ToC for Network Slicing - Revised Problem Statement

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Abstract

This document introduces Network Slicing problems and the motivation

for new work areas. It represents an initial revision of the Network

Slicing problem statement derived from the analysis of the technical

gaps in IETF protocols ecosystem. It complements and brings together

the silo efforts being carried out in several other IETF working groups

to achieve certain aspects of Network Slicing functions and operations.

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# 1. Introduction

Network Slicing (NS) refers to the managed partitions of physical

and/or virtual network resources, network physical/virtual and

service functions [RFC7665] that can act as an independent instance

of a connectivity network and/or as a network cloud. Network resources

include connectivity, compute, and storage resources.

Network Slices considerably transform the networking perspective by

abstracting, isolating, orchestrating, softwarizing, and separating

logical network components from the underlying physical network

resources and as such they enhance Internet architecture principles

([RFC1958], [RFC3439], [RFC3234]).

The management plane creates the grouping of network resources (whereby

network resources can be physical, virtual or a combination thereof),

it connects with the physical and virtual network and service functions

([SFC WG]) as appropriate, and it instantiates all of the network and

service functions assigned to the slice. On the other hand, for slice

operations, the slice control plane takes over the control and governing

of all the network resources, network functions, and service functions

assigned to the slice. It (re-) configures them as appropriate and as per

elasticity needs, in order to provide an end-to-end service. In particular,

ingress routers are configured so that appropriate traffic is bound to

the relevant slice. Identification means for the traffic may be simple

(relying on a subset of the transport coordinate, DSCP/traffic class, or

flow label), or identification may be a more sophisticated one (to be

further defined). Also, the traffic capacity that is specified for a slice

can be changed dynamically, based on some events (e.g. triggered by a

service request). The slice control plane is responsible for instructing

the involved elements to honor such needs.

Network operators can use NS to enable different services to receive

different treatment and to allow the allocation and release of network

resources according to the context and contention policy of the operators.

Such an approach using NS would allow significant reduction of the operations

expenditure. In addition NS makes possible softwarization, programmability

([RFC7149]), and the innovation necessary to enrich the offered services.

Network softwarization techniques [IMT2020-2015], [IMT2020-2016] may be used to realise and manage [MANO-2014] network slicing. NS provides the

means for the network operators to provide network programmable

capabilities to both OTT providers and other market players without

changing their physical infrastructure. NS enables the concurrent

deployment of multiple logical, self-contained and independent,

shared or partitioned networks on a common infrastructure. Slices

may support dynamic multiple services, multi-tenancy, and the

integration means for vertical market players (e.g. automotive

industry, energy industry, healthcare industry, media and

entertainment industry, etc.)

The purpose of the NS work in IETF is to develop a set of protocols and/

or protocol extensions that enable efficient slice creation,

activation / deactivation, composition, elasticity, coordination /

orchestration, management, isolation, guaranteed SLA, and safe and secure

operations within a connectivity network or network cloud / data centre

environment that assumes an IP and/or MPLS-based underlay.

While there are isolated efforts being carried out in several IETF

working groups Network WG [I-D.leeking-actn-problem-statement 03], TEAS WG

[I-D.teas-actn-requirements-04], [I-D.dong-network-slicing-problem-statement],

ANIMA WG [I-D.galis-anima-autonomic-slice-networking], [IETF-Slicing1],

[IETF-Slicing2], [IETF-Slicing3], [IETF-Slicing4], [IETF-Slicing5],[IETF-

Mobility], [IETF-Virtualization], [IETF-Coding], [IETF-Anchoring] to

achieve certain aspects of network slice functions and operations,

there is a clear need to look at the complete life-cycle management

characteristics of Network Slicing solutions though the discussions

based on the following architectural tenets:

o Underlay tenet: support for an IP/MPLS-based underlay data plane the

transport network used to carry that underlay.

o Governance tenet: a logically centralized authority for network

slices in a domain.

o Separation tenet: slices may be independent of each other and have

an appropriate degree of isolation (note 1) from each other.

o Capability exposure tenet: each slice allows third parties to

access via dedicated interfaces and /or APIs information regarding

services provided by the slice (e.g., connectivity information, mobility,

autonomicity, etc.) within the limits set by the operator.

