

Satellite edge computing for 5G rural applications

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Abstract—This demo shows the value of edge computing and local break-out in rural 5G -and beyond- deployments, where satellite is used as backhaul. It also demonstrates the use of the Open5GENESIS suite for experiment automation and results analysis.

Keywords—rural 5G, satellite/5G integration, edge computing

I. OVERVIEW

One of the ambitions of 5G -and beyond- is to provide a truly ubiquitous communication infrastructure. To that end, close integration with satellite communication infrastructures and, more generally, with Non-Terrestrial Networks (NTN) is envisaged, in order to extend 5G coverage to rural and, underserved areas. One of the most market-ready scenarios for satellite/5G integration is the use of the satellite link as backhaul, connecting the 5G radio front-end (gNB) with the core (5GC).

Naturally, the introduction of the satellite link comes with increased latency (especially for geostationary orbit satellites) as well as bandwidth limitations. To mitigate this effect for specific applications, a satellite edge computing infrastructure can be adopted, where 5G applications are deployed at the satellite edge close to the gNB, rather than in the cloud. With the use of local break-out (LBO) configurations, the data plane functions of the 5G core are also deployed at the satellite edge, allowing edge application traffic to be locally routed, rather than traverse the satellite backhaul. This is the configuration to be showcased in this demo.

Our setup makes use of the integrated satellite/5G infrastructure of one of the 5G experimental platforms of the H2020 5GENESIS project [1], namely the Limassol platform [2]. The demo setup implements a 5G stand-alone (SA) network, backhauled by a geostationary satellite link. The experiment and the measurements are automated using the experiment automation suite (“Open5GENESIS”) [3], developed in the 5GENESIS project.

The network setup comprises three main segments:

- the core data centre, also hosting the 5G core functions (based on the open-source Open5GS core), the Management and Orchestration components, as well as the Open5GENESIS suite, deployed at Primetel premises in Limassol, Cyprus
- the satellite backhaul link, over the Avanti Hylas 2 geostationary satellite

- the remote “5G hotspot”, comprising the satellite antenna terminal, the edge computing infrastructure (compact edge server) and the 5G gNB, integrated in a portable rack (Fig.1).



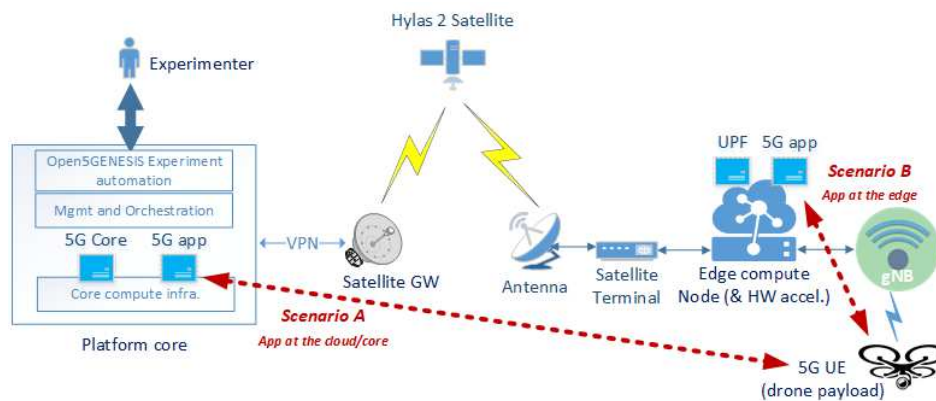
Fig.1. Portable “5G Hotspot” deployed at the satellite edge

Table I provides further details on the technical specifications of each segment.

