D6.2: PoC preliminary design document

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Abstract	This deliverable describes the POC bench for the STARDUST demonstrations
Keywords	PoC, NTN, 3GPP, TN, Physical architecture, test bench

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DISCLAIMER

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EXECUTIVE SUMMARY

The present document addresses the definition of the bench associated to the PoC, which is one of the main outputs expected from the 5G-STARDUST project.

As such, this deliverable represents a bridge between the first phase of the project mostly devoted to the definition of the system architecture and the second phase, where the integration of the developed component will provide the building blocks necessary for the realisation of the PoC, which will be then used at the end of the project in key dissemination and promotional activities, aimed at showing the research delta and the added technological value achieved by the project with respect to the existing state of the art.

As such, this document takes as references the main indications drawn in the first phase of the project from an architectural standpoint and breaks down further the system into physical and logical components, constituting the terrestrial and non-terrestrial paths involved in the end-to-end connectivity concept developed in the project. In particular, it is worth noticing that the target TRL for the project is 4-5, so that key elements for the realisation of a fully integrated 5G-NTN system are here considered. In this respect, a key role is being played by the UE and gNB implementing the necessary NTN adaptation.

Then one of the main merits of the architecture developed in the project is the use of a regenerative payload onboard satellite. Last but not the least, one of the objectives to be reached with the planned PoC is also to support the case of multi-connectivity, in order to show how switching from one path to another or even the simultaneous use of both can be beneficial for the overall system performance.

The overall PoC is then aimed at reproducing the performance of a realistic 5G-NTN integrated system with respect to a number of use cases and related possible configurations, hence reaching an important milestone in the demonstration of the capabilities that a unified technology system may offer.

The main findings contained in this document with respect to physical layout and functional architecture will be the description of the bench and the implementation of the functionalities needed for the concept demonstration.

The consolidated architecture design will be finally provided in deliverable D6.4, due end of June 2025 (i.e., M30 in the project timeline).

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ABBREVIATIONS

AI	Artificial Intelligence,
CU	Centralised Unit
DU	Distributed Unit
GTP	Generic Tunnelling Protocol
HW	Hardware
IAB,	Integrated Access and Backhaul
IP	Internet Protocol
KPI	Key Performance Indicator,
MC	Multi Connectivity,
MEC	Multi-Access Edge Computing,
ML	Multi Link,
MP	Multi Path,
MPL	Multi-Path Layer, etc.
MPQUIC	Multi-Path QUIC
MPTCP	Multi-Path Transmission Control Protocol
NGAP	NG Application Protocol,
NTN	Non-Terrestrial Network,
PCI	Peripheral Component Interconnect,
PoC	Proof of Concept
PSA	PDU Session Anchor
RF	Radio Frequency,
RU	Radio Unit,
SCTP	Stream Control Transmission Protocol,
SDR	Software Defined Radio,
SLE	Satellite Link Emulator,
SMA	Sub-Miniature version A,
SU	Switching Unit

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SW	Software
TCP	Transmission Control Protocol
TGA	Traffic Generator and Analyse,
TN	Terrestrial Network,
UE	User Equipment**,**

1 INTRODUCTION

1.1 POC CONCEPT AND DEVELOPMENT PHASES

Deliverable D6.2 contains the preliminary definition of the PoC bench in the context of WP6 'Integration, testing, and validation' overall aimed at the definition and integration of the PoC according to the system architecture defined in WP3 (Architecture Design) and on the basis of the activities carried out within WP4 (Radio Technologies) and WP5 (Networking Operations), whose main outputs in the form of SW/HW pieces are then the object of the PoC integration. In turn, once the PoC will be fully integrated and operational, the corresponding demonstration campaigns will be carried out, whose results analysis is performed immediately afterwards. A dedicated study-logic illustrating such a process is shown in Figure 1.

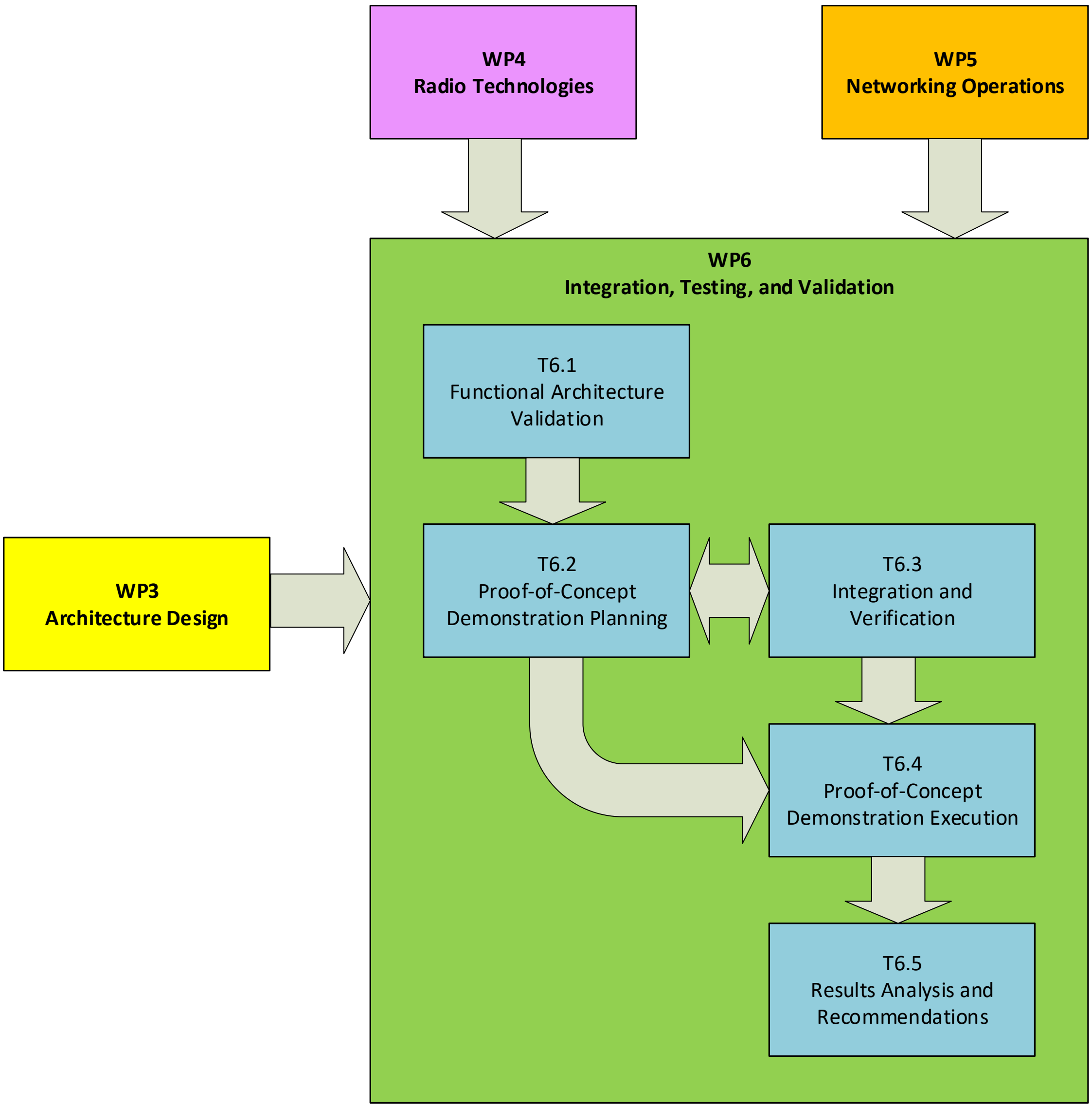


Figure 1 WP 6 interaction with development activities in 5G-STARDUST

From the above picture is then clear the role of this deliverable as output of Task 6.2 in providing the foundation of the PoC, as it elaborates physical architecture and overall component projection on the physical architecture of the PoC. As such, the main indications provided in this document will be later used to plan the actual demonstration and how the different building blocks here defined will be integrated and tested towards the full system verification. In this respect, obviously, a prerequisite for the definition of the functional architecture is the system design as developed in the course of WP3, so that in particular D3.2 [2] is the starting point for the definition of the PoC functional architecture.

In more detail, the discussions and findings summarised at the end of D3.2 [2] allowed to define the macro-architecture (see Figure 2) for the project PoCs so as to address both direct and indirect access, hence offering the possibility to address multiple scenarios.