NS approaches that do not adhere to these tenets are explicitly

outside of the scope of the proposed work at IETF.

In pursuit of the solutions described above, there is a need to

document an architecture for network slicing within both wide area

network and data center environments.

Elicitation of requirements ([RFC2119], [RFC4364]) for both Network

Slice control and management planes will be needed, facilitating

the selection, extension, and/or development of the protocols for each

of the functional interfaces identified to support the architecture.

Additionally, documentation on the common use-cases for slice

validation for 5G is needed, such as mission-critical ultra-low latency

communication services; massive-connectivity machine communication

services (e.g. smart metering, smart grid and sensor networks); extreme

QoS; independent operations and management; independent cost and/or

energy optimisation; independent multi-topology routing; multi-tenant

operations; etc.

The proposed NS work would be coordinated with other IETF WGs (e.g.

TEAS WG, DETNET WG, ANIMA WG, SFC WG, NETCONF WG, SUPA WG, NVO3 WG,

DMM WG, Routing Area WG (RTGWG), Network Management Research Group

(NMRG)and NFV Research Group (NFVRG)) to ensure that the commonalities

and differences in solutions are properly considered. Where suitable

protocols, models or methods exist, they will be preferred over

creating new ones.

## 1.1. Notes

(1) This issue requires efficient interaction between an upper layer

in the hierarchy and a lower layer for QoS guarantees and for most

of the operations on slicing.

# 2. Suggested Problems and Work Areas

The goal of this proposed work is to develop one or more protocol

specifications (or extensions to existing protocols) to address specific

slicing problems that are not met by the existing tools. The following

problems were selected according to the analysis of the technical gaps in

IETF protocols ecosystem.

o Uniform Reference Model for Network Slicing (Architecture document):

Describes all of the functional elements and instances of a network slice.

Describes shared non-sliced network parts. Establishes the boundaries to the

basic network slice operations (creation, management, exposure, consumption).

Describes the minimum functional and non-functional roles derived from basic

network slice operations including infrastructure owner (creation, exposure,

management), slice operator (exposure, management, consumption), slice user

(management, consumption). Describe the interactions between infrastructure

owner -- slice operator, slice operator -- slice operator, slice operator --

slice user. Additionally, this working area will normalize nomenclature and

definitions for Network Slicing.

**Alex – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(links with gap analysis & framework documents)**

o Review common scenarios from the requirements for operations and

interactions point of view. Describes the roles (owner, operator, user) which

are played by entities with single /multiple entities playing different roles.

**Ravi – TODO - approx 0.5 page: Description of relevant types of scenario/ UCs (Links with gap analysis & UCs documents) & new/revised protocols needed**

o Slice Templates: Design the slices to different scenarios

([ChinaCom-2009], [GENI-2009], [IMT2020-2016bis], [NGMN-2016],

[NGS-3GPP-2016], [ONF-2016]); Outlines an appropriate slice template

definition that may include capability exposure of managed partitions

of network resources (i.e. connectivity ([CPP]), compute and storage

resources), physical and/or virtual network and service functions that can

act as an independent connectivity network and/or as a network cloud.

**Liang - TODO – approx 0.5 page: Description & links wit the Framework document & new/revised protocols needed**

**(Links with UCs & framework documents)**

o Network Slice capabilities (where some prioritization may be

needed) are expected to be:

\* Four-dimensional efficient slice creation with guarantees for

isolation in each of the Data /Control /Management /Service

planes. Enablers for safe, secure and efficient multi-tenancy

in slices.

**Carlos - TODO – approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

**Network slices MUST support multi-tenancy, ensuring that isolation and performance guarantees are provided at the data, control, management and service planes. This involves the following:**

* **A network slice SHOULD provide a guaranteed level of service, according to a negotiated SLA between the customer and the slice provider.**
* **Slices MUST be isolated at service level (e.g., one slice must not impact on the level of service of the other slides, even if sharing resources).**
* **Slices MUST be isolated at data level, even if sharing resources. Security and privacy mechanisms should be in place to ensure this.**
* **A network slice SHOULD be provided with exclusive control and/or management interfaces (depending on the type of network slice), enabling the deployment of different logical network slices over shared resources.**

\* Methods to enable diverse requirements for NS including

guarantee for the end-to-end QoS of service in a slice.

