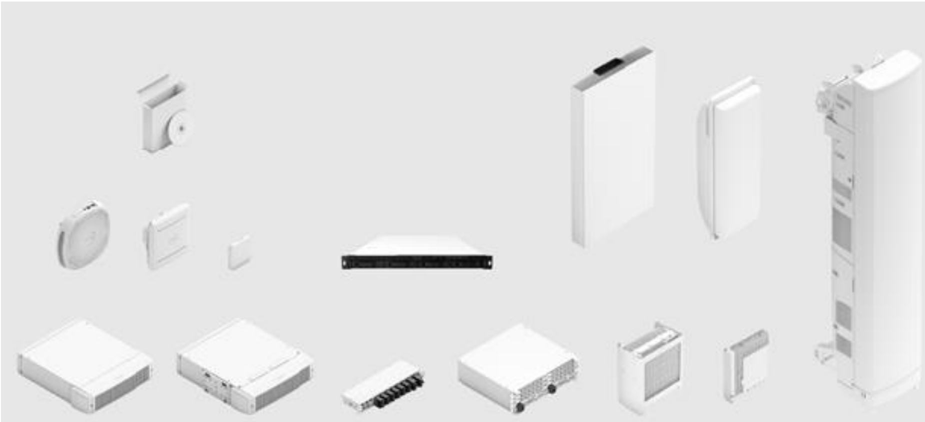


Figure 5: Nokia AirScale Radio Access Elements

The combination of elements needed for the deployment of the “Connected Ambulance” use case will be determined upon the finalization of the area where the use case verification will take place.

2.2.1.3 CORE components

Ref#O1 refers to the virtual EPC that will also be available by OTE's Athonet platform (see Section 2.2.6.1) which provides a complete software-based mobile packet core solution (EPC) which also includes a Home Subscriber Server (HSS), Voice-over-LTE (IMS for VoLTE), and LTE Broadcast (eMBMS) [4]. This is one of industry's most efficient mobile core solution that can be deployed in fully virtualized environments (NFV), enterprise data centers or on standard off-the-shelf servers. It can be used in highly distributed deployments in Tier 1 Mobile Operators and OTE has deployed it in its lab Athonet vEPC architecture. Athonet's LTE mobile core complies with the default 3GPP (Third Generation Partnership Project) interfaces as shown in Figure 6 below.
Ref#E3 and **Ref#E11** include the core network equipment that will be available at M9.

A 5G EPC-in-a-box is proposed that fulfils the requirements for cost-effective test systems with few subscribers and minimal footprint. It is a further evolution of the Virtual Network Function (VNF) single server deployment enabling multiple VNFs on a single server. The deployment contains vEPG, vSGSN-MME and vSAPC.

EPC-in-a-box is designed to run on top of Ericsson OpenStack IaaS i.e., Cloud Execution Environment (CEE) and can use either HDS 8000 CRU or Dell 630 as HW. It is also tuned to be as efficient as possible when all VNFs are running at the same time. However, there is no requirement that all VNFs have to be deployed. For example, it is possible to deploy vEPG only. EPC-in-a-box deployment is built on Ericson Cloud Execution Environment (CEE) which includes the following functions necessary for EPC-in-a-box:

- Virtualized CIC (Cloud Infrastructure Controller);
- Support to run the vCIC in a non-redundant single-vCIC mode;
- Hyper-Threading;
- Pinning of the VM vCPUs to specific Hyper-Threads (HTs). ePC, slicing

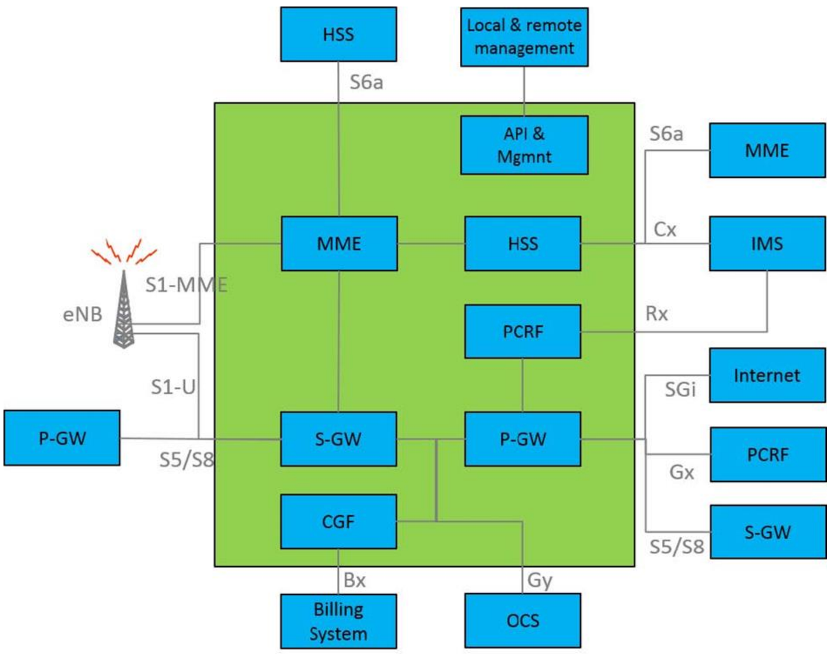


Figure 6: Athonet vEPC architecture

Option 3, including all three variants 3, 3a & 3x shown in Figure 7, are supported by Ericsson 5G EPC.

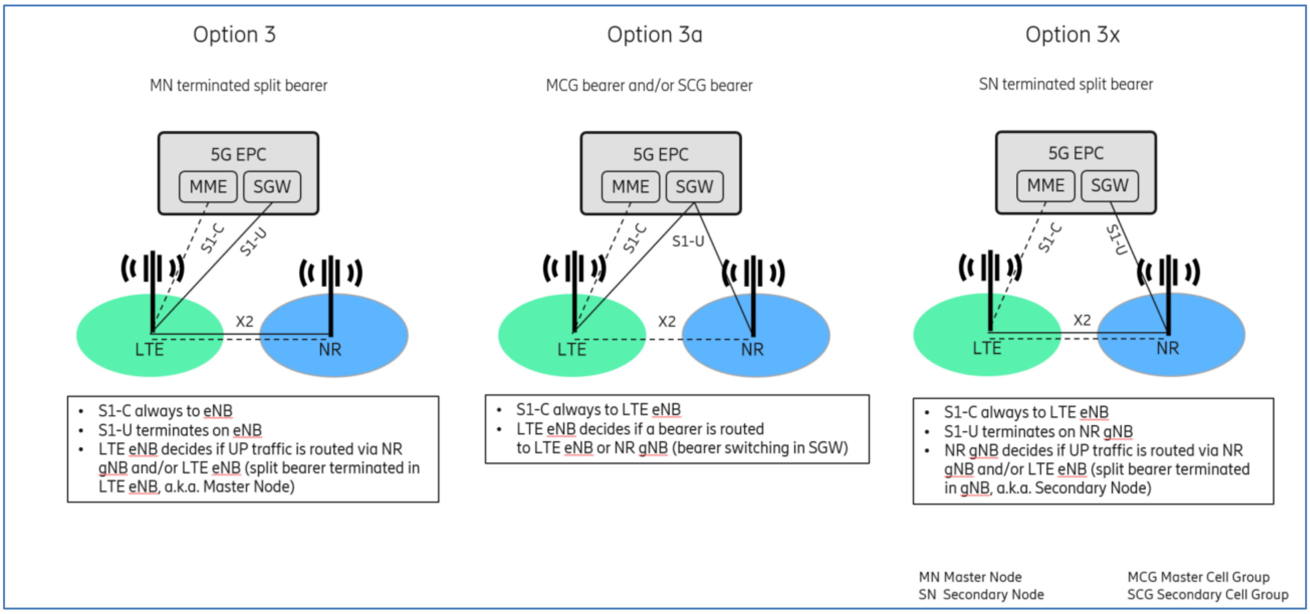


Figure 7: Option 3, including all three variants 3, 3a & 3x

- A 5G Option 3 capable UE anchors to the Option 3 enabled LTE radio and 5G EPC and may use LTE and NR for user plane traffic. The eNB gets this knowledge from UE indications of capability. This device is backward compatible with legacy LTE RAN, 2G, and 3G;
- An LTE-only UE (not 5G Option 3 capable), will still be accepted into the Option 3 enabled EPC and RAN architecture, but for LTE access only;
- Session continuity from 5G to 4G is supported that can be leveraged as a bridge to lower generation systems.

For Option 3 architecture and operation, the following key network functions are affected:

- MME (Software functionality of proposed SGSN-MME);
- S/PGW (Software functionality of proposed EPG);
- HSS (evolved);
- PCRF (evolved).

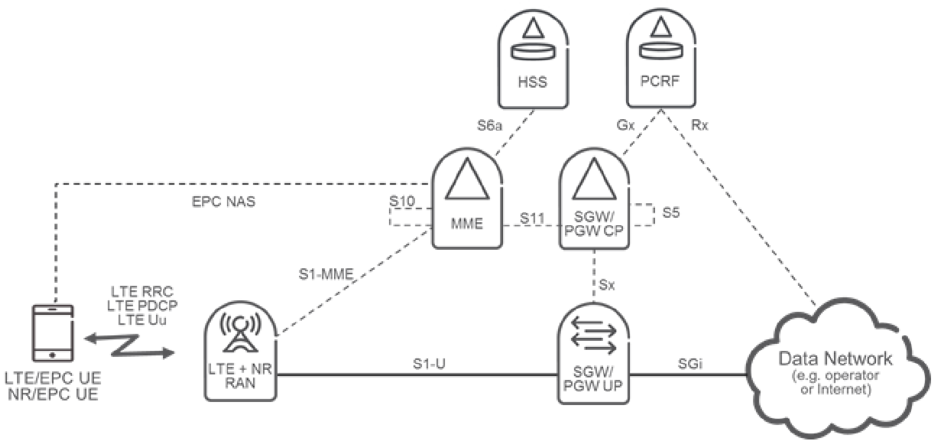


Figure 8: Overall network architecture

Ref#N3 will be available at **M9**. It will consist of R14 CMM (Mobility Management in Cloud Architecture), CMG (Cloud Mobility Gateway which provides access in subscriber user plane, i.e. 4G now, 5G within 2019), SAM (CLI Administration/Configuration interface to CMM). CMM VNF (i.e.MME+SGSN) is a virtualization of the MME, SGSN network functions. Functional behavior is the same as with non-virtualized nodes. CMM VNF is composed of multiple internal components (VNFCs). A high-level architecture of components can be found in Figure 9.

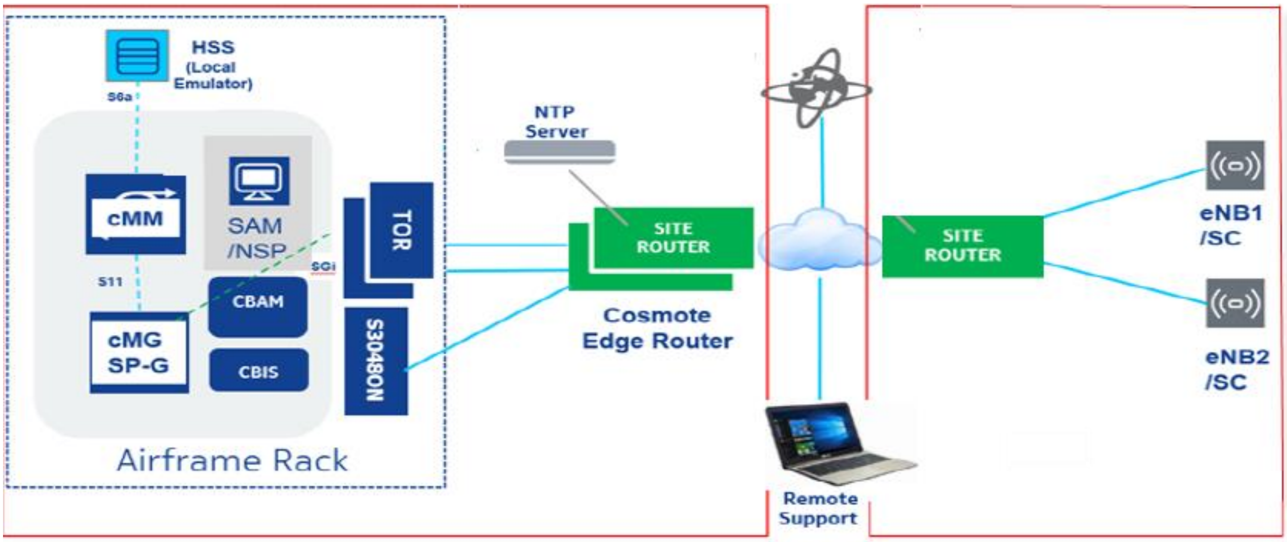


Figure 9: Nokia cloud EPC Integration

Ref#N10 refers to the upgraded elements that will include R15 core, supporting 5G NR (option 3x), which will be available at **M17**. The edge cloud will play an essential role in the 5G architecture, enabling cloud RAN and new vertical use cases. The solution comprises of compact size HW and real-time/low latency optimized infrastructure SW. It supports pluggable acceleration modules enabled by ReefShark, x86 and other processing acceleration technologies and its low latency and acceleration capabilities optimize the performance of machine learning and AI workloads. Even though the exact testbed architecture will be determined in the following steps, according to the use case needs, Figure 10 depicts an indicative core architecture with different utilization of the edge cloud to support use cases with extremely low latency requirements.

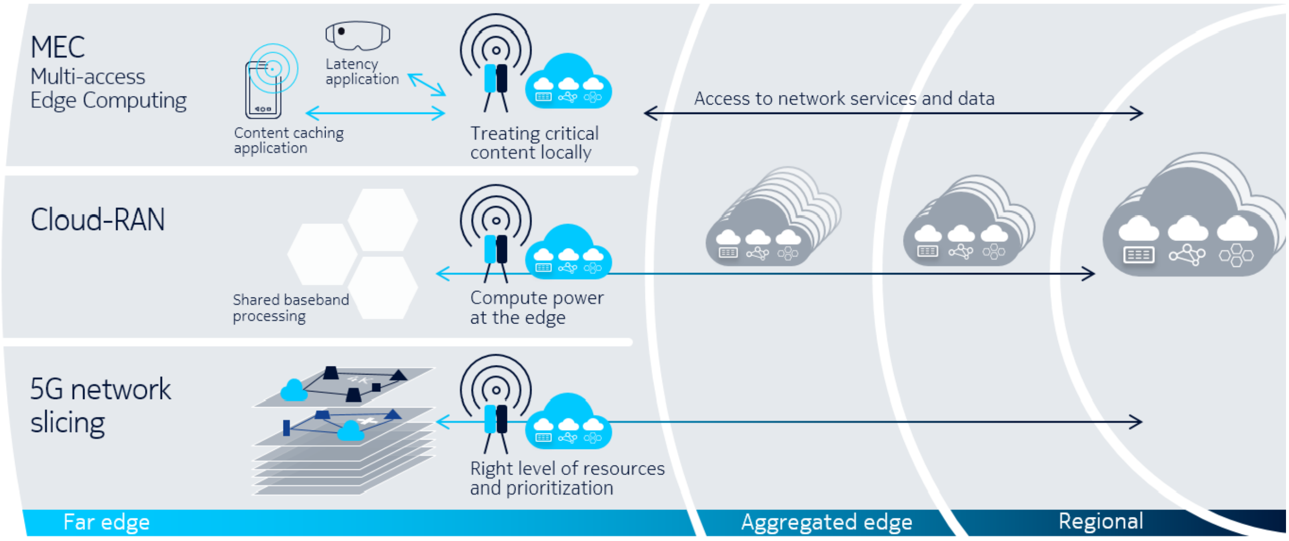


Figure 10: Enabling new extremely low latency dependent use cases (e.g. AR/VR)

2.2.1.4 Frequency bands

Ref#E4 is the frequency band available at **M9**. The frequency band that will be used for 4G+ deployment is B7 which is, FDD 2600 MHz with 20 MHz spectrum deployment. Since there is already another vendor providing LTE FDD coverage in the surrounding region, it is important to ensure that the facility has no overlapping FDD coverage at 2600 to avoid intra-frequency interference in the facility.

Ref#E6 is the frequency band available at **M17**. Following the initial phase, 5G NR will be deployed in parallel to 4G+ in a Non-Standalone deployment (NSA) by using 100 MHz of spectrum in band n78, i.e.

3400-3800 MHz. The centered carrier frequency will be decided on to the assignment of a specific purpose industry 4.0 NR carrier frequency from the local regulation authority (EETT).

Ref#N4 will be available at **M9**, where the following apply per band:

- First Band: Class 1 UL: 1920 – 1980 MHz, DL: 2110 – 2170 MHz
- Second Band: 5GHz LTE-U

Ref#N9 will be available in **M17**. The frequency spectrum is expected to be 3.5 GHz-3.7 GHz (depending also on licensing and the operator's policy).

2.2.2 Network management

2.2.2.1 Resources management

Ref#N5 will be available at **M9**: VNFM and application management: CloudBand Application Manager which handles the configuration, lifecycle management and element management of the virtualized network functions and Virtualized Infrastructure Manager (OpenStack /CBIS). The following main operations belong to VNF lifecycle management:

- Instantiate new VNF entity
- Scale-out – add virtual resources and expand VNF (e.g. by adding a functional unit to increase capacity)
- Scale-in – remove virtual resources and reduce VNF (e.g. by removing the functional unit to decrease capacity)
- Terminate whole VNF entity
- Upgrade/Update – perform system SW upgrade/update
- Heal a VNF entity

According to ETSI reference model [5] VNFM entity is responsible for VNF lifecycle management. In Nokia implementation, CBAM is responsible for lifecycle management.

