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6GSNS

IMAGINE-B5G

Advanced 5G Open Platform for Large Scale Trials and Pilots across Europe

IMAGINE-B5G Platform Extensions

Version v1.0

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Imagine B-5G

1. Radio Equipment and Advanced Modem Devices (Spanish, Norwegian, Portuguese Facilities)

1.1 Description

IMAGINE-B5G aims to extends its facilities with several units of advanced 5G connected devices, including 5G Indoor routers, 5G Industrial gateways, 5G Outdoor CPEs, and 5G Mobile hotspots. These devices will support advanced features of 5G, enabling new Use Cases (UCs) and Vertical Experiments (VEs) in future Open Calls (OCs) of IMAGINE-B5G. The main integration of the devices will take place in the Spanish facility, however, a subset of them will be used by the Portuguese and Norwegian facilities as well.

1.2 What is available

Release-16 (Rel-16) 5G modem devices supporting commercial 5G bands in Europe. The available devices do not offer support for multiple slices in standalone (SA) configuration mode. In addition, access to 5G modem or debug traces can't be provided.

1.3 Desired extension

Advanced 5G modem devices that support, at least, Rel-16, but preferably Release-17 (Rel-17) and beyond. Such devices should:

- Use new bands not currently available in commercial deployments (e.g., n257, n40, and n77)
- Have the potential to accept adb commands for device configuration.
- Have access to the Qualcomm logs (or similar) for analysing the network packet activity inside the device.
- Support frequency band and operation mode (NSA or SA) configuration.

Maintenance and support must be included until the end of the project. In addition, during the project the provider can include additional 5G connected devices that could support new advanced features. The provided products should support network slicing configurations on the experimentation platforms (supporting several slices simultaneously will be of additional value).
The provider will propose a price per unit for each type of proposed device. The capacity of the provider to provide some level of ruggedization or to integrate renewable sources of energy or batteries will also be considered of added value. The beneficiary will provide support for the integration of other modems.

2. Immersive Equipment (Spanish, Norwegian Facilities)

2.1 Description

Bi-directional transmission of immersive technology data is one of the key drivers of 6G, as this information has very strict E2E latency and bandwidth requirements. In IMAGINE-B5G, we take a step closer to 6G by integrating XR, haptics, and robotics technologies with the B5G platform to test and validate immersive applications. These B5G applications will be developed and tested between Spain (UPV) and Norway (UiO), and trials for the education vertical will be performed, under the project's UC: Immersive Remote Education.

In addition, holographic B5G applications will be developed and tested in the Spanish facility (UPV campus), under the project's UC: Holographic Communications, with the objective of assessing KPIs and KVIs of holographic communications and perform trials for the education vertical and others. This PE aims to extend UPV's Immersive Lab with additional holographic equipment.

2.2 What is available

Norwegian Facility:

UiO's SIN-Lab is a playground for immersive networking research. SIN-Lab consists of:

- State-of-the art cameras and LIDARs (e.g., tracking camera, Velodyne LIDAR, Intel RealSense LIDAR(L515), Azure Kinect, and several headsets for VR and AR)
- A Shadow Hand and a UR10e arm
- Haptic gloves and Suit Full Body

The lab also has access to an advanced 5G indoor network to enable wireless and remote scenarios.

Spanish Facility:

UPV's Immersive lab is an experimental facility that supports multiple immersive communication technologies, such as haptics and remote driving. UPV's Immersive lab consists of:

- Haptic gloves and suites with feedback and control capabilities
- Immersive cockpits with monitors, controls, and VR/AR headsets
- Volumetric and 360° video capture
- Multiple AGVs and a robot arm
- Chromas suited with specific processing HW and SW
- LEDWalls

The lab also has advanced 5G connectivity, with both indoor and outdoor coverage to enable wireless and remote scenarios.