**Ravi – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

\* Efficiency in slicing: specifying policies and methods to realize

diverse requirements without re-engineering the infrastructure.

**Med – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

\* Recursion: namely methods for NS segmentation allowing a slicing

hierarchy with parent - child relationships.

**Liang / Alex – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

* Customized security mechanisms per slice.

**Med TODO – approx 0.5 page: Description & new/revised protocols needed**

\* Methods and policies to manage the trade-offs between flexibility

and efficiency in slicing.

**Carlos – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

**Mechanisms SHOULD be in place to allow different levels of flexibility when providing network slices:**

* **from the ones that provided greater levels of flexibility in the provided resources and services that compound the slice, allowing to dynamically change/scale/migrate it over time within a negotiated range,**
* **to the ones that ensure the efficiency of the use of the resources at the cost of a smaller degree of flexibility.**

\* Optimisation: namely methods for network resources automatic

selection for NS; global resource view formed; global energy view

formed; Network Slice deployed based on global resource

and energy efficiency; Mapping algorithms.

**Luis – approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

\* Monitoring status and behaviour of NS in a single and/or

muti-domain environment; NS interconnection.

**Alex – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

* Capability exposure (e.g. openness) for NS; plus APIs for slices.

**Pedro – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

To exploit the flexibility offered by network slices they must be structures in a way their users (customers, overlying operators) are able to know the features offered by both individual resources and complete slices. This means that there must be interfaces to deliver such information to the entity that needs it, but that will be also transitively delivered to the following chains of the slicing structure towards the final users.

To this sense, there are two specific interfaces that must be defined to address such function:

- The bottom-up interface, offered by underlying resource providers to resource consumers (operators) of any layer.

- The top-down interface, offered by overlying operators to lower level providers.

On the one hand, the first interface will, obviously, enable slice operators to access the slices owned by underlying providers and manage the resources they have been assigned in them. On the other hand, the second interface will enable lower layers to know details about the resources managed by overlying operators and the requirements they impose to the overlying network slices.

To this respect, both interfaces will emphasize the relation among the original resources, as well as the links from them to the resulting resources. This forms the main key of their management operations.

* Programmability and control of Network Slices.

**Slawomir – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

o Network slice operations (again some prioritization may be needed) are

expected to be:

\* Slice life cycle management including creation,

activation / deactivation, protection (note 2), elasticity (note 3),

extensibility (note 4), safety (note 5), sizing and scalability of the

slicing model per network and per network cloud: slices in access, core

and transport networks; slices in data centres, slices in edge clouds.

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**(Links with UCs & framework documents)**

\* Autonomic slice management and operation: namely self-configuration,

self-composition, self-monitoring, self-optimisation,

self-elasticity are carried as part of the slice protocols.

**Slawomir – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

\* Slice stitching / composition: having enablers and methods for

efficient stitching /composition/ decomposition of slices:

- vertically (service + management + control planes) and/or

- horizontally (between different domains part of access,

core, edge segments) and /or

- vertically + horizontally.

**Pedro – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

Network service composition has demonstrated to be highly beneficial for both operators and final users [GRAMMATIKOU-2012]. It allows the formation of an infinite number of different services, which will be specialized to the particular needs of a user or a specific situation. However, the current network architecture is far for being ideal to implement such function.

One of the keys of network slicing is the flexibility it adds to the network and the resulting “deossification” of network resources. Thus, this environment is much more optimal to allow the proliferation of network service composition, but it means that some sort of specific requirements must be pushed towards the architecture that supports the general slicing.

First, a proper composable network service model needs network resources to be compatible, regardless of the abstraction level they live or the domain to which they pertain. Then they must be homogeneously described, so a user can actually understand their individual capabilities and “draw” the service they want to build by combining them. Finally, the resources living among separated network slices must be “connectable” to each other. This means that they must cross the domain of their providers/owners in order to reach their destination.

