Overview of SDOs' work on network slicing

Orange

3GPP/SA5 No.114

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Foreword

- This slide set contains a snapshot of the state-of-art re. various SDOs / fora initiatives on network slicing, at end of July 2017.

- It may be not 100% complete.

Main SDOs / fora working on Network Slicing

From Concepts to per-domain Standards

NFV / MANO as an enabler for network slicing

ngmn – the engine of broadband wireless innovation; GSMA

Business drivers, concepts, high-level requirements

ITU; tmforum

High-level description, business scenarios, cross-domain architecture, incl. management & orchestration

3GPP; broadband forum; IETF *; OIF; ONF – OPEN NETWORKING FOUNDATION

Domain-specific use cases, requirements, architecture, interface specifications

ETSI – World Class Standards

- * IETF did not start yet any WG (only BOF – Birds of a Feather)
- + some activity in other SDOs/fora (5G Americas, ATIS)

NGMN

- Sources:
  - 5G White Paper (Feb. 17th , 2015)
  - Description of Network Slicing Concept V1.0 (Jan. 16th , 2016)

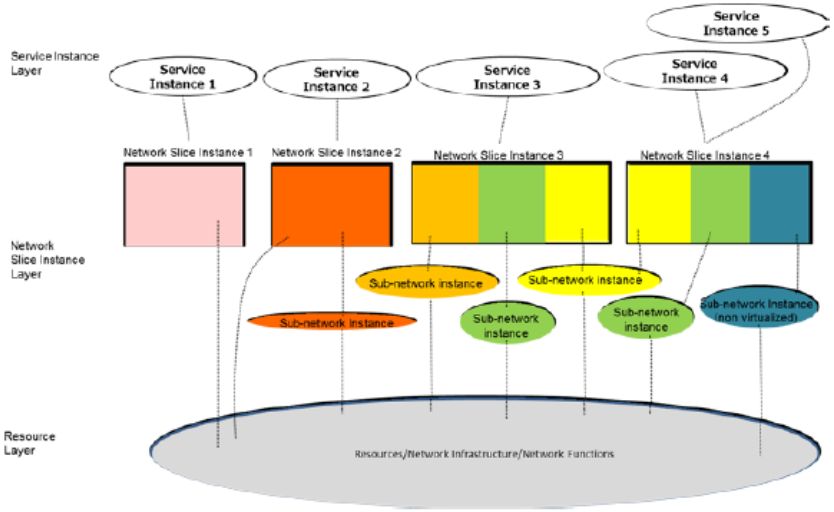


Figure 1: Network slicing conceptual outline

4.2 Definition

Service Instance: An instance of an end-user service or a business service that is realized within or by a Network Slice

Network Slice Instance: a set of network functions, and resources to run these network functions, forming a complete instantiated logical network to meet certain network characteristics required by the Service Instance(s).

- A network slice instance may be fully or partly, logically and/or physically, isolated from another network slice instance.
- The resources comprises of physical and logical resources.
- A Network Slice Instance may be composed of Sub-network Instances, which as a special case may be shared by multiple network slice instances. The Network Slice Instance is defined by a Network Slice Blueprint.
- Instance-specific policies and configurations are required when creating a Network Slice Instance.
- Network characteristics examples are ultra-low-latency, ultra-reliability etc.

Network Slice Blueprint: A complete description of the structure, configuration and the plans/work flows for how to instantiate and control the Network Slice Instance during its life cycle. A Network Slice Blueprint enables the instantiation of a Network Slice, which provides certain network characteristics (e.g. ultra-low latency, ultra-

Does 'complete' mean « end-to-end »?

GSMA (1/3)

- Source: « Unlocking Commercial Opportunities From 4G evolution to 5G (Network 2020) » – Feb. 2016 (Future Networks programme)

The orchestration architecture also presents challenges considering the lack of a well-defined overall framework. The current view based on some of the recommendations seems to be multiple levels of orchestration whereby SDN orchestration, individual or combined NFV orchestration and service orchestration distinctions are being made.

In a longer term, SDN and NFV promise many desirable benefits, including total cost of ownership (TCO) reduction, flexibility (e.g., dynamic lifecycle management and placement of network services), agility (e.g., time-to-market reduction), and network operation intelligence (e.g., automated end-to-end quality-of-service management). The main benefits of NFV and SDN are described in more detail in the remainder of section 4.2.

4.2.2.2 Network Slicing

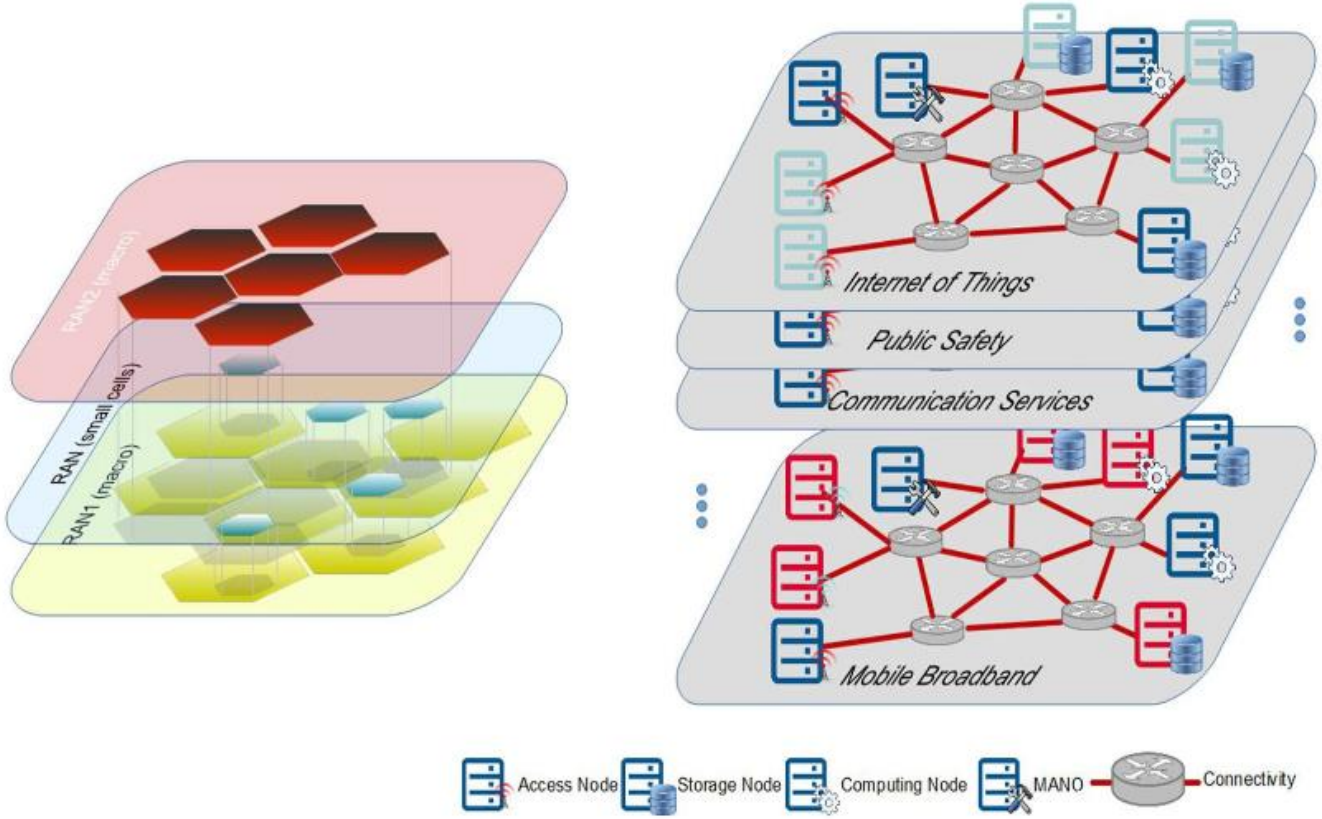
Mobile operator networks currently support a range of vertical services with diverse service requirements. With mobile operators expanding their service portfolio to generate new revenue streams by supporting more vertical services, this diversity is expected to grow even further.

Rather than operators deploying multiple physical networks for each of the vertical services to be supported, one viable approach to satisfy highly diverse service requirements from a single physical infrastructure may be to first virtualize the physical infrastructure with NFV and SDN, and define multiple virtual networks (or network slices) in accordance with the requirements of the vertical services. A network slice can be seen as a dedicated network with its own processing, management and connectivity characteristics that shares the same physical resources with other network slices. Both NFV and SDN are key enabling technologies for overcoming the barriers to the realisation of network slicing.

Using the network slicing concept, it is thus possible to run instances of multiple networks – such as a smart meter network and a public safety communications network – over the same physical infrastructure with possibly different levels of network level security, support for mobility management, latency and throughput.

GSMA (2/3)

Figure 16: Example of network slicing



GSMA (3/3)

- Source: S5-174046 (LS from GSMA cc SA5 on Network Slicing initiative):

The GSMA Future Networks Programme would like to notify your organisation of the recent launch of a project concerning Network Slicing.

Description

The GSMA Network Slicing Taskforce initially aims to create a harmonised definition of network slice that can be used to illustrate the capability and value of network slicing to vertical industry representatives. The project will then focus on gaining as deep as possible an insight of what vertical industries expect the 5G network to deliver to serve their business needs.

Based on such insights, GSMA intends to create a limited set of reference network slice types, that are globally available, with each serving specific business needs and reusable across as many vertical industries as possible. By capturing the characteristics of the basic set of slice types in a GSMA permanent reference document (PRD), such network slice types can be documented through well-defined roaming agreement templates and therefore made available globally. The PRD may also provide guidelines on how certain vertical industries' requirements could be met by the device, potentially through concurrent use of a set of slice types.

The definition of network slice types is intended to build upon and complement the specification of network slicing currently ongoing in 3GPP.