2.3 Desired extension

This PE aims to extend the UiO and UPV labs with advanced telepresence, haptic, holographic HW and SW, and robotics equipment and technologies. The equipment and work to perform for the PE is listed below:

- Body sensors (e.g., gloves, vests, suits, etc.) for capturing different parts of the remote participants, especially those that include haptic and force feedback.
- Volumetric capture setups, capable of capturing and transmitting point clouds, representing the remote participants and large volumetric displays capable of representing in real-time remote subjects, either as 3D video or avatars.
- Actuators that can reflect in the local scenario the actions of remote participants (robotic hand and arms, hand, and arm exoskeleton, etc.).
- Realistic avatar technology capable of animating photorealistic models of remote participants (ideally presenting their real aspect), including clothes.
- Holographic equipment to possess the capability to capture a subject against a solid color background and faithfully represent it without altering its aspect ratio, ensuring an immersive and lifelike viewing experience. Moreover, the setup must be portable, enabling its transportation to various locations beyond the immersive lab, thereby facilitating diverse telepresence scenarios. Additionally, it is crucial that the chosen equipment can execute the entire capture-transmission-display process in

real time, while also facilitating bi-directional communication between the audience observing the holographic display and the subject being represented.

Maintenance and support for the VEs experiments of the Immersive Remote Education or the Holographic Communications UC until the end of the project.

3. Advanced Open-Source RAN Solutions (French Facility)

3.1 Description

In IMAGINE-B5G, the French facility offers a completely open-source implementations based on OpenAirInterface (OAI), which is the only 100% open-source project that provides 3GPP compliant reference implementations of the 5G NR gNB running on general purpose computing platforms in conjunction with off-the-shelf SDR cards with vibrant developer communities. The ambition of the project is to go beyond the state-of-the-art 3GPP Rel-16 features that are already deployed in the current experimental facility. The goal of this PE is to introduce new features from 3GPP Rel-17 and explore features from the upcoming Rel-18, currently under standardisation. The proposed features should leverage the 5G facility with new RAN features that will allow running advanced vertical UC, such as relay with flying drones.

3.2 What is available

- A 5G facility composed of open-source solutions, mainly OAI 5G platform [2]. An extensive description of the facility is available in the facility description document.
- A CI/CD platform to test features before merging to the official code base. The details on the CI/CD platform is available in [3].

3.3 Desired extension

- Implement 3GPP compliant features to support Short Data Transmission (SDT) such as the Two-step RACH feature.
- Implement the F1 relaying feature to support the Integrated Access and Backhaul (IAB). We can imagine a DU onboarded on a drone playing a role of a relay between the ground mmWave gNB and Non-Line Sight (NLoS) User Equipments (UEs) where the drone' DU communicates with the ground CU using the mmWave link.
- Adapt OAI to support Reduced Capability (RedCap) devices. OAI should be tested with a real COTS RedCap device.
- Implement an FR2 MAC scheduler, in OAI, that considers beams and radio resources management.
- Integrate and test Reconfigurable Intelligent Surfaces (RIS) with OAI mmWave platform.
- Propose and implement RIS control algorithms to enhance the cell coverage and avoid UE' disconnection due to obstacles.
- Propose and implement algorithms to enable Joint Communication and Sensing (JCAS) using OAI and RIS.

Maintenance and support must be included until the end of the project.

4. 5G Core (Norwegian, French, Portuguese, Spanish Facilities)

4.1 Description

PNI-NPN (Norway, Spain): Advanced core network solutions supporting network exposure and data analytics APIs are currently gaining high interest from developers within the telco domain and from various verticals. The said APIs can be consumed by (network/vertical) applications for tailored and programmable services. Moreover, P4-based UPF is gaining momentum for the data plane acceleration and programmability, among others. The concept of Non-public network (NPN) or private network is a network intended for private use and is supported by the 5G specifications. NPN is necessary for organizations that require their data to stay within their premises due to privacy and security concerns. The benefits of NPN include optimized coverage, reduced latency, and local control. Stakeholders from various sectors (e.g., PPDR, Healthcare, Media, etc.) have expressed significant interest on public network integrated NPN (PNI-NPN) to seamlessly support their operations between the two domains.
Advanced Open-Source Core Solutions (France): In Imagine-B5G, the French facility offers a completely open-source implementations based on OpenAirInterface (OAI). OAI CN is 3GPP Rel-16 compliant including the following Network Functions (NFs): NRF, AMF, SMF, UPF, UDM, UDR, AUSF, NSSF, PCF, NEF, LMF and NWDAF. The ambition of the project is to integrate new Network Functions (NFs) and add more features to the current Core Network to support Beyond 5G UCs.

