ARTES 5G TINA

A novel approach in regenerative payload for supporting emergency use case over Push-to-Talk application.

Authors: Panagiotis Mystridis, Vaia Kalokidou, Arunprakash Jayaprakash, Ashweeni Beeharee
(Satellite Applications Catapult)

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EXECUTIVE SUMMARY

The ESA ARTES 5G TINA project explores and demonstrates future 3D architectures, between terrestrial and non-terrestrial networks. Transparent payload scenarios, as well as processing payload scenarios where 5G RAN, core and application functions are hosted on a satellite will be analysed to meet the use case requirements of the project. In this paper, we propose as well, a novel architecture for next generation regenerative satellite payloads, by introducing a P4 language-based software switch on the payload in the 5G user plane path, as a traffic steering and offloading function, to support a Push-to-Talk (PTT) emergency use case.

INTRODUCTION

Terrestrial communications have evolved from 3G to 4G and 5G, offering high data rates and low latency for various technologies. However, they have limitations like poor remote coverage and transmission delays. Advancements in aerospace technology, including LEO satellites and HAPs, expand non-terrestrial platforms for telecommunications, opening new possibilities for research and their use in terrestrial applications [1]. In this context, the third-generation partnership project (3GPP), has been investigating, and gradually standardizing, the adaptation of 5G wireless technology to support Non-Terrestrial Networks (NTN), looking at the merits and challenges that Terrestrial Networks (TN) and NTN coexistence brings [2]. Paving the way towards satellite integration into the 5G ecosystem, various payload architectural options for a satellite-based NG-RAN have been defined in 3GPP TR 38.821. In transparent bent-pipe satellite-based architecture, the payload implements frequency translations and power amplification for uplink and downlink directions. The regenerative payload-based architecture enables on board processing and implementation of gNodeB (gNB) functionalities like modulation/coding, demodulation/decoding, switching, routing, etc. on the satellite, collocated with 5G VFs such as AMF and UPF [3]. However, this architectural shift comes with certain challenges, related to the limited computing resources on the payload as well as the increased overhead caused by 5G Virtual Functions (VFs) interaction.

This white paper introduces an emergency use case based on Push-to-Talk application and a novel architecture based on the deployment of a P4 software switch on the satellite payload, over the user plane N3 interface between gNB and UPF, as a traffic steering, traffic offloading function, proposed as part of ESA ARTES 5G-TINA project.

The ARTES 5G TINA is an ESA funded project that aims to identify applicable 3D NTN topologies, as well as the use cases they individually are meant to support. In addition, scope of the project is to establish a clear framework within which future designs of NTN can be critically evaluated and demonstrated. The proposed solution exploits the advantages of programmable software switches to provide reduces latency, less overhead and reduced load in the limited hardware and software resources on a satellite payload.

EMERGENCY USE CASE

The objective of the emergency use case is to provide immediate, reliable, and efficient voice communication, enabling rapid response, effective coordination, and enhanced situational awareness for emergency response teams.

PTT brings critical two-way radio communications into the IP era. Using the data services of cellular IP networks, broadband services and the Internet, PTT allows its radio dispatching functionalities to be used to co-ordinate communications within and across agencies, organisations and territories without the coverage and capacity restrictions of traditional dedicated private mobile radio infrastructure. Users of the PTT service access always-on, always-connected operational chat channels, instantly broadcasting to groups in real time through the push of a button.

In an emergency use case, a PTT application can be incredibly valuable due to its ability to provide fast and efficient communication among individuals or groups. PTT enables:

Rapid Communication: PTT enables instant voice communication, allowing emergency responders, such as police, firefighters, or medical personnel, to quickly relay critical information to one another. It eliminates the need to dial phone numbers or wait for connections, providing immediate access to a communication channel.

Group Coordination: PTT applications support group communication, making it easier for emergency response teams to coordinate their efforts. Multiple users can be connected to the same channel, enabling simultaneous communication among team members. This facilitates better collaboration, ensuring that everyone stays informed about the evolving situation.

Location Sharing: PTT applications include features that allow users to share their real-time location information. This feature is especially beneficial during emergencies, as it helps in tracking the location of responders and guiding them to the scene quickly or ensuring they are safe and accounted for.

Priority Calling: In emergency scenarios, there may be a need for priority communications. PTT applications can implement priority features, where certain individuals or designated roles, such as incident commanders or supervisors, have the ability to interrupt ongoing conversations and convey critical messages.