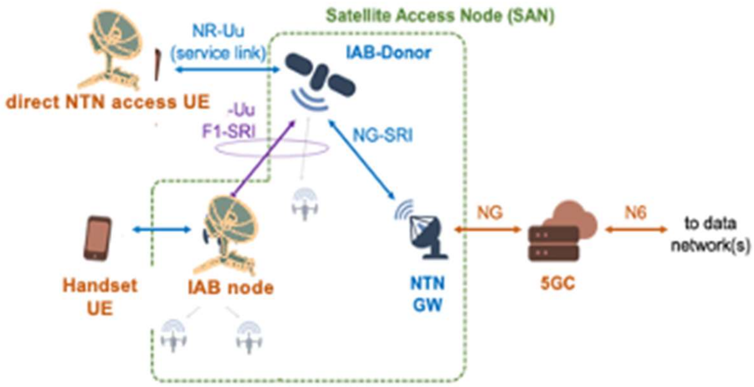


Figure 2 Macro-architecture of the NTN segment for the PoC (TN segment not shown here)

As a matter of fact, the access to the satellite in the indirect configuration will happen through a relay node, hence resembling that of IAB node functionality, although this is not exactly the approach taken in the project. The adopted methodology does not rely on IAB implementation (for which no NTN adaptations have been addressed so far in 3GPP), but on the contrary the idea is to take advantage of an intermediate node responsible for interacting with a UE and extending its connectivity so as to reach the gNB, which will be implemented (either fully or in distributed manner) in the space segment. Further to this, it is expected to have different classes of UE, able to achieve data connectivity in either FR1 or FR2 with different bandwidth availability. Last but not least, the satellite path is then complemented by a terrestrial counterpart in order to show the coexistence of different paths and demonstrate the added value of a unified network architecture, where both TN and NTN segments are available.

In general, the main objective of the PoCs will be that of proving the added value coming from integrated TN and NTN networks implementing a regenerative LEO satellite system. In that respect, first of all it is assumed to consider a transparent LEO setup as actual benchmark. Then in turn, some of the main functions to be considered for the demonstration to prove the value of integrating TN and NTN will be about:

1) Support of FR1 frequency band and some characteristics of the FR2 frequency band (100 MHz band width).

2) End-to-end connectivity through a unified radio interface

3) Multi-link/path achievement towards effective utilisation of the available TN/NTN resources

The demonstration of the FR2 capacities will not be performed on the PoC but with theoretical demonstration. This demonstration is in line with the objective 4 where the measurable results can be performed either by on laboratory test beds and numerical simulation.

To this end, the overall PoC picture will address network disaggregation by considering different functional splitting models aimed at showing performance fluctuations and corresponding configuration adjustment.

Last but not the least, the final version of the demonstrator will be plugging real user applications in order to have impactful demonstrations of the added value of the 5G-STARDUST concept by achieving a close-to-real setup (though still up to max. TRL 5).

1.2 TRL REVIEW

On the basis of the first iteration presented at the end of D3.2 [2], a successive refinement has been conducted to identify the macro-blocks necessary for the definition of the PoC, which are further summarised in Table 1, here below:

Table 1 PoC Macro-blocks and related TRL progression

Technology	Initial TRL	Estimated TRL	Support (full/partial)[1]	Notes
Regenerative payload	2	4	full	Key demonstration objective of the project, also in relation to embark a gNB in space with all necessary functions from physical layer up to PDCP
Unified UE interface	2	4/5	full	Key demonstration objective of the project, with respect to proving the benefits of integrating a UE into TN/NTN segments interchangeably.
ML supported TN/NTN MC on higher layers	2	4	partial	Multi-connectivity supported in terms of multi-path protocols and related integration between core network, RAN, and UEs
AI data driven networking solutions for MC (management)	2	4	partial	Multi-connectivity management carried out in static manner, since AI would not bring much benefit in a PoC of limited size (i.e. few UEs)
AI data driven networking solutions for MC (slicing)	2	4	partial	Network slicing supported in the sense of differentiating QoS classes, through static classes separation.
MEC platform for NTN nodes	2	4	TBC[2]	-

[1] In the case of partial support, not all functionalities as planned within 3GPP will be part of the PoC. Detailed description will be provided in the technical specification, object of D6.2 and D6.3.

[2] WP5 will come up with a dedicated testbed to show the potentials of a MEC agent in space. Its actual integration in the WP6-developed PoC is a nice-to-have feature, but not strictly fundamental to reach the objectives of the project. Such an opportunity will be better assessed in the next phases of WP6, while planning the integration of PoC and the related demonstration execution.

Technology	Initial TRL	Estimated TRL	Support (full/partial)[1]	Notes
RAN softwarization	2	4	full	Pretty much oriented to the achievement of gNB in space, either in the form of full gNB in space or in distribute manner (i.e. function CU/DU splitting)
Core Network Functionality	**4**	**5**	**full**	The core network was tested already with gNBs placed at large distance, however not with gNBs at continuous variable delays. However, we do not expect to be a major issue

1.3 OBJECTIVE AND ORGANISATION OF THE DOCUMENT

The document is organised in four main parts:

- A recall of the expectation of the bench for covering the demonstration in chapter 2.1
- An overview of the physical architecture regarding the three main functional prerequisites, architecture implementation, time synchronization and remote control capabilities, needed to perform the demonstration on chapter 2.2, 2.3 and 2.4
- A description of all the hardware component for the PoC bench manufacturing
- A description of all identified software component

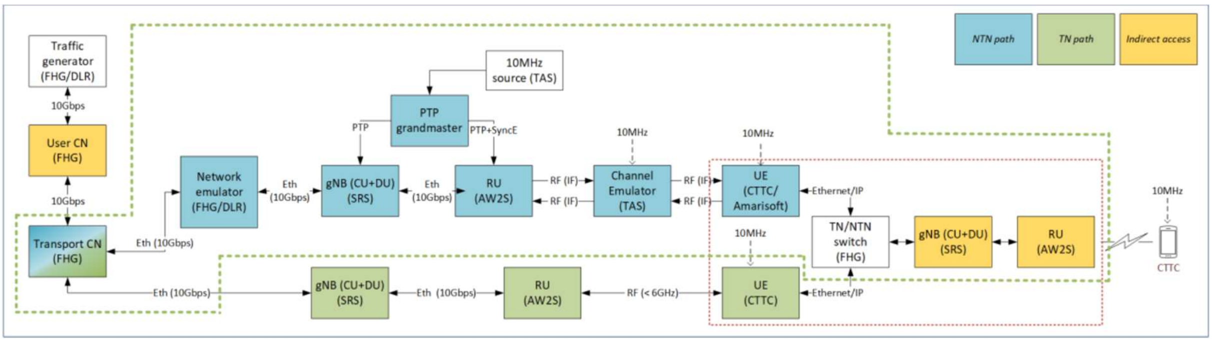
2 BENCH DESCRIPTION

2.1 RECALL OF OBJECTIVES AND PRELIMINARY DEFINITION

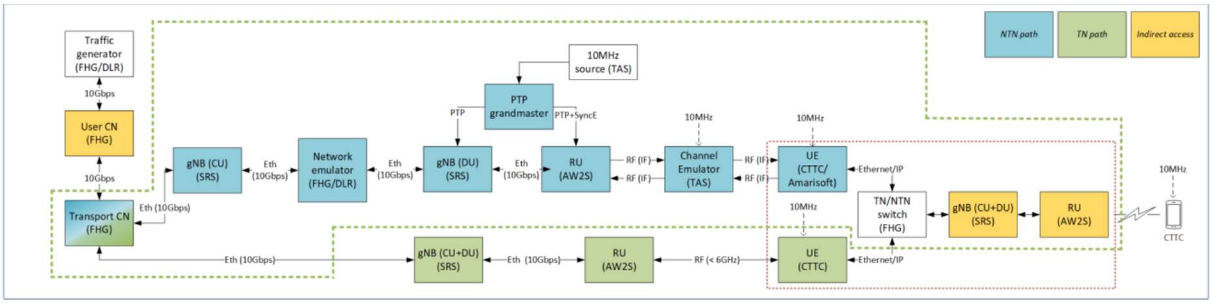
The PoC bench shall be able to demonstrate the Use Cases identified in the D2.1 [1] in line with the different splitting defined in the D6.1 [3] PoC functional architecture document.