ITU-T SG13

- SG 13 (Future networks, with focus on IMT-2020, cloud computing and trusted network infrastructures) / Q.21 : Network softwarization including software-defined networking, network slicing and orchestration

[2017-2020] : [SG13] : [Q21/13]

[Declared patent(s)] - [Associated work]

Work item:	Y.NSOM
Status:	Under study [issued from previous study period]
Approval process:	AAP
Type of work item:	Recommendation
Version:	New
Provisional name:	-
Equivalent number:	-
Timing:	2018-06 (High priority)
Liaison:	-
Subject/title:	Network slicing orchestration and management
Summary:	More and more emerging services with diverse network performance requirements will be a challenge for the telecommunication networks and will require new approaches to make the network more flexible and programmable than today. Network slicing is proposed to provide network slices to meet diverse service scenarios in telecommunication network (e.g., mobile network, fixed network). In network slicing, functions to orchestrate functions inside a slice and/or functions shared among slices are indispensable, e.g., function to map service requirement to network slice resource requirement, lifecycle management of slice, integrated/global management/coordination for multiple slices. These capabilities, network slicing orchestration and management, are the key for applying network slice technology into telecommunication networks. The objective of this document is to describe the scenarios, requirement, architecture, functional design and reference points of network slicing orchestration and management, including in distributed networking and for telecommunication network.
Comment:	-
Base text(s):	[TD 41-WP1 🔒]
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	Miao Xue, Editor
	Miao Xue, Editor

ITU-T SG15

- SG 15 (Transport, Access and Home) / Q.12: Transport network architectures

Technical Report (TR) GSTR TN5G

- "Transport network support of IMT-2020/5G"
  - Reference Model for the IMT2020/5G transport network
  - Deployment Scenarios
  - Identify how IMT2020/5G requirements will drive modifications to the existing transport network recommendations

GSTR TN5G Outline

- A reference model for the IMT-2020/5G transport network (with the terminology clarified)
- A set of deployment scenarios including details on:
  - Transport network topology
  - Interfaces between the IMT-2020/5G entities to the transport network
    - distance between these entities
    - number of interfaces; interface bit rate; total capacity
    - latency requirements
    - synchronization requirements
- Control/Management interfaces
- Support of IMT-2020/5G network slicing (data plane and control plane)

TM Forum

- Source: IG1152 - TM Forum Exploratory Report: Dynamic Network Slices Management and Business Models

2.1.4. TM Forum definition

Network Slice is a logical network serving a defined business purpose or customer, consisting of all required network resources configured together. It is created, changed and removed by management functions.

- 'End to end' within a provider
- Enabler for services, not a service
- Mobile and fixed
- Resources may be physical or virtual, dedicated or shared
- Independent/'Isolated' but may share resources

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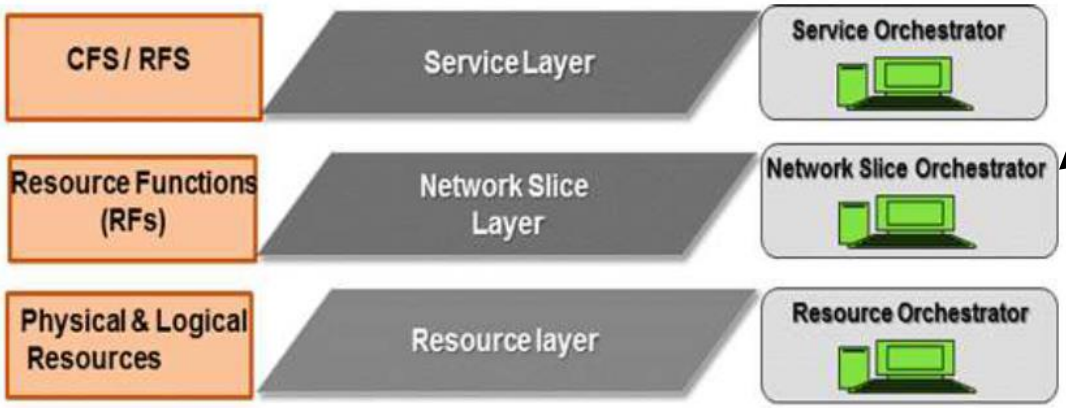
- May integrate services from other providers, facilitating e.g. aggregation and roaming

TM Forum (cont'd)

a) Slice layering model

The slice layering model shall also follow the orchestration layering model it is managing as depicted, along with 'Managed Entities' in pink color in Figure 5.

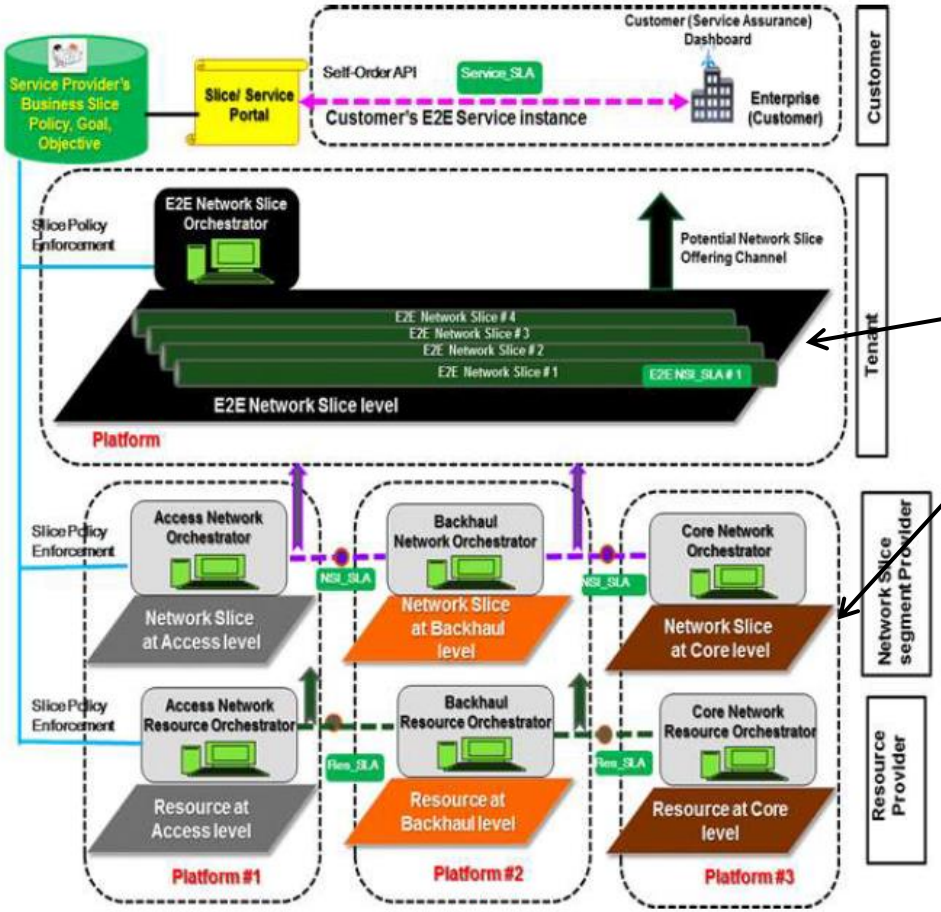


Identifies a « Network Slice Orchestrator »

Figure 5: 5G Slicing Orchestration layering model

TM Forum (cont'd)

Dynamic Network Slices Management and Business Models



Identifies two levels of Network Slices:

- End-to-end
- Per network domain

Figure 6: Deployment scenario: 5G Slicing Orchestration layering model in Multi-domain (Access Network, Backhaul, Core Network) use case

3GPP / SA1

- Source: TR 22.261 V16.0.0 (2017-06): Service requirements for the 5G system; Stage 1 (Release 16)

SA1 does not differentiate « network slice » from « network slice instance »

6 Basic capabilities

6.1 Network slicing

6.1.1 Description

Network slicing allows the operator to provide customised networks. For example, there can be different requirements on functionality (e.g., priority, charging, policy control, security, and mobility), differences in performance requirements (e.g., latency, mobility, availability, reliability and data rates), or they can serve only specific users (e.g., MPS users, Public Safety users, corporate customers, roamers, or hosting an MVNO).

A network slice can provide the functionality of a complete network, including radio access network functions and core network functions (e.g., potentially from different vendors). One network can support one or several network slices.

6.1.2 Requirements

The 5G system shall allow the operator to create, modify, and delete a network slice.

The 5G system shall allow the operator to define and update the set of services and capabilities supported in a network slice.

The 5G system shall allow the operator to configure the information which associates a UE to a network slice.

The 5G system shall allow the operator to configure the information which associates a service to a network slice.

The 5G system shall allow the operator to assign a UE to a network slice, to move a UE from one network slice to another, and to remove a UE from a network slice based on subscription, UE capabilities, the access technology being used by the UE, operator's policies and services provided by the network slice.

The 5G system shall support a mechanism for the VPLMN to assign a UE to a network slice with the needed services and authorised by the HPLMN, or to a default network slice.

The 5G system shall enable a UE to be simultaneously assigned to and access services from more than one network slice of one operator.

Traffic and services in one network slice shall have no impact on traffic and services in other network slices in the same network.

Creation, modification, and deletion of a network slice shall have no or minimal impact on traffic and services in other network slices in the same network.

The 5G system shall support scaling of a network slice, i.e., adaptation of its capacity.

The 5G system shall enable the network operator to define a minimum available capacity for a network slice. Scaling of other network slices on the same network shall have no impact on the availability of the minimum capacity for that network slice.

The 5G system shall enable the network operator to define a maximum capacity for a network slice.

The 5G system shall enable the network operator to define a priority order between different network slices in case multiple network slices compete for resources on the same network.

The 5G system shall support means by which the operator can differentiate policy control, functionality and performance provided in different network slices.

The serving 5G network shall support providing connectivity to home and roaming users in the same network slice.

In shared 5G network configuration, each operator shall be able to apply all the requirements from this clause to their allocated network resources.

3GPP / SA2

- Source: TS 23.501 V1.1.0 (2017-07): System Architecture for the 5G System; Stage 2

5.15 Network slicing

5.15.1 General

A Network Slice is defined within a PLMN and shall include:

- the Core Network Control Plane and user plane Network Functions, as described in clause 4.2,

and, in the serving PLMN, at least one of the following:

- the NG Radio Access Network described in 3GPP TS 38.300 [27],
- the N3IWF functions to the non-3GPP Access Network described in clause 4.2.7.2.

5.18 Network Sharing

Editor's note: Relation between network slicing and network sharing should be clarified.

5.18.1 General concepts

A network sharing architecture shall allow multiple participating operators to share resources of a single shared network according to agreed allocation schemes. The shared network includes a radio access network. The shared resources include radio resources.

Editor's note: Whether core network functions and resources could be also shared is FFS.

The shared network operator allocates shared resources to the participating operators based on their planned and current needs and according to service level agreements. The shared resources are allocated separately for each participating operator and for signalling traffic and user data traffic within each participating operator. When there is a need for additional resources for a participating operator, the shared network operator may allocate available shared resource to the participating operator according to the service level agreement.

