ETSI GR NGP 011 V1.1.1 (2018-09)

Next Generation Protocols (NGP); E2E Network Slicing Reference Framework and Information Model

Disclaimer

The present document has been produced and approved by the Next Generation Protocols (NGP) 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.

Reference
DGR/NGP-0011

Keywords
network, virtualisation

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 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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 only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

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

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is 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/).

Pursuant to the ETSI IPR Policy, no investigation, 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.

Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Next Generation Protocols (NGP).

Modal verbs terminology

In the present document "**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 (Verbal forms for the expression of provisions).

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

1 Scope

The present document describes an information specification of resources used by services in network slices to provide true resource-assured multi-tenancy across multiple administrative and technology domains. It does not, cover the data plane or hardware aspects of traffic associated with a slice, nor does it alter the core control plane functionality of physical network infrastructure and domains. Any specific language to describe a network slice is out of scope as well.

As such, the topic of network slices encompasses the combination of virtualization, cloud centric, NFV and SDN technologies the primary gap identified is a lack of normalized resource information flow over a plurality of provider administration planes (or domains). Resource requirement of a given network slice can be satisfied in different networks using different technologies; the goal of the present document is to provide a simple manageable and operable network through a common interface while hiding infrastructure complexities. The present document defines how several of those technologies may be used in coordination to offer description and monitoring of services in a network slice.

Please note that the scope does not try to formally define a network slice, instead it relies on background material for the purpose.

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] NGMN Alliance: "5G White Paper V1.0".

NOTE: Available at https://www.ngmn.org/fileadmin/ngmn/content/downloads/Technical/2015/NGMN_5G_White_Paper_V1_0.pdf.

[i.2] NGMN Alliance (V1.0): "Description of Network Slicing Concept".

NOTE: Available at https://www.ngmn.org/fileadmin/user_upload/160113_Network_Slicing_v1_0.pdf.

[i.3] IETF RFC 5440: "Path Computation Element (PCE) Communication Protocol (PCEP)".

[i.4] ETSI GS NGP 001: "Next Generation Protocol (NGP); Scenario Definitions".

[i.5] IETF RFC 7665: "Service Function Chaining (SFC) Architecture".

[i.6] IANA: "Path Computation Element Protocol (PCEP) Numbers".

NOTE: Available at https://www.iana.org/assignments/pcep/pcep.xhtml.

[i.7] IETF RFC 2998: "A Framework for Integrated Services Operation over Diffserv Networks".

[i.8] IETF Traffic Engineering Architecture and Signaling (teas) Working Group.

NOTE: Available at https://datatracker.ietf.org/wg/teas/.

[i.9] NGMN White Paper on Security for Network Slicing.

NOTE: Available at https://www.ngmn.org/fileadmin/user_upload/160429_NGMN_5G_Security_Network_Slicing_v1_0.pdf.

[i.10] Recommendation ITU-T Y.3110/3111: "IMT-2020 network management and orchestration requirements & framework".

[i.11] Recommendation ITU-T Y.3112: "Framework for the support of Multiple Network Slicing".

[i.12] Recommendation ITU-T Y.3150: "High-level technical characteristics of network softwarization for IMT-2020".

[i.13] ETSI TS 123 502: "5G; Procedures for the 5G System (3GPP TS 23.502)".

[i.14] 3GPP TR 28.801: "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects: Telecom Management (SA5) - Study on management and orchestration of network slicing/Network slice management".

[i.15] 3GPP TS 28.531: "Provisioning of network slicing for 5G networks and services: Detailed specification of network slice provisioning/Network slice management".

[i.16] 3GPP TS 28.541: "Management and orchestration of networks and network slicing; NR and NG-RAN Network Resource Model (NRM); Stage 2 and stage 3".

[i.17] IETF draft-netslices-usecases-02: "Network Slicing Use Cases: Network Customization and Differentiated Services".

NOTE: Available at https://datatracker.ietf.org/doc/draft-netslices-usecases.

[i.18] draft-ietf-spring-segment-routing-14: "Segment Routing Architecture".

NOTE: Available at https://tools.ietf.org/html/draft-ietf-spring-segment-routing-14.

[i.19] IETF: "Deterministic Networking (detnet)".

NOTE: Available at https://datatracker.ietf.org/wg/detnet/.

