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5G-STARDUST

5G-STARDUST's ambition is to deliver a fully integrated 5G-NTN autonomous system with novel self-adapting end-to-end connectivity models for enabling ubiquitous radio access.

OVERVIEW

5G-STARDUST is aimed at proving the unification of Terrestrial Networks (TNs) and Non-Terrestrial Networks (NTNs) into a holistic architecture, building on the foundations of 5G and paving the way towards 6G communication systems. The proposed unification framework is conceived to flexibly serve a number of possible Use Cases (UCs), relevant for mobile and satellite operators, vendors, and service providers. In this respect, the overall concept "orbits" around the exploitation of regenerative satellite payloads, hence allowing NTN nodes to act as smart 5G space nodes, implementing gNB functions in space as well as User Plane Functions.

CONCEPT/ ARCHITECTURE/ TECHNOLOGIES

The architecture concept is centred on the implementation of gNB functionalities in space, either entirely within each space node or distributed (i.e. through 5G functional splits in space). In particular, the main focus is on the case of integrating 5G-enabled Low Earth Orbit satellite constellations with TNs. Hence, 5G-STARDUST's ambition is to prove the coexistence of TN and NTN segments within a unified network architecture concept, building on key pillars: 1) unified 5G NR-native radio interface, 2) self-organised network architecture, 3) user-centric satellite system design, 4) multi-link exploitation, and 5) AI-based optimisation of radio and network functions. The selected key functionalities are then being integrated in a dedicated lab testbed for final demonstration.

INNOVATION

The main innovation pillars constituting the baseline of 5G-STARDUST are i) self-organised network architecture building on a flexible space configuration with gNB operated in space, ii) unified radio interface counting on user-centric beamforming and AI-based Radio Resources Management (RRM) optimisation, as part of a reference O-RAN based architecture fusing together TN and NTN components, iii) AI-based multi-link optimisation aimed at scheduling communication link and dispatching traffic flows according to Quality of Service (QoS) requirements and link capacity availability, iv) QoS-oriented network architecture relying on an overarching Software-Defined Networking (SDN)-based layer and on Artificial Intelligence (AI)-based network slicing optimisation. As to this latter point, an important role is certainly also played by the deployment of routing algorithms in space and the switch from TN to NTN infrastructures, which is triggered and managed at Core Network (CN) level. Last but not the least, an important innovation element is the allocation of dedicated network functions in space and the potentials of even deploying application service onboard satellites, such as multi-access edge computing, further reduce the overall latency of reference services.

USE CASES/ SCENARIOS

5G-STARDUST project identified key UCs to demonstrate the functionalities of an integrated 5G-based TN-NTN network, comprising mobile transportation systems, PPDR, private and governmental networks, residential broadband, and hyperconnected automotive sector. Out of these scenarios, 5G-STARDUST further narrowed down the selection to 5G-enabled residential broadband and aeronautical communications to demonstrate the corresponding functionalities in the so-developed lab testbed. As to the first scenario, the objective is to show the seamless transition from TN to NTN achieve more cost-effective operations (i.e. network switch at night). On the other hand, the second scenario deals with the coexistence and later switch from TN to NTNs in the various phase of aircraft flights, i.e. from take-off to landing through cruising phases. As such, the objective is to provide the switch from on e network to another, once either of the two available networks (i.e. TN or NTNs) are not any longer available or offer less satisfactory QoS/QoE guarantees than the other, hence necessitating a network handover. The considered scenarios are being implemented in a common testbed lab (expected to reach TRL4/5 at the end of the project), where the main elements necessary to demonstrate end-to-end connectivity are being integrated. The overall layout of the functional testbed architecture and the description of the related SoftWare/HardWare (SW/HW) components is then summarised in the next section, where the status of the integration process is also shortly discussed. Finally, it is also worth noticing that the procured testbed will be considered the main outcome of the project in light of its capabilities of showcasing the full functionalities of an integral 5G-enabled NTN system. Nevertheless, the project has been also developing standalone simulation and emulation tools to prove the other findings of the project, though not reaching the necessary maturity for being implemented in the general Proof-of-Concept (PoC) of the project.

RESULTS

The main outcome of 5G-STARDUST is a PoC for demonstrating integrated 5G/6G-NTN communication system. The PoC includes TN and NTN segments, transporting data from servers to User Equipment through shared RAN and 5G CN infrastructures. In particular, UE prototypes operating at FR1 and FR2 frequency ranges are used, able to either use TN or NTN connectivity, achieved through dedicated gNBs, either on ground or space. The space segment is characterised by realistic channel emulators. The Centralised/Distributed Unit parts of the gNB are implemented as SW components in a dedicated HW, while the Radio Unit is directly embedded in Xilinx boards. It is noteworthy that the overall setup will be used for verifying the overall system architecture and for validating the benefits of an end-to-end 5G enabled NTN architecture, through real-world applications such as video streaming, file transfer, and web browsing. Finally, the preliminary results collected for the assessment of the unified radio interface and the self-organised network paradigm prove the performance improvements coming from the deployment of a unified 5G/6G unified network architecture in terms of servicing many use cases and offering satisfactory Key Performance Indicators.

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