***Disclaimer***

The present document has been produced and approved by the Experiential Networked Intelligence (ENI) ETSI Industry Specification Group (ISG) and represents the views of those members who participated in this ISG.  
It does not necessarily represent the views of the entire ETSI membership.

ETSI GR ENI 036 V0.0.2 (2023-12)

**Group Specification**

Experiential Networked Intelligence (ENI);

Space-Ground Cooperative Network Slicing

<

Reference

DGS/ENI-0034v411\_ConflictDetec

Keywords

conflict detection, OAM, policy management

***ETSI***

650 Route des Lucioles

F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B

Association à but non lucratif enregistrée à la

Sous-préfecture de Grasse (06) N° w061004871

***Important notice***

The present document can be downloaded from:  
<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at [www.etsi.org/deliver](http://www.etsi.org/deliver).

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at <https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:  
<https://portal.etsi.org/People/CommiteeSupportStaff.aspx>

If you find a security vulnerability in the present document, please report it through our

Coordinated Vulnerability Disclosure Program:

<https://www.etsi.org/standards/coordinated-vulnerability-disclosure>

***Notice of disclaimer & limitation of liability***

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or

other professional standard and applicable regulations.

No recommendation as to products and services or vendors is made or should be implied.

No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.

In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

***Copyright Notification***

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.  
The content of the PDF version shall not be modified without the written authorization of ETSI.  
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2023.

All rights reserved.

Contents

Intellectual Property Rights 4

Foreword 4

Modal verbs terminology 4

Executive summary 4

Introduction 4

1 Scope 5

2 References 5

2.1 Normative references 5

2.2 Informative references 5

3 Definition of terms, symbols and abbreviations 5

3.1 Terms 5

3.2 Symbols 5

3.3 Abbreviations 5

4 Overview of Network Policy Conflict Detection 6

4.1 Introduction 6

4.2 Architecture 6

4.2.1 Space-Ground Cooperative Network Slicing Architecture 6

4.2.2 Space-ground Slicing Session Collaboration 7

4.2.3 Intelligent Slice Mapping 8

Annex A (normative or informative): Title of annex 10

A.1 First clause of the annex 10

A.1.1 First subdivided clause of the annex 10

Annex (informative): Bibliography 11

Annex (informative): Change History 12

History 13

# Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server ([https://ipr.etsi.org](https://ipr.etsi.org/)).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

**DECT™**, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™**and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

# Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group Experiential Networked Intelligence (ENI).

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

# Executive summary

The present document specifies a high-level functional abstraction of the process of intent policy Multi-Stage translating in ENI system in terms of Functional Modules, Internal Reference Points and working pipelines.

# Introduction

Space-ground cooperative network includes the mobile communication network on the ground and the satellite network in the space, and the slicing configuration rules of the two networks are different. A slicing adaptation technology connecting mobile communication network and satellite network can effectively support the requirement of the end-to-end slicing service guarantee for space-ground cooperative network. Through the adaptation mapping of data plane and the collaborative management of control plane for NS, it can improve the customized service capability of space-ground cooperative network for differentiated services.

# 1 Scope

The present document provides information concerning space-ground cooperative network slicing. This GR intends to describe a method of network architecture and slicing mapping for the interconnection between the mobile communication network slicing and satellite network slicing. The detailed plan include:

Support identity resolution such as VLAN and IP address on the data plane, support precise identification and control for user services, and realize the slicing adaptation between mobile communication network and satellite network.

Exchange the slicing control information with the control plane of ground mobile communication network and satellite network (5GC and satellite network operation control center SNOCC), optimize the global service quality of network slicing, and ensure the consistency and continuity of slicing service in space-ground cooperative network environment.

The present document will encompass research and investigation activities that will further explore the related techniques that can be used to employ connection improvement for space-ground network slicing.

# 2 References

## 2.1 Normative references

Normative references are not applicable in the present document.

## 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non‑specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long-term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GR ENI 004: "Experiential Networked Intelligence (ENI); Terminology for Main Concepts in ENI".

[i.2] ETSI GS ENI 005 (V2.1.1): "Experiential Networked Intelligence (ENI); System Architecture".

[i.3] ETSI GR ENI 008: "Experiential Networked Intelligence (ENI); Evaluation of categories for AI application to Networks"

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in ETSI GR ENI 004 [i.1], ETSI GS ENI 005 [i.2].

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GR ENI 004 [i.1], ETSI GS ENI 005 [i.2], ETSI GR ENI 008 [i.3].

# 4 Overview of

## 4.1 Introduction

.