Ref#O2 refers to the Athonet Element Management System (EMS), for the core management system of the OTE platform (see Section 2.2.6.1). It can manage system configuration and 3GPP nodes, user management and QoS profile management, detailed user activity and secure access, using:

- Integration points are available for connecting the vEPC to third parties;
- SNMP for KPI and performance monitoring;
- SNMP traps for alarm monitoring;
- RESTful API for user provisioning and profile assignment and activating and de-activating users.

Supported protocols, interfaces and standards

- Architecture enhancements for non-3GPP access, according to 3GPP 23.402;
- Intra-domain connection of Radio Access Network (RAN) nodes to multiple Core Network (CN) nodes according to 3GPP 23.236;
- Network sharing according to 3GPP 23.251;
- Stream Control Transmission Protocol (SCTP) according to RFC 4960;
- User Datagram Protocol according to RFC 768;
- Internet Protocol according to RFC 791;
- Transmission Control Protocol according to RFC 793;
- Internet Protocol version 6 (IPv6) specification according to RFC 2460;
- GTP-U based interfaces according to 3GPP 29.060-29.281;
- QoS architecture according to 3GPP 23.107;
- Diameter interfaces according to 3GPP 29.230;
- S1-AP according to 3GPP 36.413;
- S1 data transport according to 3GPP 36.414;
- NAS-EPS according to 3GPP 24.301;

- Gy interface according to 3GPP 32.299 and RFC 4006;
- Bx interface according to 3GPP 32.251, 3GPP 32.297, 3GPP 32.298;
- Rx interface according to 3GPP 23.203;
- Gx interface according to according to 3GPP 29.212;
- Cx interface according to 3GPP 29.228-9.

2.2.2.2 Orchestration

Ref#N7 will be available at **M9** Orchestration (service, network and security): CloudBand Network Director.

2.2.2.3 Interconnections

Ref#O3 refers to the interconnection of the vEPC of the OTE Athonet platform as described in Section 2.2.1.3, which contains the core network nodes MME, S-GW, P-GW, HSS, PCRF and connects externally via the following 3GPP compliant interfaces (see also Figure 6):

- Rx: connects the PCRF to external AF (application function such as IMS) which notifies the PCRF of some events (e.g. user making a VoLTE call);
- S1: Connects EPC to access nodes;
- S5/S8: connects S-GW and P-GW;
- S6a: connects MME and HSS for the authentication of user access and profiling;
- Gx: connects PCRF and P-GW and enables the PCRF to prioritize certain type of data;
- Rx: connects the PCRF to external AF (application function such as IMS);
- Gx: connects PCRF and P-GW and enables the PCRF to prioritize certain type of data traffic;
- Gy: for online charging;
- Bx: FTP(S) based interface which allows billing systems;
- Cx: Diameter interface;
- SGi: connects the P-GW to Intranet and Internet.

MME

The MME supports the following features:

- S1-MME: it is the interface to connect the MME to eNBs;
- S6a: Diameter interface for authorization of the users.

S-GW

The S-GW follows 3GPP specifications R12 and supports the following features:

- S1-U: GTPv1-U interface for connecting the S-GW to the eNBs;
- S5/S8: GTPv2 interface to connect S-GW and P-GW;
- X2 handover;
- S1 Release procedure.

P-GW

The P-GW follows 3GPP specifications R12 and supports the following features:

- SGi: connects the P-GW to Intranet and Internet;
- S5/S8: GTP2v interface to connect S-GW and P-GW;
- Gx: connects PCRF and P-GW and enables PCRF to prioritize traffic;
- VRF support.

PCRF

The PCRF also follows R12 and supports the features:

- Rx: to connect PCRF to external application function;
- Create/delete bearers;

- Subscription repository;
- Policy-based services.

HSS

The HSS follows also 3GPP R12 specifications and supports the following features:

- S6a: Diameter interface for transfer transcription;
- USIM credentials;
- EPC user profile management.

2.2.2.4 Northbound and Southbound interfaces

Ref#O6 refers to the connectivity of the OTE premises and platform to the outside world, through a local switch and then a router. Connectivity to the OTE testbed will be provided through a VPN concentrator for partners that need to access the network from the outside.

2.2.3 Technologies

Ref#E7 is the RAN SW to be available at **M9**. It builds on the Ericsson's 5G plug-ins. These are software-driven innovations that bring essential 5G technology concepts to today's 4G+ cellular networks enabling a flexible 5G evolution as well as improving operators' network mobile broadband performance allowing to introduce an array of new services and applications. The 5G plug-ins are built on 3GPP R13/15 specifications.

Ericsson's proposed 5G plug-in SW solution can deploy advanced network functionality which greatly improves network performance. One of the proposed mechanisms is the reduced latency functionality which builds on two steps developed in 3GPP R14 and 15 specifications. Specifically, the R14 concept of Instant Uplink Access (IUA) eliminates the need for explicit scheduling request and individual scheduling grants. Through pre-allocation of radio resources, IUA can reduce the average radio Round Trip Time (RTT) latency (i.e., UL and DL) to 9 ms, which is a significant improvement compared to traditional LTE R13 RTT latency of 16 ms. The second method, which is specified in 3GPP R15, enables shorter transmission durations. The concept is to compress the whole transmission chain of waiting for a transmit opportunity and transmitting the data. The associated control and feedback are performed faster. Both these SW plug-ins are described in more detail in D2.1 **Error! Reference source not found.**.

Ref#E8 available at **M17** is the introduction of 5G NR compatible to the 3GPP R15 release specifications. Ericsson's 4G/5G intelligent connectivity enables early and gradual deployment of 5G, by the introduction of a non-standalone NR solution (NSA) that plugs into the existing radio resource control (RRC) of LTE. Through the intelligent connectivity plug-in, 5G capable UEs can benefit from the high bitrates of NR, and the wide area coverage of LTE. This is achieved by a smooth transition of the user plane between LTE and 5G nodes as the UE moves in and out of 5G coverage. Meanwhile, the control plane is anchored in the LTE node to secure robustness. A 5G NR supporting AGV's connectivity to remote cloud application servers is planned for deployment during the end of 2019.

As it can be seen in Figure 11 concerning the EN-DC architecture, the master node (base station) is LTE based, which means that the initial RDS RAN deployment (4G+) will be fully reused to enable NR coverage deployment as a secondary node (gNB) in the 3rd year of the project timeline. Both nodes have a direct interface with the existing core network, Evolved Packet Core (EPC), in the user plane that carries the user data but only the master node has the direct interface towards the EPC in the control plane that carries the signaling traffic between the device (AGV) and the core network. Therefore, the LTE node is responsible for maintaining the connection state transitions handing the connection setup, release and initiating the first -time secondary node addition (gNB), that is the EN-DC setup.

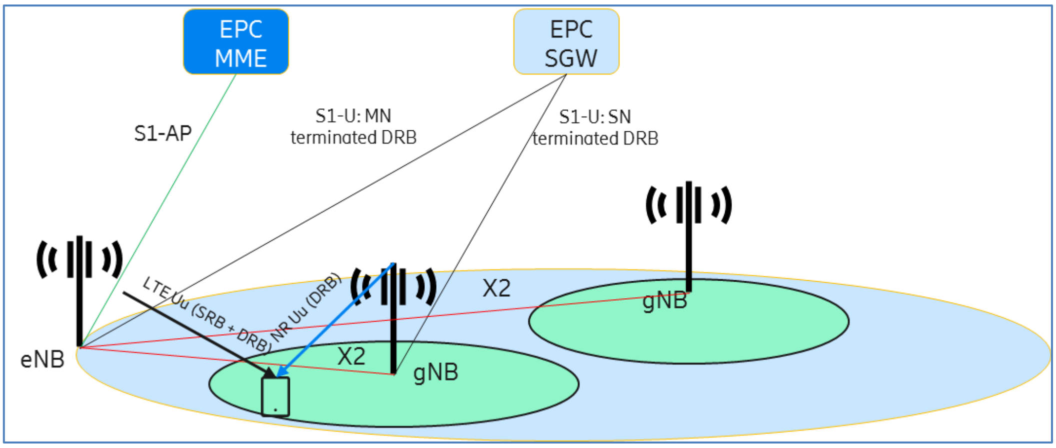


Figure 11: Evolved UTRA-NR Dual Connectivity (EN-DC) architecture

Ref#N12 which will be available at **M17** will be introducing 5G NR (option 3x), connecting to 3GPP R15 specification Core equipment.

- During **M17**, Nokia has the capability to deliver an end-to-end 5G portfolio comprising of several innovative components that will bring value to the Greek site facility. The finalized list will be determined at a later stage following an alignment with the rest of the partners and the operator. Such components include AirScale Radio Access with baseband upgrades for 5G.
- AirScale beamforming and massive MIMO Adaptive Antennas that can support up to 128 transmit and 128 receive streams for both 5G and 4.9G. The revolutionary ReefShark chipset dramatically reduces the size, cost, and power of massive MIMO antennas while increasing their intelligence and performance.
- **5G New Radio** meets the sub 6GHz mid-band needs of 5G applications that require mobility support, wide area coverage, multi-gigabit throughput speeds, and millisecond low latency. In addition, mmWave bands provide the added capacity needed for hotspot deployment and services.
- **5G ready microwave transport**, fiber for the 5G era and IP backhaul offer cost-effective backhauling and ultra-low latency end-to-end transport. Wavence UBT-single backhaul supports multi-frequency carrier aggregation for optimal use of existing spectrum. UBT-single is optimized for high capacity, low latency needs in dense urban areas in preparation for 5G and supports carrier SDN to implement network-node SON features based on the cognitive analysis.
- Cloud packet core with cloud-native architecture to support essential service capabilities such as network slicing and DevOps cloud systems. The core also provides the scalability needed for 5G, through "state-efficient" processing, software disaggregation and centralized and distributed deployment models.
- A subscriber data management function and an authentication management function that comply with the 5G 3GPP specification.

2.2.4 User Equipment

Ref#E12 will be available at **M10** and will be an LTE CAT4 capable dongle will provide the AGV connectivity to the radio network.

Ref#E13 will be available at **M18** when 5G access will be provided and new UEs compatible to 3GPP R15 will have to be provided to connect to both 5G NR and LTE network via dual connectivity (EN-DC).

Ref#N15 will be available at **M17** referring to devices measuring and transmitting patient's vital health data (e.g. blood pressure) to the network, which (data) will be subsequently conveyed to the IoT platform and finally the end user.

2.2.5 Deployment

Ref#E9 and **Ref#E10** refer to the two-phase deployment of Ericsson equipment/functionality at the Greek site facility at **M9** and **M17**.

- Phase 1: LTE connectivity based AGV use case oriented architecture.
- Phase 2: 5G/NR based AGV use case oriented architecture.

Ref#N6 and **Ref#N13** refer to the two-phase deployment of Nokia equipment/functionality at the Greek site facility at **M9** and **M17**.

- Phase 1: It will consist of R14 core and radio. The deployment of this phase is expected to last for one month and in **M10** it will be possible to demonstrate the use case through the transmission of vital sign data.
- Phase 2: Radio and core are planned to be upgraded with 5G functionality in **M17** and at that time **Ref#N13** will start. During this phase of the test bed, it should be possible to transmit data both from a static as well as the mobile environment (see Figure 12).

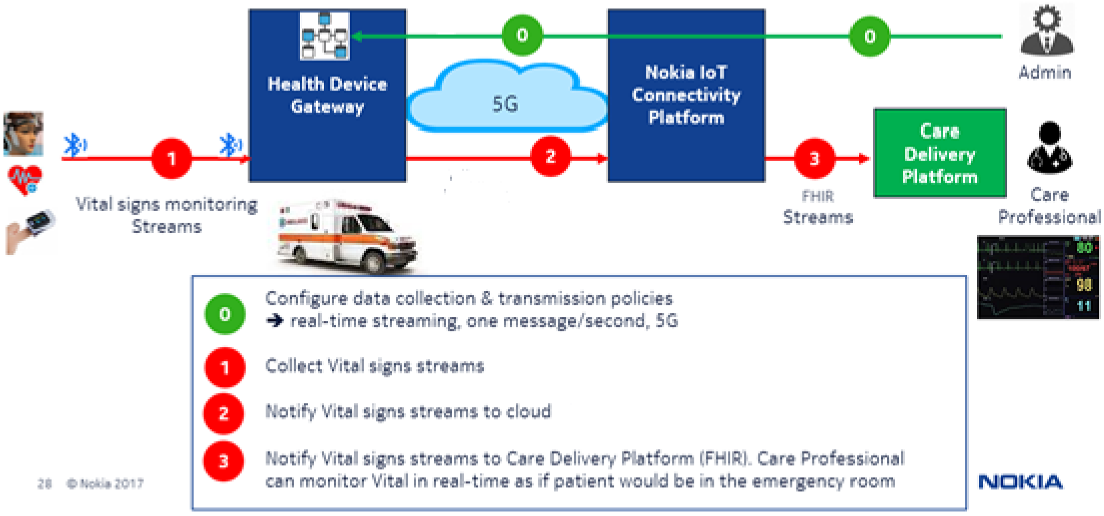


Figure 12: Envisioned deployment for the phase 2 deployment of the Connected ambulance use case

2.2.6 Platforms integration

2.2.6.1 OTE Athonet Platform

Ref#O4 is the **Wireless Technology platform** which consist of a flexible platform to enable an open 4G-5G ecosystem. The platform is an open-source software-based implementation is based on the 3GPP protocol stack for both E-UTRAN and EPC. It can be used to build and customize a base station (e.g. OAI eNB or gNB), a user equipment (OAI UE) and a core network (OAI EPC) in a PC. In addition, there is available a vEPC based on the Athonet technology [4].

OAI provides a rich development environment with a range of built-in tools such as highly realistic emulation modes, soft monitoring, and debugging tools, protocol analyser, performance profiler, and configurable logging system for all layers and channels. The hardware of the OAI is based on the Ettus USRP cards. Details regarding the core components of the platform and its management functionality are given in Sections 2.2.1.3 and 2.2.2.1 respectively while the physical topology and the logical architecture at OTE are shown in Figure 13 and Figure 14 respectively.

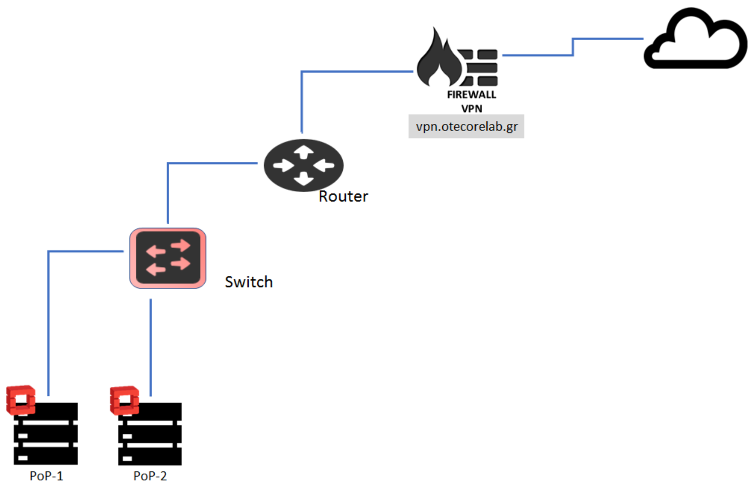


Figure 13: Physical core infrastructure at OTE premises

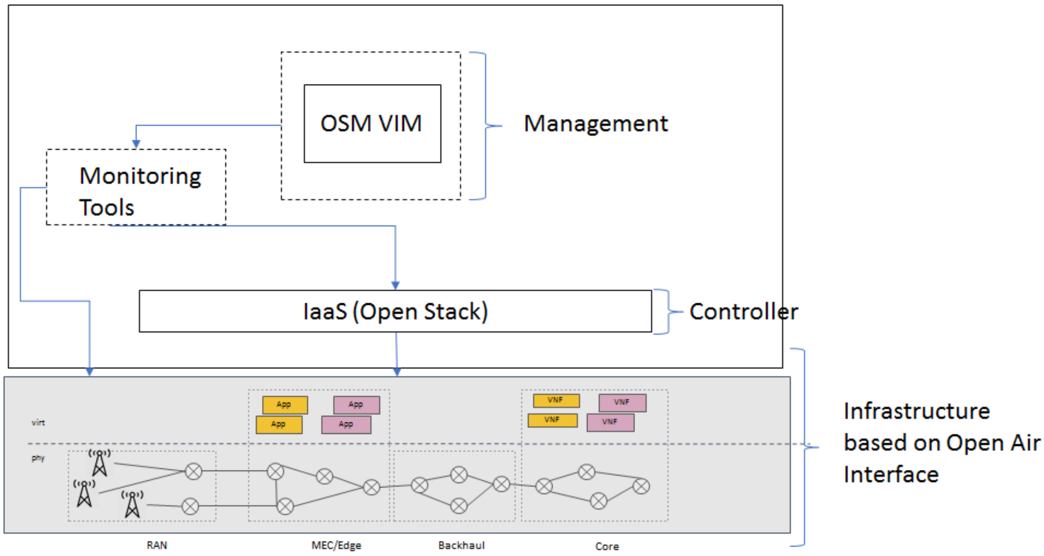


Figure 14: Logical architecture of the OTE testbed

2.2.6.2 Nokia IoT Platform

Ref#N8 will be available at **M10** for the Connected Ambulance use case. It will be Nokia IoT platform which will be interconnecting sensors and IoT devices to applications on end-user level. Data will be conveyed via the EPC radio interfaces to the IoT platform where it will be consumed accordingly (depending on protocols and interfaces used).

