
ENI ISG - PoC Proposal

1 PoC Project Details

1.1 PoC Project

PoC Number (assigned by ETSI):

PoC Project Name: NTN, 5G SRv6 integration for TSN (Time Sensitive Network) by Artificial Intelligence

PoC Project Host: CNR ISTI

Short Description: As the communication technology moves toward 5G Advanced and soon toward 6G, there is a growing need to develop the next generation of wireless infrastructure that can meet the escalating demands for higher data rates, lower latency, massive and global connectivity, energy efficiency, higher reliability, and seamless user experiences accomplish this transparently for the customers. However, 5G still faces many challenges and open issues that need to be addressed by the research community and technology providers, such as connecting intelligence, global coverage, a network of networks, and trustworthiness. The technological solutions to these problems will enable pre-6G wireless communications to redefine the possible boundaries, enabling new applications and services beyond the scope of 5G, such as holographic communications, extended reality, and massive twinning.

Integrating Non-Terrestrial-Networks (NTNs) with 5G-based Terrestrial Networks (NT) can be the key to facing those open challenges for converging toward a new 6G wireless infrastructure, integrating, for example, the NT platforms as components of the Radio Access Network (RAN).

Other enabling technologies for the 5G to 6G transition are AI-based decision-making for the design of algorithms to optimize communications and telemetry, such as the in-band. For this reason, our main objective is to investigate new communication and networking solutions based on the 5G infrastructure integrated with the NTN to guarantee the pervasiveness of the communication services by limiting the infrastructural costs and the enhancement of Quality of Service (QoS) for the communication services in terms of bandwidth and reliability.

Moreover, it will be investigated that the design of network solutions based on proper IP technologies to accomplish the complete automation of service creation and predictive Service Level Agreement (SLA) breach using AI-based approaches supported by telemetry architectures, which can jointly be adopted to optimize the network resources.

ENI-based technologies can fit the needs of this PoC to demonstrate which technologies could be needed in future network evolutions. The connections with the architectural solution proposed for the ENI are related to how to implement service for the telemetry and a distributed infrastructure of AI/ML agents that generate an optimal policy for network management according to the gathered telemetry information in a distributed way.

The PoC is based on EU project TRANTOR: <https://www.trantor-he.eu/>

1.2 PoC Team Members

Table 1.1

	Organization name	ISG ENI participant (yes/no)	Contact (Email)	PoC Point of Contact (see note 1)	Role (see note 2)	PoC Components
1	CNR ISTI	Yes	Pietro Cassarà pietro.cassara@isti.cnr.it	x	Academic	- User Stories / Use Cases definition - PoC development - PoC documentation - PoC demos
2	CNIT	Yes	Fabrizio Granelli fabrizio.granelli@unitn.it		Academic	-Help with concept proof
3	Huawei	Yes	Aldo Artigiani aldo.artigiani@huawei.com		Vendor	-Help with architecture design, protocol design, intelligent solution, and platform verification
4	China Telecom	Yes	Yu Zeng zengyu@chinatelecom.cn		Operator	-Validate solution and support test execution, provide use cases
5	Futurewei Technologies	Yes	strazpdj@gmail.com		Research	- Contribute to ENI evolution to support new scenarios to be validated in PoC execution
NOTE 1: Identify the PoC Point of Contact with an X. NOTE 2: The Role will be network operator/service provider, infrastructure provider, application provider or other as given in the Definitions of ETSI Classes of membership.						

All the PoC Team members listed above declare that the information in this proposal is conformant to their plans at this date and commit to inform ETSI timely in case of changes in the PoC Team, scope or timeline.

1.3 PoC Project Scope

1.3.1 PoC Goals

The PoC will demonstrate aspects of various Use Cases, namely:

Use Case #1: grant SLA in normal operation of NTN network

Use Case #2: Interface the applications and negotiate proper SLA level

The detailed goals include:

- PoC Project Goal #1: grant SLA in operation of NTN network**
- PoC Project Goal #2: AIGC distributed computing control.** Demonstrate how to organize multiple computing node to provide a distributed solution for AIGC application.

1.3.2 PoC Topics

PoC Topics identified in this clause need to be taken for the PoC Topic List identified by ISG ENI and publicly available, i.e. the three topics identified in clause 4.5 of the ENI PoC Framework. PoC Teams addressing these topics commit to submit the expected contributions in a timely manner.