## 4.2 Architecture

## 4.2.1 Space-Ground Cooperative Network Slicing Architecture

The space-ground cooperative network slicing architecture is shown in the Fig. 1. We have deployed the programmable slicing gateway and the space-ground cooperative slicing control system between the terrestrial mobile communication network and the satellite network. Among them, the programmable slicing gateway is the transit channel for the slicing service data flows of space-ground cooperative network. With definable Message parsing, processing and forwarding capabilities, the gateway accurately identifies and controls slicing services, and achieves the data mapping between slices according to the configuration policy provided by the control system. It can ensure the service consistency and continuity of service data in space-ground cooperative network slicing and realize the adaptation of heterogeneous network slices. The space-ground cooperative slicing control system interacts with the space-ground network slicing control planes respectively, to open up the slicing session channel between the space and ground network cooperatively. Aiming at the differences between mobile communication network and satellite network in slicing service classification, slicing quantity and slicing construction form, the control system can optimize the matching mode of service traffic and network resources, and intelligently generate the configuration policy of the programmable slicing gateway, thus improving the end-to-end quality of slicing service in space-ground cooperative network.



Figure 1: Space–ground cooperative network slicing architecture

## 4.2.2 Space-ground Slicing Session Collaboration

The main function of slice-session collaboration is to coordinate the management of PDU sessions in mobile communication network and satellite network, and establish PDU session channels from UE to ground-based 5G mobile communication network, space-based satellite network and up to Data Network.



Figure 2: Slicing session collaboration architecture

As shown in Fig. 2, the functional modules of slicing session collaboration unit include slicing mapping management module, session collaborative processing module, ground-based core network interface module, and space-based core network interface module. The slice mapping management module is mainly responsible for maintaining the mapping relationship between ground-based PDU sessions and space-based PDU sessions. The session cooperative processing module can cooperate with the process of establishing, modifying and releasing sessions of ground-based and space-based networks, according to the mapping relationship maintained by the slice mapping management module. The interface module of ground-based core network is responsible for the interface with the core network of ground-based 5G mobile communication network. The space-based core network interface module is responsible for the interface with the space-based satellite network core network.

The establishment process of UE-initiated PDU sessions is used as an example to illustrate the slicing session collaboration process. In the following example, assuming that the mapping rule is based on service type, UE1 and UE2 initiate PDU sessions of the same type to access Data Network. The process is as follows:



Figure 3: Data channel establishment process of UE1

For the PDU session initiated by UE1, the data path establishment includes three stages, as shown in Fig. 3.

The first stage is PDU session establishment process from UE to ground mobile communication network. Step1: UE1 initiates a PDU session establishment request. Step2: The request is processed by the ground-based core network, and select the ground-based SMF and UPF for the session. Step3: The ground-based core network establishes an N4 session with the selected ground-based UPF. Step4: The ground-based core network notifies the space-ground cooperative session management unit of the currently established ground-based session information. The ground-based core network notifies the information about the current ground-based session to space-ground session management unit. At the same time, the ground core network notifies RAN and users to build RAN tunnels.

The second stage is the slicing session collaborate unit for slicing mapping. Step5: After receiving the notification from the ground-based core network, the slicing session coordination unit carries out the space-based session mapping. Since the session of UE1 is a new service type, a new space-based session ID needs to be assigned to the session of UE1.

The third stage is the PDU session establishment process of the satellite network. Step6: The slicing session collaboration unit notifies the establishment of a new space-based session to the space-based core network. Step7: The space-based core network selects the space-based SMF and UPF for the session after receiving a session establishment notification. Step8: The space-based core network establishes the N4 session with the selected space-based UPF.

At this point, for the PDU sessions of UE1, The channel from UE1 to ground-based 5G mobile communication network, space-based satellite network and up to Data Network has been established and opened.



Figure 4: Data channel establishment process of UE2

As shown in Fig. 4, after UE1 has established the channel to the Data Network, and when UE2 intends to access the Data Network, the establishment of the data channel also includes three stages, as shown in Figure 4.

The first stage is the process of PDU session establishment from UE to ground-based mobile communication network. Step1~Step4: The process of ground-based network for the session establishment request of UE2 is the same as that of UE1.

The second stage is the slicing session collaborate unit for slicing mapping. Step5: The slicing session cooperative unit carries out the space-ground session mapping after receiving the notification of the ground-based core network. Based on resource allocation, it judges that the sessions of UE2 and UE1 can be aggregated, and maps the ground-based sessions of UE2 and UE1 to the same space-based session

The third stage is the PDU session establishment process of the satellite network. Step6: The slicing session cooperative unit notifies the space-based core network to modify the space-based session, and the modification can be for QoS parameters. Step7: The space-based core network performs a modification operation for the session after receiving the session modification notification. Step8: The space-based core network notifies the corresponding space-based UPF to perform session modifications.