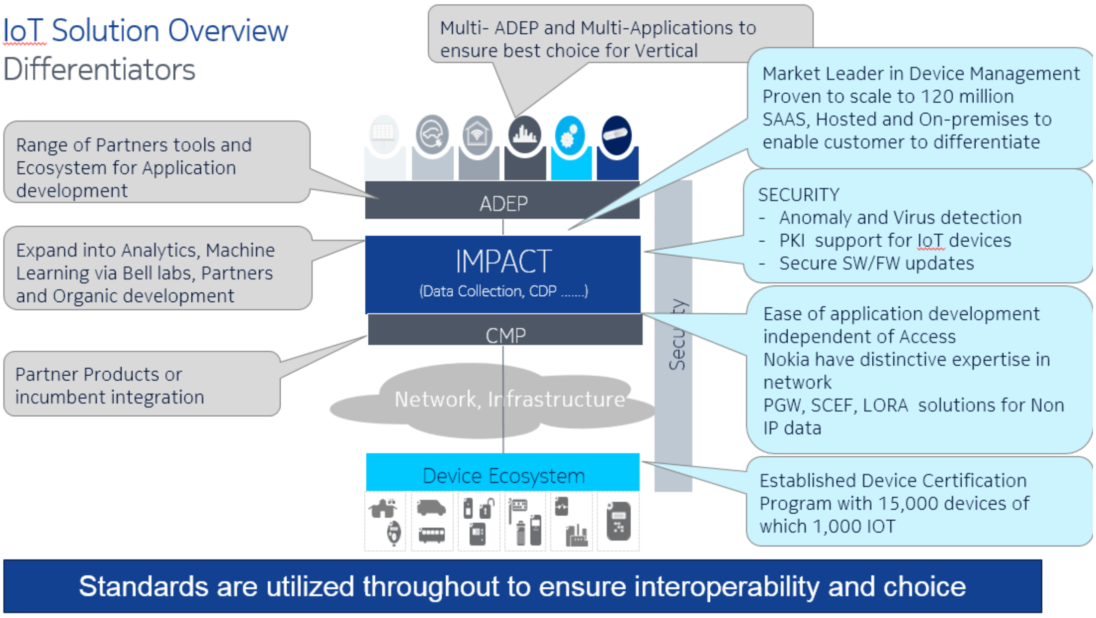


Figure 15: Nokia IoT platform high-level architecture

The Nokia IoT Platform, whose high-level architecture is depicted in Figure 15, will interoperate with network equipment from a variety of network vendors and is agnostic in terms of network connectivity, supporting a variety of technologies, including 3G, 4G/LTE, Wi-Fi. Several low-power wide area network (LPWAN) connectivity interfaces are also available, including NB-IoT (licensed) and LoRA (unlicensed).

Ref#N14 refers to the upgraded platform which will support traffic via a 5G network and will be available at **M18**.

2.2.6.3 WINGS STARLIT Platform

As mentioned in Section 2.1.2, the WINGS STARLIT platform will be used for at least parts of the smart city use cases to be piloted in the Greek site facility. STARLIT follows a REST-based microservices architectural paradigm. The core functionality of the platform (i.e., the backend) has been developed using the Java programming language. The assisted living mobile application and the web-based dashboards have been implemented using the Android Java API Framework and the AngularJS Framework, respectively. For the predictive analytics functionality, which is based on machine learning algorithms, the Python programming language and the Django Framework [6] have been leveraged.

Information in STARLIT is modeled by means of a target vocabulary realized as an OWL ontology. The data themselves are stored in RDF format in an RDF4J-based triple store. To query the triple store, the STARLIT services make use of a SPARQL endpoint. The corresponding data management and processing mechanisms are cloud-based, leveraging OpenStack and Docker on Kubernetes, for extensibility and scalability purposes among decentralized, distributed and independent cloud platforms and technologies. The deployment of the platform components as cloud components allows to control and manage the scalability of the platform in an easy and high-performing way.

Overall, STARLIT combines a plethora of information sources so as to offer advanced navigation services to citizens and local authorities leveraging various sensing devices and in-house developed ML-based algorithms. While a very large part of existing smart home and health products are tied to devices made available from specific vendors, STARLIT is independent of devices and technologies. Leveraging 5G, STARLIT's connectivity capabilities will be also enhanced, offering, at the same time, certain quality guarantees that are substantial when it comes to health and wellbeing setups. Figure 16 gives an overview of the system architecture and supported protocols and technologies of the STARLIT smart city platform.

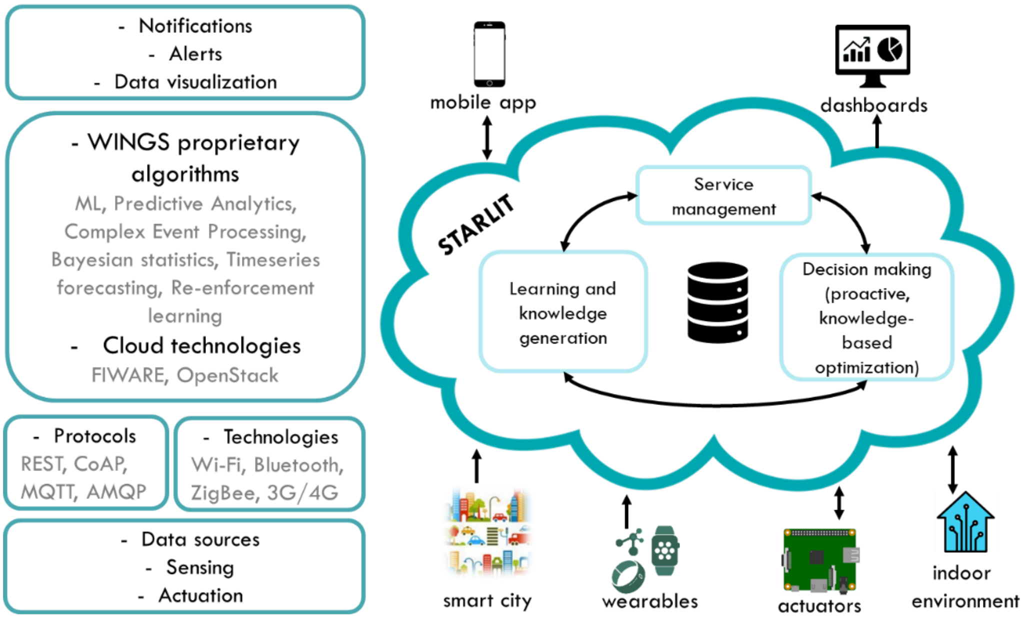


Figure 16: Overview of STARLIT

Ref#W1: On **M6**, the first version of STARLIT will be issued supporting the following functionalities.

Automated indoor environment adaptation

STARLIT offers functions for learning the preferences of the user with respect to their indoor environment (temperature, humidity, and luminosity, among others). In specific, STARLIT monitors (and learns from) the user's actions against several home devices installed within their home environment. For instance, actions relevant to adjusting the temperature (turning the heating/air-conditioning up/down), switching on/off or dimming the lights, etc. are recorded. Such records are accompanied by information relevant to the date, time and outdoors (weather) conditions. This way, STARLIT gradually derives knowledge on the preferences of the user and starts applying this knowledge by autonomously and proactively adjusting the user's devices and home appliances. To this end, several of sensors and actuators within the user's home environment, both COTS and ones developed by WINGS, are leveraged.

Remote health monitoring and forecasting

With respect to remote health monitoring, the aim of STARLIT is to acquire knowledge about the user's health status and, potentially, their behavior and identify possible irregularities that may call for medical treatment. Notifications/alarms are raised even in case something is not yet abnormal, but the recorded values show a trend towards a potentially problematic situation. For instance, increasing blood pressure, which has still not reached a certain threshold, may still be worrying and alarms or suggestions could be offered so as to avoid reaching the aforementioned threshold. The acquired knowledge may also be exploited for automated decision-making considering the user's health status. Advanced ML algorithms are exploited for the prediction of future vital signs, also considering other contextual factors, such as air quality. Notifications are issued to an application running on the user's smartphone, informing them about possible upcoming health situations.

Smart mobility: personalized navigation within the smart city

Finally, STARLIT provides personalized assistance to individuals indoors and outdoors by processing environmental data, such as pollen and pollution levels in the air, and combines them with traffic and additional weather data to provide a personalized navigation user experience within the city, e.g., avoiding routes with increased pollen count in case of allergies. STARLIT surpasses the competitive solutions, which do not usually have the user at the center of attention or do they offer health- or wellbeing-related added-value services. STARLIT also draws information on nearby Points of Interest (POIs) or on POIs within the user's route and provides the respective suggestions, as well as real-time notifications/alerts in case there is a relevant update (e.g., cancellation of a concert due to weather conditions). The mobile application offered to the user allows the completion of a thorough user profile, personal details, preferences, and limitations are completed therein in favor of personalized and targeted navigation and suggestions.

STARLIT sensors and data sources

In the context of STARLIT, WINGS has developed several Arduino boards that host sensors for measuring temperature, humidity, and luminosity, as well as light actuators. These devices are mainly leveraged in the automated home environment adaptation scenario. However, the temperature, humidity and luminosity sensors can also be deployed in exterior environments, e.g., within the city. Apart from the above, STARLIT interoperates seamlessly with COTS sensor-based devices and wearables. With respect to STARLIT's sensors and actuators, by **M6**, these will have been enhanced with WiFi modules leveraging also the WiFi capabilities of the Athens facility.

STARLIT also draws information (outdoors temperature, humidity, luminosity, air pollution, and pollen count) from weather APIs, such as DarkSky API [7], whereas the health-based navigation within the smart city has been implemented on top of the Google Maps Platform [8]. The same platform is used to visualize traffic in STARLIT's smart city dashboards. The external data sources integrated to STARLIT are gradually increased while new functionality is added to the platform.

STARLIT vertical KPIs

Besides the 5G KPIs that will be validated in the Greek pilot, as have been defined for the Smart city use case in D1.1 [3], WINGS will also define concrete vertical KPIs that will, later on, guide the testing and validation processes of the STARLIT platform in a 5G context. Indicative vertical KPIs that will be measured include (a) accuracy of notifications and alerts, (b) user satisfaction about suggested routes, (c) time required for STARLIT/STARLIT app adaptation to a home environment forecast, (d) average data retrieval (e.g., with regards to the number of data sources), while the first set of scenarios for testing can be found in D1.1 [3]. The methodology developed in the project's framework will be applied for the validation and benchmarking.

Ref#W2: On **M15**, the second version of STARLIT will be accompanied by enhancements made to the STARLIT sensors and actuators so as to support LTE / LTE+ connectivity and a direct connection to the Greek site facility's 4G+ network will be established. Further details will be given at later version of this document, as the development roadmap becomes more concrete.

2.2.6.4 WINGS Utilities platform

The main objective of the CATARACT platform is the exploitation of data that are produced by sensors and the derivation of knowledge that is useful for guaranteeing an efficient and seamless operation of smart energy grids. Therefore, its operation is based on gaining access to different sources of information. In this direction, CATARACT includes several mechanisms for data ingestion, i.e. for receiving data and storing them in databases. At this point, it is worth mentioning the existence of data management processes that are responsible for the storage of accurate and reliable data. In addition, several algorithms undertake the analysis of the data and the derivation of sophisticated information such as the prediction of measurements, event detections and remediation actions in case of abnormalities. All information is available to the interested parties through web interfaces. Security/privacy is assured through appropriate measures such as users' authentication and data encryption. CATARACT is based on diverse technologies, e.g. programming languages (C, Java, Python), Servers (nginx, uWSGI), Interfaces (REST-based), Backend (Django framework), databases (Postgres DBMS), Frontend (HTML5, CSS3, Ember, Bootstrap).

CATARACT's key functionalities will be delivered in 3 milestones, Ref#W3 (**M6**), Ref#W4 (**M12**) and Ref#W5 (**M18**) respectively. The complete solution that addresses fault management scenarios for distributed electricity generation in smart grids will be available by **M18**, in accordance with the project's "First release of the 5G end to end facility" that will be delivered at the same month, allowing the 5G end to end facility to be used by the vertical industries for initial experimentation.

Ref#W3: On **M6**, online monitoring of the consumed energy at desired granularity will be available. All measurements are retrieved in real-time and are presented through user-friendly customizable dashboards. Mechanisms for data ingestion and management are implemented.

Ref#W4: On **M12**, prediction of demand and supply-demand matching functionalities will be implemented. For this milestone, the focus is placed on the development of algorithms for predicting energy demands and for identifying optimal schemes for energy supply-demand matching.

Ref#W5: On **M18**, mechanisms for detection of abnormalities and corresponding remediation actions will be delivered. Advanced functionalities that aim at the identification of fault situations and the immediate power restoration are ready for experimentation.

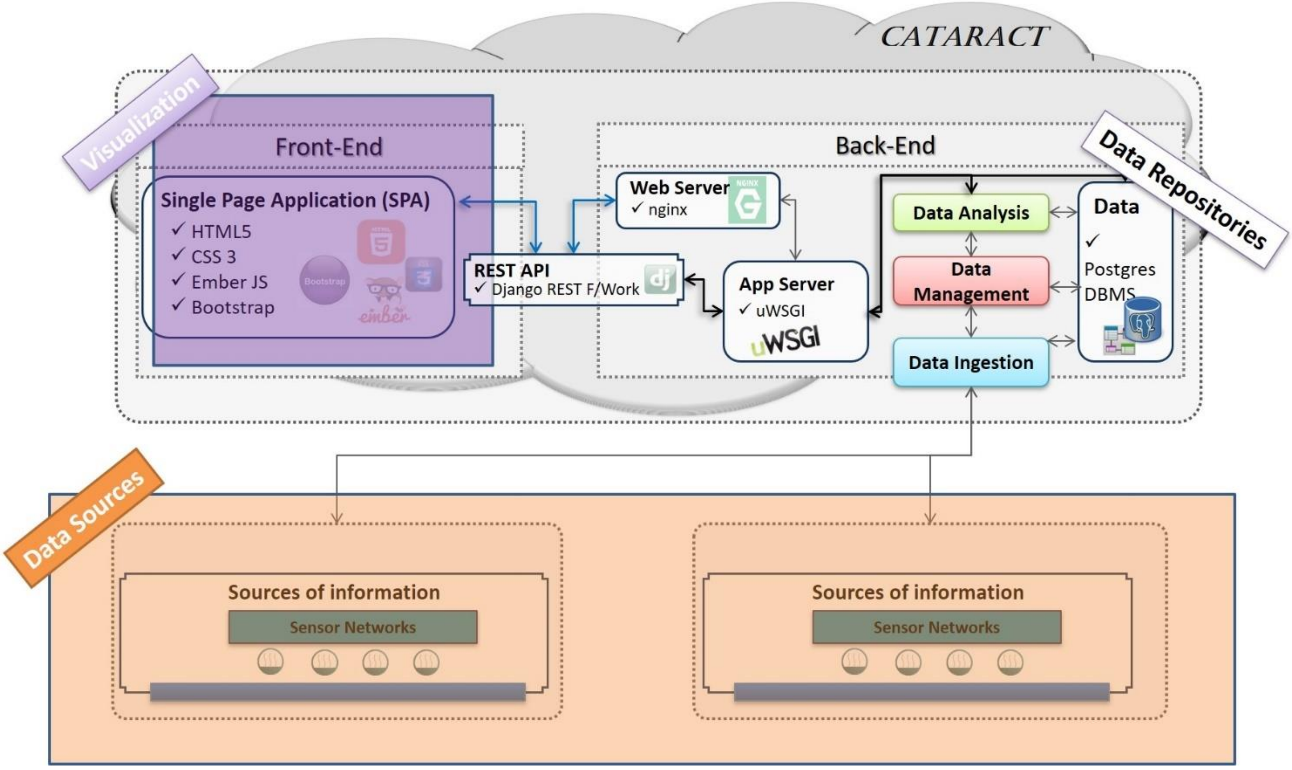


Figure 17: CATARACT high-level architecture and technologies

3 Italian site facility planning

3.1 Introduction

5G EVE site facility in Italy is deployed in the city of Turin, where an initiative to experimentally evaluate the 5G systems has been already started by some of the partners of the project, called “Torino 5G”.

The 5G EVE site facility in Turin will primarily serve to validate KPIs and 5G functionalities in two use cases under the definition in [1], and specifically:

- Smart Transport: Intelligent railway for smart mobility (use case 1)
- Smart cities: Safety and Environment - Smart Turin (use case 5)

5G technology will be provided by Ericsson as part of TIM mobile infrastructure based on the Torino 5G Initiative and integrated into the EVE Italian facility to support identified use cases.

As a first step, a test lab environment will be established in TIM headquarter in Torino. The test will focus on verifying components and functionalities of 5G NSA architecture. In a second stage, different sites in Torino will be established based on this new architecture and a part of this infrastructure will create the basis for 5G EVE’s development and use case deploying.

The “verticals” involved in the validation of the Italian site facility belong to three major categories:

- “Transport”, related to the testing activities of use case 1, having the leading actor in Trenitalia, the incumbent train's operator in Italy;

- "Smart city", related to the testing activities of use case 5, where the Municipality of Turin has a primary role in setting requirements and defining proper tests on the basis of the 5G-empowered services under consideration in the "Torino 5G" initiative;
- "Campus", related to both use cases 1 and 5, in which CNIT will drive specification, deploy and evaluation of 5G services within the area of the *Politecnico di Torino*.