The different splits are reminded here after:

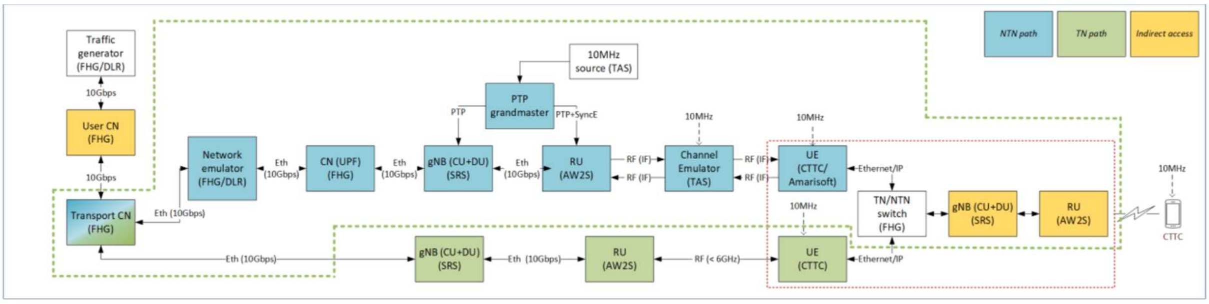
1. Full GNB On Board:



2. CU/DU splitting



3. Full gNB on board with 5GC functions



The splits defined introduce some constrains on the design and the logical architecture. The three splits imposed to separate the gNB in a minimum of two logical partition, one for the CU, one for DU/RU, and to separate the Core Network in two logical partitions (one for the UPF function, one for the rest of the Core Network).

Considering the feeder link for the NTN, the technology usually used for the link is well none and presents no major point to be de-risked, Based on this assumption, only time delay is taken into account for the feeder link. The PoC will use an Ethernet link to simulate the feeder RF link, limited currently to the traffic delay (propagation time) without other type of interferences (weather, location discrepancies …).

Considering the NTN “user” link, the complexity and specificity of the RF parts (OFDM wave form, Doppler effects, losses …), the satellite to user link will be emulated with a two way RF satellite link emulator connected through RF wire (coaxial).

For the TN link, the connexion will be also performed with coaxial wires despite over the air link. The aim of the demonstrator is not to verify the TN capacities that are already demonstrated in many ways but ensure that the commutation between the TN and the NTN is feasible.

The link between the end user device and the IAB can be performed “on the air” or by wire. This link is well known and only the access principle shall be demonstrate.

2.2 TN AND NTN ARCHITECTURE OVERVIEW

2.2.1 Principle

The PoC bench will be able to sustain the TN and NTN demonstrations. The physical architecture is based on several servers, one dedicated simulator (SLE) and further cards representing the RF emulation (RU cards and associated software).

The bases are:

- When needed, a dedicated computer is associated to a functional component.
- Except specific needs, the functional components are planned to use a container or a VM, depending on the provider specification. This will imply also a virtualisation of the Ethernet link for each HW component. As option, a slitting of the resources regarding the application needs can also be done (core processing, Ethernet interface when multiple one available on the server).

The network capacity is based on the maximum traffic load to avoid any overloading or discrepancies.

2.2.2 Description

The TN and NTN network is based on the following equipment:

- One server for the “Core Networks”. It will host the following functionalities:
    - Core Network system
    - Core Network TN/NTN without NTN UPF functions
    - Core Network NTN UPF functions
    - Feeder link emulator
- One server for gNB TN/NTN. It will host the following functionalities:
    - With direct access to hardware component, the DU NTN

  - CU NTN
  - DU TN
  - CU TN

- One IAB server. It will host the following functionalities:
  - CU System
  - DU system
  - IAB switching function
  - The RU TNT software from AMARISOFT
- The RU cards to perform the conversion from the frame issued of the DU to generate the RF signal and its reverse link.
- The SLE hardware to emulate the system.
- The switch with the capacity of a 10Gbits network to ensure the data transfers between each server.

The overview of this network is presented in the following figure.

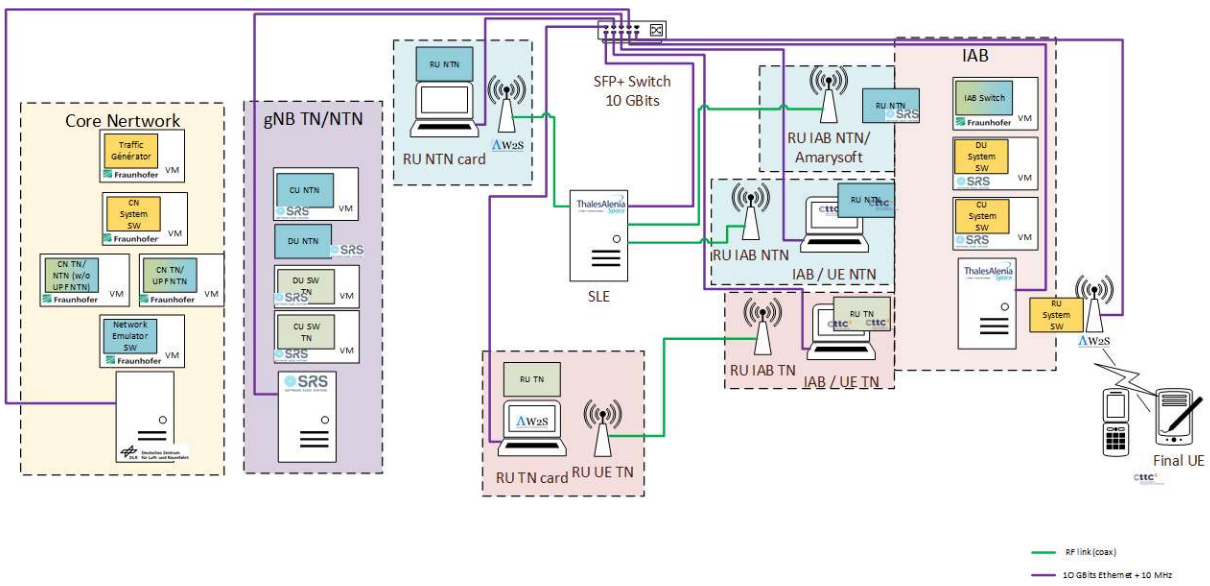


Figure 3: Bench TN/NTN architecture

All the equipment presented in this architecture are located in the TAS-F facilities.

For the NTN simulation, only a part of the presented architecture will be used. The following figure presents the components used for the part of the simulation.

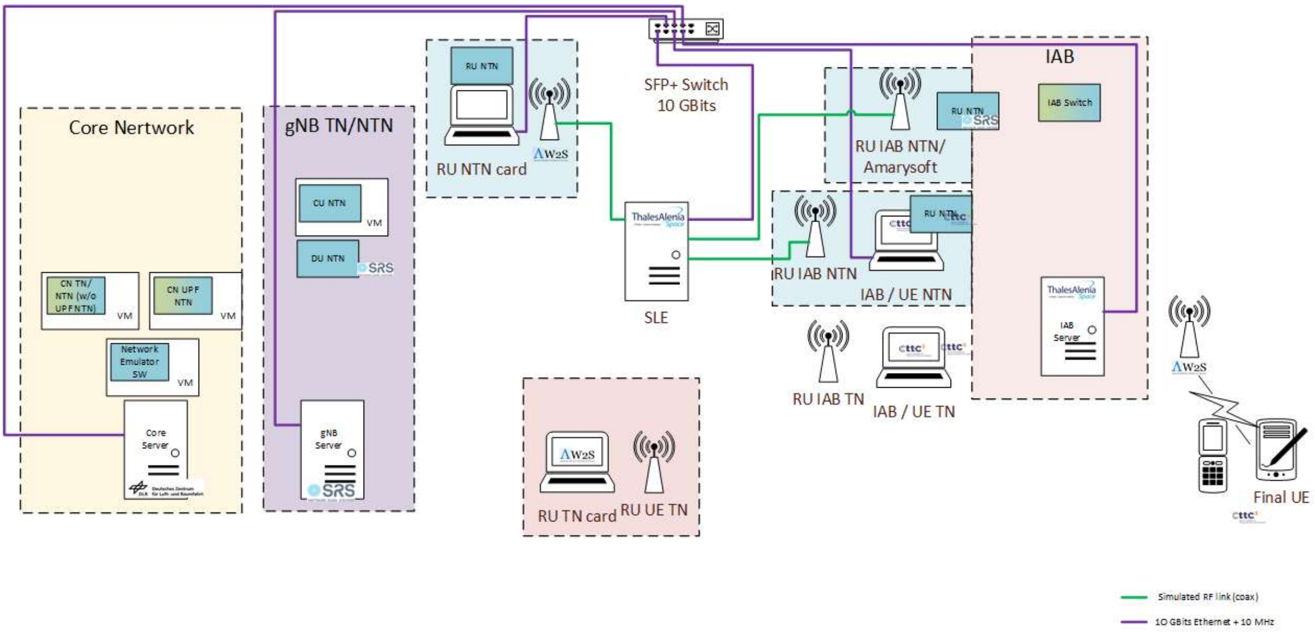


Figure 4: NTN bench components

In the same way, the TN network is simulated with the components presented in the following figure.