[i.20] draft-ietf-ippm-ioam-data-02: "Data Fields for In-situ OAM".

NOTE: Available at https://tools.ietf.org/html/draft-ietf-ippm-ioam-data-02.

[i.21] BBF SD-406: "End-to-End Network Slicing".

NOTE: Available at https://wiki.broadband-forum.org/pages/viewpage.action?spaceKey=BBF&title=SD-406+End-to-End+Network+Slicing.

[i.22] Generic Network Slice Template Version 0.1.

NOTE: Available at https://infocentre2.gsma.com/gp/pr/FNW/NEST/WorkingDocuments/GST%20document%20baselines/GST_Baseline_v0.8_20180712_clean.docx

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Network Slice (NS): network slice is a description of a service aware logical network that is composed of different physical or virtual network elements, resources and functions

Network Slice Agent (NSA): entity that has complete view and control of its network infrastructure

NOTE: An agent can be a logical component of controller that performs special functions relating to network slices and exports them to network slice provider.

Network Slice Instance (NSI): instance of a type of network slice that has resources allocated to it from underlying network infrastructure and is independently managed and monitored by the tenant

Network Slice Provider (NSP): entity that provides access to network slice instance and resources associated with it

NOTE: Network slice providers coordinate and aggregate network resources from multi-domain, multi-technology networks.

Network Slice Subnet (NSS): subnet represents single or multiple networks under the control of an agent

NOTE: A complete network slice is inter-connection of subnets.

Network Slice Service Profile (NSSP): structure high-level format in which a network slice is described

slice: simplified text to represent 'network slice' in the context of the present document only

tenant: entity that consumes a network slice instance from network slice providers

NOTE: Such tenants do not care about implementation and technology details of the physical networks.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

5GC	5G Core
API	Application Programming Interface
BBF	BroadBand Forum
DB	DataBase
Diffserv	Differentiated services
EVC	Ethernet Virtual Circuit
FIB	Forwarding Information Base
GSM	Global System for Mobile
GSMA	GSM Alliance
GST	Generic Slice Template
IETF	Internet Engineering Task Force
Intserv	Integrated services
IP	Internet Protocol
IPPM	IP Performance Measurement
MANO	MANagement and Orchestration (of NFV framework)
MPLS	Multi-Protocol Layer Switching
NEST	NEtwork Slice Template
NS	Network Slice
NFV	Network Function Virtualization
NG	Next Generation
NGMN	Next Generation Mobile Networks
NGNS	Next Generation Network Slice
NS	Network Slice
NSA	Network Slice Agent
NSI	Network Slice Instance
NSP	Network Slice Provider
NSS	Network Slice Subnet
NSSP	Network Slice Service Profile
OAM	Operations, Administration and Maintenance
PCE	Path Computation Element
PCEP	Path Computation Element Protocol
QoS	Quality Of Service
RAN	Radio Access Network
RSVP	Resource Reservation Protocol
SDN	Software Defined Networking
SDO	Standards Developing Organization
SFC	Service Function Chaining
SLA	Service Level Agreement
TCAM	Ternary Content-Addressable Memory

TE Traffic Engineering
TEAS Traffic Engineering Architecture and Signaling
TED Traffic Engineering Database
UCL University College Of London
VDI Virtual Device Interface
VM Virtual Machine
VPN Virtual Private Network
VXLAN Virtual eXtensible Local Area Networks
WG Work Group

4 Network Slicing Architecture

4.1 Overview

Network slicing concept allows support of logical networks that are tailored for a specific service or set of services over a shared common network infrastructure for the purpose of efficient utilization of network resources. NGMN white paper [i.1] states that "the intention of a 5G slice is to provide only the traffic treatment that is necessary for the use case and avoid all other unnecessary functionality". In this regard network slice is a framework aimed at providing flexible on-boarding of newer verticals as a consequence of higher definition broadband, machine to machine communication, industrial automation, advanced emergency services and so on [i.17]. These verticals cannot be served cost-effectively by traditional network architectures because of the diversity of requirements. Network slicing techniques abstract several infrastructures and provide a communication framework for verticals to build their own services.