The networks that will implement the mobile access in this site facility will be composite and will range from wireless networks based on 5G standards (3GPP R15_Option 3x, as initial deployment) down to 4G LTE for preliminary tests aiming at performance benchmarking, local WiFi networks and NB-IoT respectively for indoor environments and specific connectivity with IoT devices.

The infrastructures to be deployed in this site facility will include radio elements and PoPs with NFV infrastructure for computing, storage, and network, which will host the 5G network functions and the application layer service functions required by the use cases. TIM will provide its indoor testing facilities in their Labs in Turin, as well as the deployment of the live network in cooperation with Ericsson. CNIT will provide testing facilities (radio and PoP) in the area of *Politecnico di Torino.*

More details on the preliminary use case scenarios and infrastructure elements are provided in the following.

3.1.1 Smart Transport use case: architecture

The City of Turin represents the third largest node in the Italian railway network with two railway stations (Porta Nuova and Porta Susa) and main connection lines with major Italian cities nearby (Genoa and Milan) as well as with France, operated by public local transport and High-Speed Rail (HSR) trains segments. The main railway station (Porta Nuova) is the third in Italy for several passengers, while both stations are multimodal hubs connecting railway and local public transportation networks.

The Smart Transport use case presents two main scenarios of practical interest from the railway operator in 5G EVE:

1) ***5G On-Board Media content provisioning***

This scenario mainly covers new enhanced onboard train services for passengers, based on the improved connectivity and data mobility enabled by 5G. The new services planned by the train transport operators require Ultra Reliable and Low Latency Communications (URLCC) and enhanced Mobile Broad Band (Embb) connectivity performances offered by 5G Networks. The goal of Trenitalia is to deliver media contents considering the best level of image resolutions that are currently available in the market. In details, it will be considered as floor level a Full HD service (High Definition) and 4K resolutions as best service condition to be used as standard resolutions for Blue-Ray quality content streaming.

2) ***Urban Mobility 5G data flow analysis and monitoring***

This scenario is related to the integration of 5G data and mobility data from different transport operators to enhance multi-modally between railway network and other collective transportation services.

Automatic identification of passenger mobility patterns and related transport modalities is necessary for both descriptive and predictive purposes to realize informative systems and services meeting end user's requirements and expectations in terms of mobility efficiency. Mobility profiles play a fundamental role in identifying different transportation modality demands, in performing spatial planning [9], [10], [11], and in enabling efficient, context-aware and user-centric info-mobility services. Moreover, the vertical aims at preventing the situation of traffic peak by real-time automatic identification of critical mobility patterns and managing bottlenecks in public transport by realizing suitable info-mobility services for both citizen and passengers by the above-mentioned On-Board Media entertainment services.

3.1.2 Smart cities: Safety and Environment - Smart Turin

This use case will be facilitated by the collaboration between TIM and *Comune di Torino* for the 5G deployment in the city of Turin, managed under the "5G Memorandum of Understanding" signed on May

2017, and by the collaboration between TIM and *Politecnico di Torino* (partner of the CNIT consortium) managed under the "Campus 5G" framework.

One of the objectives of this use case is the management of large crowds, mainly students, in their daily commute between *Politecnico di Torino* and the Porta Susa railway station. The two sites are roughly 1 km apart, connected by a large avenue with many sidewalks and a bike path. It is estimated that around 20000 students daily attend *Politecnico di Torino* during regular class semesters. No figures are currently available to characterize the fraction of these students who move on the *Politecnico di Torino -Porta Susa* axis. Therefore, one of the first objectives of the use case would be to provide these figures, by monitoring the flow of students during different times of the day. We plan to achieve this goal by real-time readings from proximity sensors disseminated along the axis between the two sites, and on the sites as well. Additional information, specifically related to the movements of students on the *Politecnico* campus (classrooms/canteen/study rooms), can be provided through small-cell-based localization. It is to be remarked that a part of these students can be classified as "limited mobility" pedestrians when they carry around large suitcases on their way to/from the railway station.

3.2 Planning

The overall planning of the Italian site is reported in a specific sheet in the global Excel file [2]. Appendix B is reporting the Italian site facility roadmap implementation.

In the next sections, a more detailed explanation of the references used in the planning is given. The references are labeled as:

- "E" in case they are referred to Ericsson as the main owner of the related contribution;
- "T" in case of TIM;
- "P" in case of Politecnico di Torino on behalf of CNIT;
- "TR" in case of Trenitalia;
- Aggregation of mixed references ("E" + "T"+ …) is related to multiple owners.

3.2.1 Network infrastructure

3.2.1.1

Ref#P1+E1 on **M7**:

- A digital BaseBand Unit (BBU) will be deployed at *Politecnico di Torino*, co-located with the only currently existing macro site on campus, and CPRI interconnections will be established with small cells around the campus.
- At the same time, optical/Ethernet links will be provisioned to guarantee backhaul connectivity to the TIM customer network.
- 10 small cells in either fronthauling or backhauling will be deployed on *Politecnico di Torino* indoor and outdoor premises (mainly Graduation Hall, central courtyard, ICT department premises). The technological solutions will still be LTE-based at this point and they will feature Ericsson RDS (Radio DOT System) RD2242, composed of 20 dBm Radio Dot devices and IRUs (Indoor Radio Units).
- The deployment of 3 macrocells in outdoor locations on the *Politecnico campus* is expected to be completed. CPRI interconnections will be established with the BBU.

Ref#P2 on **M7**, a small number of NB-IoT sample sensor nodes will be deployed in *Politecnico di Torino* premises. This will allow the initial testing and calibration of the sensors in view of their onboarding on the OneM2M IoT platform.

Ref#E2 will be available at **M9**. It corresponds to the testing lab availability in TIM facilities in Turin. The infrastructure will be an early 5G complete network chain composed by 5G RAN architecture, 5G EPC enclosed in a flight rack system.

Ref#P3 on **M12**, full-scale deployment of NB-IoT sensor nodes on campus as well as in the vicinity, specifically on the axis joining *Politecnico di Torino* and the High-Speed Railway Station.

Ref#P4 on **M16**, the gradual phasing-in of 5G NR will allow replacing the legacy radio infrastructure on campus starting from the small cell installation.

Ref#E3 will be available at **M18**. It corresponds to the availability of a dedicated 5G mini network setup orientated to develop and test verticals' use cases. The infrastructure will be composed by 5G NR NSA in overlay with the commercial LTE network. The setup is in line with 3x option by 3GPPP on 5G networks as described deeply in D2.1 **Error! Reference source not found.**. The exact location for the purpose and the deployment of the specific use case will be detailed in a further phase (Figure 19)

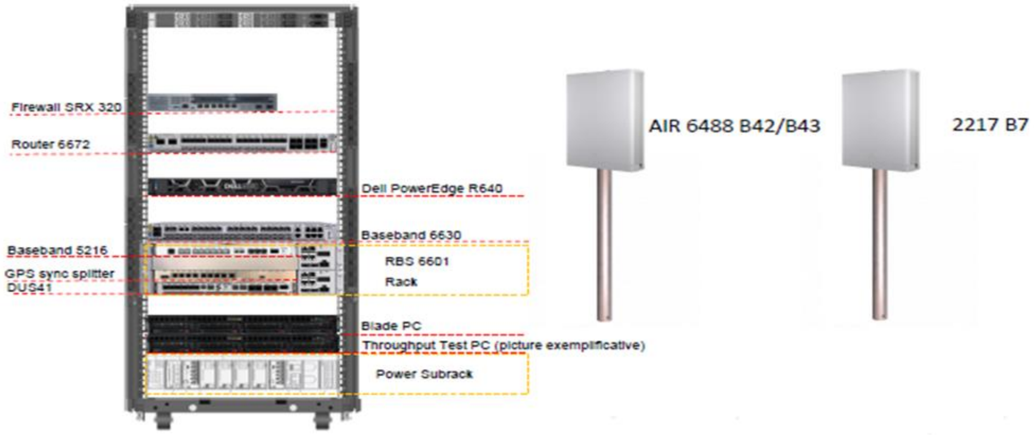


Figure 18: Flight rack system

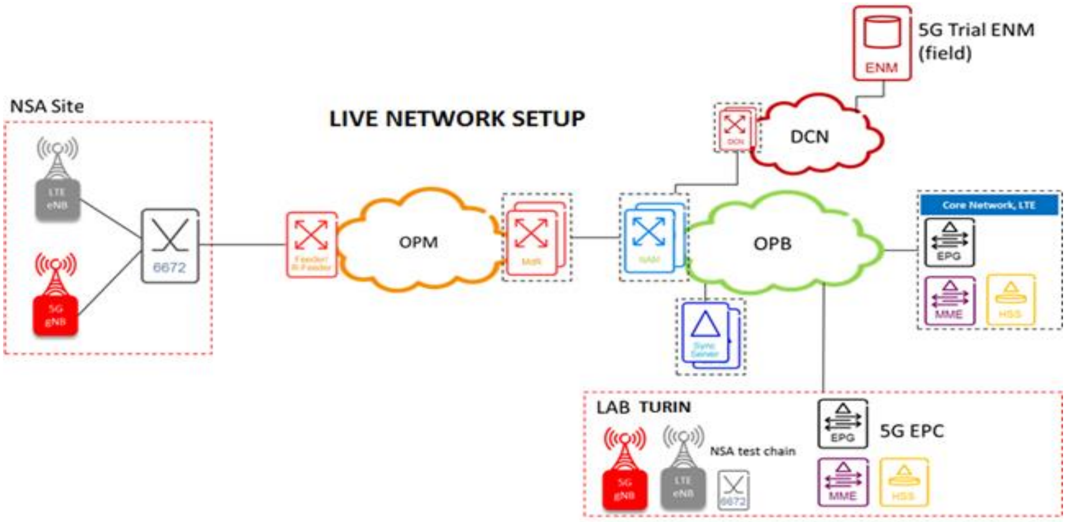
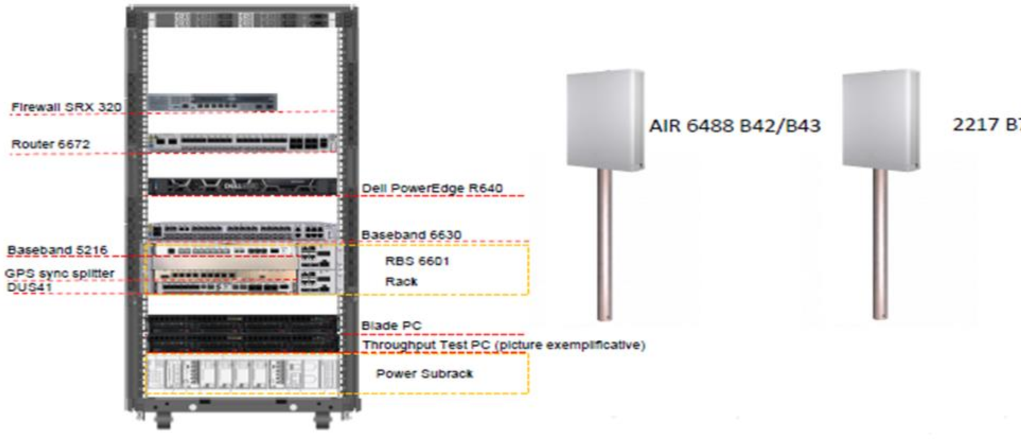


Figure 19 5G New Radio Non Stand Alone

3.2.1.2 RAN components

Ref#E4 on **M9**: A flight rack system will be available as reported in [2]



. Components of this compact system are:

- Firewall
- Router
- Terminal server
- 2 Basebands
- Fronthaul equipment (outdoor and indoor)
- GPS sync splitter
- DUS41
- RBS
- Power Sub-rack
- Air 6488
- RBS 2217 B7

Ref#E5 M17: 5G NR NSA system will include in addition to the components already available in the lab the following elements**:**

- Deployment of additional radio units with the following equipment:
    - Lab installation (B42/B43)
    - On field specific coverage with AIR6488 (B42/43) and baseband
    - gNodeb co-located with LTE eNodeb equipped with a baseband
    - Switch for the interworking between basebands

The setup of the infrastructure is reported in Figure 19.

3.2.1.3 CORE components

Ref#E6 on **M9**: A flight rack system will be available as reported in Figure 19. Components of this compact system are:

- Blade PC
- EPC-box: Data center for core network

3.2.1.4 Frequency bands

Initially, in *the Politecnico di Torino* campus, the frequencies will be the same legacy frequency currently in operation on the TIM commercial network. Therefore, 1800 MHz and 2600 MHz frequency bands will be maintained, with the possible introduction of 1500 MHz for the macro sites on campus at **Ref#P6** and consequent tuning of the campus small cells at **Ref#P5** upon 1800 MHz and 2600 MHz frequency bands.

The frequency band for initial deployment of 5G NR NSA foreseen in **M10** will be on band B42 and B43. The availability of these frequencies is planned to be official by January 2019 **Ref#T1**. As for the solution 5G NSA, the LTE will be used as an overlay frequency with one of the following layers: 800 MHz (B20), 1800 MHz (B3), 2600 MHz (B7)

The utilization and availability of any applicable band are in function of the results of the frequency auction for 5G under finalization by the Ministry of Development, Italy.

3.2.2 Network management

3.2.2.1 Resources management

Ref#E7 Element manager called Ericsson Network Manager will be available at **M9**.

3.2.2.2 Orchestration

Ref#E8 Type of orchestrator and orchestration model will be available at **M9**. It is still under evaluation if Ericsson Orchestrator (by Ericsson) or MANO orchestrator (by Nextworks) will be deployed.

3.2.3 Technologies

Ref#T2 at **M7** the LTE based TIM network will be available in the area of the selected experimental validation of the Italian testbed.

Ref#E9 at **M10** Ericsson will enable network functionalities and capabilities based on 5G NSA infrastructure NR compatible with the 3GPP R15 release specifications.

Ericsson's 4G/5G enables an early and gradual deployment of 5G, by the introduction of a non-standalone NR solution (NSA) that plugs into the existing radio resource control (RRC) of LTE.

Through the intelligent connectivity plug-in, 5G capable UEs can benefit from the high bitrates of NR, and the wide area coverage of LTE. This is achieved by a smooth transition of the user plane between LTE and 5G nodes as the UE moves in and out of 5G coverage. Meanwhile, the control plane is anchored in the LTE node to secure robustness.

Data-throughput improvement and reduced latency offered by 5G NSA network will enable a good cohesion with verticals expectation on application development.

Ref#TR1 at **M10** the LAN based Trenitalia On Board Wi Fi embedded in one train of the High speed segment (FRECCIAROSSA-FRECCIARGENTO) and enabled by Telecom Italia network, will be considered for the PoC validation of the Italian testbed

3.2.4 User Equipment

Ref#E10 will be available at **M10** when 5G access will be provided and new UEs compatible to 3GPP R15 will have to be provided to connect to both 5G NR and LTE network via dual connectivity.

3.2.5 Deployment

According to the expected timescale of the project, the Italian testbed will have two phases until Month 18 when a specific roadmap for verticals' inclusion will be elaborated.

Ref#E11+T3 First phase: Laboratory environment setup for whole chain testing (**M10**) in view of the inclusion of the verticals in 5G EVE project

Ref#E12+T4 Second phase: the realization of a mini 5G NSA network for internal and external verticals' use case integration and testing (**M18**), in view of the deployment foreseen from M18 onwards

3.2.6 Platform Integration

Platform #1 **oneM2M**

Ref# T5 OneM2M Platform for 5G EVE test bed will be released **M10** in Laboratory Environment for whole chain testing.

Ref# T6 Second phase: OneM2M Platform will be released integrated with the mini 5G NSA network for verticals' use case integration and testing (**M18**).

4 Spanish site facility planning

4.1 Introduction

As it was indicated in D2.1, the 5TONIC laboratory has already an end-to-end mobile network infrastructure to support trials for different use cases with several verticals. This infrastructure comprises network elements and network functions provided by both 5G EVE project members and other companies that do not participate in the project (e.g., CommScope, Intel, Red Hat, Altran). Hitherto, beyond the basic common facilities like communications and power, the deployment of new infrastructure has been associated with the specific needs of the use case that were being tested. These use cases always involve 5TONIC members and potentially also 5TONIC collaborators. With the participation in the 5G EVE project, a milestone-based planning of the network evolution has been adopted, in order to support the use of the site to third parties not members of 5TONIC.