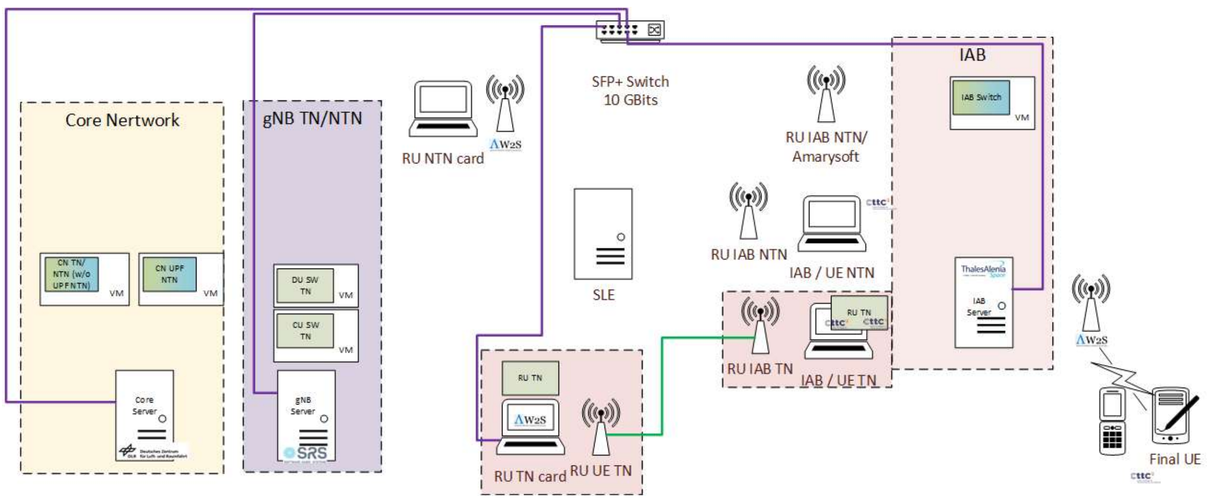


Figure 5: TN bench components

For the TN and NTN network, the switching component are common to those two networks and represented with two colours box.

The encapsulating network constitution is summarised in the following figure:

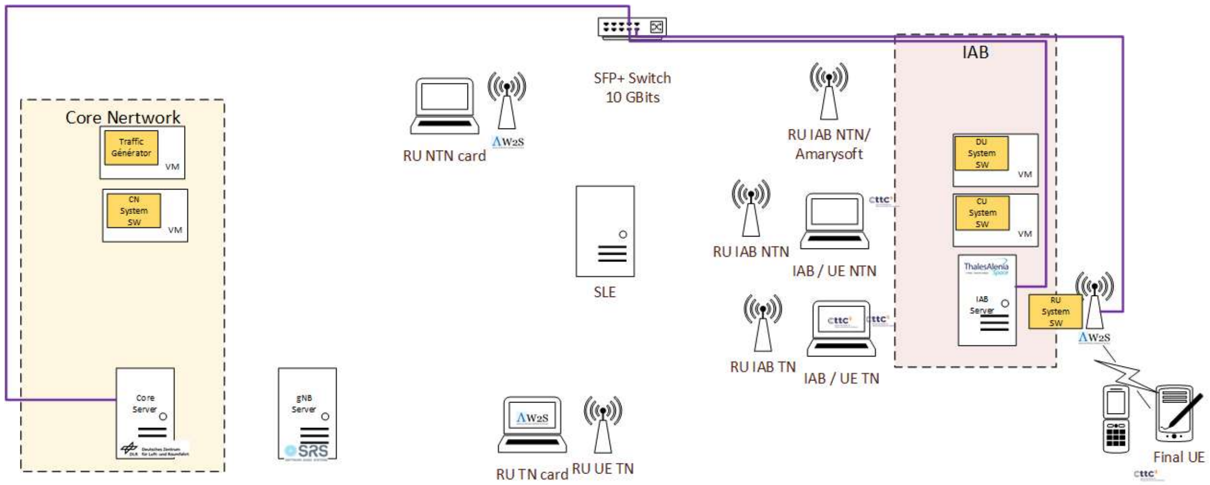


Figure 6: Encapsulating network

This last configuration also contents the traffic generator that will be used to simulate the inputs for the different use cases that will be demonstrated.

2.3 TIME SYNCHRONISATION

2.3.1 Principle

The time synchronisation is a huge need for the NTN and TN network.

Depending on the functionality, the synchronisation shall be performed as absolute of relative time. This is done at different level regarding the component.

As specified in the 3GPP NR, a PTP synchronisation shall be distributed to all component for synchronisation purpose.

The PTP is defined in the IEEE 1588. For telecommunication purpose, it is defined under the ITU specification G.8265.1, G8275.1 and G.8275.2.

The principle of the PTP is based on time stamp exchange between the master and the slaves.

It's a “four steps” as presented hereafter:

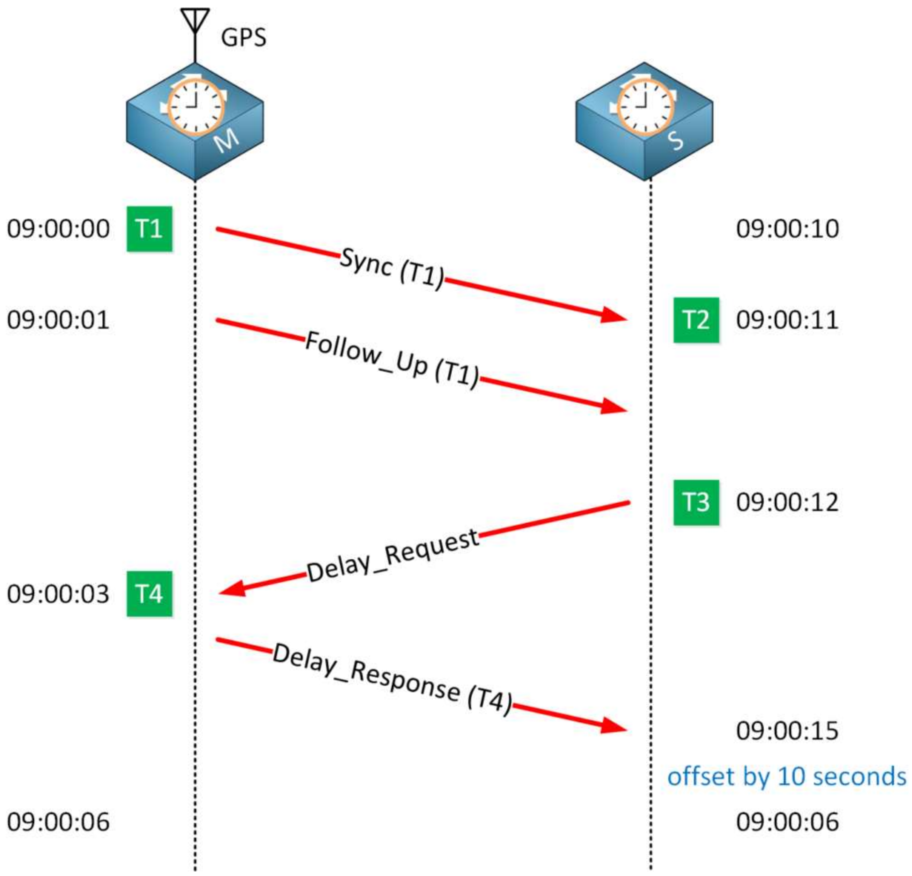


Figure 7: PTP message principle

The computation of the transmission time and offset time between messages allows the synchronisation of the client clock (slave clock) to the Grandmaster clock (master clock).

For the system, based on the µFalcon equipment, the time can be provided by Ethernet link or on O-RAN configuration.