Interfaces to Private Network 5G Core (Portugal): One of the focus areas of the Portuguese facility is 5G private networks. Several standalone 5G cores, for use in private networks, available in the market, that implement most of the defined 3GPP functions (e.g.: UPF, SMF, AMF, PCF, etc) for simplicity don't follow the standard interfaces to communicate between functions. This approach creates difficulties in the integration of external functions with the functions inside the core 5G (e.g.: connect external PCF with core NRF or SMF).

4.2 What is available

Norwegian Facility: The Norwegian facility has a multi-vendor and cloud-native 5G SA core that includes AMF, SMF, AUSF, NSSF, NRF, UDM and UPF. NEF and NWDAF integration are in progress, but are highly dependent on what can be exposed from the other CNFs. In addition, the Norwegian facility has a public network (main platform) and a number of private networks (e.g., Network on Wheels, customer-premise NPNs).

Spanish Facility: In the Spanish facility, there are several private networks (e.g., the private 5G network of UPV) that could be interconnected to the public network of Telefonica. The private 5G network of UPV will have a private APN provided by Telefonica.

French Facility: A 5G facility composed of open-source solutions, mainly OAI 5G platform [2]. An extensive description of the facility is available in the facility description document. All the NFs status is available in the OAI GitLab [4]. The facility includes a CI/CD platform to test features before merging to the official code base [3].

Portuguese Facility: The Druid Raemis 5G core [1] is specifically targeted at private networks and optimised for business UCs. The Raemis platform exposes the internal state and interoperates with external applications through a REST API, which is not fully compliant with relevant 3GPP standards.

4.3 Desired extension

Norwegian and Spanish Facility:
We are interested in 5G SA core vendors that could (further) develop and integrate:

- CNFs with a rich set of network capability/data exposures either in a single-vendor or multi-vendor setting.
- A P4-based UPF in a multi-vendor setting.
- PNI-NPN support either in a single-vendor or multi-vendor setting, in both the Norwegian and Spanish facilities.

Maintenance and support must be included until the end of the project.

French Facility:
We are interested in the following aspects:

- Extend the current NEF implementation with new features to support Imagine B5G UCs.
- Extend the current NWDAF implementation with new features, including Machine Learning UCs to support the project's UCs.
- Implement new CAMARA APIs to support B5G UCs.
- Extend the current LMF to support B5G UCs.
- UPF extension to support monitoring.
- develop an OEM for OAI 5G CN that allows deploying, configuring, terminating CN instances via a graphical web interface. Besides, it allows the visualisation of different events exposed by the CN.

Maintenance and support must be included until the end of the project.

Portoguese Facility:
This PE is aimed at companies that wish to develop integration gateways to expose standardized 3GPP interfaces allowing the interconnection of external 3GPP functions with the internal 3GPP 5G core functions of the private network core vendors. As a result, it is expected that PNI/NPN scenarios can be realized on the facility by leveraging the integration gateways and the different core solutions available at the facility.
Maintenance and support must be included until the end of the project.

5. OPENRAN (Spanish, Norwegian, Portuguese Facilities)

5.1 Description

The O-RAN advancement in both standardization and open-source front, have incredibly enhanced the technology readiness for Open RAN in Europe and globally. However, the widespread adoption of Open RAN in Europe is still facing significant challenges. For example, vendor diversification, although brings flexibility and new features, can bring significant challenges on integration complexity and costs, especially when standard in O-RAN is also in the process of being materialized. In fact, operators have identified such integration complexity as one of the biggest challenges that may greatly hinder the adoption of Open RAN in Europe. IMAGINE-B5G has the ambition towards advancing the development, integration, and validation of the Open RAN components, including newly developed xApps solutions from third parties in the project.

5.2 What is available

- A 5G facility composed of open-source solutions, mainly OAI 5G platform [2]. The platform includes two O-RAN interfaces: the Fronthaul interface and the E2 interface. An extensive description of the facility is available in the facility description document.
- A CI/CD platform to test features before merging to the official code base.

5.3 Desired extension

- Integrate and test third party RUs supporting split 7.2 in both FR1 and FR2.
- Implement and test intelligent xApps to control/configure the RAN to enforce IMAGINE-B5G UCs.

Maintenance and support must be included until the end of the project.

