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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Future networks

Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network

Recommendation ITU-T Y.3153

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Recommendation ITU-T Y.3153

Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network

Summary

The IMT-2020 network comprises an embedded capability exposure functionality that enables a third party (3rd party) to directly use a customised network slice under certain restrictions in order to efficiently provide optimized solutions for different market scenarios which have their own diverse requirements. Automated processes for orchestration and management are also important from the perspective of efficiency.

Recommendation ITU-T Y.3153 describes the requirements, architecture, key functionalities and typical procedures of network slice orchestration and management for providing network services to a 3rd party in the IMT-2020 network.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network

1 Scope

This Recommendation describes requirements, architecture, key functionalities and typical procedures of network slice orchestration and management for providing network services for third party (3rd party) in the IMT-2020 network.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.3011] Recommendation ITU-T Y.3011 (2012), *Framework of network virtualization for future networks*.

[ITU-T Y.3100] Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network.*

[ITU-T Y.3108] Recommendation ITU-T Y.3108 (2019), *Capability exposure function in the IMT-2020 networks.*

[ITU-T Y.3110] Recommendation ITU-T Y.3110 (2017), *IMT-2020 network management and orchestration requirements*.

[ITU-T Y.3111] Recommendation ITU-T Y.3111 (2017), *IMT-2020 network management and orchestration framework.*

[ITU-T Y.3112] Recommendation ITU-T Y.3112 (2018), *Framework for the support of network slicing in the IMT-2020 network.*

[ITU-T Y.3150] Recommendation ITU-T Y.3150 (2018), *High-level technical characteristics of network softwarization for IMT-2020.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 data plane [b-ITU-T Y.2011]: The set of functions used to transfer data in the stratum or layer under consideration.

3.1.2 IMT-2020 [ITU-T Y.3100]: Systems, system components, and related technologies that provide far more enhanced capabilities than those described in [b-ITU-R M.1645].

NOTE – [b-ITU-R M.1645] defines the framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000 for the radio access network.

3.1.3 management [ITU-T Y.3100]: In the context of IMT-2020, the processes aiming at fulfilment, assurance, and billing of services, network functions, and resources in both physical and virtual infrastructure including compute, storage, and network resources.

3.1.4 orchestration [ITU-T Y.3100]: In the context of IMT-2020, the processes aiming at the automated arrangement, coordination, instantiation and use of network functions and resources for both physical and virtual infrastructure by optimization criteria.

3.1.5 network slice [ITU-T Y.3100]: A logical network that provides specific network capabilities and network characteristics.

NOTE 1 – Network slices enable the creation of customized networks to provide flexible solutions for different market scenarios which have diverse requirements, with respect to the functionality, performance and resource separation.

NOTE 2 – A network slice may have the ability to expose its capabilities.

NOTE 3 – The behaviour of a network slice is realized via network slice instance(s).

3.1.6 network slice blueprint [ITU-T Y.3100]: A complete description of the structure, configuration and work flows on how to create and control a network slice instance during its life cycle.

NOTE – A network slice template can be used synonymously with a network slice blueprint.

3.1.7 network slice instance [ITU-T Y.3100]: An instance of network slice, which is created based on network slice blueprint.

NOTE 1 – A network slice instance is composed of a set of managed run-time network functions, and physical/logical/virtual resources to run these network functions, forming a complete instantiated logical network to meet certain network characteristics required by the service instance(s).

NOTE 2 – A network slice instance may also be shared across multiple service instances provided by the network operator. A network slice instance may be composed of none, one or more sub-network slice instances which may be shared with another network slice instance.

3.1.8 network function [ITU-T Y.3100]: In the context of IMT-2020, a processing function in a network.

NOTE 1 – Network functions include but are not limited to network node functionalities, e.g., session management, mobility management and transport functions, whose functional behaviour and interfaces are defined.

NOTE 2 – Network functions can be implemented on a dedicated hardware or as virtualized software functions.

NOTE 3 – Network functions are not regarded as resources, but rather any network functions can be instantiated using the resources.