A UE that has a subscription to a participating network operator shall be able to select this participating network operator while within the coverage area of the shared network and to receive subscribed services from the participating network operator.

3GPP / SA3

- Source: TR 33.899 V1.2.0 (2017-06): Study on the security aspects of the next generation system (Release 14)

5.8 Security area #8: Network slicing security

NOTE: Network slice related terms should be referred to work of other WGs, for example, TR 23.799 [2], TS 23.501 [74], and TS 23.502 [83] and otherwise, it should be understood as general terms.

5.8.1 Introduction

Network slicing will be an important component of the Next Generation network. It enables the operator to create networks customised to provide optimized solutions for different market scenarios which demands diverse requirements, e.g. in the areas of functionality, performance and isolation. A network slice is composed of a collection of logical network functions that supports the communication service requirements of particular use cases.

Functionalities and capabilities within 3GPP scope that enables the next generation system to support the Network Slicing and Network Slicing Roaming requirements are defined in TR 22.864 [6]. Solutions for the network slicing which include architecture and functionality are defined in TR 23.799 [2].

Among the features related to network slicing in TR 23.799 [2], several have potential security implications such as the sharing of network functions and the isolation between the different slices. In particular, in relation to isolation, in some of the security requirements of [6] it is mentioned that network slices might be potentially open for 3rd parties to run their own functions or even might be entirely managed by external parties such as an enterprise or a public safety organization.

Other requirements and use cases from TR 22.864 [6] indicate that the service access model is different in the Next Generation systems. UEs are not only able to access the services through different types of access networks: 3GPP, non-3GPP, trusted and less trusted, but also able to simultaneously access services provided by different network slices. All these capabilities combined lead to a proliferation in the number of possible deployment scenarios for example depending on which functions are shared, which type of network access is used, what is the trust relationship between the service provider and the network operator, etc.

3GPP / SA5

- Sources:
  - Ongoing:
    - TR 28.801 V1.2.0 (2017-05): Study on management and orchestration of network slicing for next generation network (Release 15)
    - TR 28.800 V0.7.0 (2017-05): Study on management and orchestration architecture of next generation networks and services (Release 14)
  - New:
    - TS 28.530: Management of network slicing in mobile networks; Concepts, use cases and requirement (Release 15) – Starting at SA5#114
    - TS 28.531: Provisioning of network slicing for 5G networks and services (Release 15) – Starting at SA5#114
    - Potentially new Work Items approved at SA5#114 meeting.

3GPP / RAN3 (1/2)

- Source: TR 38.801 V14.0.0: Study on new radio access technology: Radio access architecture and interfaces (Release 14)

From clause 3.1 Definitions:

Network Slice: A Network Slice is a network created by the operator customized to provide an optimized solution for a specific market scenario which demands specific requirements with end to end scope as described in TR 23.799 [6].

8 Realization of Network Slicing

8.1 Key principles for support of Network Slicing in RAN

Network Slicing is a new concept to allow differentiated treatment depending on each customer requirements. With slicing, it is now possible for Mobile Network Operators (MNO) to consider customers as belonging to different tenant types with each having different service requirements that govern in terms of what slice types each tenant is eligible to use based on Service Level Agreement (SLA) and subscriptions.

NSSAI (Network Slice Selection Assistance Information) includes one or more S-NSSAIs (Single NSSAI). Each network slice is uniquely identified by a S-NSSAI, as defined in TR 23.799 [6]. The UE may store a Configured and/or Accepted NSSAI per PLMN. The NSSAI can have standard values or PLMN specific values.

NOTE 1: For signaling between RAN and CN a Slice ID is represented by an NSSAI or S-NSSAI. For the air interface, it is up to RAN groups to decide how to carry/define NSSAI information in RRC (the term "slice ID" is used in the following to refer to this).

The following key principles apply for support of Network Slicing in RAN. The RAN throughout the whole section refers to the new RAN, including both gNB and eLTE eNB.

RAN awareness of slices

- RAN shall support a differentiated handling of traffic for different network slices which have been pre-configured. How RAN supports the slice enabling in terms of RAN functions (i.e. the set of network functions that comprise each slice) is implementation dependent.

Selection of RAN part of the network slice

- RAN shall support the selection of the RAN part of the network slice, by one or more slice ID(s) provided by the UE or the CN which unambiguously identifies one or more of the pre-configured network slices in the PLMN. The Accepted NSSAI is sent by CN to UE and RAN after network slice selection

Resource management between slices

- RAN shall support policy enforcement between slices as per service level agreements. It should be possible for a single RAN node to support multiple slices. The RAN should be free to apply the best RRM policy for the SLA in place to each supported slice.

Support of QoS

- RAN shall support QoS differentiation within a slice.

RAN selection of CN entity

- For initial attach, the UE may provide one or more slice ID(s). If available, RAN uses the slice ID(s) for routing the initial NAS to an NGC CP function. If the UE does not provide any slice ID(s) the RAN sends the NAS signalling to a default NGC CP function.
- For subsequent accesses, the UE provides a Temp ID, which is assigned to the UE by the NGC, to enable the RAN to route the NAS message to the appropriate NGC CP function as long as the Temp ID is valid (RAN is aware of and can reach the NGC CP function which is associated with the Temp ID). Otherwise, the methods for initial attach applies.

NOTE 2: the definition of the Slice ID for use over the air interface is subject to further discussions

3GPP / RAN3 (2/2)

- TR 38.801 (cont'd)

Resource isolation between slices

- RAN shall support resource isolation between slices. RAN resource isolation may be achieved by means of RRM policies and protection mechanisms that should avoid that shortage of shared resources in one slice breaks the service level agreement for another slice. It should be possible to fully dedicate RAN resources to a certain slice. How RAN supports resource isolation is implementation dependent.

Slice Availability

- Some slices may be available only in part of the network. Awareness in a gNB of the slices supported in the cells of its neighbouring gNBs may be beneficial for inter-frequency mobility in connected mode. If such awareness is also beneficial for intra-frequency mobility may be discussed in the normative phase. It is assumed that the slice configuration does not change within the UE's registration area.
- The RAN and the CN are responsible to handle a service request for a slice that may or may not be available in a given area. Admission or rejection of access to a slice may depend by factors such as support for the slice, availability of resources, support of the requested service by other slices.

Possible solutions for how slice availability may be handled during mobility may be discussed in the normative phase e.g.:

- Neighbours may exchange slice availability on the interface connecting two nodes, e.g. Xn interface between gNBs.
- The core network could provide the RAN a mobility restriction list. This list may include those TAs which support or do not support the slices for the UE.
- The slices supported at the source node may be mapped, if possible, to other slices at target node. Examples of possible mapping mechanisms that can be studied in normative phase are:
  - Mapping by the CN, when there is naturally a signalling interaction between RAN and CN and performance is thus not impacted;
  - Mapping by the RAN as action following prior negotiation with the CN during UE connection setup;
  - Mapping by the RAN autonomously, when involving the CN would not be a practical solution and if prior configuration of mapping policies took place at RAN;

Support for UE associating with multiple network slices simultaneously

- In case a UE is associated with multiple slices simultaneously, only one signalling connection shall be maintained.

- Couldn't find out ref. to RAN slicing in:
  - TS 32.401 V0.1.0 (2017-05) NG-RAN; Architecture Description (Release 15)
  - TS 32.410 V0.2.0 (2017-05) NG-RAN; NG general aspect and principles (FFS) (Release 15)

Broadband Forum

- WT-370: FANS Overall Architecture and Requirements

SDN&NFV	WT-370	FANS Overall Architecture and Requirements		FANS Overall Architecture and Requirements investigates on the technical aspects associated with Fixed Access Network Sharing (FANS), which covers the Access Network and part of the Customer Network in case of PON architecture, addressing the typical infrastructures, topologies and deployment scenarios. It also provides security considerations necessary to support multi-operator access sharing. This project outlines technical aspects related to the migration of TR-101 and TR-178 based architectures toward a shared converged broadband access network architecture that supports the business drivers defined in SD-351. Besides multi-operator sharing scenarios, this project can be also appropriate for a network operator that wants to slice its access network to offer different services toward customers (e.g., for residential or enterprise markets) and wants to be able to manage it using a vertical organization structure. Furthermore, FANS Overall Architecture and Requirements is the ongoing pilot project for the upcoming activities related to Access Network Sharing interface(s) and SDN-Enabled FANS.

FANS: Fixed Access Network Sharing

Broadband Forum (cont'd)

5 Sharing Alternatives

In the following sections two solution models for resources sharing/slicing are analysed:

- Management System
- Virtual Access Node

5.1 Management System

The solution based on a Management System (MS) performs the network slicing at the management system level and not directly into the equipment itself. The MS could be virtualized and hosted in the Cloud or in other operator locations.

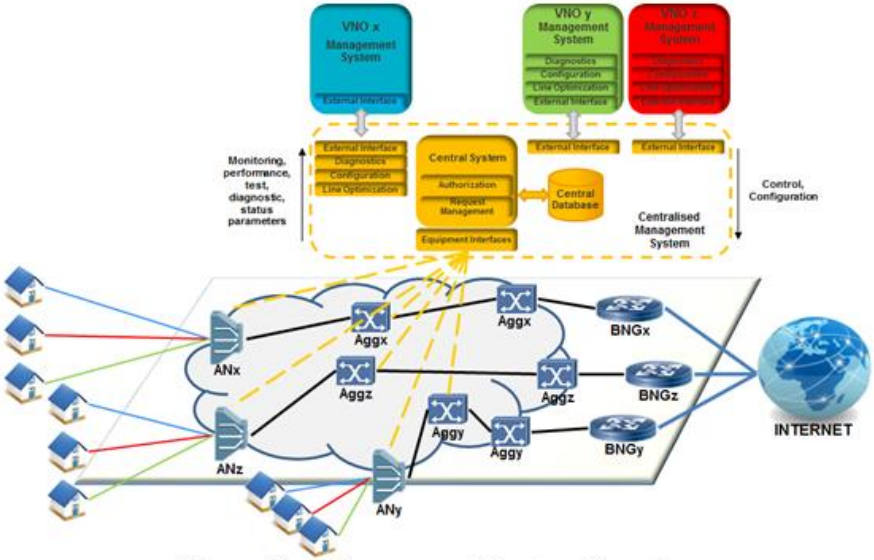


Figure 21 – Management System Overview

Broadband Forum (cont'd)

5.2 Virtual Node

5.2.1 Virtual Access Node

The Virtual Access Node model is based on the paradigm that physical access nodes (e.g., AN, ONU or OLT) in the access network can be abstracted by an InP into multiple virtual Access Nodes (vANs) related to VNOs.
The virtual Access Node (vAN) element provides similar functions to those of a physical AN (pAN) but in a virtual environment. The solution is composed of a vAN for each VNO and this allows a separate management of user traffic.