Each device will be connected through an Ethernet link to the µFalcon to get the PTP service.

A 10 MHz clock is also delivered by the Falcon to ensure an external synchronisation.

2.3.2 Description

The architecture used for the time synchronisation is based on a µFalcon Rx or Mx. The µFalcon is used as Grandmaster clock. It is connected to a GNSS antenna. The GNSS system is used as the reference clock.

In each component, a hardware or software PTP is implemented to synchronise the time to the Grandmaster one.

The first draft of the architecture will be:

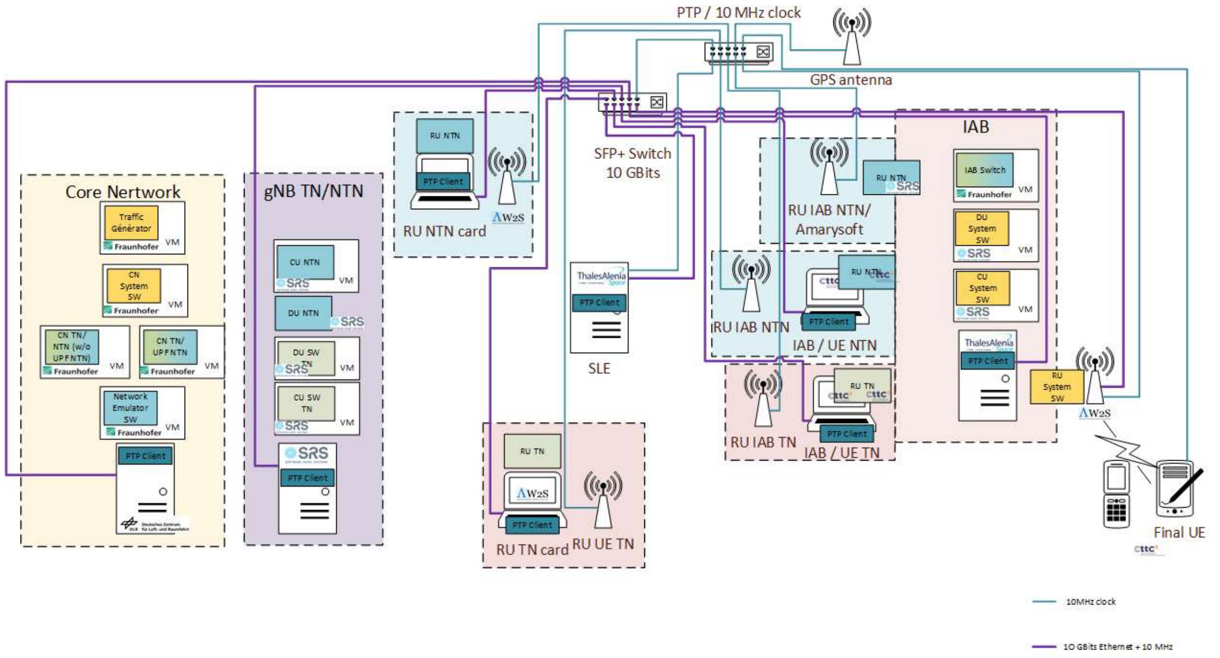


Figure 8: Time and Reference oscillator sharing architecture

The server OS can be:

- Linux distribution
- Windows

For each OS, there is a software client that synchronise the local clock.

The precision that can be reached is lower than the µs. This precision needs to be shared to ensure that the NTN and TN are based on the same time synchronisation (TDD OFDM synchronisation and delay accuracy computation). It is also used for standalone device to monitor the LO (ensuring stability).

All the equipment presented in this architecture are located in the TAS facilities.

2.4 REMOTE CONTROL ARCHITECTURE OVERVIEW

2.4.1 Principle

The aim of the remote-control system is to ensure that every partner could access their component in the bench located in TAS facilities and also be able to demonstrate some use cases remotely from their own location.

The principle is to use, for each partner, a VPN connexion between the partner facilities and the bench resources.

The installation can be performed in two ways:

- The VPN server is installed in the bench. This implementation implies the following constrains:

  - The entry point must be, at minimum, with a fixed address.
  - A security barrier shall be implemented to avoid cyber security failure.
  - A management of the access permission shall be implemented for each partner (access right).
- Only VPN client are used on the bench.
  - Each partner has its own client to connect to its company VPN (need to be done with the partner DSI).
  - The partner could install as much as needed VPN client (up to one per VM)
  - No visibility of the bench on internet (no open port on the firewall).

The second solution is the one proposed as basic solution for the bench

The VPN client can be defined at the OS level or at the VM level, depending of the customer needs and interaction.

2.4.2 Description

The remote-control system is composed of:

- An internet access point (rj45 internet connection, 4G or 5G connexion) with or without routing capacity
- A switch with or without routing capacity to allow routing of the flux between systems
- VPN client for the computer (associated with partner VPN service)
- A set of terminal located in the bench facility to remotely access to the server.

The LAN is based on a 1GBits network with RJ45 plugs. If needed, regarding the computer connexion, an SFP+ / RG45 adaptor can be used.

The architecture is presented here after.

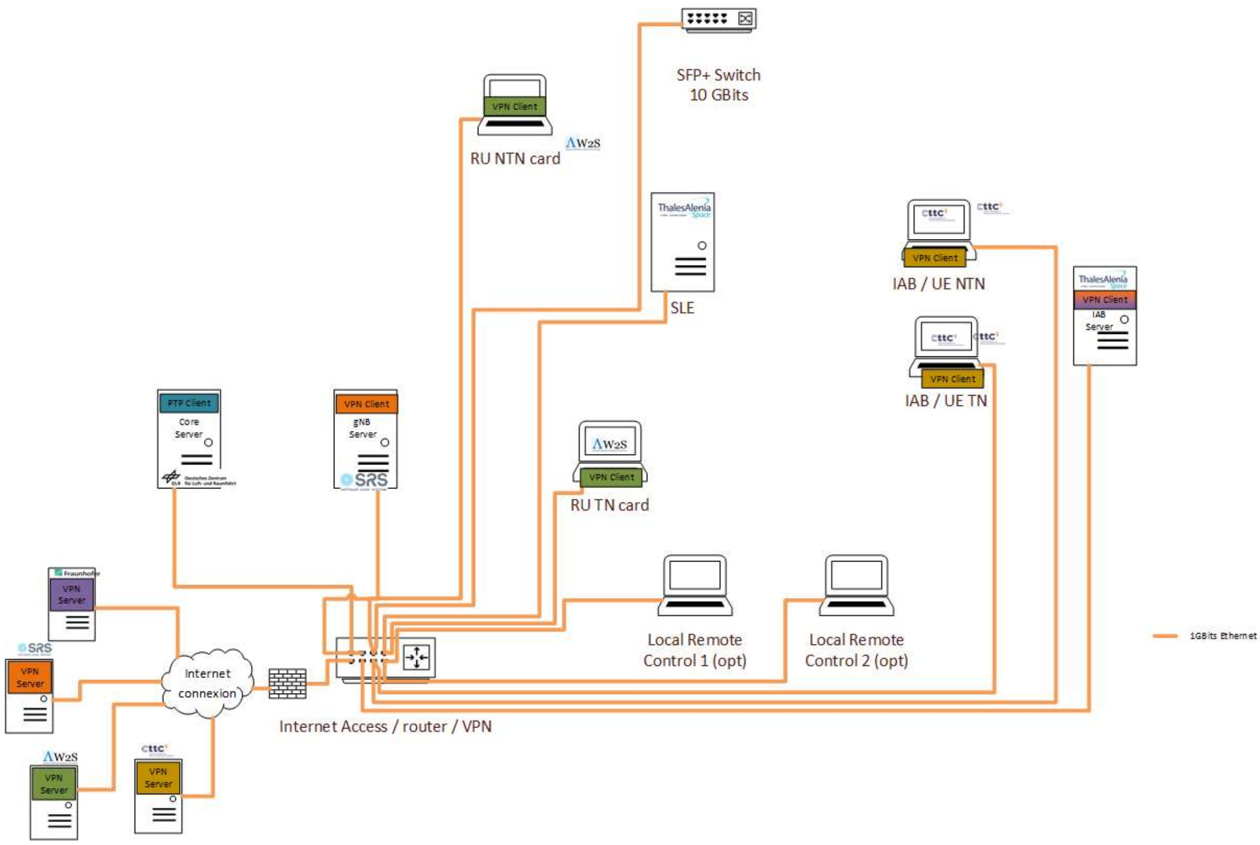


Figure 9: Remote control architecture

Due to the fact that the bench is located in TAS facilities, only external partners are connected. TAS equipment will not be accessible remotely.