3.1.9 virtual resource [ITU-T Y.3011]: An abstraction of physical or logical resource, which may have different characteristics from the physical or logical resource and whose capability may be not bound to the capability of the physical or logical resource.

3.1.10 network functions virtualization (NFV) [b-ETSI GS NFV 003]: Principle of separating network functions from the hardware they run on by using virtual hardware abstraction.

3.1.11 software-defined networking (SDN) [b-ITU-T Y.3300]: A set of techniques that enables to directly program, orchestrate, control and manage network resources, which facilitates the design, delivery and operation of network services in a dynamic and scalable manner.

3.1.12 third party (3rd party) [ITU-T Y.3100]: In the context of IMT-2020, with respect to a given network operator and network end-users, an entity which consumes network capabilities and/or provides applications and/or services.

NOTE 1 – An example of 3rd party, a virtual network operator (VNO) may use capabilities exposed by a network operator, e.g., to manage specific network slices. Another example of 3rd party, a service and/or

application provider (e.g., an over the top (OTT) player) may provide applications and/or services to enhance the network capabilities.

NOTE 2 – Network end-users are not regarded as 3rd parties.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API	Application Programming Interface
DC	Data Centre
eMBB	enhanced Mobile Broadband
E2E	End-to-End
IMT-2020	International Mobile Telecommunication 2020
LCM	Lifecycle Management
LPWAN	Low-Power Wide-Area Network
mMTC	massive Machine Type Communication
NFV	Network Functions Virtualization
QoS	Quality of Service
RAN	Radio Access Network
SDN	Software Defined Networking
SLA	Service Level Agreement
uRLLC	ultra-Reliable Low Latency Communications

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

6 Introduction

Network slicing [ITU-T Y.3112] is a key feature for the next generation IMT-2020 network. Compared with a traditional static "one fits all" network, network slicing explores a new paradigm where logical networks, which serve a particular service category or customer, are created with a specific requirement on functionality, isolation level, resource allocation, topology and performance quality. The management and orchestration for network slicing is one of key network slicing functions, and the function realizes new business models by enabling automatic lifecycle management of an end-to-end (E2E) network slice with the guarantee of service quality. In the IMT-2020 network, the E2E network slice consists of three sub network slices in different domains: core network, transport network and access network, and each of these is an object of management and orchestration.

The network slicing management and orchestration architecture basically consists of three functional entities: network slice customer, slice management and orchestration and resource management. Network functions virtualization (NFV) and software defined networking (SDN) can be the underlying technologies [ITU-T Y.3150].

NOTE 1 – A topic on co-operation with traditional and/or enhanced network management system is treated by [ITU-T Y.3111]; however, this aspect is out of the scope of this Recommendation.

This Recommendation focuses on the following aspects of network slicing orchestration and management:

– Requirements and key functional architecture from the viewpoint of relations with 3rd party;
– Supporting an E2E cross-domain scenario (including radio access network/fixed access network, core network and transport network);
– Automatic processing including optimization by network slice lifecycle management.

Automatic processing for network slicing make a substantial contribution for efficiently and effectively providing network services to a 3rd party.

NOTE 2 – The concept of "autonomic" is the advanced stage of automatic processing. [b-ITU-T Y.3324] defined autonomic management and control as a behaviour or action that is determined in a reactive or proactive manner based on the external stimuli (environment aspects) as well as the goals they are required to fulfil, principles of operation, capabilities, experience and knowledge.

This Recommendation treats requirements on automated healing, automated (re)configuration and automated optimization:

– Automated healing: is a process wherein the impacts from failure are automatically solved or reduced;
– Automated (re)configuration: is a process wherein operational parameters of network nodes/components are automatically arranged;
– Automated optimization: is a process wherein network behaviours are automatically changed based on observation of network situation.

NOTE 3 – A self-optimization functionality monitors data such as performance measurements, fault alarms, notifications, etc. After analysing the data, optimization decisions are made according to the optimization algorithms. Finally, corrective actions on the affected network node(s) are triggered automatically or manually when necessary.