The general scheme of the 5TONIC Spanish site for the 5G EVE projectis represented in the following Figure 20:

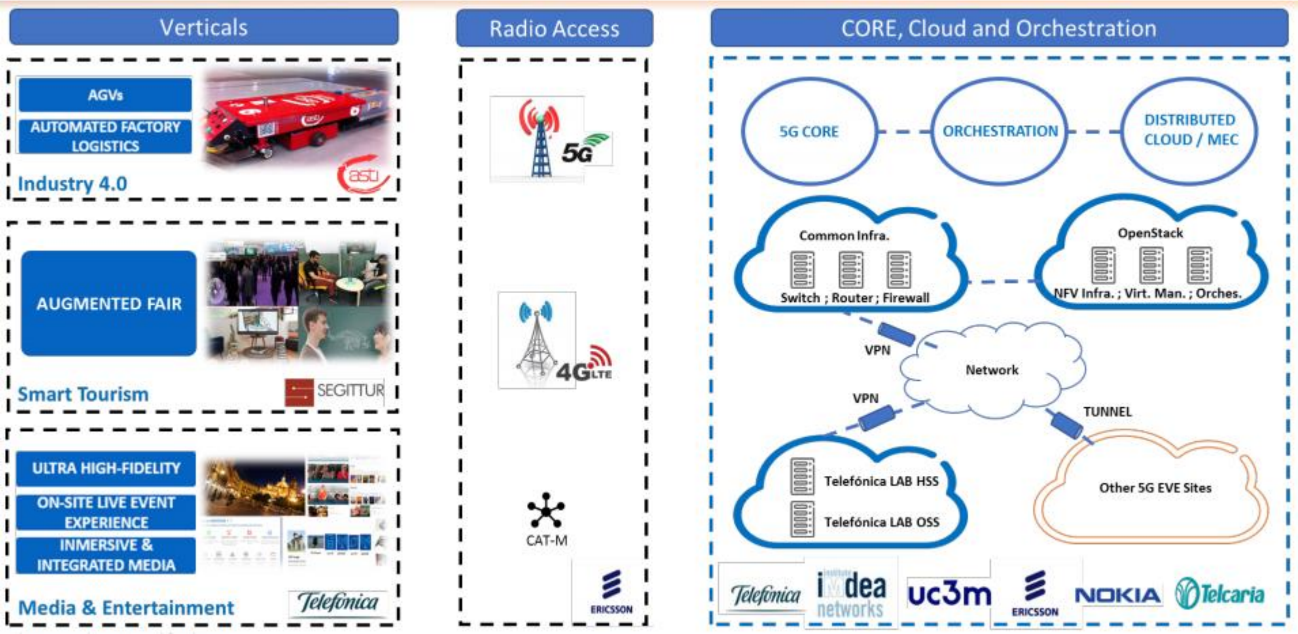


Figure 20: Generic scheme of the 5G EVE Spanish site facility

4.2 Planning

As pointed out in the Excel file [2] and also in APPENDIX C, the main development/deployment components are specified. More details are given in the following subsections.

4.2.1 Network infrastructure

4.2.1.1 Equipment

Ref#14 includes the basic equipment required for the operation of the 5TONIC site, including racks, power, ventilation, etc. In its current status, the 5TONIC data center has twelve racks, each one assigned to a 5TONIC member, plus 2 for supporting communications. Figure 21 to 25 show the main elements of the 5TONIC infrastructure.

Figure 21: 5TONIC data center

It also has both indoor and outdoor areas where experiments can be carried out.

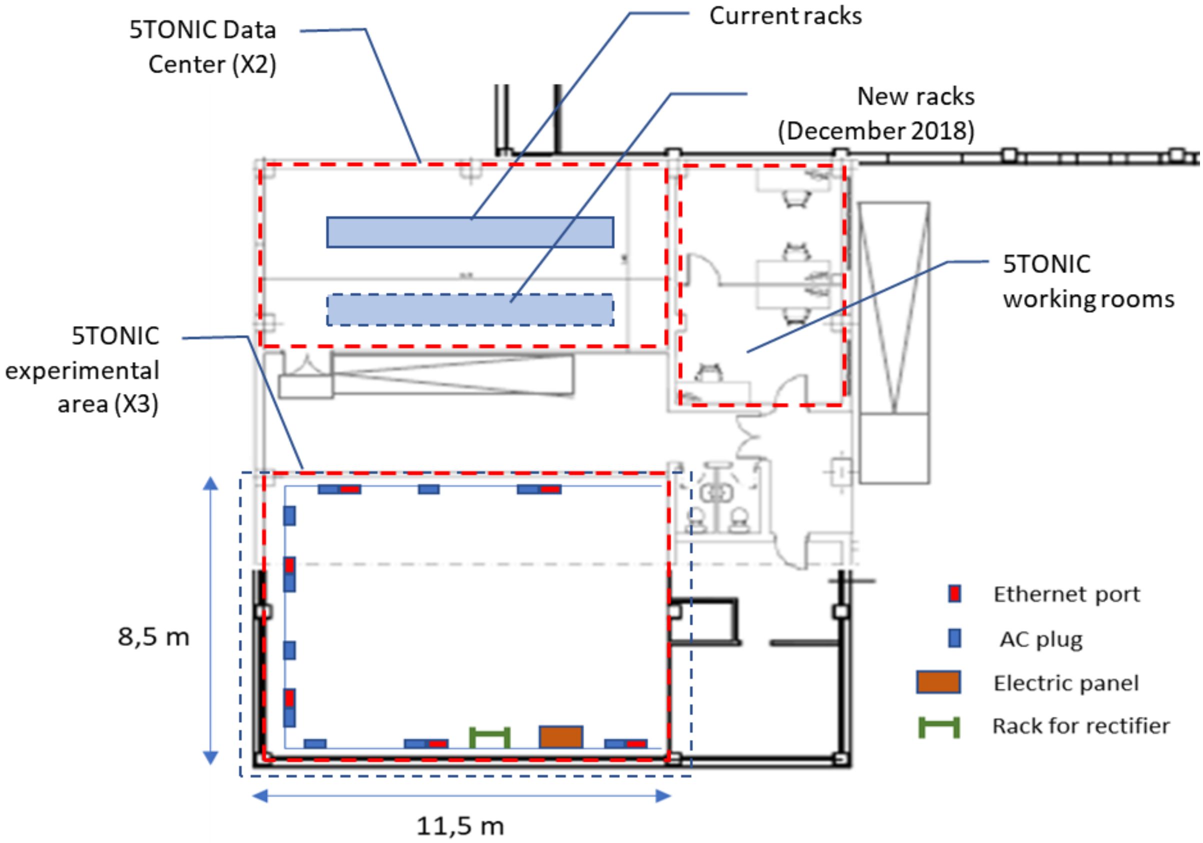


Figure 22: 5TONIC laboratory facilities

Figure 23: 5TONIC indoor experimental area

Figure 24: 5TONIC outdoor experimental area

Additionally, 5TONIC has its own showroom where demos can be presented, located at IMDEA Network premises. This showroom has been used in the review of several European projects.

Figure 25: 5TONIC showroom

Ref#15 identifies the milestone associated with the expansion of facilities due to the increase in laboratory activity. A new row of 12 racks will be installed, and the corresponding expansion of the ventilation capacity and power supply (the latter already completed) will be carried out. Enhanced electrical protection to guarantee uninterrupted operation is also in the roadmap and expected to be completed by the beginning of 2019.

The 5TONIC laboratory is also protected with different security measures, including fingerprint-based controlled access to the facilities, perimeter intruder detection, video cameras, etc.

4.2.1.2 RAN components

Ref#1 includes the Ericsson radio access network equipment that is already available in **M1**. The hardware comprises the baseband node, Baseband 5216, and one radio unit 2203 B7. The initial software has support to operate the 3GPP wireless system including LTE and IoT. It also supports advanced features like higher order modulation (256QAM downlink, 64QAM uplink), uplink prescheduling for latency reduction and lean carrier operation for interference reduction.

Ref#2 includes the Radio access network equipment that will be available at **M7**. The new HW includes a new baseband node, Baseband 6630, and new radio unit AIR 6468 B42. The HW is 5G NR ready, fully compliant to 3GPP R15 and later. 5G Plug-in Massive MIMO over LTE TDD will be available at **M7**.

More detailed description of the RAN components can be found in D2.1 **Error! Reference source not found.**.

With respect to the Nokia based RAN, the objective is to have it deployed and operating by April 2019, although the detailed planning is not yet fixed, due to uncertainty in the procurement of some of the equipment.

By April 2019, 5TONIC is expected to be able to support outdoor deployments at both Leganes and Distrito Telefónica. Physical infrastructure for the latter is already available, with two masts deployed at the roof of one of the buildings and connection with Telefónica Spain labs at Alcobendas by means of a dedicated fibre.

Figure 26: 5TONIC masts at Distrito Telefónica

4.2.1.3 CORE components

Ref#3 includes the core network equipment already available at **M1**. This is a vEPC-in-a-box that fulfils the vEPG, vSGSN-MME, and vPCRF functions.

More detailed description of the CORE components can be found in the D2.1. For the implementation of the vEPG, control and user plane separation will be provided, in order to support local breakout, as represented in the following figure:

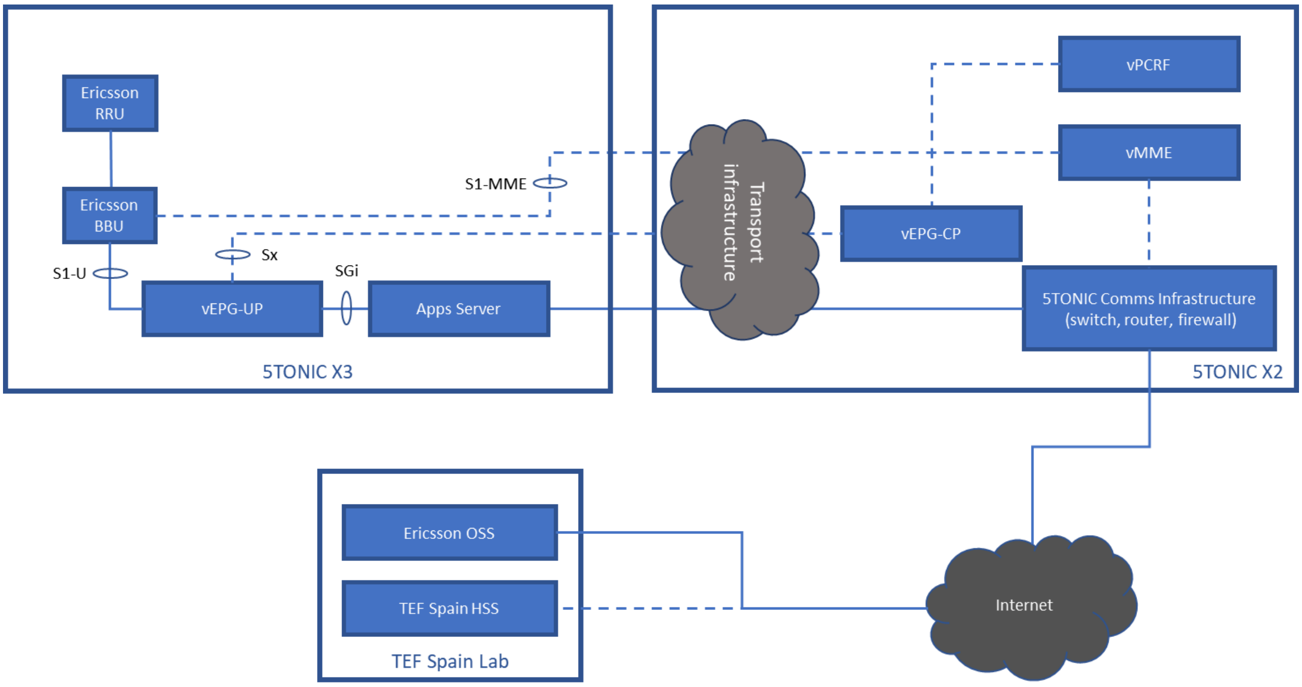


Figure 27: vEPC configuration in 5TONIC site

Ref#4 includes the core network equipment that will be available at **M13**. This is a new EPC compact HT with more VNFs flexibility.

Both types of CORE HW have the processing capability to support 5G Non-Stand Alone 3GPP architecture, and the second one could support Stand Alone architecture with a SW upgrade in the next phases.

4.2.1.4 Frequency bands

Ref#5 is the frequency band already available at **M1**. The frequency band is B7, 2600 MHz FDD and it is used for LTE with higher order modulations. No interferences are expected in this band since Telefónica has not commercial B7 coverage around the 5TONIC Site.

Ref#6 is the new frequency band, B42 3500 MHz TDD, available at **M8**. The spectrum has been recently acquired by Telefónica.

Frequency band B20 800 MHz is still under discussion for supporting NB IoT and Carrier Aggregation.

4.2.2 Network management

4.2.2.1 Controller

5TONIC is planning to deploy an SDN controller for the transport layer, specifically, for the interconnections between 5G site facilities, including 5G EVE sites, in order to provide them with very high performance, resiliency, and scalability. The deployment is identified as **Ref#16** in the site planning, corresponding to **M6**.

The current thinking regarding this issue is based on the deployment of a cluster of ONOS SDN controllers jointly with some SDN capable hardware switches in order to enhance the interconnection between 5G end to end facilities. It should be noticed that in 5TONIC there are already available some SDN hardware switches (edge-core AS4610-30T and Pica8 P-3297) with PicOS license installed, which are suitable for slicing configuration and for programming the data plane. However, it is not discarded that additional hardware will be acquired for these purposes.

4.2.2.2 Resources management

5TONIC has dedicated personnel for the management of the facilities that oversee the coordination between the different projects that use the laboratory. A booking procedure has been established and potential conflicts are solved under the guidance of 5TONIC Steering Board.

4.2.2.3 Orchestration

As has been described in greater details in [1], 5TONIC has from the beginning of the project an orchestration infrastructure that is being used by other European projects, like 5GinFIRE [12] or 5G TRANSFORMER [13], identified as **Ref#11** in **M1**. 5TONIC has decided to have a production solution, based on OSM Release TWO, and a testing solution, which is based on OSM Release FOUR. The OSM manages a local NFVI composed by three high-profile servers, which are controlled by an OCATA OpenStack acting as the VIM.

Moving Release FOUR into production is expected to happen in **M6**, as identified in **Ref#17**. Further updates will depend on the future OSM Releases, and wheter they atre stable enough for being incorporated into production by 5TONIC.

4.2.2.4 Interco

The current interconnection facilities in 5TONIC, identified as **Ref#12**, is being used for the management of the internal communications in 5TONIC premises, the secure connectivity with the Internet and other sites. The security infrastructure deployed allows for the implementation of VPNs with IPSec.

This infrastructure will be enhanced by **M6**, as identified in **Ref#13**, with the deployment of a firewall FortiGate 501E that provides:

- Firewall performance for IPv4/IPv6, SCTP and multicast traffic with ultra-low latency down to 2 microseconds;
- VPN, CAPWAP and IP tunnel acceleration;
- Anomaly-based intrusion prevention, checksum offload, and packet defragmentation;
- Traffic shaping and priority queuing.

On top of this, in **December 2018**, 5TONIC will also enhance the capacity and reliability of its connection to RedIRIS, the academic and research network in Spain, which is also part of GÉANT. The capacity will increase to 10 Gbit/s and reliability will be enhanced by means of a double fibre ring that will connect to UC3M and University Rey Juan Carlos nodes of RedIRIS.

5TONIC is also working on a solution to deploy a high capacity and reliability connection with Telefónica I+D laboratories in Almagro Central Office.

4.2.2.5 Northbound and Southbound interfaces

Through a VPN connection, an authorized client may have access to different services provided by the 5TONIC administrator. One of the most important services is the possibility to access the OSM orchestrator. Since release THREE, OSM includes a role-based access control module to configure permissions to users to selected projects previously defined by the system administrator. This module allows users to have different roles in different projects, so they could perform different operations.

Since release FOUR, OSM provides a new northbound interface aligned with ETSI NFV specification SOL005 [14]. This API allows client to manage the lifecycle of Virtual Network Functions and Network Services: creation, uploading, update, and deletion.

4.2.2.6 Supervision

Supervision of Ericsson RAN, and EPC is carried out by the OSS system deployed at Telefónica Spain labs in Alcobendas, through a secure connection established with 5TONIC premises at Leganés. The same approach is expected to be adopted for the Nokia based infrastructure. This is identified as **Ref#18** in **M1**. The upgrade of the OSS depends on Telefónica Spain, which has indicated that a continuous upgrade approach is being taken (and not one based on milestones). However, it is expected that in **M8** the OSS will support 5G NSA deployments. This is identified as **Ref#19**.

Regarding the orchestration platform, in release FOUR, OSM has included a Monitoring module, which is mainly an interface between the clients and the underlying VIMs. In this OSM version, the monitoring module includes plugins to connect to OpenStack Aodh and OpenStack Gnocchi.

4.2.3 Technologies

Ref#7 is the technology already available at **M1**:

- LTE with higher order modulations.

Ref#8 is the new technologies that will be supported at **M7**:

- LTE-M.
- NB IoT still under consideration.
- Software upgrade of the vEPC

Ref#9 is the new technology that will be supported at **M8**:

- 5G Plug-in: Massive MIMO. Built on 3GPP R13/15 specifications.

Ref#10 is the new technology that will be supported at **M16**:

- 5G NR Non-Stand-Alone mode.

4.2.4 User Equipment

Because of the use cases that are being supported by, the 5TONIC UEs are data devices, i.e., LTE routers and MiFi devices. Several of them support high modulation levels, 256QAM downlink and 64QAM uplink.

Regarding 5G UEs, their availability is linked to potential agreements with third parties not directly involved in the project, Intel being the most likely one.

4.2.5 Deployment

In terms of deployment, three phases have been identified. A phase corresponds to the availability of network elements that allow for the support of use cases’ implementations that are not feasible in earlier phases.

The first phase: It corresponds to the infrastructure that was already available at the project kick-off, in **M1**. This infrastructure allows for the support of early versions of some of the use cases that will be later refined and expanded, like the centralized control of AGVs implemented as a MEC application.