TABLE I. DEMO SETUP SPECIFICATIONS

Component	Specs
5G Core	Open5GS v.2.2.6 (Rel.16)
5G configuration	Stand-Alone (3GPP Option 2)
Experiment automation framework	Open5GENESIS suite [3]
Satellite backhaul	Ka-band over Hylas 2 satellite, 15Mbps DL/5 Mbps UL
ML acceleration @ Edge (NPU)	Intel Neural Compute Stick 2
gNB	Amari Callbox Classic
5G NR configuration	50 MHz, 2x2 MIMO, band 78
UE	Raspberry Pi 4 w/ Waveshare 5G Hat (Snapdragon X55)

Regarding the use case to be demonstrated, we have developed a smart agriculture bespoke application, which is more relevant for rural deployments. The application uses computer vision and Deep Learning-based analysis of drone-captured crop images for detection of unwanted weed in rural fields.



The model runs on Tensorflow and benefits from hardware acceleration capabilities (Neural Processing Unit – NPU) at the edge. The images are captured by a 5G UE (Raspberry Pi with 5G modem attached) mounted on a drone scanning the crop and are sent for analysis to the back-end application. To demonstrate the value brought by satellite edge computing, we consider two alternative scenarios:

- In Scenario A (without edge computing), all 5G Core functions are deployed at the core data center. The smart agriculture application is also deployed at the core. Traffic handled by the application has to traverse the satellite link.
- In Scenario B (with edge computing enabled), the data handling functions are deployed at the edge to enable local break-out functionality. The smart agriculture application is also deployed at the edge.

The demo setup topology is presented in Fig.2. The main KPI to be measured is the application response time measured at the UE, i.e., the time interval from the submission of the captured image by the UE until the reception of the outcome of the image analysis. This is drastically reduced in the edge deployment scenario.

For the planning and automation of experiments, as well as results analysis, the Open5GENESIS suite is employed. Open5GENESIS uses a centralised coordination platform (deployed at the core), which communicates with a bespoke measurement agent at the UE. The agent, in turn, interfaces with the smart agriculture application using a REST API to collect application-level metrics. The experimenter interacts with the Open5GENESIS Portal (Fig.3) to plan and execute the experiment as well as to visualise the results.

- A demo of the application working on-air
- A live presentation of the KPI measurements, as conducted via Open5GENESIS, including the experiment planning procedure and the visualisation and analysis of results, both for Scenario A and Scenario B.

II. INNOVATION

To our knowledge, this is the first public demo to integrate 5G Stand-Alone, satellite backhauling, edge computing and local break-out under a single platform. All these technologies are highly complementary and, when combined, offer significant added-value. A second key innovation is the integration and presentation of the Open5GENESIS suite, the main open-source result of the 5GENESIS project, which can be easily integrated with any 5G -and beyond- testbed to enable automation in verticals experimentation as well as KPI validation.

III. RELEVANCE AND INTEREST

The scope of the demo is directly relevant to many research areas identified in the IEEE MeditCom Call for Demos, including: *5G Mobile Systems and their Components; Network Architectures, SDN, NFV; Satellite and Space Communications; Network Applications and Services; Performance Evaluation of Communication Systems*. We believe the communities/audience should be particularly interested in this demo for two main reasons; First, because of the innovative nature of the end-to-end integrated network bringing together multiple relevant technologies (as explained above). Second, for the opportunity to get to know relevant open-source solutions, such as Open5GS (as core) and Open5GENESIS (as experimentation enabler), which can be exploited for other experimental 5G setups also.

ACKNOWLEDGMENT

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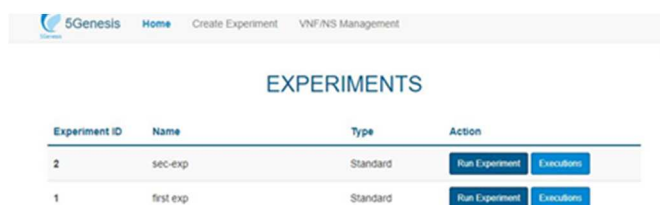


Fig. 3. Experiment management using the Open5GENESIS portal

In this context, the demo includes the following elements:

- An overview of the demo setup and presentation of the equipment and main specs