This Recommendation specifies requirements, architecture and detailed functionalities of a network slice management and orchestration system.

7 Requirements for network slice management and orchestration

High-level requirements on network slice management and orchestration in the IMT-2020 network are introduced in [ITU-T Y.3110], and they are applicable to this Recommendation. Additional requirements, especially from the viewpoints for providing network services for a 3rd party, are described in this clause.

7.1 Requirements for network slice lifecycle management

The IMT-2020 network is required to have the capability to create, modify and delete network slice with no or minimal impact on traffic and existing network services in the same network.

The IMT-2020 network is required to have the capability to support both service-level and resource-level lifecycle management of a network slice.

The IMT-2020 network is required to transfer customer's service requirements to network slice requirements.

The IMT-2020 network is required to design network functions and their topology of a specific network slice according to network slice requirements.

The IMT-2020 network is required to have the capability to configure network services and their resources relevant to a specific network slice.

IMT-2020 network is required to have the capability to allow an operator to modify, add and remove network functions to a specific network slice.

The IMT-2020 network is required to have the capability for evaluating the feasibility of providing a new network slice instance.

The IMT-2020 network is required to have the capability to determine whether to reuse an existing network slice instance or create a new network slice instance.

The IMT-2020 network is required to create a network slice shared by multiple network services.

7.2 Requirements for network slicing performance assurance

The IMT-2020 network is required to have the capability to guarantee the quality of service (QoS) of a network slice instance.

The IMT-2020 network is required to have the capability to monitor and measure performance/operation status of all the network slice instances (per network slice instance).

7.3 Requirements for network slicing isolation

The IMT-2020 network is required to have the capability to guarantee that a network slice instance has no impact on other network slices during its runtime.

The IMT-2020 network is required to provide isolated management functionality for each network slice instance.

7.4 Requirements for network slicing exposure

The IMT-2020 network is required to have the capability to support the 3rd parties to create, manage and configure a network slice via suitable application programming interfaces (APIs).

The IMT-2020 network is required to have the capability to expose a set of management data requested by the customer.

7.5 Requirements for network slicing deployment

The IMT-2020 network is required to support E2E network slice deployment over cross-domain (RAN, core network and transport network).

The IMT-2020 network is required to provide for on-demand created slices in a short slice provisioning time.

The IMT-2020 network is required to create an E2E network slice as a combination of existing and new created sub network slices.

7.6 Requirements for mobile network slicing automation

The IMT-2020 network is required to support automated processes to create, update and delete a network slice based on the requirements of customers.

The IMT-2020 network is required to allow the operator to provide and update a policy configuration of network slice automation.

The IMT-2020 network is required to have the capability of automated healing for a network slice instance according to operators' policies.

The IMT-2020 network is required to support automated (re)configuration of a network slice instance.

The IMT-2020 network is required to conduct automated optimization for a network slice instance.

The IMT-2020 network is required to resolve the conflicts of automated optimization actions for a network slice instance.

The IMT-2020 network is recommended to have the capability to prevent the conflicts of automated optimization actions for a network slice instance.

The IMT-2020 network is required to report automated results.

8 High-level architecture aspects of network slice management and orchestration

8.1 Architecture for network slice management and orchestration

This clause describes high-level architecture of network slice management and orchestration for providing network services for 3rd party. Figure 1 shows the functional architecture.