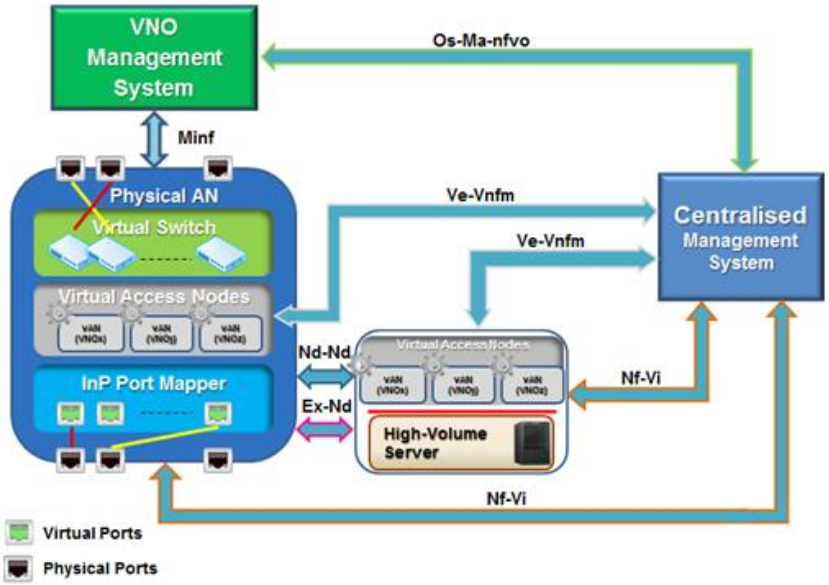


Figure 24 – Virtual Access Node Model

Broadband Forum (cont'd)

- SD-406 : project just starting
- "End-to-End Network Slicing: Use Cases, Principles & Requirements" – see below:

Use Cases: A Business View

- **Virtual Network Operator (WT-370)**
  - Inf operator shares with virtual operator
  - Operators share common infrastructure
- **Vertical Segment (e.g. IoT service)**
  - Service provider without own network needs to collect/push data from/towards end devices
- **Application provider (e.g. OTT Video)**
  - Application provider without own network needs to use network resources to provide application to end customer
  - Application provider has control of the application
- **Enterprise interconnect**
  - Connecting remote locations
  - Cloud CO (functional decomposition/allocation)

broadband forum

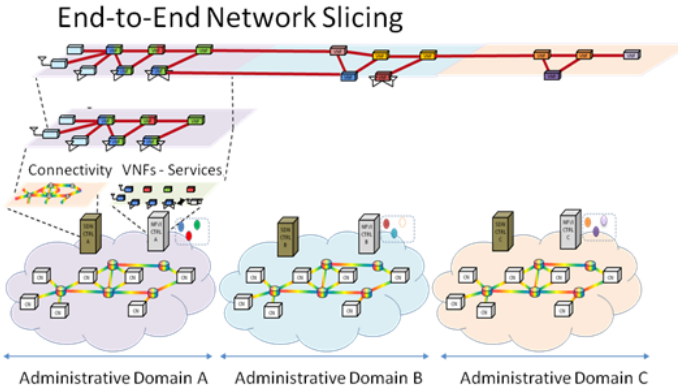
Broadband Forum (cont'd)

- "End-to-End Network Slicing: Use Cases, Principles & Requirements" – Cont'd

Network Slice Principles

- Slicing facilitates
  - Automation: Signaling based – on-demand
  - Isolation: Control/Data plane – Shared resources
  - Customization: VNFs, provision policy, protocols, C-plane, etc.
  - Flexibility: Slice resources, VNFs can dynamically change

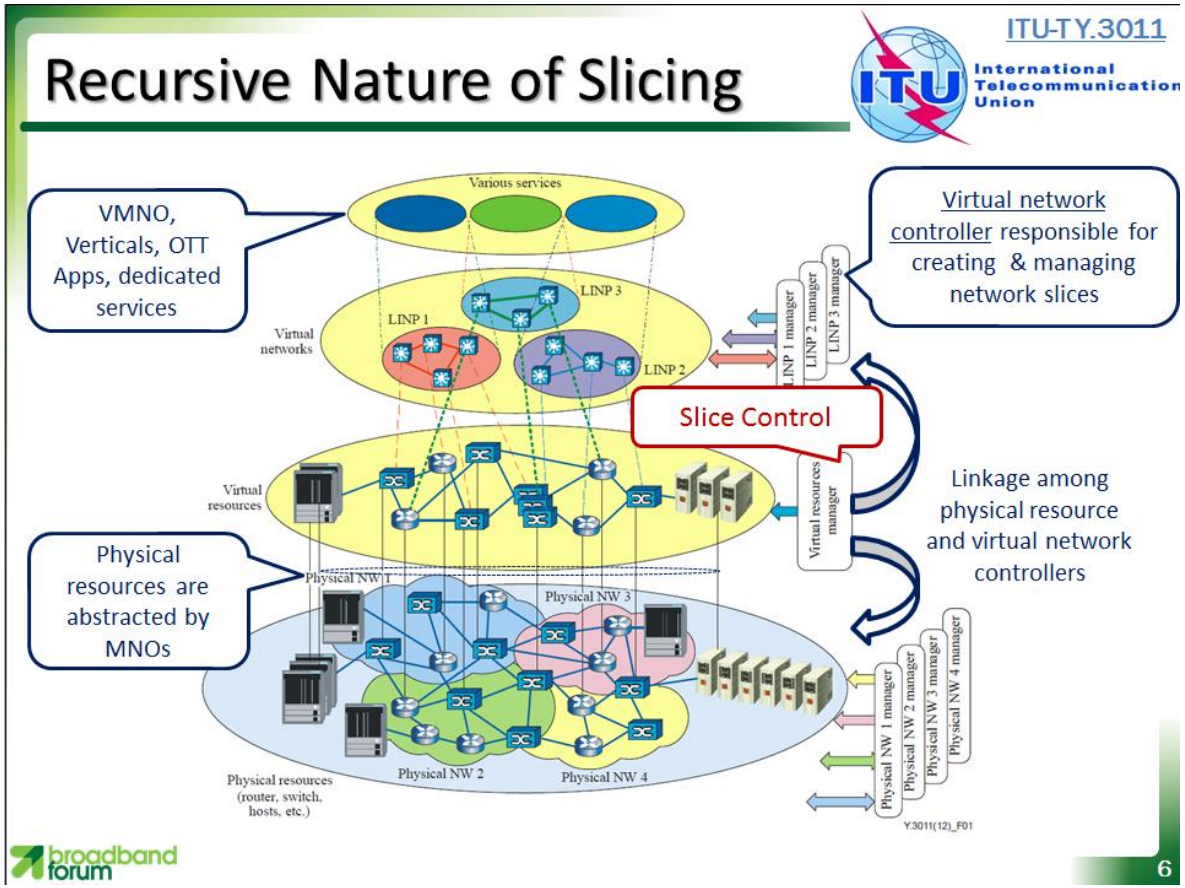
- End-to-End Slicing
  - Across different administrative domains and technologies (FMC)
  - Across RAN, core, transport and cloud



broadband forum

Broadband Forum (cont'd)

- "End-to-End Network Slicing: Use Cases, Principles & Requirements" – Cont'd



Broadband Forum (cont'd)

- "End-to-End Network Slicing: Use Cases, Principles & Requirements" – Cont'd

Network Slicing Vs VNP

- **A network slice reflects a service**
  - **Beyond VPN** - access and connectivity
  - No need of traditional contractual agreements - no human intervention
- A slice request should reflect
  - SLA: All traditional VNP service requirements (capacity, delay, jitter, etc.)
  - Automation: Timing
    - When a slice request should be initiated
    - Duration – for how long a slice should be alive
    - Periodicity - regularity
  - Flexibility: Customers group, service type, location, feedback
  - Customization: data/control plane

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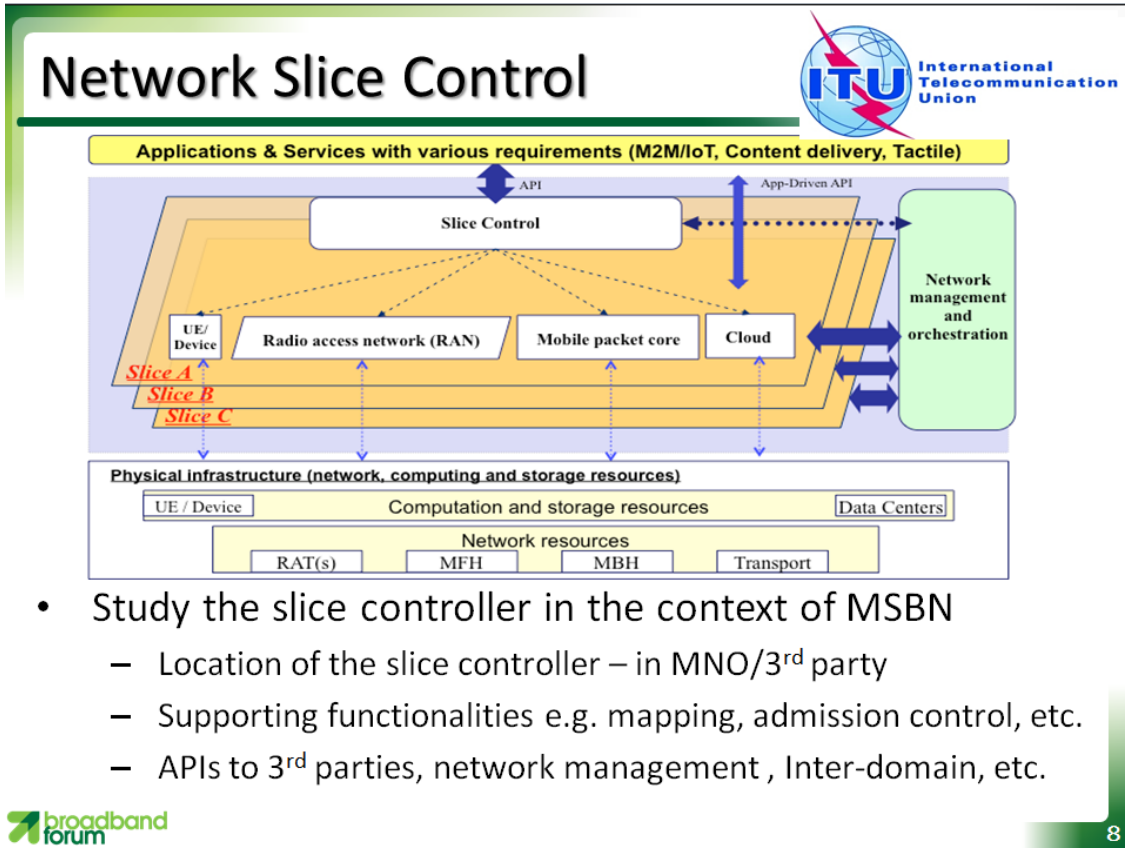
Broadband Forum (cont'd)

- "End-to-End Network Slicing: Use Cases, Principles & Requirements" – Cont'd



- Study the slice controller in the context of MSBN
  - Location of the slice controller – in MNO/3rd party
  - Supporting functionalities e.g. mapping, admission control, etc.
  - APIs to 3rd parties, network management , Inter-domain, etc.