An option is also available to introduce a VPN server into the bench remote control network to be able to connect remotely for demonstration purpose. This point will be analysed and an update of the configuration will be performed if needed.

2.5 HARWARE COMPONENTS

2.5.1 PTP

2.5.1.1 Description

The PTP server is the equipment needed to distribute the Time reference to all connected equipment.

The current reference is the Fibrolan FALCON

Two family exist with the Rx or Mx one.

The MX one is limited at a 10 GBits Ethernet link

2.5.1.2 Interface

Figure 10: Fibrolan Falcon RX interface view

The µFalcon has:

- A GPS antenna compatible with GPS, Galileo, GLOSNASS and Beidou constellation with 32 channels,
- 12 SFP+ ports @ 10 GBits
- 8 SFP+ port @ 25 GBits
- 3 sync clock @ 10MHz

2.5.1.3 Form factor

The form factor is equivalent to a 19inches rack module.

2.5.2 Network TN/NTN switch

Depending on the PTP server and its capacity, a need of a dedicated switch will be needed with the capacity to connect the different server with a SFP+ (10GBits) or SFP28 (up to 25GBits).

A 1 GBits switch shall be also used for the time distribution (standard RJ45).

2.5.2.1 Description

The switch will be defined with the requested number of link.

2.5.2.2 Interface

The interface are SFP+ or SFP28

A 9 ports switch minimum is required for supporting the architecture.

2.5.2.3 Form factor

The form factor is the same as the PTP due to the fact the switch is included in the PTP server component.

2.5.3 Traffic generator

This server is optional if the application can be run on the Core Network Server.

The description will be provided in the D6.4.

2.5.4 Core network server

2.5.4.1 Description

The server will be capable of running the 5G core used for PoC. It will also be able to execute AI/ML operations to assist in decision making tasks (e.g., for multi-connectivity), if needed.

The hardware intended to host the server has the following specifications:

- CPU: Intel i9
- RAM: 32 GB
- GPU: NVIDIA GeForce RTX 4070
- Storage: 1 TB SSD

2.5.4.2 Interface

The machine will have an Ethernet interface with two SPF+ adapters. An interface considered as reference is Intel X710 Quad Port 10GbE SFP+ Adapter, PCIe Full Height, V2.

2.5.4.3 Form factor

The dimensions of the machine will be equivalent to be placed in a 19-inch rack.

2.5.5 gNB server

The description will be completed in the D6.4, while the next subsections provide a high-level view of the main characteristics.

2.5.5.1 Description

The gNB server is responsible for hosting both the CU and the DU of the NTN enabled gNodeB from SRS.

The gNodeB consists of L1 to L3 and is compliant to release 17 of the 3GPP features to support NTN.

2.5.6 RU TN server

The description will be performed in the D6.4,

2.5.7 RU NTN server

The description will be performed in the D6.4,

2.5.8 SLE

2.5.8.1 Description

The SLE (Satellite Link Emulator) is provided by National Instrument.

The system is based on a PXI rack and a set of PXi cards.

The cards are:

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- One PC card for interfacing and managing the SLE (PXIe-8881)
- Two PXIe-5842 VST for the acquisition and generation of the RF signal
- Two PXIe-7915 FPGA co-processing hosting the SLE main functions.

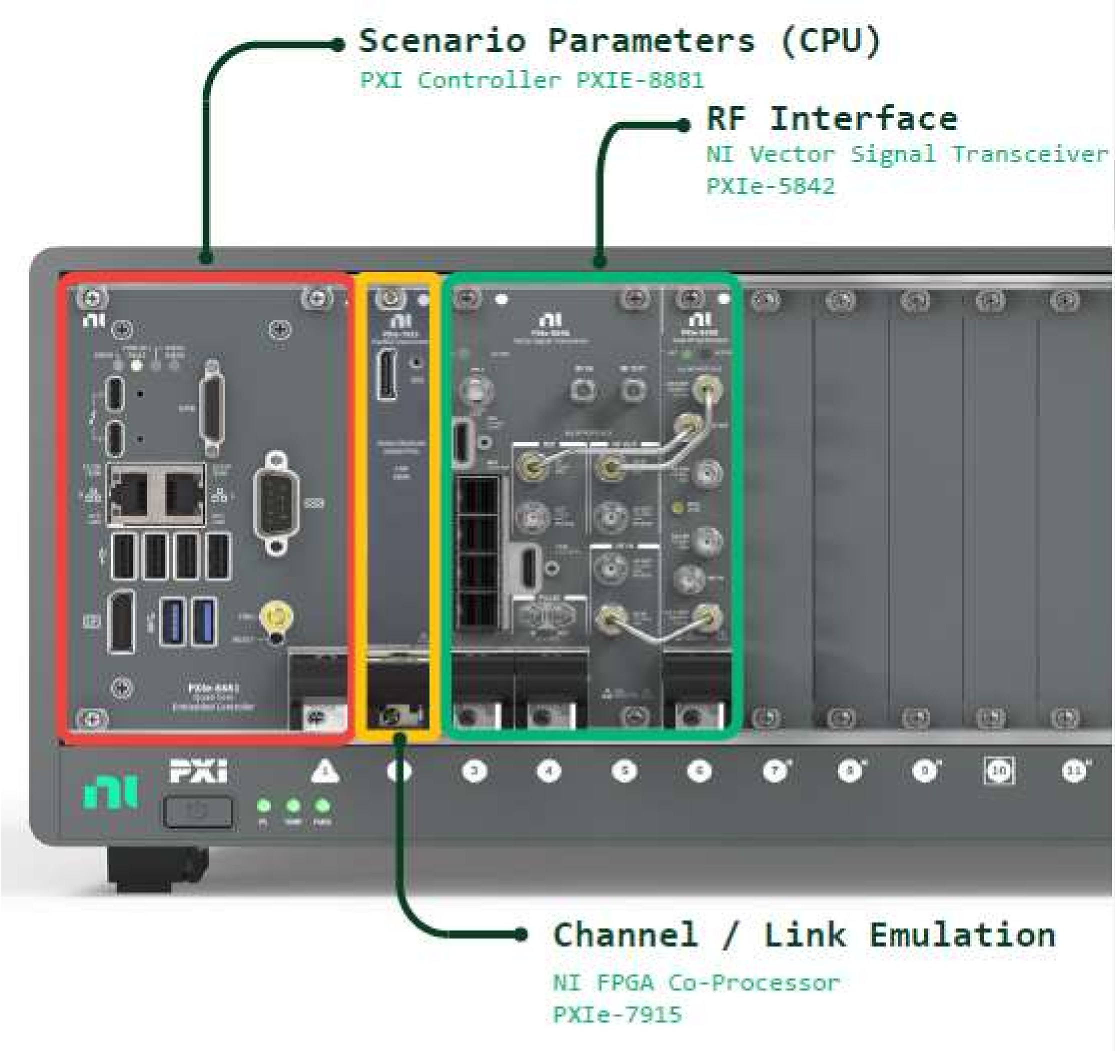

Figure 11: SLE front panel layout (one channel layout)

2.5.8.2 Interface

The SLE is connected to the RF signal through specific coaxial RF connection.

The SLE is connected to network through 2 RJ45 link. One supports the WOL (Wake On Land) that could be used to start remotely the SLE is the bench is used in full remote mode.

The SLE has an synchro input based on a 10MHz clock

2.5.8.3 Form factor

The SLE is based on a PXI cabinet.

2.5.9 UE IAB NTN 20 MHz

2.5.9.1 Description

The UE IAB NTN device is responsible for backhauling the cellular traffic that is fed into the switch through the NTN link.

The UE IAB NTN is compliant with the Rel. 17 and implements the necessary features to support NTN.

The UE protocol stack, which terminates at Layer 3, runs on a portable Linux computer with Core i7. This computer will be connected with a COTS software defined radio frontend from Ettus research.

2.5.9.2 Interface

The frontend is connected to the TX/RX RF signals through SMA connectors.

The frontend is connected to the 10MHz reference clock through an SMA connector.

The host computer and the software defined radio frontend can be connected through USB or Ethernet cables, depending on the selected USRP model.

The host computer is interfaced with the network switch via RJ45 2.5G.