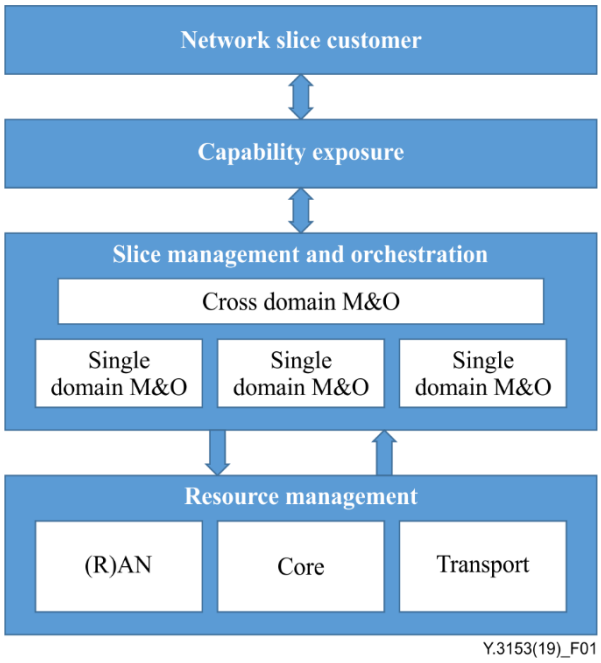

Figure 1 – Functional architecture of network slice management and orchestration

Network slicing enables an operator to create logically partitioned networks customized to provide optimized solutions for different market scenarios which demand diverse requirements in terms of service characteristics, required functionalities, performance and isolation level [ITU-T Y.3111].

The functional architecture of network slice management and orchestration shall provide a complete set of network functions required to support customer services over different network domains. The functional architecture consists of four (functional) entities: network slice customer, capability exposure as defined in [ITU-T Y.3108], slice management and orchestration and resource management. Once capability exposure accepts a network slice requirement from a customer, then the requirement is sent to the slice management and orchestration to instantiate, modify or release a network slice instance. The responsibilities of resource management are to manage the lifecycle of required network functions and their needed virtualized resources respectively. The detailed functional descriptions for slice management and orchestration and resource management can be found in clauses 8.2 and 8.3 respectively.

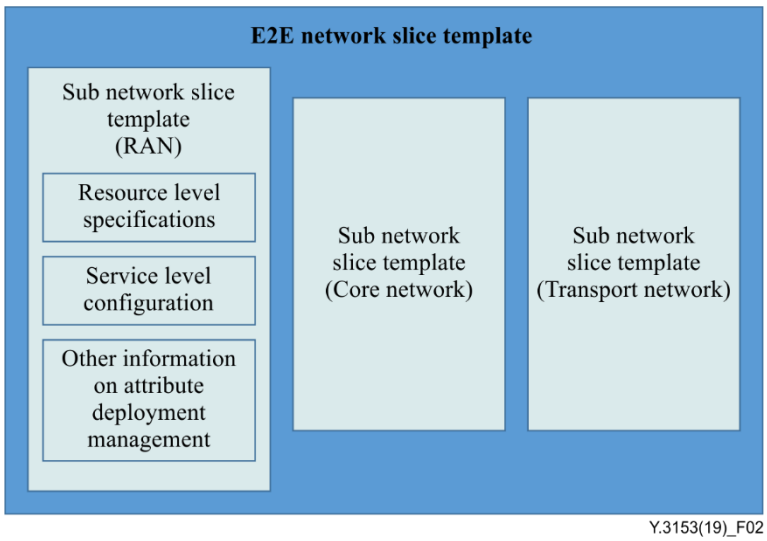

Figure 2 – Functional architecture of network slice template

A network slice template is a key object to be managed by the slice management and orchestration. An E2E network slice template, as shown in Figure 2, consists of sub network slice templates relevant to a specific network domain such as a radio access network (RAN), a core network and a transport network in the IMT-2020 network. The sub network slice templates are filled with information on each domain. The sub network slice template consists of three functional information parts: resource level specifications, service level configuration and other information on network slice attributes, deployment and management.

NOTE – This Recommendation uses the term "network slice template" which is a synonym of a term "network slice blueprint" defined in clause 3.1.6.

8.2 Functional description of network slice management and orchestration

There are three usage scenarios in the IMT-2020 network, enhanced mobile broadband (eMBB), massive machine type communication (mMTC) and ultra-reliable low latency communications (uRLLC), which are introduced in Appendix I. These usage scenarios should be dealt with by the network slice management and orchestration.