Broadband Forum (end)

- "End-to-End Network Slicing: Use Cases, Principles & Requirements" – Cont'd

Slice Operations – Further Contributions

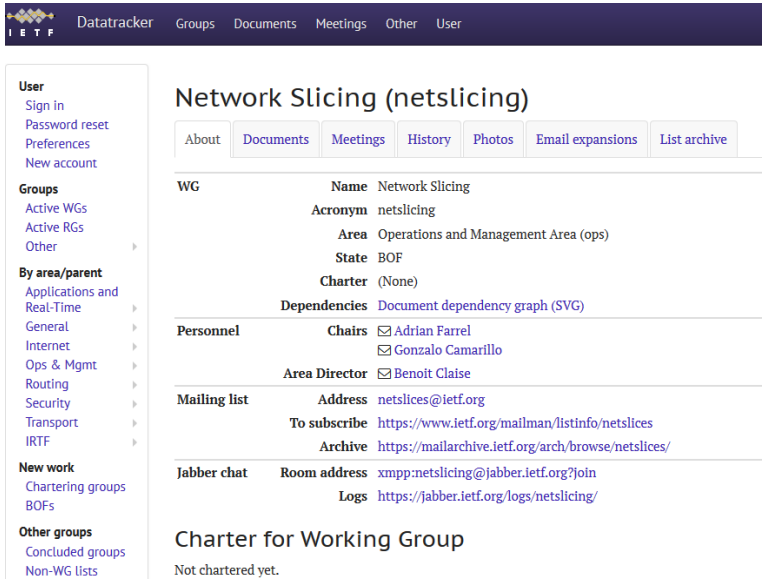
- Supporting slice selection – "handover"
- Supporting multiple slices
  - Slices may have colliding address plans, therefore they would need to be isolated at layer 2
  - Extending VLAN tagging to the home would be required
  - Dealing with the control plane
- VLAN tagging
  - Do we carry forward 1:1, N:1 or both tagging mode
  - Do we deprecate 1:1 single tagged as an option
    - Lack of scalability?
- QoS: We may consider phases of 5G fixed access
  - Phase 1 – single slice, reflective QoS?
  - Phase 2 – multi-slice, via dynamic configuration of VLANs to the premises

broadband forum

9

IETF

- A BOF has been created on Network Slicing (several presentations made at IETF 99)



- Some related activities also in:
  - ACTN (Abstraction and Control of Transport Networks) – concluded BOF
  - TEAS (Traffic Engineering Architecture and Signaling) Working Group

BOF: Birds of a Feather

IETF (cont'd)

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draft-geng-netslices-architecture-02 **Network Slicing Architecture**	2017-07-03 27 pages	I-D Exists		
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draft-netslices-usecases-01 **Network Slicing Use Cases: Network Customization and Differentiated Services**	2017-07-03 44 pages	I-D Exists		
draft-qiang-netslices-gap-analysis-01 **Gap Analysis for Transport Network Slicing**	2017-07-03 26 pages	I-D Exists		

IETF (cont'd)

Network Slicing - 3GPP Use Case	https://datatracker.ietf.org/doc/draft-defoy-netslices-3gpp-network-slicing/	2017-04-26
Network Slicing Management and Orchestration	draft-flinck-slicing-management-00	2017-07-03
Autonomic Slice Networking-Requirements and Reference Model	https://datatracker.ietf.org/doc/draft-galis-anima-autonomic-slice-networking/	2017-03-31
Network Slicing - Revised Problem Statement	draft-galis-netslices-revised-problem-statement-01	2017-07-03
Network Slicing Architecture	draft-geng-netslices-architecture-02	2017-07-03
Applicability of Abstraction and Control of Traffic Engineered Networks (ACTN) to Network Slicing	draft-king-teas-applicability-actn-slicing-01	2017-07-03
Network Slicing Use Cases: Network Customization and Differentiated Services	draft-netslices-usecases-01	2017-07-03
Gap Analysis for Transport Network Slicing	draft-qiang-netslices-gap-analysis-01	2017-07-03

IETF (cont'd)

- Network Slicing Architecture (draft-geng-netslices-architecture-02)

3.1. Requirements

To meet the diversified Quality of Experience (QoE) demands of different vertical industries, the gap analysis document has identified the following requirements:

- o Req.1 Network Slicing Resource Specification
- o Req.2 Cross-Network Segment; Cross-Domain Negotiation
- o Req.3 Guaranteed Slice Performance and Isolation
- o Req.4 Slice Discovery and Identification
- o Req.5 NS Domain-Abstraction
- o Req.6 OAM Operations with Customized Granularity

```
Internet-Draft        Network Slicing Architecture            June 2017

   +-------------------------------------------------------------------+
   |                       Service Component                           |
   +-------------------------------------------------------------------+
   +-------------------------------------------------------------------+
   |         Network Slice Management and Orchestration                |
   |       +---------------+ +-----------+  +----------------+        |
   |       |    Template   | |    NS     |  |Life cycle Mngt.|        |
   |       |  Management   | |Repository.|  |and monitoring  |        |
   |       +---------------+ +-----------+  +----------------+        |
   |     +-------------++---------------++---------++----------+      |
   |     | E2E         || Domain        || NS      || Resource |      |
   |     |Orchestration|| Orchestration || Manager || Registrar|      |
   |     +-------------++---------------++---------++----------+      |
   +-------------------------------------------------------------------+
   +-------------------------------------------------------------------+
   |                       Resource Component                          |
   |    +---+         +---+             +---+      +---+               |
   |    |NE1+----+    |NE3+------+   +--+NE5+------+NE6|               |
   |    +---+    |    +-+-+      |   |  +-+-+      +---+               |
   |           +-+-+    |      +-+-+ |    |                            |
   |           |NE2+----+      |NE4+-+    |                            |
   |           +-+-+           +-+-+      |                            |
   |             |               |        |                            |
   |             +-------------------------+                            |
   +-------------------------------------------------------------------+
                                 |
                                 |
                                 \/
   +-------------------------------------------------------------------+
   |              Created Network Slice Instance                       |
   | +-----------------------------------------------------------------+ |
   | | +-----------+      +-----------+   +-----------+    +-----+ | |
   | | |NS-Subnet 1+----+ |NS-Subnet 3|   |NS-Subnet 6|----| SBC | | |
   | | +-----------+ |    +-----------+   +-----------+    +-----+ | |
   | |               |                      |                       | |
   | |         +-----------+     |+-----------+                     | |
   | |         |NS-Subnet 2+-----| NS-Subnet 4|                     | |
   | |         +-----------+     +------------+   Network Slice     | |
   | |           |                       |          Instance 1       | |
   | |           +-----------------------+                           | |
   | +-----------------------------------------------------------------+ |
   | +-----------------------------------------------------------------+ |
   | |                                                Network Slice    | |
   | |                                                 Instance N      | |
   | +-----------------------------------------------------------------+ |
   +-------------------------------------------------------------------+

                 Figure 1: Network Slicing Architecture
```

IETF (cont'd)

III. Network Slicing Terms used in this draft

Resource Slice - A grouping of physical or virtual (network, compute, storage) resources. It inherits the characteristics of the resources which are also bound to the capability of the resource. A resource slice could be one of the components of Network Slice, however on its own does not represent fully a Network Slice.

Network Slice - A Network slice is a managed group of subsets of resources, network functions / network virtual functions at the data, control, management/orchestration planes and services at a given time. Network slice is programmable and has the ability to expose its capabilities. The behaviour of the network slice realized via network slice instance(s).

IETF (cont'd)

Network Slice Instance - An activated network slice. It is created based on network template. A set of managed run-time network functions, and resources to run these network functions, forming a complete instantiated logical network to meet certain network characteristics required by the service instance(s). It provides the network characteristics that are required by a service instance. A network slice instance may also be shared across multiple service instances provided by the network operator. The network slice instance may be composed by none, one or more sub-network instances, which may be shared by another network slice instance.

Network Slice Template - A complete description of the structure, configuration and the plans/work flows for how to instantiate and control the Network Slice Instance during its life cycle.

Network Slice Type - Network slices are categorized into different types according to the abstraction of characteristics of the services they facilitate. The methodology used for defining network slice types may be different for the network slice provider. Some typical examples of network slice types according to 5G implementation include eMMB, mMTC and URLLC. Network slice type may be used to map specific network resources, VPNs, QoS categories according to real implementation. It is advised that mutual types should be defined according to existing main-stream service implementation scenarios. Extensions should be allowed for network slicing service provider to make according to new requirements.

IETF (cont'd)

Network Slice Provider - A network slicing provider, typically a telecommunication service provider, is the owner or tenant of the network infrastructures from which network slices are created. The network slicing provider takes the responsibilities of managing and orchestrating corresponding resources that the network slicing

Network Slice Tenant - A network slice tenant is the user of specific NSIs, with which specific services can be provided to end customers. Network slice tenants can make requests of the creation of new network slice instances. Certain level of management capability should be exposed to network slice tenant from network slice service provider.

2.3. Network Slicing as a Service

It is anticipated that the operation of 5G and future networks will involve new business models. Given that the network is more flexible, elastic, modularized and customized, the shared network infrastructure can be sliced and offered as a service to the customer. For instance, dedicated, isolated, end-to-end network resources with a customized topology can be provided as a network slice service to the tenant of this network slice.The tenants are allowed to have a certain level of provisioning of their network slices.