At this point, for the PDU sessions of UE2, The channel from UE2 to ground-based 5G mobile communication network, space-based satellite network and up to Data Network has been established and opened. PDU sessions of the same service type in UE1 and UE2 are allocated to the same slice, and the slicing sessions finish collaboratively.

## 4.2.3 Intelligent Slice Mapping

In the space-ground cooperative network, there are many types of service requirements and wide coverage. The performance requirements of services such as real-time voice, data transmission, control signaling, and short message have different performance requirements, and the service delay, bandwidth, and security requirements all change in real time. To meet the differentiated application requirements of wide-area information networks, the space-ground cooperative network needs to dynamically construct differentiated network slices involving different service characteristics, accurately match the resource requirements of different service data, and realize multi-service converged application. This proposes an intelligent slice mapping mechanism based on spatio-temporal correlation. Through traffic predictionto establish the prediction model of resource demand of network services, it can respond to the service characteristics and the transformation of access node in real time. Thus, the slices of network resources can be matched as needed with the wildly fluctuating traffic in the space-ground cooperative network.



Figure 5: Intelligent slice mapping based on spatial-temporal correlation

Figure 5 shows the smart slice mapping diagram based on spatial-temporal correlation. Graph Convolutional Network (GCN) and Gated Recurrent Unit (GRU) are used to extract the temporal-spatial characteristics of the historical traffic load of each node in the space-ground cooperative network slicing, which is to provide a decision basis for slice mapping. Firstly, the network topological features are captured by GCN to obtain the spatial dependence. Secondly, the dynamic changes of node attributes are captured by GRU to obtain the local time trend of traffic load. Finally, the multi-output fully connected layer of artificial neural network is used to realize the transformation from traffic load to resource demand, and output the predicted result. The system monitors the network resource status in real time, slices are allocated network resources based on the predicted results of slicing service requirements to complete slicing adaptation decisions and ensure the service requirements of the business.

Following the earlier discussions, the desired system performance suggests that the slicing can benefit from an adaptive mechanism. As the trade offs between the bandwidth and power efficiency are non avoidable, A well designed slicing algorism may fit seamlessly to its designated applications whilst may not necessarily handle a similar environment with altered system parameters The slicing scheme here was initially intended to mitigate the data rate drop in a random link, where interference is present. The candidate switching schemes have been chosen based on the merit of combined power and bandwidth efficiency. More realistic models will also be addressed in this section. For model simplicity and discussion continuity, the following assumptions are made:

1. The channel is a direct link channel.
2. Synchronisation is maintained
3. The system operates in 2 data rate (moderate and high)

In the test model two sets of BER test data will be used. The first set will range from 10-9 to 10-7, to represent moderate degradation and second set will range from 10-8 to 10-6, to represent severe degradation. The data rate will be chosen as a realistic 4Mbps and a higher rate of 250Mbps.

Data rate degradation in Space Ground network

|  |  |  |  |
| --- | --- | --- | --- |
| Moderate Degradation (BER) 10-9 → 10-7 | | Severe Degradation (BER)  10-8 → 10-6 | |
| Initial Rb (Mbps) | Final Rb (Mbps) | Initial Rb (Mbps) | Final Rb (Mbps) |
| 4 | 3.0 | 4 | 2.9 |
| 250 | 187.9 | 250 | 179.4 |

In above Table, whilist in the moderate degradation, the data rates have fallen for 4Mbps and 250Mbps respectively to 3Mbps and 187.9Mbps, which is about 25% of throughput lost. For severe degradation, the data rate fell for 4Mbps and 250Mbps respectively to 2.9Mbps and 179.4Mbps, which is about 28% of throughput lost.

Comparing data rate loss for systems operating at 4Mbps, the difference between the moderate and severe model is not significant. In contract, for a system operating at 250Mbps, the data rate loss between the moderate and severe model indicates a large departure from the operating speed. This suggests that systems operating at a higher speed are more susceptible to environmental change than their lower speed counterparts. The comparisons between these two data rate bands can be further demonstrated.

Annex A (normative or informative):  
Title of annex

# A.1 First clause of the annex

## A.1.1 First subdivided clause of the annex

Annex (informative):  
Bibliography

Annex (informative):  
Change History

| Date | Version | Information about changes |
| --- | --- | --- |
| <Month year> | <#> | <Changes made are listed in this cell> |
|  |  |  |
|  |  |  |
|  |  |  |

# History

|  |  |  |
| --- | --- | --- |
| **Document history** | | |
| <Version> | <Date> | <Milestone> |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

*Latest changes made on 2022-03-14*