Figure 28: Phase 1 implementation of AGV centralized control

The second phase: It will be completed in **M8**, when a new set of network elements will be deployed at 5TONIC. The idea behind completing this phase in the proposed date is to have a couple of months for working in the integration of the 5G EVE use cases. The main new network elements expected to be available on that date include:

- Incorporation of new RAN network elements that either support 5G NR radio interface or can be software upgraded to support it.
- New LTE Core Network platform, supporting NSA 5G as well as mMTC services.
- Evolved NFV infrastructure, with OSM Release FOUR orchestrator.
- SDN controller for enhanced transport flexibility.

Third phase: This phase is foreseen by **M16** and will allow the support of an Stand Alone (SA) 5G deployment, with the upgrade of the RAN to 5G NR and the EPC to 5G NGC (the effective support of this architecture will depend on the availability of devices and other aspects).

4.3 Risks

Two main risks have been identified at this stage affecting the planning proposed:

- 5G NR NSA UE availability for Band 42 during 2019.
- In the 3,4-3,8 GHz frequency band, Telefónica Spain has acquired a license divided into slots, where part of the spectrum is in Band 42 and part in Band 43. There is the risk that in order to consolidate the frequency assets of different operators in contiguous blocks, all the spectrum assigned to Telefónica Spain is consolidated in Band 43. This would require changing the RRU hardware deployed in 5TONIC. The outcome of this process will depend on the negotiations between Telefónica and the other Spanish 5G operators.

5 French site facility planning

5.1 Introduction

The French site facility is highly detailed in **Error! Reference source not found.**. It is composed of a cluster of 4 nodes located in different cities. Its main feature is that it rests on two main pillars. The first pillar comprises pre-commercial Nokia 4G/5G E2E network facility composed of the pre-commercial 5G platform based on open-source and inner-source products developed by Nokia Mobile Networks Business Unit (so-called “NOKIA pre-commercial platform” or IFUN that stands for “Internal Friendly User Network”) that is located in Paris-Saclay.

The second pillar is mainly based on Open Source building blocks and distributed on several facilities interconnected by VPN, namely:

- Orange Plug’in platform located in Châtillon-Paris (operated by Orange France). This innovative 5G platform proposes a whole framework for developing 5G components;
- *Flexible Netlab* platform located in Rennes (operated by b<>com). It is a multi-tenancy dedicated environment, taking benefit from some key corporate resources as a private cloud infrastructure
- Open5Glab playground located in Sophia Antipolis (operated by Eurecom);
- “Nokia research platform” that is a research platform based on open-source and inner-source developed in Nokia Bell Labs that relies, in terms of hardware, on specific and local resources (Edge and Central). In terms of software, it relies on NGPaaS technology [15] based on cloud-native and micro-services. RAN and CORE are deployed on different platforms operated by an end-to-end service orchestration.

The 4 sites provide their own HW/W resources, as explained in the following sections. They are viewed as cloud edge node being able to host the first two 5G EVE use cases defined below. The 4 sites will be at M10 interconnected via L2/L3 VPN tunnels IPsec and managed via an ONAP based orchestrator [16]. This orchestrator will be, via its Northbound interface, connected to the project portal where the different verticals will register to use case deployment request. Orange will oversee the orchestrator providing as well as the network infrastructure. The interworking with the others European site facilities will be carried out at the point of entry of the Orange infrastructure that could serve any French sites. Figure 29 depicts the global architecture overview of the French site facility.

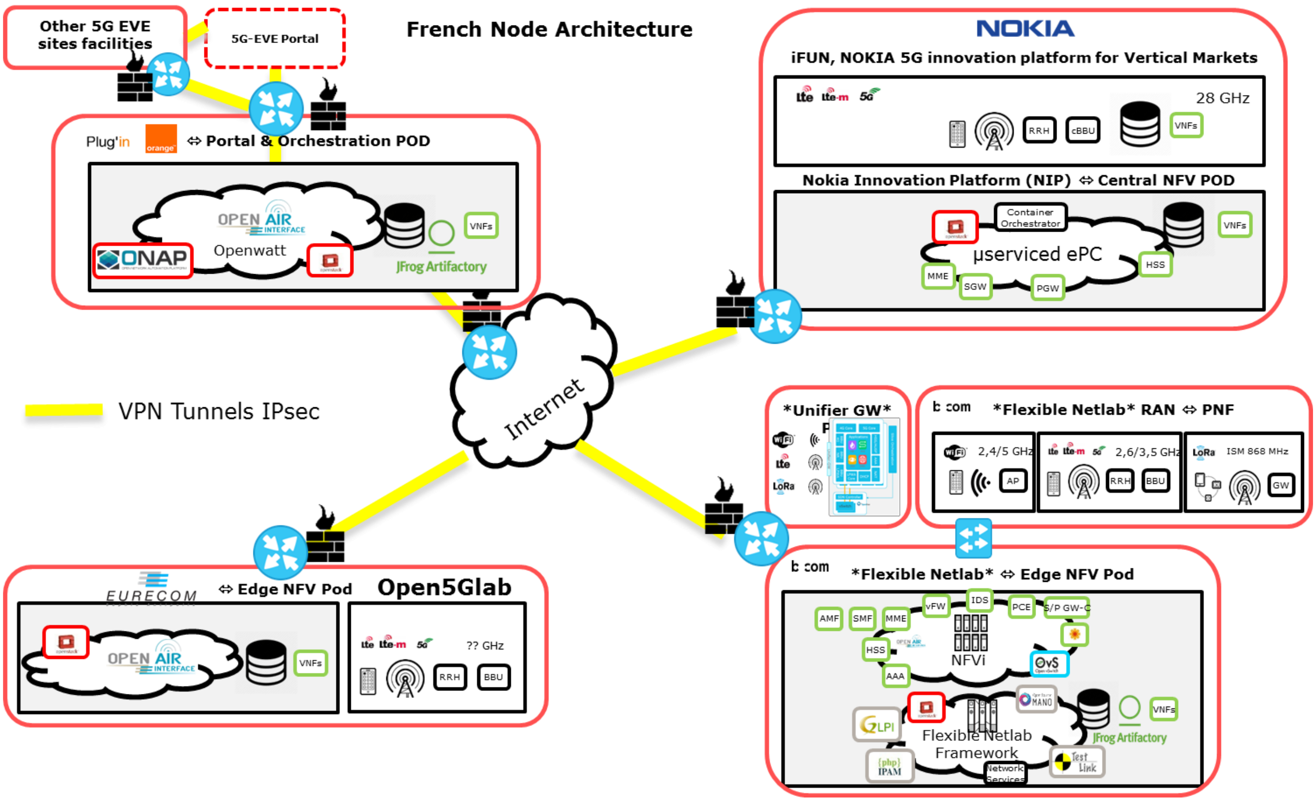


Figure 29: French site facility architecture

The 2 first 5G EVE use cases hosted by the French sites are [1]:

1) Critical utilities (Smart Energy), proposed by EDF deal about and focuses on fault management for distributed electricity generation in smart grids. The main issue addresses Ultra-Reliable Low-Latency Communications URLLC and critical massive Machine Type Communications (mMTC) scenario. Currently, fault detection and management in energy grids take place through fiber connectivity among the centralized electricity generation points (e.g. power plants). The move towards Distributed Generators (DG) offers great potential but also makes a fiber-communication monitoring solution prohibitive due to its deployment cost. 5G technologies can enable ultra-fast and ultra-reliable fault detection and management among an extensive number of DGs, with decreased CAPEX and OPEX. Such a fault management system is essential for modern smart grids, enabling the immediate reaction to change in the network thus avoiding unwanted islanding, providing dynamic stability and protection to the network and eventually allowing for the integration of an even greater number of DGs. The use of smart metering and fault detection mechanisms in combination with Mobile Edge Computing (MEC) functionality for ultra-fast processing could even lead towards a centralized grid protection system, elevating the level of control over the energy grid. The use of 5G New Radio (NR) may control the system and only disconnects the equipment in alarm. EDF will provide a platform emulating the system that will be linked to 5G NR transmission.

2) The second use case that is proposed by Orange France is related to video 360° transmission. This use case promotes enhanced Mobile BroadBand (eMBB) and URLLC scenario with high data rates and

low latency requirements. The main objective is to contribute on the identification of application-layer performance metrics relevant to a 360° video streaming service as well as on the identification of 5G performance metrics that are expected to be the key drivers for the performances of a 360° video streaming service. Orange will integrate a 360° video streaming platform including contents, streaming servers, and head-mounted-displays to 5G EVE's site facility. On this basis, the tools necessary for collecting the application-layer performance metrics will be developed and integrated with the testing frameworks developed in the project in order to feed a cross-layer dataset that would then be leveraged by Orange to provide an analysis of the correlation 5G network performances and 360° video streaming performances (KPI requirements).

5.2 Planning

As pointed out in [2], the main development/deployment components are specified. More details are given in the following where:

- "EU" refers to Eurécom;
- "N" refers to Nokia;
- "O" refers to Orange;
- "B" refers to b<>com;
- "ED" refers to EDF;
- Aggregation of mixed references ("E" + "N"+ …) is related to multiple owners.

In addition, the planning for the French site facility is given in APPENDIX D.

5.2.1 Network infrastructure

5.2.1.1 Equipment

As already explained, each French node provides its own resources in terms of HW and SW. The list of equipment is described below:

REF#O1 corresponds to the video 360° set-up that includes the video platform, the head mountain display, and the video content. This component will be available at **M9**.

REF#ED1 corresponds to the critical utility (smart energy) system emulator. This equipment is emulated energy traffic with alarms due to default management. This equipment will be available at **M16**.

REF#O2 corresponds to the Orange infrastructure deployment with the implementation of High-density switches and routers, with VPNs management for French sites interconnection. This feature will be available at **M9**.

REF#O3 corresponds to the SW infrastructure of the Orange Plug'in platform for components developments, test, and storage. It includes the servers used for ONAP implementation. The list of equipment is given in Table 1:

Table 1: Orange Plug'in HW/SW resources

<table>
<tr><th>Host</th><th>Characteristics</th><th>Hosted tools</th></tr>
<tr><td>VM1</td><td rowspan="3">2 vCPU, 4GB RAM, 40GB Storage</td><td>AtomStore</td></tr>
<tr><td>VM2</td><td>AtomDocs, Formulas, Toolbox</td></tr>
<tr><td>VM3</td><td>Wall</td></tr>
<tr><td>VM4</td><td>4 vCPU, 16GB RAM, 40GB Storage</td><td>1st instance of PlayGround</td></tr>
<tr><td>BM1</td><td rowspan="2">12 CPU, 128 GB RAM, 2TB Storage</td><td>2nd instance of PlayGround</td></tr>
<tr><td>BM2</td><td>AtomInsight</td></tr>
</table>

The provisioning of the servers is done using Ansible playbooks and docker-compose files. Currently, Vagrant combined with Ansible is considered and can is able to create a PlayGround of Virtual Machines and Bare-Metal resources.

In addition, 4 Dell servers R640 OpenStack cluster is used to host ONAP platform (Release 3 “Casablanca”). On top of the VIM, a Kubernetes cluster is set up which is later used to create ONAP instance. The same OpenStack and its compute resources are used for deployment of VNF orchestrated by ONAP.

Servers have the following specifications

- 256 GB RAM
- 2xCPU – every 14 cores (2,6 GHz)
- 4.8 TB HDD each in RAID 10 configuration

For the NR 5G gNodeB/CN and UE based on OAI framework development, 2 servers Dell PowerEdge R640 servers (Xeon Gold 6154) will be integrated on the Orange Plug’in compute farm.

This infrastructure will be available at **M6**.

REF#B1 is Dell PowerEdge R640 computer servers_and will be available at **M3**. These servers are the core NFVi of *__Flexible Netlab__*. They will be used as computing and infrastructure nodes inside OpenStack.

The following equipment will be implemented inside the **Open5Glab** Eurécom platform:

REF#EU1 corresponds to 3 Dell PowerEdge R640 servers (Xeon E5-v4) available **at M3** for 4G RAN/CN functions;

REF#EU2 corresponds to 4 Dell PowerEdge R640 servers (Xeon Gold 6154) available at **M6** for 5G RAN/CN functions;

REF#N1 and REF#N2 correspond to France Nokia Paris Saclay Architecture for the pre-commercial Network

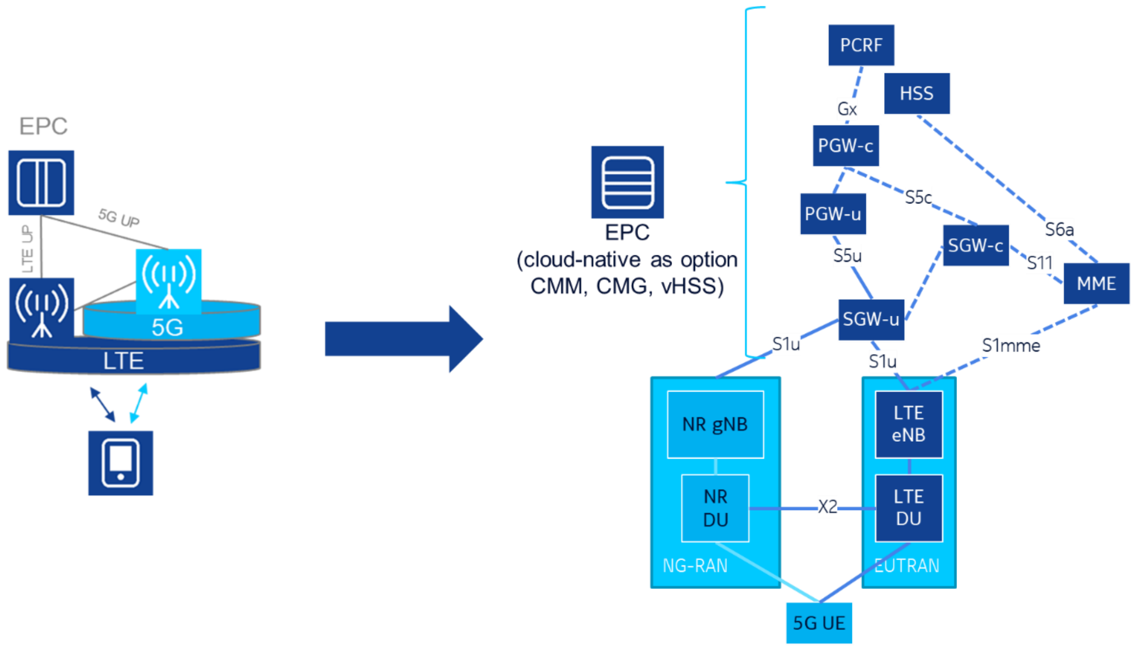


Figure 30: iFUN equipment

REF#N3, REF#N4 and **REF#N5** correspond to “Nokia research platform”. Contrarily to classical functional approaches, they correspond to cloud types where various functions can be deployed, depending on cases. Front-end cloud is a pico-datacenter connected via the front-haul network to the antenna site. Front-end cloud is connected via a mid-haul network to the edge-cloud with good processing capabilities, acceleration, and large memory capacity. Edge-cloud may be connected to a central data center called the central cloud, a typical IT datacenter, having much more memory storage capacity and very poor antenna connectivity. For simplification purpose, REF#3 and REF#N4 will be described in the RAN section whereas REF#N5 will be described in the CORE section.

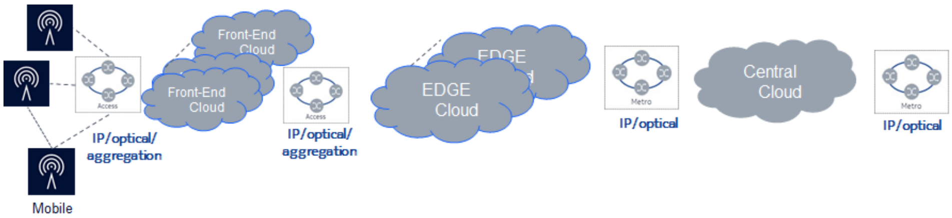


Figure 31: Nokia research platform equipment

5.2.1.2 RAN components

REF#B2: it corresponds to the 2.6 GHz LTE eNodeB RAN composed of the USRP X310, all the radio equipment (antennas, power amplifiers, filtering …) and BBU processing performed via OAI software. This component is available at **M3.** The main specifications are:

- 3GPP release: Will follow Open Air Interface roadmap.
- Location: Rennes, outdoor sub-urban
- Cell radius: 1,5 Km
- Frequency: 2,6 GHz TDD
- Base station number: 1

REF#B3: Similar as REF#B2, excepted that the radio will work at 3.5GHz. This 3.5 GHz LTE eNodeB will be available at **M8.** The main specifications are:

- 3GPP release: Will follow Open Air Interface roadmap
- Location: Rennes, outdoor sub-urban
- Cell radius: 1,5 Km
- Frequency: 3,5 GHz TDD
- Base station number: 1

REF#B4: Upgrade of the functionalities of REF#B2 by integrated the NB-IoT to the LTE eNodeB. This will be available at **M12.** The main specifications are:

- 3GPP release : R15
- Location: Rennes/Lannion, outdoor sub-urban
- Cell radius: 1,5 Km
- Frequency: 2,6 GHz TDD
- Base station number: 1

REF#EU3 corresponds to twelves 4G Indoor RRUs and six 4G Outdoor RRUs (Band 38 2580 MHz, TDD). This component will be available at **M6**. The main specifications are:

- 3GPP release 15.2: Will follow Open Air Interface roadmap
- Location: Sophia Antipolis (BIOT), indoor/outdoor small-cell
- Cell radius: 500 m around campus
- Frequency: 2,6 GHz TDD (Band 38)
- Radio Units: 12 indoor RRUs, 6 outdoor RRUs, cloud-native eNodeB functions.