IETF (cont'd)

3.4. Network Slices Capability Exposure

4. Data Plane of Network Slicing

4.3. Hard vs Soft Slicing in the Data-plane

4.5. The Role of VPNs

VPNs are considered candidate technologies for network slicing.

5. Control Plane of Network Slicing

5.1. NS Infrastructure Control Plane

The NS infrastructure control plane receives the instruction of creating a network slice with particular requirements from the orchestration layer. It then creates the network slice by allocating a set of network resources in the corresponding network

5.4. Intra-Slice Control Plane

IETF (cont'd)

6. Management Plane of Network Slicing

6.1. Network Slice Creation - Reservation / Release Messages Flow

6.2. Self- Management Operations

6.3. Programmability of the Management Plane

6.4. Management plane slicing protocols

Internet-Draft Network Slicing Architecture June 2017

```
   Inter Network Slice  Slice Element      Element          Network
     Orchestrator       Manager            Manager          Function
          |                |                  |                |
          |   Discovery -  |  Discovery -     |   Discovery    |
          |   -Response    |  Response        |   Response     |
          |   <------------>|<-------------->|<-------------> |
          |                |                  |                |
          |                |                  |                |
          |     Request    |                  |                |
          |    Net Slice   |                  |                |
          |---------------->|   Request        |                |
          |                |  Net Sice        |                |
          |                |----------->      |  Request       |
          |                |                  |  Net Slice     |
          |                |                  |------------>   |
          |                |Confirm-Waiting|                |
          |                |<--------------|                |
          |                |                  |  Negotiation   |
          |                |                  |(Single/Multiple|
          |                |                  |         Rounds)|
          |                |                  |<-------------> |
          |Confirm-Waiting |                  |                |
          |<---------------|                  |                |
          |                | Negotiation      |                |
          |                |Single/Multiple|                |
          |                | Rounds           |                |
          |     Negotiation | <----------->   |                |
          |Single/Multiple |                  |                |
          |  Rounds        |                  |                |
          | <-------------> |                  |                |
```

Figure 3: Network Slice Reservation / Release Messages Flow

IETF (cont'd)

- Network Slicing - 3GPP Use Case
- https://tools.ietf.org/pdf/draft-defoy-netslices-3gpp-network-slicing-01.pdf

Internet-Draft Network Slicing 3GPP Use Case April 2017

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IETF (cont'd)

- Gap Analysis for Network Slicing
- https://www.ietf.org/id/draft-qiang-netslices-gap-analysis-01.pdf

Requirements	Gaps
Req 1. Network Slicing Specification (NSS)	1) A detailed specification of NSS 2) A companion YANG data model for NSS
Req 2. Network Slicing Cross-Domain Coordination (NS-CDC)	3) A companion data model for NS-CDC
Req 3. Network Slicing Performance Guarantee and Isolation (NS-PGI)	4) Slicing specific extension on existing technologies
Req 4. Network Slicing OAM (NS-OAM)	5) Mechanisms for dynamic discovery of service function instances and their capabilities. Mechanisms for dynamic discovery of instantiated network slices 6) non-overlay OAM solution 7) Mechanisms for customized granularity OAM

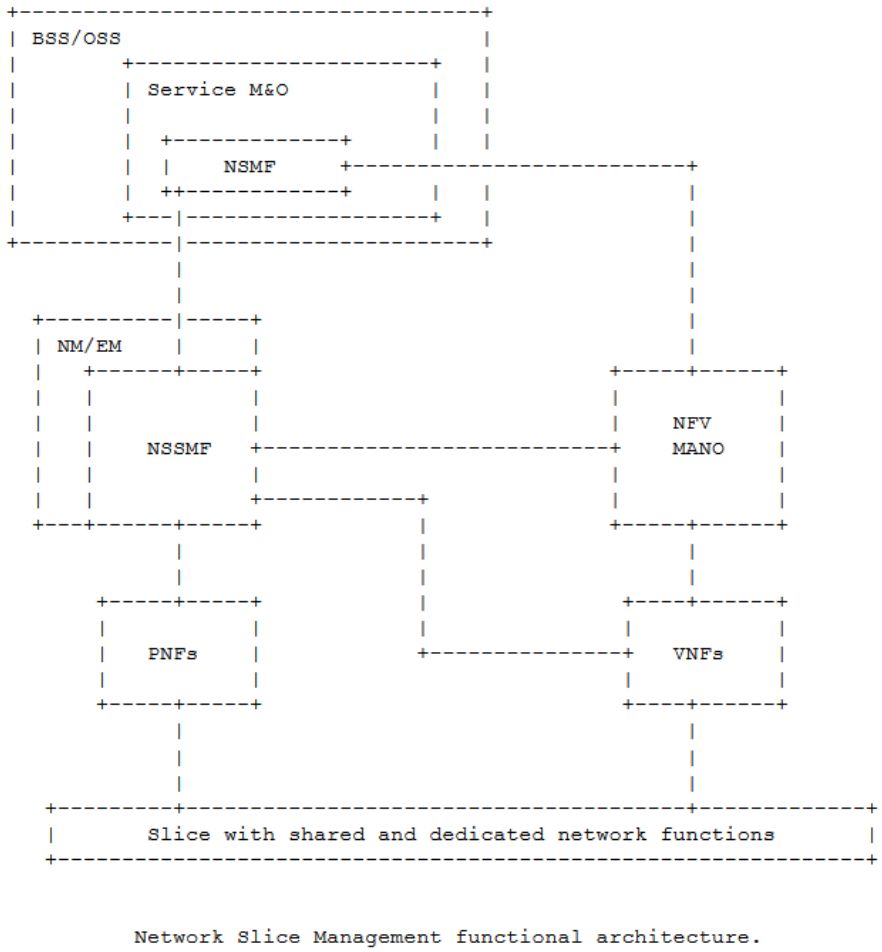
IETF (end)

- Network Slicing Management and Orchestration
- https://tools.ietf.org/pdf/draft-flinck-slicing-management-00.pdf

This draft introduces the role of NSMF in the context of 3GPP [TR28.801], [TS28.530] and ETSI [MANO] work and reflects that back to netslices-architecture presented in [NS-Framework]. We argue that the NSMF is at the Service M&O level, even at a tenant. This is because of several reasons:

o Need for exposing different levels of network slice control to the tenants.

o Different life cycle management approaches for PNFs and VNFs. NSMF must have interfaces both to NFVO and to PNFs Management and is therefore above of the NFVO and PNF management and it should support service level abstractions.



Network Slice Management functional architecture.

Figure 1

OIF – Optical Internetworking Forum

- Source: IA OIF-VTNS-01.0 « Virtual Transport Network Services Specification 1.0” - April 28, 2017

OIF OPTICAL INTERNETWORKING FORUM

IA OIF-VTNS-01.0
Virtual Transport Network Services Specification 1.0

6 Virtual Transport Network Service Definition

A Virtual Transport Network Service (VTNS) is the creation and offering of a Virtual Network (VN) by a provider to a user in accordance with agreements reached between them (e.g., satisfying the users' objectives). Such agreements may be negotiated statically or dynamically; in the latter case VNs may be dynamically created, deleted, or modified in response to requests from the user. This implies dynamic provider modification of resources reserved for the user. The user may then act upon the Virtual Network resources to perform connection management (set-up/release/modify connections), connection monitoring (activate/deactivate MEP functions and activate/configure/deactivate OAM flows) and connection protection (activate/configure/deactivate protection switch processes).

VTNS is built on the virtualization of transport network resources. The physical transport network resources are sliced and assigned usually with an abstract view to different users. The user request may include traffic matrix, Service Level Agreement (SLA), topology, Operation, Administration, and Maintenance (OAM), recovery requirements etc. Users of VTNS may own the right to control and manage the assigned virtual network as if they were operating a physical transport network, more than just get managed connectivity. For example, users may choose their preferred routing algorithm to select the route and set up a virtual connection by configuring each virtual cross connect. Users may also choose to add OAM and protection to the virtual connections they have set up. From the user of a VTNS perspective, virtual nodes and virtual links will not appear to be virtual.

The virtual network can be reconfigured based on the request from the user, e.g. capacity expansion, topology change, without adding/removing the physical network resources.

ONF (Open Networking Foundation) (1/3)

- TR-526 Applying SDN Architecture to 5G Slicing - Issue 1 - April 2016
- https://www.opennetworking.org/images/stories/downloads/sdn-resources/technical-reports/Applying_SDN_Architecture_to_5G_Slicing_TR-526.pdf

ONF (2/3)