2.5.9.3 Form factor

2.5.10 UE IAB NTN 100 MHz

The description will be provided in the D6.4.

2.5.11 UE IAB TN

2.5.11.1 Description

The UE IAB NTN device is responsible for backhauling the cellular traffic that is fed into the switch through the TN link.

The UE protocol stack, which terminates at Layer 3, runs on a portable Linux computer with Core i7. This computer will be connected with a COTS software defined radio frontend from Ettus research.

2.5.11.2 Interface

The frontend is connected to the TX/RX RF signals through SMA connectors.

The frontend is connected to the 10MHz reference clock through an SMA connector.

The host computer and the software defined radio frontend can be connected through USB or Ethernet cables, depending on the selected USRP model.

2.5.12 IAB server

2.5.12.1 Description

The IAB server is designed to hold multiple applications (CN DU & RU, switching application between TN and NTN, 100MHz UE Amarysoft emulator).

For this purpose, a DELL computer is provided.

The main characteristics of this computer is:

- Processor: I7-14700 with 20 cores
- 32 Go of RAM
- HDD 1To
- Operating system: Linux Ubuntu 22.02

2.5.12.2 Interface

The system is equipped with:

- 1 RJ45 1 Gbits, associated to the motherboard
- 4 SFP+ 10 GBits Intell X710

2.5.12.3 Form factor

The PC is a standard tower PC.

2.5.13 RU Final User

The description will be provided in the D6.4.

2.5.14 UE Final User

2.5.14.1 Description

The UE final user is the device responsible for initiating the communication with the cellular network.

The UE protocol stack, which terminates at Layer 3, runs on a portable Linux computer with Core i7. This computer will be connected with a COTS software defined radio frontend from Ettus research.

2.5.14.2 Interface

The frontend is connected to the TX/RX RF signals through SMA connectors.

The frontend is connected to the 10MHz reference clock through an SMA connector.

The host computer and the software defined radio frontend can be connected through USB or Ethernet cables, depending on the selected USRP model.

2.5.15 WAN/LAN gateway

2.5.15.1 Description

The WAN/LAN gateway is composed of two main equipment. The first one is the WAN/LAN access point with routing firewall and DHCP capacities. The second one is a 24 port switch for connecting all remote control network.

2.5.15.2 Interface

The interface is based on RJ45 connector. The wire shall support 1Gbits flow (Cat 6 mini).

2.5.15.3 Form factor

The form factor will be defined following the purchasing of the equipment.

2.6 SOFTWARE COMPONENT

This chapter detailed the main characteristics of the software component that will be implemented in the PoC.

After a rapid definition of the goal of the component, the needs of the component is described as the implementation potentials (Virtual machine, containers, dedicated component, resources sharing …).

In terms of needs, the following parameters can be precisely defined:

- Computing power (number of core, frequency, memory)
- Interfaces capacity: network capacity (estimate of the volume)
- Synchronisation constrains : time precision, oscillator reference …

The chapter interface presents the component interaction (overview), when defined, the specification as reference (based on 3GPP TS or other reference).

2.6.1 Traffic generator

The description will be provided in the D6.4.

2.6.2 Core Network System

The description will be provided in the D6.4.

2.6.3 Core Network TN/NTN (w/o UPF NTN)

The description will be provided in the D6.4.

2.6.4 Core Network UPF NTN

The description will be provided in the D6.4.

2.6.5 Network Emulator

The description will be provided in the D6.4.

2.6.6 CU NTN

The description will be provided in the D6.4.

2.6.7 CU TN

The description will be provided in the D6.4.

2.6.8 DU NTN

The description will be provided in the D6.4.

2.6.9 DU TN

The description will be provided in the D6.4.

2.6.10 RU TN

The description will be provided in the D6.4.

2.6.11 RU NTN

The description will be provided in the D6.4.

2.6.12 UE IAB NTN 20 MHz

2.6.12.1 Description

This network element implements a UE protocol stack that terminates at layer 3. It supports the RRC procedures defined in D6.1 PoC Functional Architecture, for non-terrestrial deployments. The UE supports all FR1 bands with 15 KHz subcarrier spacing and up to 20 MHZ bandwidth.
To enable direct satellite connectivity in FR1, the functionalities specified in Release 17 have been implemented. The UE stack modifications are described in D4.2 Development and Test Plan.

2.6.12.2 Hosting needs and principle

It will run as an application on a Linux-based operating system. It will be implemented on a dedicated machine, as it is specified in Section 2.5.9.

2.6.12.3 Interface description

To transmit and receive radio signals, the UE will require an SDR hardware. The interface with this hardware is described in Section 2.5.9.

2.6.13 UE IAB NTN 100 MHz

The description will be provided in the D6.4.

2.6.14 UE IAB TN

2.6.14.1 Description

This network element implements a UE protocol stack that terminates at layer 3. It supports the RRC procedures defined in D6.1 PoC Functional Architecture, for terrestrial deployments. The UE supports all FR1 bands with 15 KHz subcarrier spacing and up to 20 MHz bandwidth.

2.6.14.2 Hosting needs and principle

It will run as an application on a Linux-based operating system. It will be implemented on a dedicated machine, as it is specified in Section 2.5.11.

2.6.14.3 Interface description

To transmit and receive radio signals, the UE will require an SDR hardware. The interface with this hardware is described in Section 2.5.11.

2.6.15 IAB Switch

The description will be provided in the D6.4.

2.6.16 DU System

The description will be provided in the D6.4.

2.6.17 CU System

The description will be provided in the D6.4.

2.6.18 RU System

The description will be provided in the D6.4.

2.6.19 UE final user

2.6.19.1 Description

This network element implements a UE protocol stack that terminates at layer 3. It supports the RRC procedures defined in D6.1 PoC Functional Architecture, for terrestrial deployments. The UE supports all FR1 bands with 15 KHz subcarrier spacing and up to 20 MHz bandwidth.

2.6.19.2 Hosting needs and principle

It will run as an application on a Linux-based operating system. It will be implemented on a dedicated machine, as it is specified in Section 2.5.14.

2.6.19.3 Interface description

To transmit and receive radio signals, the UE will require an SDR hardware. The interface with this hardware is described in Section 2.5.14.

2.7 CONFIGURATION OF THE BENCH

2.7.1 TN/NTN Network configuration

This chapter presents the configuration of the hardware used for the network. It presents the IP addressing plan and the reserved set of IP address regarding modules and computers.

The subnet mask is 255.255.255.0

The address will be 192.168.20.xxx.

Due to the specificity of this network, no DHCP server will be implemented and only fixed address will be allowed to ensure the TN/NTN network identification.

If a need of non-fixed address is needed, a specific DHCP server will be introduce.

2.7.2 Remote control network configuration

The remote-control network is separated from the TN/NTN network regarding the address subnetwork configuration.

Each equipment will be addressed with a specific IP V4 address

The subnet mask is 255.255.255.0

The address will be 192.16.10.xxx. The range 10 to 100 are reserved for the PoC component.

For other equipment, a DHCP server is used to give automatic address in the range 101-200.

2.7.3 VPN configuration

By the use of specific VPN, the IP configuration is devoted to the partner methodology.

The IP address, through the VPN is issued from the partner network configuration.

Currently, there is no bridge planned between the connected component and the rest of the PoC component.

Each component should have a VPN client to allow a remote connection.

A backup solution is under analysis to allow partners to connect to the network with a local VPN server (Open VPN or WireGuard protocol). The aim is to allow also the possibility to make demonstration without being in PoC location.

2.8 INTERFACES

2.8.1 TN/TNT interface

The TN/NTN interfaces are defined in the 3GPP 5G NR Technical Specification. The main characteristics of those interface are presented in the D6.1

2.8.2 TLE Sharing

The satellite trajectory is a specificity of the NTN network behaviour.

The TLE (Two Line Element) is a format to describe the trajectory of the satellite regarding few parameters such as position location and velocity at a defined time. The propagation law gives the orbit of the satellite in time.

The TLE is updated as needed (when deviation between real trajectory and prediction are no more converging).

Based on this reference, two transformations are performed. The first one is for the NTN. The TLE is transformed into a message for the destination UE. The second one is for the SLE for computing the Doppler and delay effect of the satellite over the UE position.

2.9 RECONFIGURATION PRINCIPLE

This chapter is dedicated to the reconfiguration of the flux for covering the 3 splits defined in the D6.1.

The main evolution concerns the input data and output data of the network emulator. This component simulates the feeder link (see component description).