\* End-to-end network segments and network clouds orchestration

of slices ([GUERZONI-2016], [KARL-2016]).

**Luis – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

\* Service Mapping: having dynamic and Automatic Mapping of Services to

slices; YANG models for slices.

**Satoru – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

o Describe the enablers and methods for the above mentioned capabilities

and operations from different viewpoints on slices (note 6).

**Pedro – TODO - approx 0.5 page: Description & new/revised protocols needed**

**(Links with UCs & framework documents)**

The viewpoints that emerge from the global and wide interaction among the Network Slice Provider (NSP), Network Slice Operator (NSO), and Application Service Provider (ASP) must be treated by network slicing to ensure their use cases are correctly covered. They are:

NSO <=> ASP:

– ASP requests to CRUD on Network Slices.

NSP <=> NSO:

– Allows the NSO to manage the “slice” of network resources from a provider.

+ Vertical interaction to request and instantiate (embed) composite network services onto the underlying physical infrastructures.

– Possibly recursive when a NSO also acts as NSP.

NSO <=> NSO:

– Allows NSOs to coordinate:

+ Inter-operator tasks (e.g. resource migration) requested by ASPs.

+ Interconnection and interoperability among NSs of different operators.

– Horizontal (non-recursive) communication between NSOs.

NSP <=> NSP:

– Horizontal communication between providers to coordinate the interaction among physical infrastructure resources, and/or the migration of slices among NSPs.

o Efficient enablers and methods for integration of above capabilities and

operations.

**Carlos – TODO - approx 0.5 page: Description & new/revised protocols needed**

In order to enable the above required capabilities and operation for network slicing, well defined reference points among the involved actors and entities are required, as well as the proper interface definitions ensuring interoperability of all involved pieces. Some examples of the required reference points/interfaces include:

* Customer/Vertical (user of the slice) – Network Slice Provider. The user of the slide SHOULD be able to specify the characteristics of the slide and provide it in a suitable/understandable format to the NSP. A proper information model might be needed to convey the customer slice requirements. And the model might need to support different levels of abstraction, to support different use cases.
* Network Slice Provider – Network Slice Provider / Network Slice Operator / Network Service Provider. The slice provider MUST be able to request resources to compose a slice to other slice providers, slice operator or service operators. The interface needs to support recursiveness and different levels of abstraction (the request might involve resources or services).
* Inter-domain interactions at different levels. Another way of composing a slice is by interaction of players at the same level (peering, instead of recursive), by delegating the request to other provides/operators. This type of interaction can take place at different levels (resource, network service, etc), and therefore would impose different requirements. In all cases, security issues are key due to the inter-operator nature.

## 2.1. Notes

(2) Protection refers to the related mechanisms so that events within

one slice, such as congestion, do not have a negative impact on

another slice.

(3) Elasticity refers to the mechanisms and triggers for the growth

/shrinkage of network resources, and/or network and service functions.

(4) Extensibility refers to the ability to expand a NS with

additional functionality and/or characteristics, or through the

modification of existing functionality/characteristics, while

minimizing impact to existing functions.

(5) Safety refers to the conditions of being protected against

different types and the consequences of failure, error harm or any

other event, which could be considered non-desirable.

(6) Multiple viewpoints on slices: I) viewpoint of the slice's owner

towards user: from this viewpoint a slice is defined as a means to

"split" physical or virtual infrastructure elements to "service" smaller

portions. This action would be recursively done from the owner of the initial and physical infrastructure element to the users. II) viewpoint of from the user towards the physical infrastructure owner. From this viewpoint a slice is viewed just as a set of resources that must be managed (requests to a provider, listed, changed, returned to the provider, etc.). This viewpoint emphasizes those issues that would be used in the SLA definition of a slice.

# 4. Security Considerations

Security will be a major part of the design of network slicing.

# 5. IANA Considerations

This document requests no IANA actions.

# 6. Acknowledgements

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# Authors' Addresses