There are several aspects that need to be resolved in terms of efficient resource scheduling, reservation and placement mechanisms at the lower layers. Many of those aspects are either hardware or particular technology related. However, a technology independent generalized reference framework for network slicing is very much needed to demonstrate how information flows for the purpose of alignment of applications and data over dissimilar communication infrastructures.

The Next-gen network slicing (NGNS) framework defined here is a generalized architecture that would allow different network service providers to coordinate and concurrently operate different services as active network slices.

4.2 Informative Background

Network slicing is an end to end paradigm initially discussed in the context of 5G to support new kind of applications that need absolute resource guarantees in terms of latencies, bandwidth, jitter, reliability and privacy. The goal is an ability to use common end to end infrastructure that is capable of delivering diverse services with their corresponding assurance. Network slicing will be expensive, due to its inherently stringent resource assurance demands. Therefore, network slices will be used to implement specific vertical markets and it does not imply to provide QoS to individual streams.

Network slicing is a multi-technology solution that spans across multiple planes. There are several SDO activities that focus on different aspects of the network slicing.

Since SDN and NFV are considered enabling techniques for network slicing, ETSI MANO, NFV ISGs activities are concerned with the orchestration perspective that involves transforming a service using NFV infrastructure.

Many other standard activities at IETF are involved in distribution of services using SFC [i.5], segment routing [i.18] or VPN mechanisms. Some additional efforts such as deterministic networks [i.19] provide data plane centric lower level functionality to meet service assurances of bounded latency and bandwidth requirements.

3GPP network slice management [i.13], [i.14], [i.15] and [i.16] together provide provisioning and resource management of RAN and 5GC slices. BBF has recently begun work on study of network slicing in the context of BBF architecture (SD-406) [i.21]. ITU-T SG13 and SG15 have published several documents [i.10], [i.11] and [i.12] on the topic motivated by IMT-2020 initiative and bulk of the effort is aligned with 3GPP related work in 5G domain.

GSMA NEST is an internal taskforce set to define a common language in the form of GST through which all operators can describe parameters of a given slice type. GST specification [i.22] complements 3GPP slice/service type work by providing its characteristics. The GST defines attributes applicable to slices in a 5G networks such as maximum packet size, terminal density, uplink/downlink bandwidth, reliability and so on. The work will help different operators describe a particular kind of slice in a standardized manner but it still requires a framework for propagation and realization of these attributes which is not part of GST work.

In contrast, proposed framework in NGP is independent of any underlying assumption about the enabling architecture, protocol or methodology. It is also technology independent and concerns with both management and control aspects of network slices. The gap identified here is to look at holistic solution of implementing network slices so that parts of the networks enabling slices in parts can use common information aspects. It is our expectation that architectures from different SDOs can be reduced to details in the present document.

The section 8.7.4 in the NG Scenario definitions [i.4] discusses NG slicing aspects and provides a conceptual view of network slicing coordinators and agents. In the following clauses these components will be described in greater detail. The NGNS information model puts together major components, managed information objects and interfaces that provide clarity about end to end network slicing functionality. It does not apply directly to low-level control and data plane functionality and provides coordination guidelines at the network level.

4.3 High level description

A Network slice is a description of a service aware logical network composed of different physical or virtual network elements, resources and functions. A network slice is an independently managed instance of a logical network; It shares underlying infrastructure with other independently managed instances. Since the infrastructure itself comprises of different interconnected domains, essentially a slice can be seen as concatenated network of subnetworks belonging to different network domains.

The NS methods are aimed at providing custom design of networks suitable for a specific use case (vertical market). Such methods need to be able to translate a service requirement into normalized description of resources across different type of network domains based on NGMN's description of network slicing, 3-layer approach [i.2] and is reproduced below in Figure 1.