The three splits are presented one by one.

The first split with the full gNB on-board is presented here after.

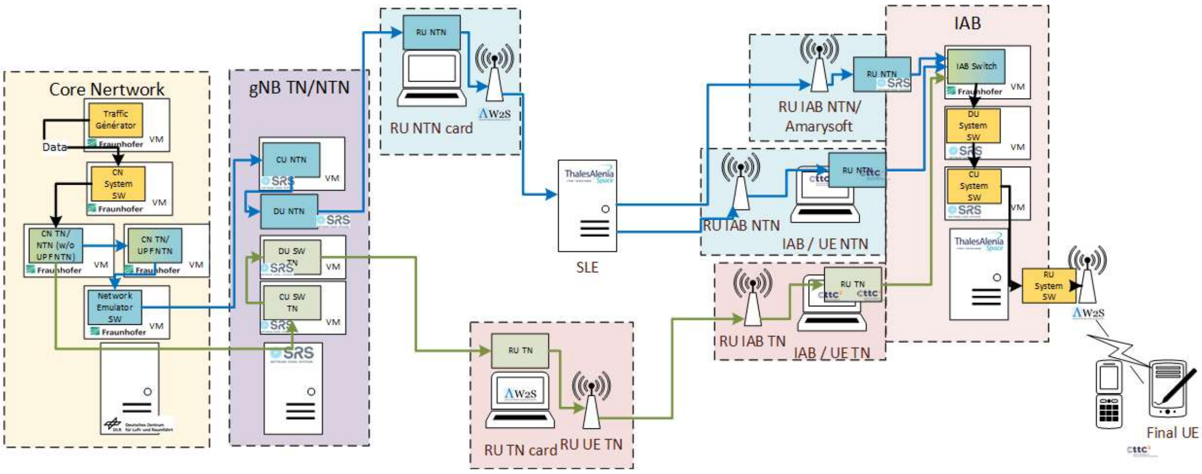

Figure 12: Data flow for Full gNB on-board

The maximum load on the Ethernet links is a two-way link.

For the second split, corresponding to the CU/DU splitting, the data flow is the following:

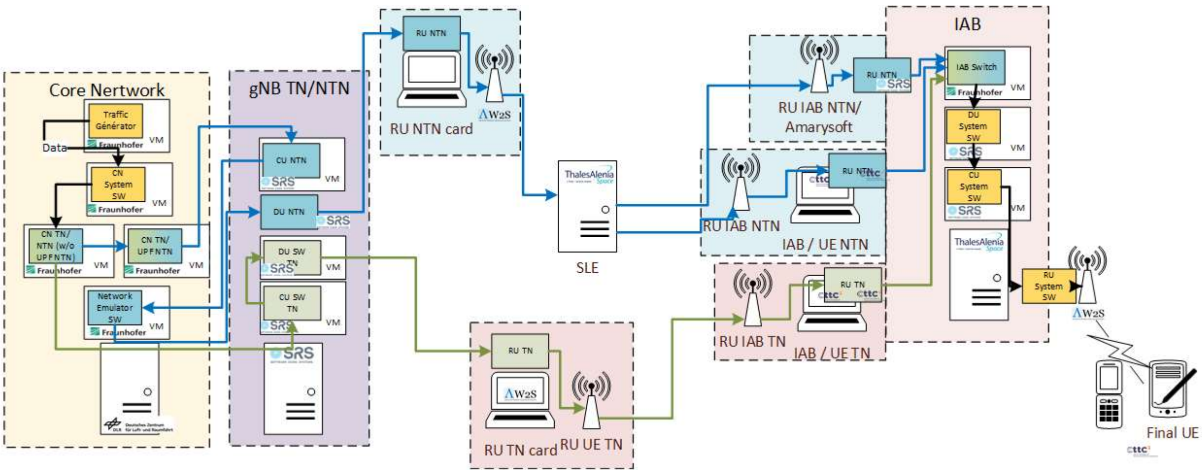

Figure 13: Data flow for the CU/DU splitting

In this configuration, the link between the Core Network logical area and the gNB TN/NTN area has a traffic doubled from the previous configuration. One option in case of congestion, it to add a physical Ethernet link to each server. This will be analysed during the integration phase.

The third split is the full gNB on-board with 5GC functions.

The data flow is presented here after.

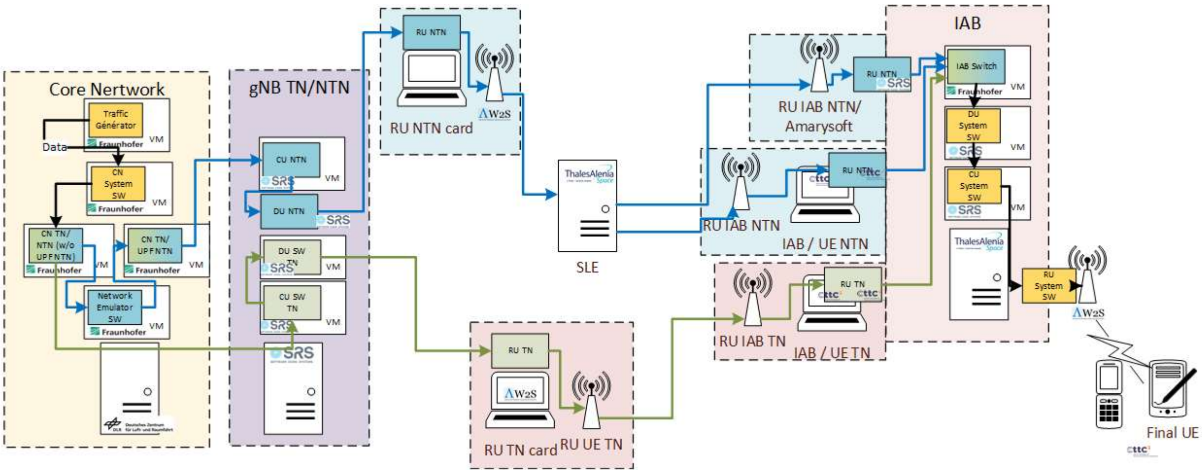

Figure 14: Data flow

3 CONCLUSIONS

3.1 POSSIBLE EVOLUTION SYNTHESIS

The current design is based on the use of VM for all non-critical component. When the integration phase will be started, some evolution regarding the splitting of computing resources will be performed to ensure the network performances and behaviour representatively.

As previously noted, the remote control principle can be also adapted regarding the possibility of each partner.

3.2 SYNTHESIS OF DELIVERIES

The following table reminds the component of the PoC bench.

Description	Provider	Reference / description	Qté	Delivered by
Server for the Core network	Will be completed in D6.4	Will be completed in D6.4	1	DLR
Server for the gNB	Will be completed in D6.4	Will be completed in D6.4	1	SRS
RU NTN	Will be completed in D6.4	Will be completed in D6.4	1	AW2S
RU TN	Will be completed in D6.4	Will be completed in D6.4	1	AW2S
Satellite Link Emulator	National Instrument	Emulate two RF links	1	TAS
RU 20 MHz bandwidth for IAB	Will be completed in D6.4	Will be completed in D6.4	1	CTTC
RU 100 MHz bandwidth for IAB	Will be completed in D6.4	Will be completed in D6.4	1	CTTC
RU TN for IAB	Will be completed in D6.4	Will be completed in D6.4	1	CTTC
Server for IAB	Dell	Desktop computer with SFP+ cards	1	TAS

Description	Provider	Reference / description	Qté	Delivered by
PTP generator	Fibrolan		1	TAS
Switch TN/NTN	Will be completed in D6.4	Will be completed in D6.4	Incl	TAS
10MHz referecence	Include in the PTP generator		1	TAS
Internet Access Point	Will be completed in D6.4	Will be completed in D6.4	1	TAS
Switch / router	Will be completed in D6.4	Will be completed in D6.4	1	TAS
Converter SFP+ -> RJ 45	Will be completed in D6.4	Will be completed in D6.4	5	Partners
SFP+ cables	Will be completed in D6.4	Will be completed in D6.4	15	Partners
RJ45 cables	Will be completed in D6.4	Will be completed in D6.4	10	Partners
RF cables	Will be completed in D6.4	Will be completed in D6.4	10	Partners

REFERENCES

[1] D2.1 : Senarios, use cases and services.

[2] D3.2 : End to end ground and space integrated architecture

[3] D6.1: PoC functional architecture document