6. Advanced Edge-Cloud Continuum (Norwegian Facility)

6.1 Description

Edge-cloud continuum refers to the seamless integration among computing facilities – ranging from public cloud, enterprise datacenters, to (far) Edge nodes. This will enable (dynamic) network function/service/application placement within the continuum, when and where needed.

6.2 What is available

The Norwegian facility has a central datacenter and multiple edge nodes that can host network functions/services and applications. Moreover, a full-stack orchestration system, supported by RedHat (infrastructure orchestration) and Nokia (network service orchestration), is currently available.

6.3 Desired extension

We are interested in extending the facility with:

- A monitoring framework for performance and energy efficiency metrics, at the infrastructure, network function/service and vertical application levels within the continuum.
- Advanced multi-cloud orchestration mechanisms for network function/service/application placement/migration and scaling decisions, among others, towards performance/energy efficiency targets. AI/ML-driven approaches are desired.

Maintenance and support must be included until the end of the project.

7. Network as a Code (NaC) (Norwegian, Spanish Facilities)

Network as Code (NaC) is a disruptive concept that simplifies and abstracts network programmability and resources configuration resulting on connectivity management and other network related or derived capabilities, guaranteeing interoperability among multi-vendor network providers, which can be bundled easily and directly from business logic down to application code generation. NaC reverses the perspective to

an ecosystem application developer point of view towards multi-domain networks and enables application developers easily to create new mission critical applications or distributed service chains that rely on network connectivity, edge cloud and network insights without the need of service provider topology awareness. For service providers Network as Code presents an opportunity to monetize 5G network capabilities far beyond basic connectivity and reduce the time to market to a bare minimum compared to current scenarios. Furthermore, NaC provides way to aggregate and abstract 5GS capabilities towards a new business model and offering for digital ecosystems.

7.1 Description

Network Programmability (Norway):
Application development team ready to experiment with the NaC APIs offered in a SaaS model, where a vertical application integrates the offered APIs to its application. NaC abstracts the complexity brought by a 5GS ecosystem, by focusing on the UC itself instead of building knowledge on a myriad of technologies and network capabilities which can change depending on the use-case by deploying and configuring the network that will support a use-case and the Service Level requirements (e.g., bandwidth, latency, and other service-related parameters).

Weather and Ground Agriculture Stations (Spain) :
The provider of sensors units will offer several units of Weather stations and Ground agriculture stations equipped with batteries and solar panels to be deployed in isolated locations without external energy power. These stations will be integrated with the NaC project API of the Spanish facility for the provisioning, configuration, and monitoring operations. This infrastructure will be used for VEs of the UC: Smart Agriculture in Rural Areas, and it will be also used to optimize the energy efficiency of the Spanish facility.

7.2 What is available

Norwegian Facility:
5G SA facility site, special network (slice) API offered through NaC integrated with SO (Service Orchestration) layer. This is offered in an SDK platform available for the application developer. During the second half of 2023 the APIs will gradually be extended with QoS and Device Insight APIs – made available for the developer.

Spanish Facility:
The rural site in Soria of the Spanish facility covers an agriculture area and it aims to trial a zero emissions solution for monitoring and surveying agricultural sites, being fully powered by renewable energy, and providing connectivity to different IoT devices and HW to perform computation at the edge.

7.3 Desired Extension

Norwegian Facility:
An application development team willing to invest time in familiarizing with the SDK and belonging APIs, that can take benefit of these high-level capabilities in its application. Ideally it should utilize the specialized network capability (slice management) where that would fit best. Drone control would be an example of a use-case where a drone is monitoring an area, and during a regular scenario, it can use a “low bandwidth SLA” which will save 5GS resources (e.g. energy consumption, processing capability), but once it detects a scenario that demands higher level of detail for processing than it starts to use an “high bandwidth SLA”, the image processing and the capability to change configuration in real-time are key elements for such a UC.