REF#EU4 corresponds to one 8-Antenna Outdoor RRUs (NR-Band 78 3600 MHz) available at **M6**; In complement to this RRU, the set-up will integrate one Base station **REF#EU5** that follows the following specific requirements:

- 3GPP release 15.2
- Location: Sophia Antipolis, outdoor sub-urban campus environment
- Cell radius: 500m
- Frequency: 3600-3680 MHz TDD (NR Band 78)

REF#EU6 corresponds to one Outdoor RRU (LTE Band 14) LTE-M / LTE-Sidelink available at **M9**;

REF#EU7 corresponds to one Outdoor RRU (LTE Band 68) NB-IoT/LTE-M available at **M9**.

REF#EU6 and REF#EU7 will be combined to provide **REF#EU8** available at **M12** that has the following requirements:

- 3GPP release: 15.2
- Location: Sophia Antipolis, outdoor sub-urban
- Cell radius: 10 Km
- Frequencies: 698 – 703/753 – 758 MHz FDD (LTE band 68),733 – 736/788 – 791 MHz FDD (LTE band 14)
- Base station number: 1

REF#O4 corresponds to one outdoor RRH implementing 5G NR 3GPP R15 main functionalities in Band 78 available at **M8**. This component is like this proposed by **REF#EU4**. It will be based on Paris-Châtillon site. The coverage will be adopted regarding the French “Autorité de régulation des communications électroniques et des postes” (ARCEP) authority regulation and the authorizations are given.

REF#N1 corresponds to NR Access Point made of:

- LTE eNB: Baseband + Radio Unit (3 sectors)
- NR gNB: Cloud Unit + Digital Unit + Radio Unit (3 sectors)

REF#N3 corresponds to front-end cloud, a pico-datacenter connected via the front-haul network to the antenna site. Such Front-End cloud canis able to execute the low RAN layers (L1, L2). It is composed of capabilities of SDR capabilities, acceleration (FPGA, DSP), I/O like CPRI or 10-25 Gbits Ethernet with some specialized embedded equipment.

The radio used in this setup is implemented using two Software-Defined Radio (SDR) USRP B210 Cards by Ettus Research, one on the UE side and the other for the eNodeB. As the USRP B210 features two antenna ports (one RX and one TX), we cross-connected them using two SMA to SMA cables, adding a 30-dB attenuator loop to each of the cables. Figure 32 represents the connected radio setup.

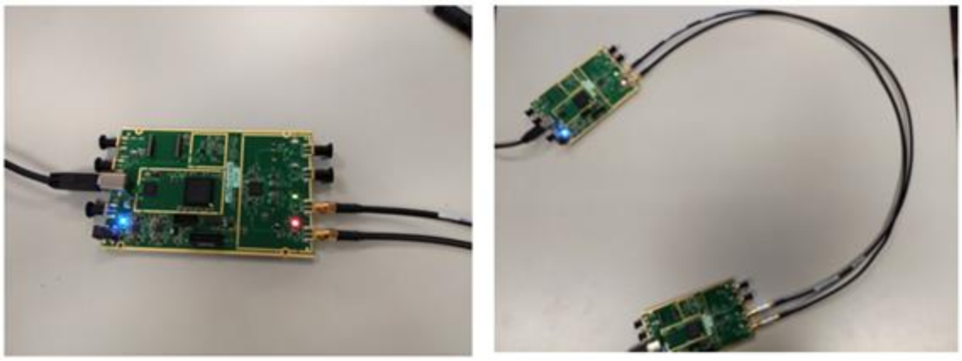


Figure 32: Front-end SDR

REF#N4 corresponds to edge cloud, a Telco Cloud with a powerful processor (ARM, x86), having capabilities of acceleration (FPGA, SoC), a large memory capacity, etc. The EDGE Cloud will host many workloads type like Cloud RAN, Mobile EDGE Computing, analytics, etc. It also could host the CORE network.

5.2.1.3 CORE components

The 3 sites (Eurécom, b<>com and Orange) use for 3GPP EPC implementation the OpenSource OAI framework (OpenCN [17]). The Core functions like HSS, MME, S-GW and P-GW (S-GW and P-GW are actually bundled together), will be updated to follow the 5G NR evolution. **REF#O5** and **REF#EU9** will integrate at **M4** this OAI core network architecture as a virtual function.

Figure 33 shows the architectural software implementation of the EPC in 3 virtual machines in the OAI framework. The main interfaces are also described.

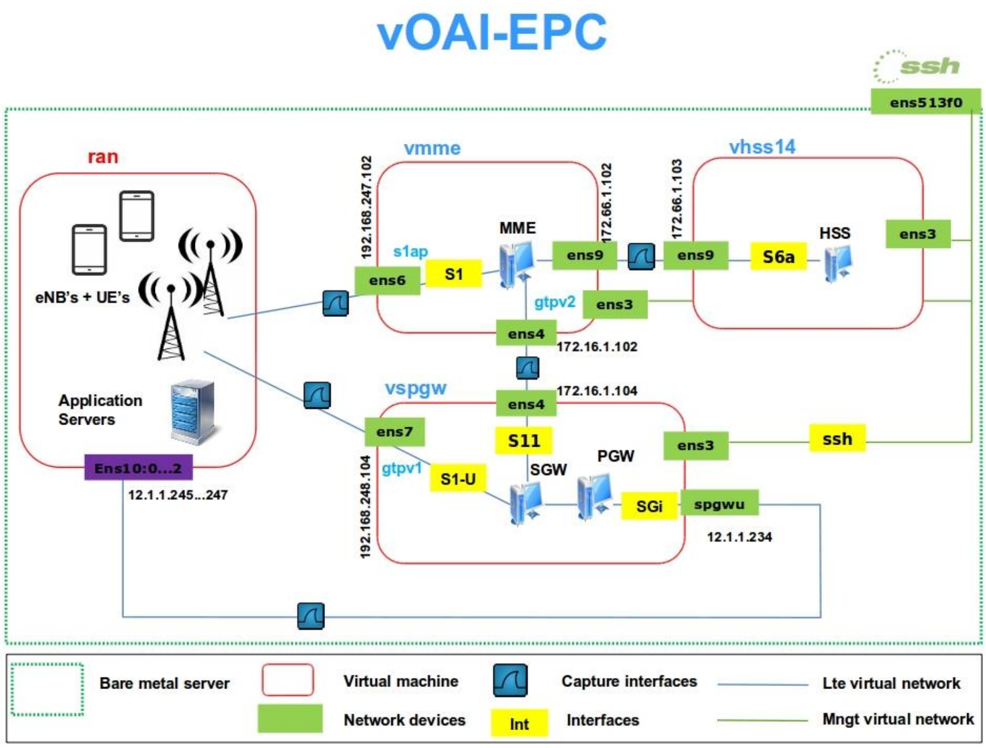


Figure 33: openairCN elements shown as three virtual machines

B<>com via the platform Flexible Netlab, depicts in Figure 34, proposes a Core network **REF#B5**, called **Wireless Edge Factory [18]** that (will) propose(s) the following features:

- 3GPP release: Follows OAI roadmap for 3GPP related features.

Interfaces:

- Wifi avalable **M3**,
- 4G LTE avalable **M3**,
- NB-IoT avalable **M12**,
- 5G NR non-standalone **M18**, based on Open Air Interface roadmap

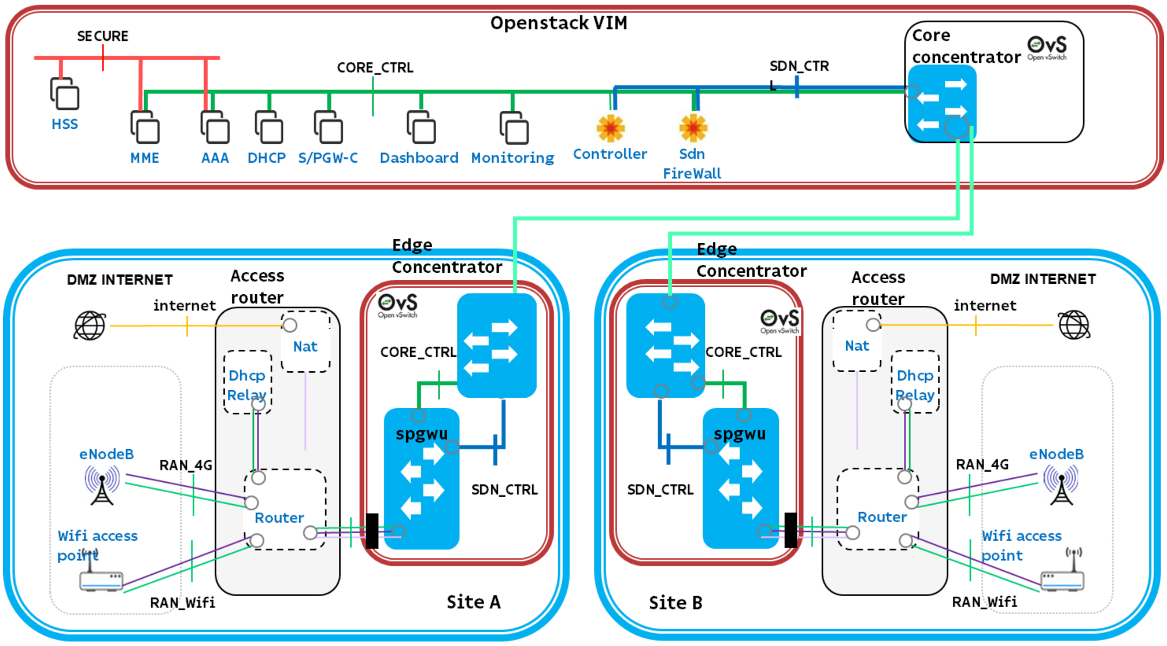


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Figure 34: *Wireless Edge Factory* architecture

REF#N2 corresponds to ePC made of:

- Full cloud-native ePC
- MME
- S/P GW
- PCRF
- SDL/HSS

REF#N5 corresponds to the central cloud with dedicated resources (compute, storage, etc.). Central cloud is not "telco-grade/carrier-grade" and not specifically geared towards hosting telco-type workloads with associated performance demands and SLAs/SLGs. In the context of 5G EVE project, Nokia Innovation Platform will play role of central cloud solution. NIP is a live development and trial environment for start-ups, industries, and other partners to accelerate innovation of IoT solutions through an open, collaborative model. NIP provides a wide range of services such as Openshift, Node-RED, GPU computing, World-Wide Streams, ENGIDI New Generation Device, Mobagel Decanter™ AI, Craft AI, Apizee, OpenDataSoft Smart Cities Solution and Cloud Compute. In this service, NIP will provide VMs which can be specified and accessed by partners using VPN. The resource in NIP is as following:

- CPU quota: 60 cores
- Memory quota: 488GB
- Instance quota: 25 instances max.

5.2.1.4 Frequency bands

Table 2 gives the frequency bands that are currently available in the French site's facilities for 5G experimentation. As mentioned, these frequencies must be renewed bi-annually. At the time being this is the current status. It must be noticed that several sites are using the same frequency bands. This could be used to perform E2E transmission between 2 sites integrating the same vertical.

Table 2: French site facility frequency bands that are available for on-air transmission

Site	Band (Frequencies)	EIRP (dBm)	Antenna Height (m)	Duplex	Status
REF#EU10 EURECOM – Sophia Antipolis	LTE band 38, 2580-2610 MHz	unspecified	unspecified	TDD	Granted, to be renewed bi-annually
REF#EU11 EURECOM – Sophia Antipolis	NR band 78, 3600-3680 MHz	61 dBm	3m	TDD	Granted, to be renewed bi-annually
REF#EU12 EURECOM – Sophia Antipolis	LTE band 68, 698 – 703/753 – 758 MHz)	pending	pending	FDD	Application filed
REF#EU13 EURECOM – Sophia Antipolis	LTE Band 14 (733 – 736/788 – 791 MHz)	pending	pending	FDD	Application filed
REF#N1 Nokia - **Paris**-Saclay	NR band 78, 3700-3800 MHz	pending	pending	TDD	
REF#N1 Nokia - Paris-Saclay	NR band 28, (708-718/ 763-773 MHz)	pending	pending	FDD	
REF#B6 b<>com – Rennes & Lannion	LTE band 38, 2580-2610 MHz	10dBm	70m	TDD	Granted, to be renewed bi-annually

REF#B7 b<>com – Rennes & Lannion	NR 5G band, band n°42, 3500 – 3520 MHz	10dBm	70m	TDD	Granted, to be renewed bi-annually
REF#B8 b<>com – Rennes & Lannion	Unlicensed bands, 868 MHz, WiFi 2.4/5 GHz	Regulated	N/A	FDD	Applicable
REF#O6 Orange – Châtillon/Paris	NR band 78, 3700-3800 MHz	unspecified	unspecified	TDD	Granted, to be renewed bi-annually

5.2.2 Network management

5.2.2.1 Controller

The *Wireless Edge Factory* ePC (**REF#B9**) has its Data Plan orchestrated by an OpenDayLight controller. This controller is decoupled from the underlying infrastructure. This feature is currently available **M3**.

The Open5GLab RAN/core network (**REF#EU14**) and edge compute resource is orchestrated by Mosaic5G/FlexRAN controllers. These controllers are decoupled from the underlying infrastructure and adhere to the Mosaic5G API. This feature will be available at **M6**.

It has to be noticed that Orange will provide the orchestration part via ONAP implementation (§5.2.2.3). ONAP is using OpenDayLight as a controller.

REFN#3,4,5 will be orchestrated using NGPaaS framework. This orchestration will be available at **M7** for Nokia Research platform, **M8** for iFUN and Nokia Research Platform, **M10** for rest of French cluster.

5.2.2.2 Resources management

As explained in the D2.1 (see clause §5.7.2), *Flexible Netlab* has a multi-tenancy approach providing Testbed-as-a-Service (TaaS). However, the some resources could be required to be assigned to a given project at a given time. While it is expected to have a centralized booking tool for the E2E site facility, for **M10**, resource booking and node support will be managed by a mailing list.

Open5GLab will provide testing services to the community using on-site reservations for physical visitors of the lab. Remote experimentation will be provided upon request via the OAI mailing list. Both the infrastructure components and terminals will be accessible for measurements. An OAI sandbox will be made available to the community for developing basic RAN/CN VNF features.

The resources management topic in the different sites will be managed by the orchestrator. Interfaces between the different French platforms will be defined to integrate resource management on the top of the French cluster. All French partners will provide resources management of their own sites (REF#O+EU+N+B).

REFN#3,4,5 will be orchestrated using NGPaaS framework. This orchestration will be available at **M7** for Nokia Research platform, **M8** for iFUN and Nokia Research Platform, **M10** for rest of French cluster.

5.2.2.3 Orchestration

Within the scope of 5G EVE, ***Flexible Netlab*** and ***Open5GLab*** NFVi resources will behave as an edge cloud and will be orchestrated from Orange Plug'in orchestrator based on the ONAP solution. The availability of the VIM is expected for **February 2019.** Different ONAP releases will be integrated: By April 2019, after having integrated the ONAP Beijing Release (**REF#O7**), the ONAP Casablanca version should be implemented and will be followed by the ONAP Dublin Release in November 2019 (**REF#O8**).

REFN#3,4,5 will be orchestrated using NGPaaS framework. This orchestration will be available at **M7** for Nokia Research platform, **M8** for iFUN and Nokia Research Platform, **M10** for rest of French cluster.

5.2.2.4 Interco

As explained in [1], the French site's facilities will be interconnected via L2/L3 VPN Tunnel IPsec as depicted in Figure 35. The input port will be Orange Plug'in platform located at Paris-Châtillon premises. This interconnection **REF#O9** will be available at **M8**. Orange is proposing a network infrastructure and will oversee to implement certificates between sites. At **M13**, interconnection with the 5G EVE portal and also with the other European sites should be available.

REF#N1, 2 and **REF#N3,4, 5** will be interconnected on **M8**. **REF#N1, 2, 3, 4, 5** will be interconnected with rest of French cluster on **M10**.

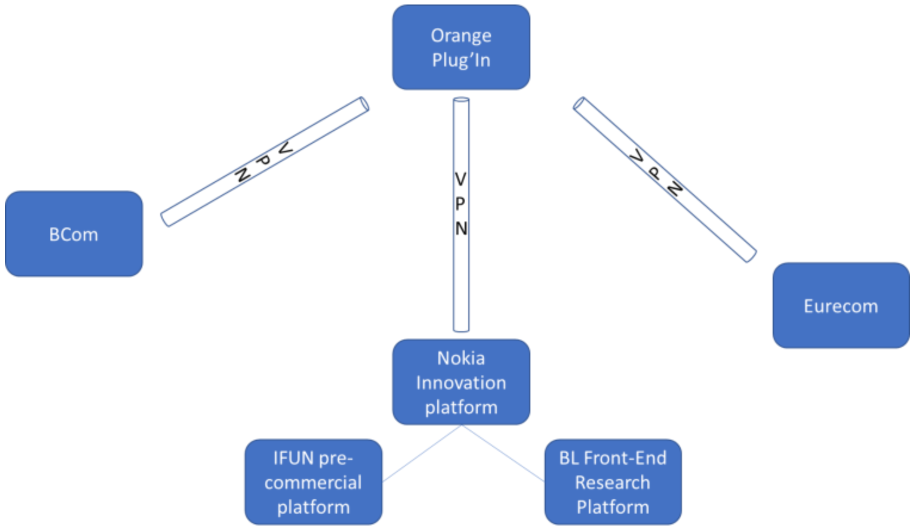

Figure 35: VPN interconnection

5.2.2.5 Northbound and Southbound interfaces

For interconnecting the French sites as well as manage the outside 5G EVE ecosystem, Orange will provide connectivity to the testbed through a VPN concentrator to 5G EVE partners that need to have access to the network from the outside. This step is directly linked to **REF#O9** and its upgrade.