Within this project, to provide critical extended coverage, we consider hosting the PTT application server on the satellite payload, so PTT end users served within the same satellite segment can communicate to each other in case of a critical incident.

OVERALL ARCHITECTURE

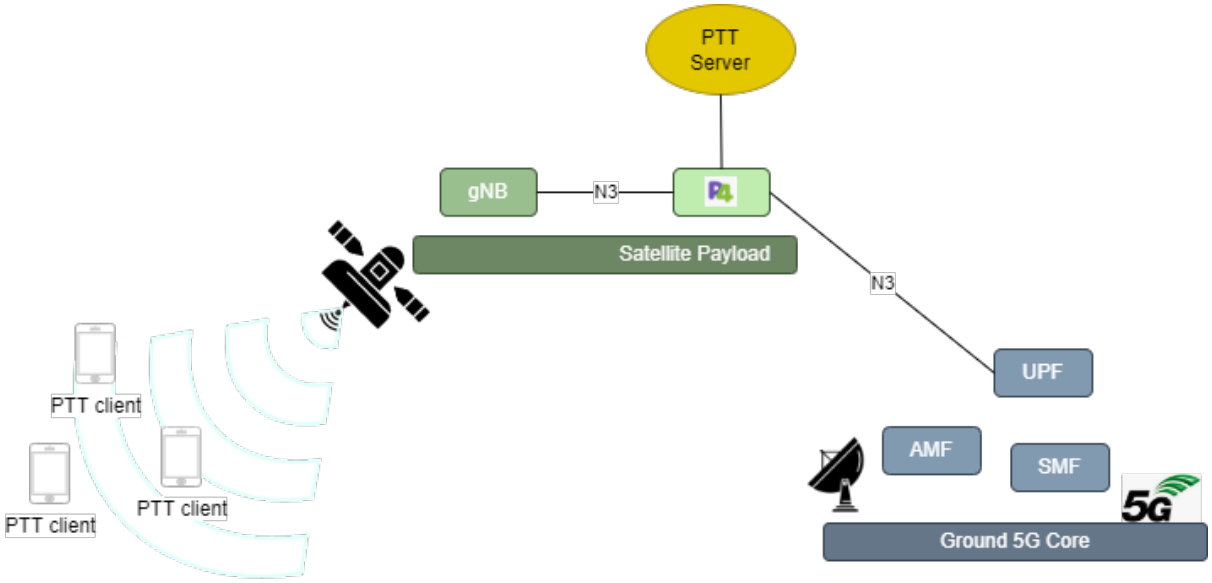

Figure 1 Proposed Regenerative Satellite based Architecture.

In this novel approach we introduce a new node, a programmable software switch based on P4 language, on the user plane path between gNB and UPF over N3 interface. The software switch plays the role of a traffic breakout function and is co-located with the gNB on the satellite payload. In addition, we propose the deployment of an instance of Push-to-Talk application server on the satellite payload, so that all PTT packets will be redirected through the software switch to the payload PTT server.

The software switch can be considered as a lightweight function of the UPF as it has been programmed to support only two functions of a UPF: encapsulating/decapsulating GTP packets and traffic steering.

This solution results in reduced latency, since round trip time (RTT) of packets is reduced drastically. Unlike UPF payload-based architectures, where N4 interface needs to be established with the ground SMF, the deployment of the software switch does not require any control plane message exchanging with the 5G core and the rest of 5G VFs. This is particularly important for NTN, due to the resulting reduction in signalling overhead.

Moreover, proposed solution reduces complexity and improves manageability of the satellite hosted virtual functions.

CONCLUSION

The ESA ARTES 5G TINA project aims to research and explore future 3D network architectures emphasizing to the role of satellite networks and solution that include the use of regenerative payloads. This paper introduces a novel solution where a P4 software switch is co-located with the gNB to provide traffic steering capabilities on the satellite payload. In addition, this paper describes a critical PTT emergency use case that is applicable for the proposed architecture. As future work, we propose improving the performance of the solution, while keeping the hardware and software resources to the minimum, as possible, and investigate if FPGA P4 deployments are more suitable for the NTN case. Furthermore, exploitation of a mesh topology satellite network and investigation of the capability of the P4 traffic steering function over the Inter Satellite Links

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