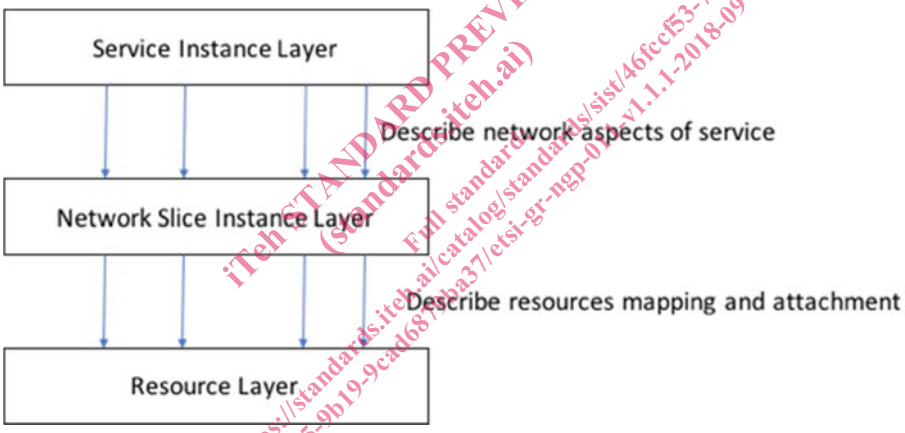

Figure 1: NGMN 3-Layer Network Slice and Service Concept

Network slice supports multi-tenancy for new set of services described in [i.1]. The focus is on the use cases that do not necessarily fit into traditional virtual networking or VPN solutions. They require much higher degree of resource assurance as well as stricter guarantees of those resource availabilities. For example, low-latency communications for V2X, high-throughput for immersive multimedia applications, extremely reliable network for emergency response situations. There are several differentiating aspects among these use cases from traditional isolation techniques, such as:

a) once allocated, the resource may be under the control of the network slice service operator (or tenant) for autonomous control of the resources,

b) absolute guarantees should be met with, even under active contention of resources in other best-effort flows,

c) every flow (per stream QoS) should receive the assured treatment, i.e. two flows within the same slice should not compete with each other.

Aligning with the NGMN's network slicing concept, there are three key areas of consideration for the NS architecture.

1) **Service description** (corresponds to service instance layer): A sketch of services instantiated, independent of any technology or underlying control plane.

2) **Network slice to abstract resource mapping** (corresponds to network slice instance layer).

3) **Resource allocation** (across different networks).

The present document describes a top-down structure and creates an information model corresponding to generalized service aware NS. Through this model, tenant of a slice is able to express service constraints and requirements. The primary contribution of present document is to identify the actors in NS architecture, the data necessary to be exchanged between different actors, how they use it and the methods associated with the information.

4.4 Network slicing design principles

4.4.1 Service Oriented Approach

In order to provide scalability and flexibility in basic network slice architecture follows these principles:

- Abstraction
- Loose coupling
- Reusability
- Autonomy

The subsequent clauses will demonstrate how these are relevant in the network slice architecture.

4.4.2 Network slice abstraction

4.4.2.1 Motivation

Abstractions hide details of underlying implementation and technologies. It is important across heterogeneous (different technologies) access and transit networks. Network slices offer a network through which a consumer can fulfil its service delivery objectives. It should be agnostic of whether a particular technology, topology or routing protocol are used. The slice specification should be well-defined and not adheres to a specific underlying solution.

4.4.2.2 Service lifecycle abstraction

This form of abstraction is dependent upon how much of the service logic is exposed as its capabilities. Each network slice has well-known create, modify, get and delete methods associated for network aspects of the service. The users or subscribers of a slice or internal data are hidden information, and a slice need not expose them.

4.4.2.3 Technology information abstraction

Any information about the underlying technology used within the service would result exposing extra information. It might result in design of a service favouring a particular technology. This takes away, flexibility and reuse aspect of a network slice. Network operations and resources relating to networks can be standardized in logical or abstract form so that they remain independent of whether underlying transport is optical or packet based, MPLS or IP, or whether the topology is L2 or L3. There will still be need for interconnections of two networks with different technologies.

4.4.2.4 Quality abstraction

Quality abstraction relates to the details provided within the service's accompanying service level agreement (SLA). Network slices should only concern with network resource information and only with the quality parameters that impact the communication aspect of the service. Separation of network and service logic policies is also necessary.

4.4.3 Loose coupling

It should be possible for network slices to be added and removed and altered flexibly across multiple administrative domains. A loosely coupled network slice ensures that changes made within one network slice domain has no adverse effects or unanticipated changes within other network domains and other network slice instances for that matter. Interconnections between domains should be clear to help isolate problems in a network slice instance.

4.4.4 Network slice reusability

Many services have similar set of network requirements. The ability to compose a slice and describe its operations in a reusable manner reduces system complexity.