Table A.2

PoC Topic Description (see note)	Related WI	Expected Contribution	Target Date
IFIT and SRv6 utilization	DGR/ENI-0022_Flow_Info_Tele (GR ENI 012)	capability to monitor the SLA and verify the implement network changes to preserve the SLA	31 Oct 2024
AI mechanisms implementation	DGR/ENI-0028_AI_Mechanisms (GR ENI 018)	Verify AI mechanisms in granting e2e Quality of service in TSN network	31 Oct 2024
IP network autonomous level	DGR/ENI-0035v411_Def_IPNAL (GR ENI 035)	Verify the application IP technologies (e.g., SRv6, IFIT) and AI control loop to increase the Autonomicity level	31 Oct 2024
ENI use cases	RGS/ENI-001v411_Use_Cases (GS ENI 001)	Contribute the investigate use cases in the PoC	30 Jun 2024
Contribute investigated architecture	RGS/ENI-005v411_Sys_Arch (GS ENI 005)	Contribute the PoC outcome related to System Architecture	31 Oct 2024
Contribute investigated APIs and Models	RGS/ENI-019v411_Sys_Arch (GS ENI 005)	Contribute investigated APIs and Models based on SLAs	31 Oct 2024
Contribute investigated transformers	RGS/ENI-030v421_Sys_Arch (GS ENI 005)	Contribute investigated in transformers based on SLAs	31 Oct 2024

NOTE: This column should be filled according to the contents of table 1.

1.4 PoC Project Stages/Milestones

Table A.4

PoC Milestone	Stages/Milestone description	Target Date	Additional Info
P.S	PoC Project Start	04/2024	Presentation
P.D1	PoC Demo 1	05/2024	CNR ISTI Pisa, Italy, F2F / Webinar
P.C1	PoC Expected Contribution 1	06/2024	contributions to ENI use case ENI 001v411.
P.R	PoC Report	10/2024	PoC-Project-End Feedback
P.C2	PoC Expected Contribution 2	10/2024	contributions to ENI-005v411_Sys_Arch.
P.E	PoC Project End	11/2024	Presented to ISG ENI for information

NOTE: Milestones need to be entered in chronological order.

1.5 Additional Details

2 PoC Technical Details

2.1 PoC Overview

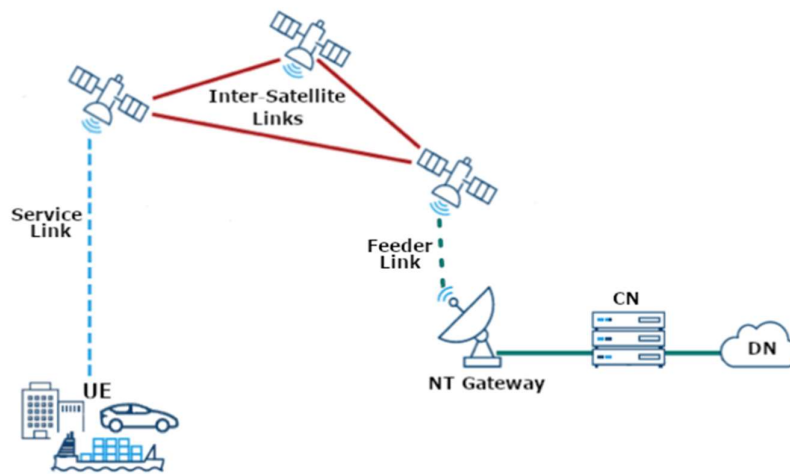
Despite the advantages of integrating NTN with the 5G-based TN for enabling the transition from 5G toward 6G communications, this integration comes with technical challenges due to more considerable distances in NTN that generate significant delay and signal attenuation; further, reciprocal movement among NT platforms and between User Equipment (UE) that can cause considerable Doppler shifts and continuous handovers between terrestrial and satellite links. Advances in intelligent antenna solutions, handling multi-beam, multi-band, and multi-orbital technologies, are essential to integrate NTNs into the 5G ecosystem. Moreover, by adopting AI-based optimization techniques and

network telemetry architecture, can be integrated to form a more efficient the point of view of the provided SLA and QoS perspective from the UE side.