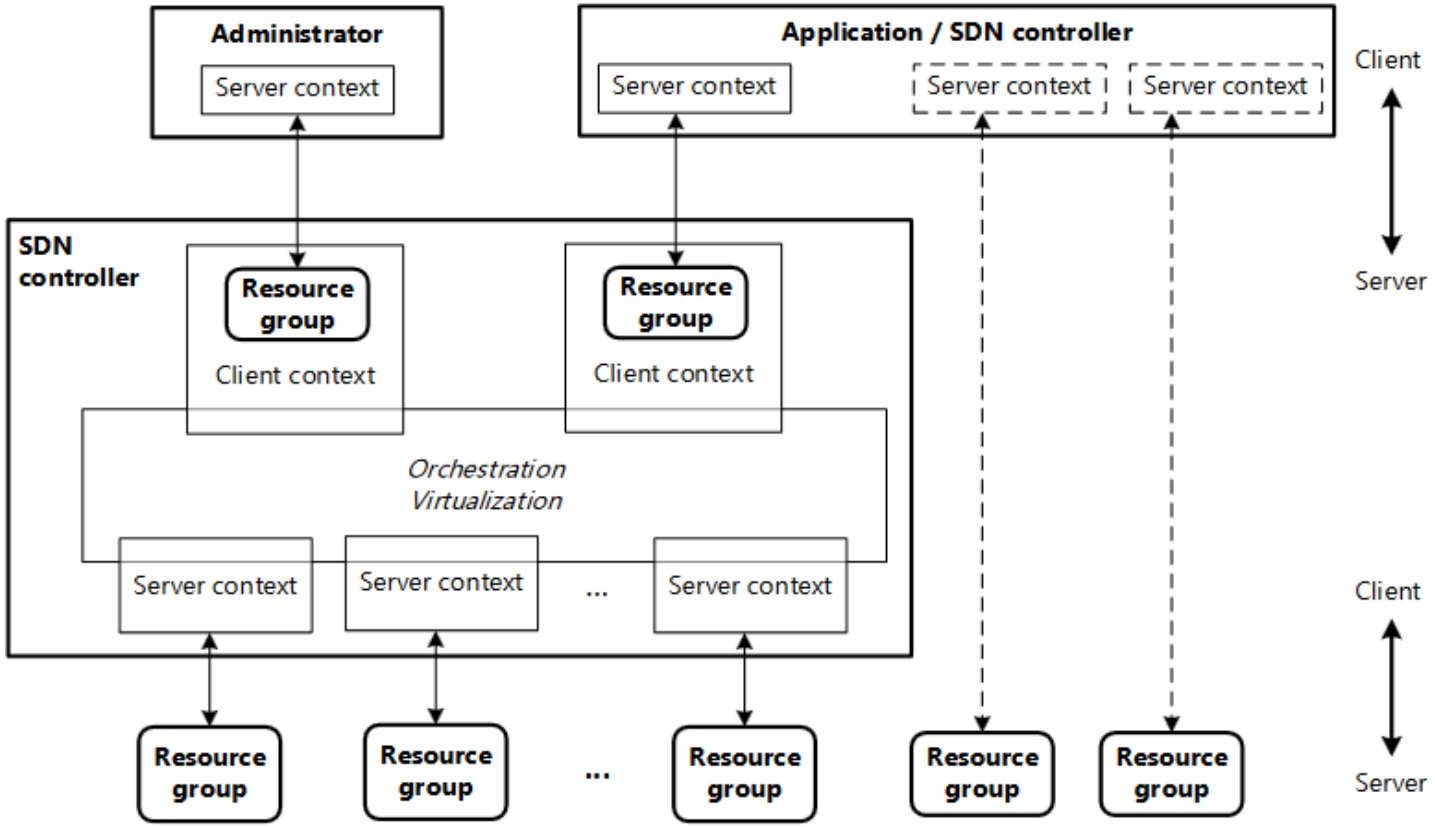


Figure 1: Core concepts of the SDN Architecture (adapted from [2])

ONF (3/3)

Figure 2 shows a mapping of the SDN architecture, terminology and abstractions to 5G slicing.

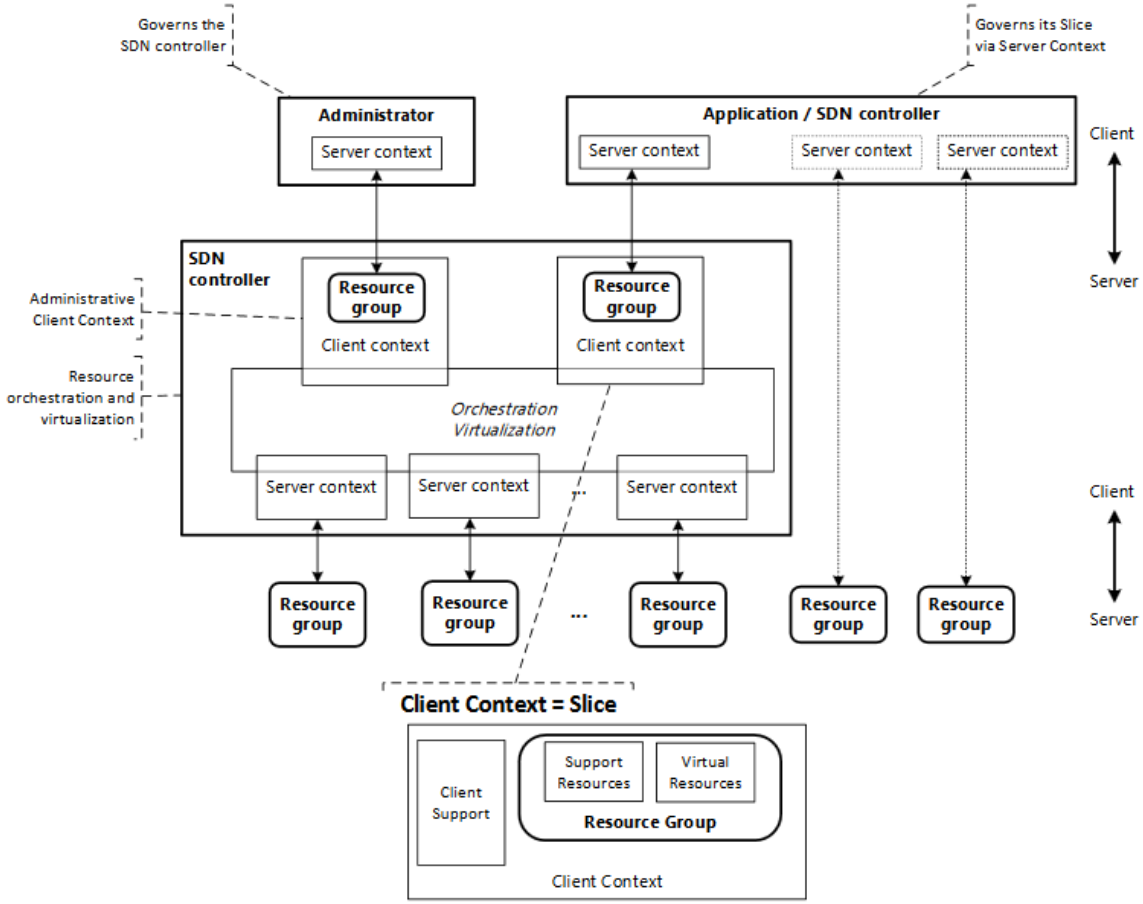


Figure 2: SDN-based Slice abstraction

ETSI NFV

- GR NFV-EVE 012 V0.0.9 (2017-07): Network Functions Virtualisation (NFV); Evolution and Ecosystem; Report on Network Slicing Support with ETSI NFV Architecture Framework

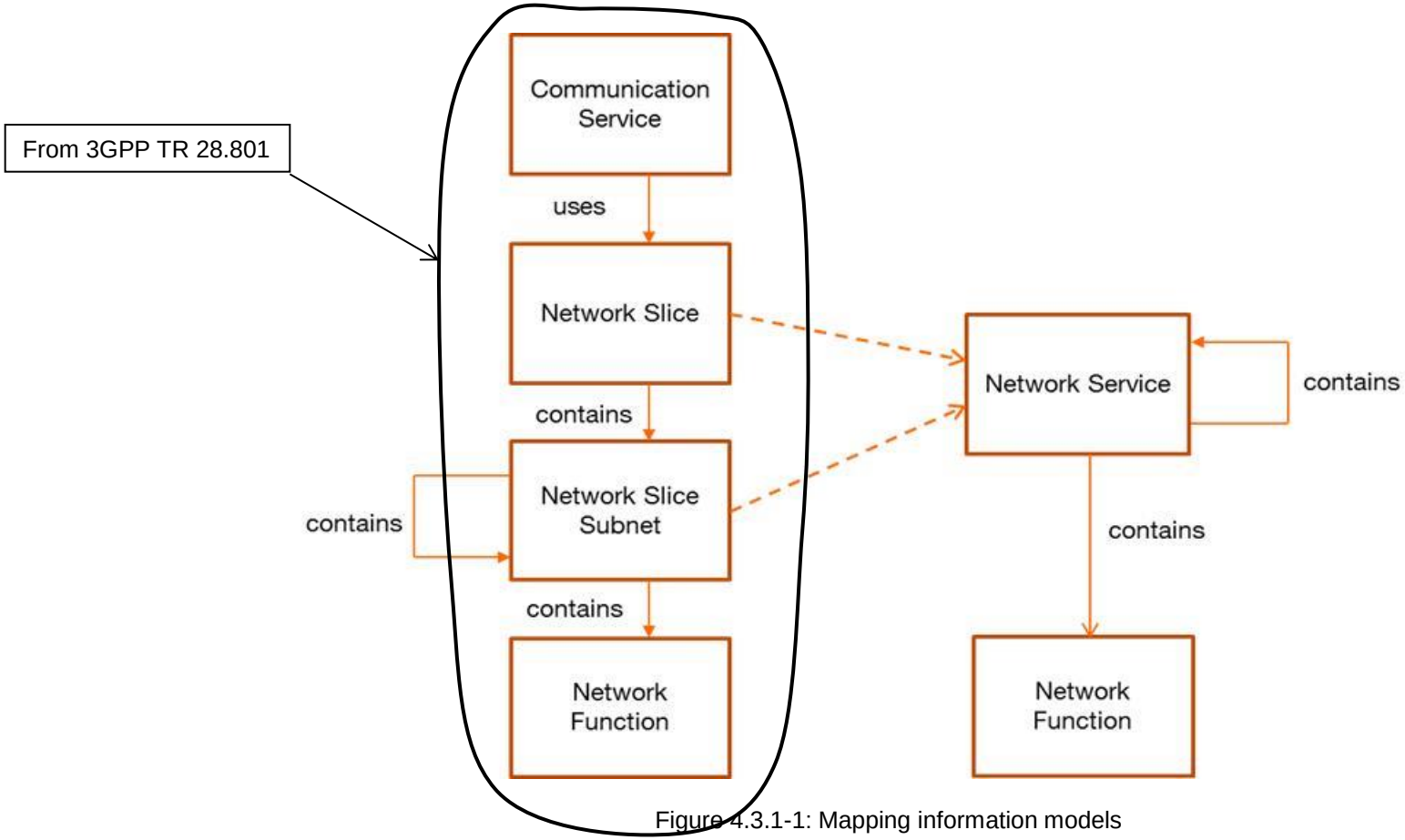


Figure 4.3.1-1: Mapping information models

5G Americas (1/2)

- Network Slicing for 5G Networks and Services – November 2016

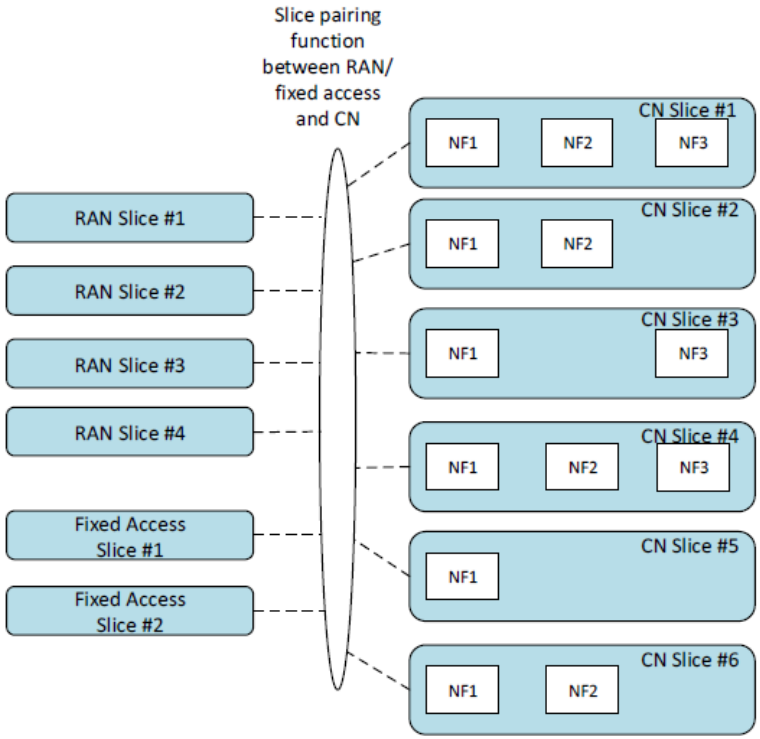


Figure 1. Network Slicing Architecture.