REF#N11,2,3,4,5 will offer unified N/S interface to rest of French cluster on **M10**.

5.2.2.6 Supervision

The different French sites will be able to recover several metrics issued from their platform to the Plug'in orchestrator and supervisor. For instance, the Flexible Netlab proposes to use access to Gnocchi metrics will be provided in order to allow metrics collection from NFVi infrastructure. The service **REF#B10** will be available from **M8**.

As explained in **Error! Reference source not found.**, Gnocchi provides Metrics-as-a-Service through its RestAPI as described in [19]. But it is also possible to connect it to other Open Source tools using plugins like:

- Grafana [20]
- Icinga [21]
- InfluxDB ingestion [22]
- Colletd [23]

Orange Plug'in platform that is the entry point of the French cluster and theoretical, the point where metrics are monitored proposes to mainly use: Prometheus [24], PCP [25], and Vector tools. They have been introduced in **Error! Reference source not found.**. Other tools could be considered, in no order of importance, among them:

- The TICK suite [26] from influxdata: Telegraf [27] (a metric collector or probe), InfluxDB (timeseries database), Chronograf [28] (a visualization dashboard), and Kapacitor [29] (a data processing engine for alerting);
- Cadvisor [30] (metrics probe) with Grafana (dashboard);
- Cadvisor with an elastic stack (Elastic search for metrics and Kibana [31] for dashboard);
- Statsd (metrics probe) and Graphite [32] (time series database for metrics)

The main issues are defined common interfaces and management of the main metrics to be recovered. First common monitoring tool **REF#O10** will be available at **M8**.

Common supervision of **REF#N1,2,3,4,5,6** will be provided on **M13.**

5.2.3 Technologies

Among the main technologies that have already been identified in this chapter and that will be implemented in the French site facility, we can notice:

LTE : **REF#B2, REF#B3**, **REF#B5, REF#EU3, REF#N1,2,3,4,5**

NR 5G: **REF#B5, REF#EU5, REF#O4, REF#N1,2,3,4,5**

Wifi: **REF#B5**

LTE-M : **REF#EU6,**

NB-IoT: **REF#B4**, **REF#B5, REF#EU7**

Orange also plans to implement LTE-M evolution 3GPP R15, during the 5G EVE project. This point is currently in discussion and the implementation is envisaged after M16. The future roadmap should integrate this status.

5.2.4 User Equipment

At the time being, the user terminals is the main risk of the project, especially when considering 5G NR UEs. Indeed, currently there are no clear roadmap for the NR 5Gand no UE provider is part of the project.

So currently several COTS UE is available among the French partners:

REF#B11: Motorola X Play smartphones, Huawei E8278 USB dongle, SDR OAI UE based on USRP available **M3**

REF#B12 : Quectel NB-IoT UE avalable **M9**

REF#EU12: Numerous Galaxy A5 for local and remote experimentation, numerous Nibelink and uBlox Cat-M / NB-IoT modules, Quectel NB-IoT modules available at M3.

REF#EU13: 5 OAI NR UEs and 3 OAI LTE-Sidelink UEs available at **M9** for local and remote experimentation

REF#O10: COTS UE Samsung Galaxy S4 mini (FDD 2.6 GHz) and Dongle (4G) Huawei E3272, Dongle Huawei E3276s-861 (FDD and TDD at 2.6 GHz) available at **M3**.

REF#O11: OAI 5G NR UEs based on USRP development available at **M10**.

5.2.5 Deployment

The French site facility aims at being ready at **M10**, where the different French nodes will be orchestrated and interconnected from the Orange Plug'in platform. Orange is in charge of providing the network infrastructure by managing the Internet Links via L2/L3 IPsec VPN tunnels and implementing a orchestrator management based on ONAP that will allow controlling at the lower layers the French platform. This first integration **REFO#12** will be available at **M10** and will be upgraded at **M16** (**REFO#13**) by deploying the common upper layer interfaces for outside interconnection.

Before providing the initial French site facility access, each French node will adopt its own integration in different phases.

Flexible Netlab

REF#B13 - Phase1 (**M3**):

- New NFVi servers purchased;
- 2.6 GHz TDD LTE eNodeB validation.

Phase2 (**M7**): NFVi deployment (Ceph distributed storage and OpenStack VIM instance);

Phase3 (**M8**): Interconnection with Orange Plug'in node (VPN, Monitoring and Orchestration);

Phase4 (**M9**): ***Wireless Edge Factory*** VNF instance deployment with LTE and WiFi RAN support;

Phase5 (**M11**): 3.5 GHz TDD LTE eNodeB deployment and validation;

Phase6 (**M13**):

- 2.6 GHz TDD NB-IoT eNodeB deployment and validation
- ***Wireless Edge Factory*** VNF instance deployment with NB-IoT eNodeB, LTE and WiFi RAN support.

Open5GLab

REF#EU15 - Phase1 (**M3**):

- New computing servers (RAN/CN) purchased;
- Full deployment of LTE indoor/outdoor Small-cells;
- Purchase of NR radio equipment and testing of NR RRU;

Phase 2 (**M7**)

- OAI RAN/CN testing on a server farm (OPNFV-based environment, RHEL 7.5);
- Deployment of test UEs (LTE/LTE-M/NB-IoT) interconnected with the experimental network for remote control and monitoring;
- Indoor testing of OAI LTE-M/NB-IoT;
- Indoor testing of OAI 5G NR gNB and UE components;

Phase 3 (**M8**)

- Interconnection with Plug-in node (VPN, Monitoring, and Orchestration);
- Testing with the extended 4G small-cell network;

Phase 4 (**M9**)

- 5G NR pico-cell and 2 test UEs online for remote experimentation;

Phase 5 (**M12**)

- LTE-M/NB-IoT cell online;
- Deployment of several modules at partner premises within the coverage zone;

LTE-Sidelink online, 3 test UEs connected for remote experimentation.

Orange Plugin

REF#O14 – Phase 1 (**M6**)

- 2.6 GHz TDD LTE eNodeB validation based on OAI framework with slice management and flow prioritization

Phase 2 (**M9**)

- 5G NR OAI lab transmission in band 78, 3700-3800 MHz

Phase 3 (**M12**)

- LTE-M for extensive coverage in the scope of 3GPP evolution

iFUN

REF #N1 - Phase 1 (**M3**): Outdoor Sites Installation

Installation of the plug-in units and cabling (1 GPS Antenna, 3 Antennas 700MHz, 1 Radio Module 700MHz, 3 Massive MIMO Active Antennas 3.7GHz, 1 airscale Baseband), Setting up the equipment, final checking of the installation (Figure 36).

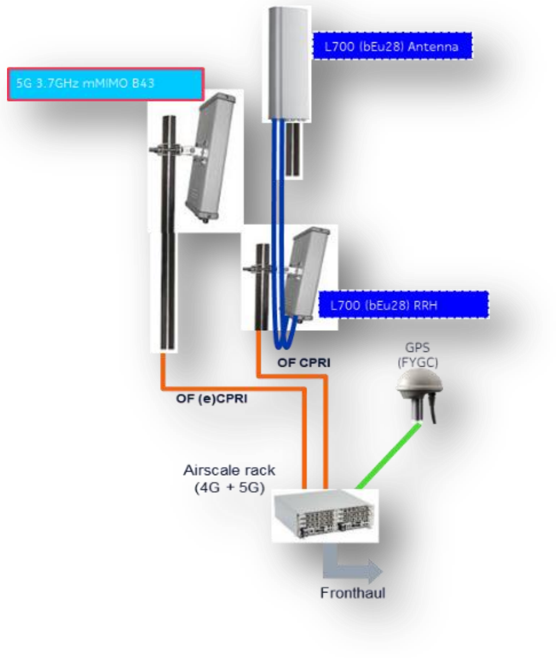

Figure 36: Nokia 5G Airscale installation

REF #N2 - Phase 2 (**M4**): Cloud Infra Structure Installation & Commissioning (Figure 37)

- Installation of Airframe data center
- Perform the software installation and feature configuration for the Cloud Band Access Manager (CBAM) components.

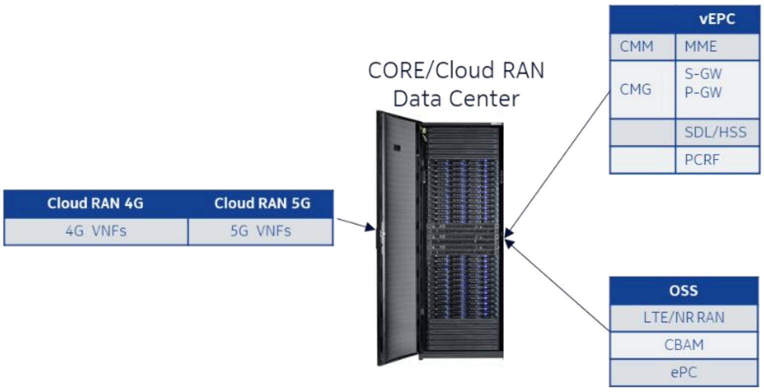

Figure 37: Nokia cloud infrastructure installation

REF #N2 - Phase 3 (**M5**): Core Installation

- VNF S&P GW
- VNF MME
- VNF SDL + HSS

REF #N1 & #N2 - Phase4 (**M6**): E2E Integration & Tests

Nokia research platform

REF#N3, REF#N4, REF#N5 – Phase 1 (**M6**): infrastructure deployment and interconnection

REF#N3, REF#N4, REF#N5 – Phase 2 (**M7**): end-to-end deployment of functions using NGPaaS framework

REF#N3, REF#N4, REF#N5 – Phase 3 (**M8**): interconnection with iFun (**REF#N1 and REF#N2**), validation of end-to-end services spanning iFun and Nokia research platform;

REF#N3, REF#N4, REF#N5 – Phase 4 (**M10**): the interconnection of iFun+Nokia research platform to rest of French cluster, offering a single interface from Nokia to e.g. ONAP and Plug'In.

5.3 Risks

The main risk that is currently identified is the 5G NR user terminal availability at the different stages of the project. Another risk is about the renewal of the frequency bands for trial operation.

6 Conclusions

This deliverable contains a detailed plan of implementation for the main components and equipment that will build the four 5G EVE site facilities. The planning is provided until April 2019 that corresponds to the date of the initial site facilities access without an interconnection between them. The expected state of the facilities after April 2019 is announced as well. In fact, this deliverable will be updated on a six-months basis as of March 2019, in order to inform about the site facilities' evolution regarding the equipment provider roadmap and also the 3GPP new specifications as they will be announced. The evolution of this deliverable will also consider new specifications and new tools that will be developed during the 5G EVE project.

Specific sections about "platform integration" provide information about how various components are combined together and also about the specific technology that will be implemented that can directly influence the vertical integration.

We can notice that starting from LTE 4G technologies, the different site facilities will move progressively to NR 5G deployment and will address some specific technologies like NB-IoT, LTE-M, WiFi to accommodate the 5G EVE use case requirements originating from the vertical industries.

Acknowledgments

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[32] https://graphiteapp.org/

APPENDIX A: Greek site facility Planning

		M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18
		YEAR 1								YEAR 2					
		Q2		Q3			Q4			Q5			Q6		
WP2: Implementation, pilot execution, and validation	T2.1: Site facility capabilties planning														
	T2.2: Site facility implementation														
	T2.3: Pilot execution and validation														
		November	December	January	February	March	April	May	June	July	August	September	October	November	December
	DELIVERABLES						MS5							D2.6	MS8
Network Infrastructure	Equipments					N1 • O5	E1 • E12							N15	E13
	RAN					E2•N2								E5•N11	
	CORE					E3•N3	O1							N10	
	Frequency bands					E4•N4								E6•N9	
Network management	Controller														
	resource management					E11•N5	O2								
	Orchestrator					N7									
	Interco						O3								
	North and South Interfaces						O6								
	Supervision														
Supported technologies	LTE					E7•N2									
	NR 5G													E8•N11	
	WiFi														
	IoT: NB-IoT, LTE-M, other					N6									N12
	Multefire, other …														
Deployment	Phase 1					E9• N6								E10	N13
	Phase 2														
	Phase 3														
	…														
Platforms integration	STARLIT (WINGS)		W1									W2			
	Nokia IoT Platform(Nokia GR)						N8								N14
	Utilities platform (WINGS)		W3						W4						W5
	OTE Athonet Platform						O4								

Legend	
Oj	OTE - Equipment / functionality x
Ex	Ericsson GR - Equipment / functionality x
Ny	Nokia GR - Equipment / functionality y
Wz	WINGS - Equipment / functionality z
Ex • Ny	Combined release of Ericsson and Nokia
Ny • Oj	Combined release of Nokia and OTE

APPENDIX B: Italian site facility Planning

		YEAR 1												YEAR 2					
		Q1			Q2			Q3			Q4			Q5			Q6		
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18
WP2: Implementation, pilot execution, and validation	T2.1: Site facility capabilties planning																		
	T2.2: Site facility implementation																		
	T2.3: Pilot execution and validation																		
		July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
	DELIVERABLES			D2.1	D2.2			2019			MS5							D2.6	MS8
Network Infrastructure	Equipments							P1+E1		E2							P4		E3
	RAN									E4								E5	
	CORE									E6									
	Frequency bands							T1											
Network management	Controller																		
	resource management									E7									
	Orchestrator									E8									
	Interco																		
	North and South Interfaces																		
	Supervision																		
Supported technologies	LTE							T2											
	NR 5G										E9								
	WiFi																		
	IoT: NB-IoT, LTE-M, other							P2					P3						
	User equipment										E10								
Deployment	Phase 1										E11+T3								
	Phase 2																		E12+T4
Platform Integration	oneM2M										E11+T3								E12+T4
	–																		
	–																		
	–																		

Legend	
E	Ericsson Reference
T	Tim Reference
P	Politecnico Reference
E+P	Ericsson+Politecnico Reference
E+T	Ericsson+TIM Reference

APPENDIX C: Spanish site facility Planning

		YEAR 1												YEAR 2					
		Q1			Q2			Q3			Q4			Q5			Q6		
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18
WP2: Implementation, pilot execution, and validation	T2.1: Site facility capabilties planning																		
	T2.2: Site facility implementation																		
	T2.3: Pilot execution and validation																		
		July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
	DELIVERABLES			D2.1	D2.2						MS5							D2.6	MS8
Network Infrastructure	Equipments	14						15											
	RAN	1							2										
	CORE	3												4					
	Frequency bands	5							6										
Network management	Controller						16												
	Resource management																		
	Orchestrator	11					17												
	Interco	12						13											
	North and South Interfaces																		
	Supervision	18							19										
Supported technologies	LTE	7																	
	NR 5G								9								10		
	WiFi																		
	IoT: LTE-M							8											
	Multefire, other ...																		
Deployment	Phase 1																		
	Phase 2																		
	Phase 3																		
	...																		

Legend	
(orange)	Ericsson based infrastructure
(blue)	Nokia based infrastructure

APPENDIX D: French site facility Planning

		YEAR 1												YEAR 2					
		Q1			Q2			Q3			Q4			Q5			Q6		
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18
VP2: Implementation, pilot execution, and validation	T2.1: Site facility capabilties planning																		
	T2.2: Site facility implementation																		
	T2.3: Pilot execution and validation																		
		July	August	September	October	Nover	December	January	February	March	April	May	June	July	August	September	October	November	December
	DELIVERABLES			D2.1	D2.2						MS5							D2.6	MS8
Network Infrastructure	Equipments			B1 / EU1			O3 / EU2			O1 / O2							ED1		
	RAN			B2 / N1			EU3/4/5 / N1,3,4		B3/O4 / N2	EU6/7			B4/EU8						
	CORE			B5	O5 / EU9 / N2	N2	N2,4						B5						B5
	Frequency bands	EU10/B6/B8	EU12/13/B6	EU11/O6 / N1															
Network management	Controller			B9			EU14												
	resource management							N3,4,5	N1,2,3,4,5		0+B+N+EU								
	Orchestrator							N3,4,5	N1,2,3,4,5		O7							O8	
	Interco								O9, N1,2,3,4,5		N1,2,3,4,5								
	North and South Interfaces								O9		N1,2,3,4,5			O9					
	Supervision								B10/O10					N1,2,3,4,5					
Supported technologies	LTE						B2/B3/B5/EU3, N1,2	N3,4,5											
	NR 5G						N1,2	N3,4,5	B5/EU5/O4										
	ViFi			B5															
	IoT: NB-IoT, LTE-M, other									EU7			B4						
	Multefire, other …																		
Deployment French site	Phase 1										O12								
	Phase 2																O13		
Platforms integration	Flexible Netlab			B13p1				B13p2	B13p3	B13p4		B13p5		B13p6					
	Open5Glab			EU15p1				EU15p2	EU15p3	EU15p4			EU15p5						
	Plug'in						O14p1			O14p2			O14p3						

Legend	
Bj	b<>com equipment / functionality j
Oj	Orange equipment / functionality j
EUj	Eurécom equipment / functionality j
EDj	EDF equipement j
Nj	Nokia equipment / functionality j