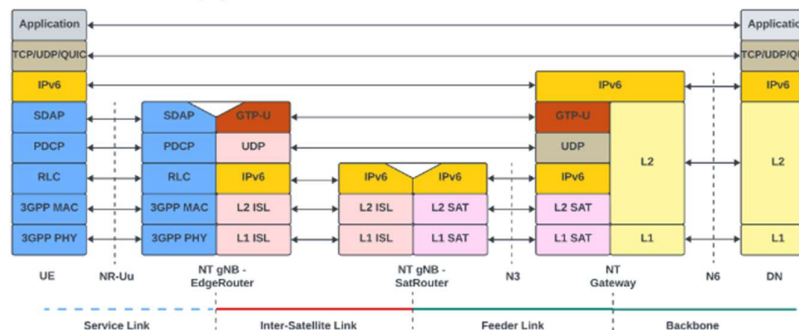
Regarding the controlling functionalities for the QoS management, it will be aimed to investigate architectural solutions for moving part of the controlling operations closer to the UE. It will be aimed to investigate traffic monitoring based on telemetry approaches such as the in-band telemetry and AI-based procedures for managing network resources and QoS for defining a framework to monitor the traffic parameters on the service, inter-satellite, and feeder links of the scenario depicted in the figure below. The exploitation of metadata related to the QoS for those links, will exploit the in-band approach, and then process the metadata by a function for extracting the features needed to feed the AI-based functionalities.

NOTE 1: involving the UE actively in selecting SLA is an early concept. Automating the solution that gathers information about the state of the network (IFIT, SRv6) and helps to generate an optimal policy for the management of the network (QoS, SLA), adopting distributed ML/AI-based algorithms.

NOTE 2: within this PoC, the aim is to propose a solution for gathering information about the status of the network delivering metadata by the extender header of the SRv6 protocol. The issue is understanding how to integrate it according to the architecture already defined in the ENI.



(a) Communication Scenario



(b) UP Protocol Stack

The main result that to be achieved, is exploiting the designed communication and networking solutions, is how to optimize the resources (links, paths) available at the RAN based on the NTN platforms for allowing the users to actively define the QoS parameters of the communications. The PoC is also interested in investigating solutions for controlling and managing the network through a zero-touch paradigm. That means the network can monitor and configure itself with the help of automatic procedures.

Another result that to be achieved concerns the analysis of networking solutions based on the digital twin of the network infrastructure that enables a-priori prediction of network resource allocation according to user needs. Once the network solution is identified and verified, the Digital Twin commits all the needed changes in the network autonomously. The

result to be obtained is to endow the user with a tool that allows the dynamic changing of its profile at the network operator and negotiate with the network the resources needed to have a given QoS level based on the production processes' data and computation load. Note that a dynamic and optimal allocation of the network resource to reach a given level of QoS allows better management of network service costs for a company and reduces the overall network dimensioning costs, reducing power consumption. In this case, The PoC will be interested in designing networking solutions based on per-flow communications, enabling Digital Twin to establish, modify, monitor, and restore each e2e connection automatically according to user intents. The combination of hard and soft slicing has to be thoroughly investigated in the Smart Manufacturing area, defining the proper role of technologies like Flex-E, FlexAlgo, and SRv6. In particular, IPv6/SRv6 and IFIT enable the propagation of QoS information from the application side to the network using protocols like APN6 to realize network as a Service paradigm with the integration of the Application in Service Function Chains where both the Compute and Network resources are handled in complete synergy. Moreover, the PoC will investigate the design of network solutions based on the above technologies to accomplish the complete automation of communication needs, using an AI-based system able to optimize the network resources, enabling cost and power saving, interfacing AI-based algorithms used to manage production systems to run efficiently and with a high level of reliability.

NOTE 3: The PoC can be “remodulated” to investigate a solution that gathers information about the state of the network (IFIT, SRv6) and is used to generate an optimal policy for the management of the network (QoS, SLA), adopting distributed ML/AI-based algorithms.

During the the proposed PoC, the state-of-the-art infrastructures for communication and computing for distributed and federated learning will be investigated regarding the scenarios for Industry 4.0. Once the state-of-the-art analysis is finished, the PoC will perform the analysis and definition of system requirements for the solutions, that are proposed. Finally, the first year's activities will conclude with the proposed architectural design investigation of the networking solutions.

Tests will ne run through IP routers that will implement the mentioned technologies, Open Source SA Core Network and simulations or emulation infrastructures and numerical analysis tools such as MATLAB to perform the performance analysis. The reference Laboratory is in CNR ISTI premise of Pisa (Italy)

In a follow up phase; the design activities, will be studied with the performance analysis of the proposed solutions.