The network slicing architecture contains access slices (both radio access and fixed access), core network (CN) slices and the selection function that connects these slices into a complete network slice comprised of both the access network and the CN. The selection function routes communications to an appropriate CN slice that is tailored to provide specific services. The criteria of defining the access slices and CN slices include the need to meet different service/applications requirements and to meet different communication requirements.

5G Americas (2/2)

Figure 10 illustrates slicing governance using the Os-Ma interface as an example.

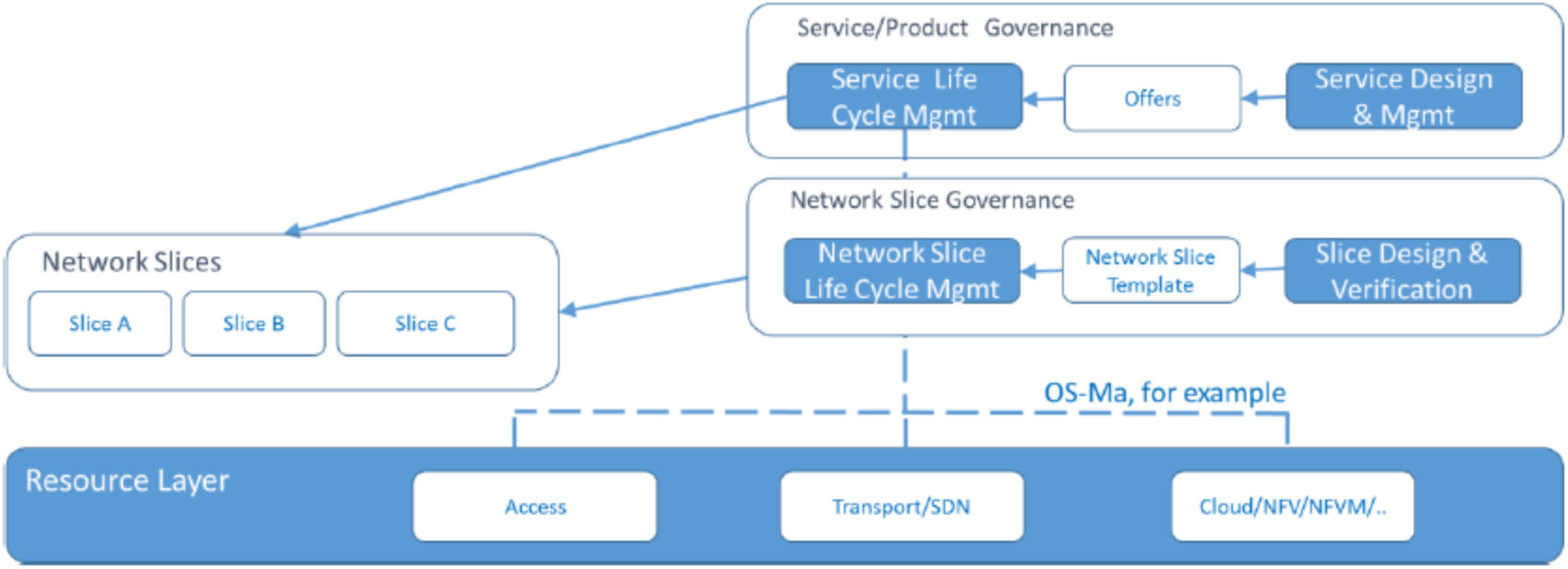


Figure 10. Network Slice Management and Resources.

ATIS

- 5G Reimagined: A North American Perspective (Issue 2) (Feb. 2017)
- https://access.atis.org/apps/group_public/download.php/32883/ATIS%96I-0000050.v002.pdf

The figure below provides a high level illustration of the concept. A slice is composed of a collection of logical network functions that support the communication service requirements of particular use case(s). Some slices will be very rich in functionality, while other slices will be very minimalist, but the network slices are not arranged in any form of hierarchy. A given network slice will simply contain the functions required for a given application or class of service(s). Devices can be directed to the appropriate network slice in a way that fulfils operator and user needs, e.g., based on subscription or device type. The network slicing primarily targets a partition of the core network, but it is not excluded that the RAN may need specific functionality to support multiple slices or even partitioning of resources for different network slices.

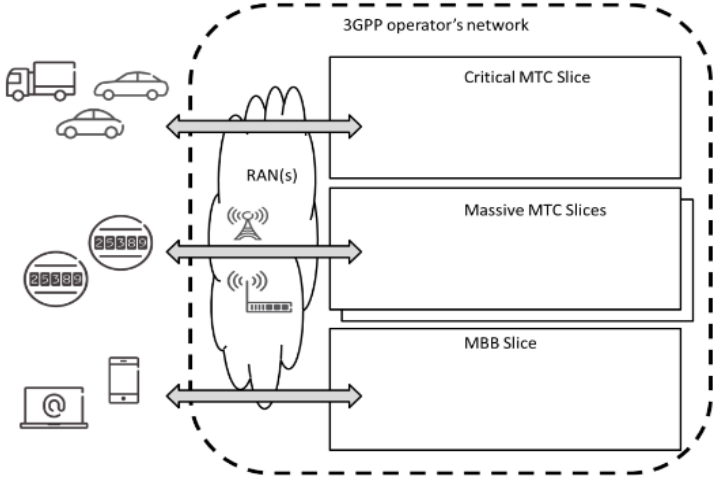


Figure 5.1: Network Slices that Cater for Different Use Cases

Some Network Slice definitions

Org.	Network Slice definition	Domain	Reference document
NGMN	a set of network functions, and resources to run these network functions, forming a complete instantiated logical network to meet certain network characteristics required by the Service instance(s).	Mobile Network	Description of Network Slicing Concept V1.0 (Jan. 16th , 2016)
GSMA	A network slice can be seen as a dedicated network with its own processing, management and connectivity characteristics that shares the same physical resources with other network slices.	Mobile Network	Unlocking Commercial Opportunities From 4G evolution to 5G (Network 2020) – Feb. 2016
3GPP	SA1: Network slicing allows the operator to provide customised networks… A network slice can provide the functionality of a complete network, including radio access network functions and core network functions … SA2: The network slice is a complete logical network network … including AN and CN. Whether RAN is sliced is up to RAN WGs … RAN3: A Network Slice is a network created by the operator customized to provide an optimized solution for a specific market scenario which demands specific requirements with end to end scope as described in TR 23.799. SA5: network slice instance: a set of network functions and the resources for these network functions which are arranged and configured, forming a complete logical network to meet certain network characteristics. SA5: network slice subnet concept.	Mobile Network	TS 23.501 V1.1.0: Study on new radio access technology: Radio access architecture and interfaces TR 28.801 V1.2.0 (2017-05): Study on management and orchestration of network slicing for next generation network
IETF	A managed group of subsets of resources, network functions / network virtual functions at the data, control, management / orchestration planes and services at a given time. Network slice is programmable and has the ability to expose its capabilities.	Transport Network	Network Slicing Architecture (draft-geng-netslices-architecture-01)
BBF	… a network operator that wants to slice its access network to offer different services toward customers …	Fixed Access Network	WT-370 (FANS Overall Architecture and Requirements)
ONF	NGMN defines slicing as an end-to -end concept, including core network (with specific functionality or by partitioning (or sharing) it) as well as access network (partitioned).	Software Defined Networks	TR-526 Applying SDN Architecture to 5G Slicing - Issue 1 - April 2016
ETSI	Refers to definitions made by other SDOs / fora	All	GR NFV-EVE 012 V0.0.5 (2017-06): Report on

Management & Orchestration architecture(s)

Org.	Architectural aspects
NGMN	Not in scope.
GSMA	Not in scope.
3GPP	In TR 28.801: Concepts of CSMF (Communication Service Management Function), NSMF (Network Slice Management Function) and NSSMF (Network Slice Subnet Management Function) – cf. draft TR 28.801. No M&O architecture yet (cf. draft TR 28.800). Future architecture will leverage on ETSI NFV MANO.
IETF	Concepts of Inter Network Slice Orchestrator (= End to End Slice Orchestration - TBC) and Slice Element Manager. May use ETSI NFV MANO, or not.
BBF	Centralized Management System + VNO (Virtual Network Operator) Management System.
ONF	M&O of network slices is done by SDN Controller thanks to a « client context ». Relationship with ETSI NFV architectural framework ?
ETSI NFV	Both 3GPP/SA5 Network Slice and Network Slice Subnet concepts map to ETSI NFV Network Service concept.

Relationships between SA5 and other SDOs / fora

- GSMA officially indicated their expectation to collaborate with 3GPP on Network Slicing (incl. SA5) – cf. their LS at SA5#114 (S5-174046)

- BBF officially indicated their expectation to collaborate with 3GPP/SA5 – cf. their LS at SA5#114 (S5-174085)

- IETF:
  - asked to 3GPP: « Does 3GPP <u>currently</u> have dedicated requirements for any kind of IETF protocol or activity related to nw-slicing?"
    - Answer from 3GPP Liaison Officer at IETF 99 (July 2017): "At the moment: No."
  - has an Internet draft on Network Slicing - 3GPP Use Case

- ETSI NFV EVE, in their Report on Network Slicing Support with ETSI NFV Architecture Framework, is making a deep analysis of 3GPP TR 28.801

Thank you