Spanish Facility:
Ground and weather stations with 5G modems that support Slicing and self-provision using NaC. The station must support new NR SA bands for experimentation like n40 or n78. The station will be connected to the 5G network with a provided 5G modem and IMSI. A sensoring backend application needs to be developed in a Virtual Network Instance and deployed in the available 5G infrastructure to support sets of sensors stations. The sensors stations can also host some USB small cameras that can provide real-time video to the backend application. The provider will use the available project NaC APIs to instantiate new sensors units with different slicing profiles. The provider will also be responsible of the installation and maintenance of the units in the several of the project locations. Some of the stations will be installed in UPV, Valencia Port and Madrid locations. The beneficiary is expected to provide 24-month support for the stations provisioning, operation and monitoring, support for the deployment of the stations in Spanish sites, and integration with NaC APIs and support in the VEs of the "Agriculture in Rural Areas" UC. Maintenance and support must be included until the end of the project.

8. Intent-driven Zero-touch Solutions (Norwegian Facility)

8.1 Description

Intent is a key enabler for zero-touch automation across multiple technology domains and to serve multiple vertical industrial customers. As intent only defines the goals and expectations while leaving the details of "how the target is achieved" to individual domains, it gives flexibility and agility to develop and improve the "how" solutions without influencing the communications of the expectations and outcomes. Intent-driven solutions will be realized in a multi-layer architecture that allows intent of different types to be defined and translated across multiple domains and layers. This feature will benefit VEs in the next OCs, for instance to enable customized network slices and configurations, tailored to the verticals' (PPDR, Media, Industry 4.0, eHealth, etc.) requirements.

8.2 What is available

The Norwegian facility has multiple computing facilities and radio sites across the country, encompassing multiple technology domains. Moreover, a full-stack orchestration system, supported by RedHat (infrastructure orchestration) and Nokia (network service orchestration), is currently available.

8.3 Desired extension

We are interested in:

- Intent blueprints and/or data models for IMAGINE-B5G UCs and tailored targets (performance, energy efficiency, security, and/or business objectives) – across layers (vertical layer, network service layer, infrastructure layer) and across technology domains (RAN, transport network, core network).
- AI/ML-driven intent translation across layers and across technology domains

Maintenance and support must be included until the end of the project.

9. Functionality Extensions and Facility Expansion (Portuguese Facility)

9.1 Description

To accommodate more demanding UCs and to showcase the potential of advanced 5G functionalities the facility infrastructure would benefit of the deployment of bleeding edge technology as well as the possibility to expand the reach of the facility beyond the currently available geographical locations. In this sense, increasing the level of exposure of the capabilities being offered at the facility, the deployment of advanced data analytics solutions, and an increased controllability of the transport network are highly desirable for exploring PNI-NPN realizations towards the fulfilment of IMAGINE-B5G UCs (e.g., Industry 4.0).

9.2 What is available

The facility has different Core and RAN solutions available in a contained geographical area but spanning over different domains. Domain interconnection is achieved through traditional networking equipment.

9.3 Desired extension

- Even though the Portuguese facility features a 5G core with LMF (Location Management Function), it does not support 5G positioning systems in the RAN according to latest 3GPP specifications (e.g., NRPPa positioning protocol, etc.).
- Bleeding edge technological solutions for exposure and data analysis.
- Flexible deployable RAN solutions (e.g., In-a-box solutions, IAB-based solutions)
- Increasing the flexibility and the functionalities offered at the data plane by leveraging programmable hardware (e.g., P4-based UPF implementations, programmable transport network between the Core and the NFVI, and between the different domains as well).

Maintenance and support must be included until the end of the project.

10. Assurance and Automation Solution (Portuguese Facility)

10.1 Description

The IMAGINE-B5G UCs targeted by the Portuguese facility require in general high reliability and performance. However, just having monitoring and orchestration capabilities are not enough to ensure that a given application is receiving the agreed upon quality of service, which in many of the UCs conceived may be critical. Instead, the system should be able to react to changing network conditions and optimize the performance automatically. To this end, an end-to-end service assurance solution is required. The impact of such solution is not contained, instead it will impact every UC realized on top of the system.

10.2 What is available

The facility has in place monitoring and orchestration solutions. Monitoring is based on a variety of tools with all monitoring information being centralized in a Prometheus server and made available through REST APIs and orchestration is mainly based in OSM.

10.3 Desired extension

Integrating an advanced end-to-end assurance solution that should is able to leverage the exiting monitoring solution (or improve it) to observe the network and extract valuable insights that are used not only for the continuous validation of the end-to-end service, but that can also react to certain network conditions leading to zero-touch and self-healing behaviours. Maintenance and support must be included until the end of the project.

References

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