The slice management and orchestration entity is responsible for service management and resource management of an E2E network slice. It has the following functions:

– Slice design
  a) Design network functions and their topology of a specific network slice based on different scenarios and requirements;
  b) Decompose the service requirement to network slice requirements on different domains (i.e., access network, transport network and core network);
  c) Generate a network slice template according to the result of a) design. The network slice template consists of sub network slice template on RAN, core and transport.
– Slice configuration
  a) Generate configuration files that can be used to configure sub network slices;
  b) Transfer the configuration files to resource management before or during network slice initialization.
– Slice lifecycle management
  a) Perform network slice lifecycle management (LCM) (e.g., create, delete, scale in, scale out) of all the instantiated slice instance;

b) Analyse all the performance data of network slice instances;

c) Generate a LCM policy;

d) Interact with the resource management.

– Slice monitoring

a) Monitor network slice instances generated by operator/3rd party;

b) Gather performance data of network slice instances.

8.3 Functional description of resource management

Resource management is responsible for cross-domain resource management for RAN, core network and transport network. A network slice instance is instantiated by resource management according to the network slice template generated in slice management and orchestration. Resource management assigns necessary resources to the network slice instance. Resource management of transport network resources can be achieved by handling of SDN technology (i.e., introducing SDN controllers). In addition, resource management treats NFV technology.

9 Typical procedures of network slicing for 3rd party

9.1 Network slice instantiation

This clause introduces general procedures of network slice instantiation. Figure 3 shows the procedure of network slice instantiation.

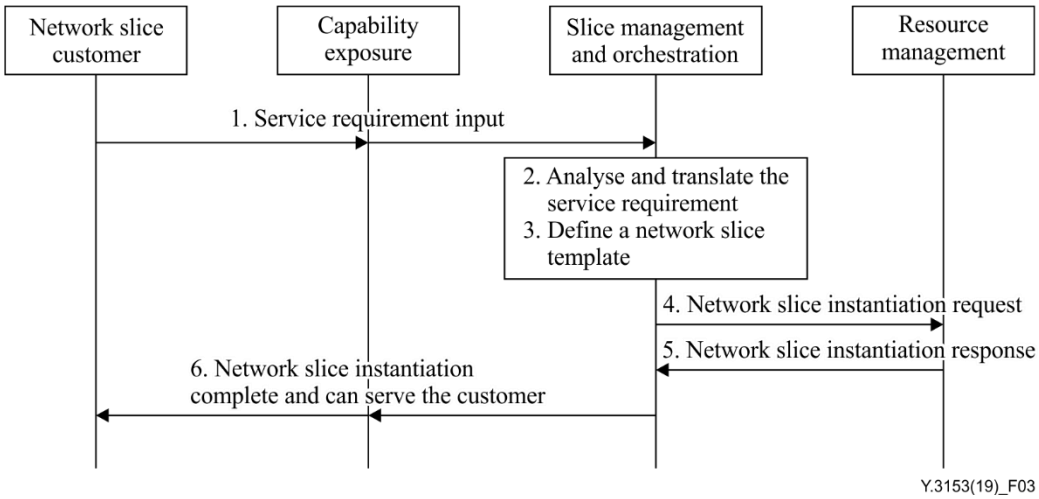

Figure 3 – Procedure of network slice instantiation

Step 1: A customer's service requirement is input into a network slice capability exposure function and sent to a network slice management and orchestration function.

Step 2: The network slice management and orchestration function analyses the service requirement and translates it into a network requirement. During the translation, the slice management and orchestration also decides if an existing network slice instance can support the new requirement. If it cannot, the slice management and orchestration has to decide what kinds of network slice instances and how many network slice instances can support the new service requirement.

Step 3-1: Define a network slice template which contains:

– Detailed specifications of resources for a network slice that can be implemented by resource management;

– Service-level configuration of each domain.

There is a network function repository in the slice management and orchestration. The repository stores the whole network slice templates. The slice management and orchestration looks for the existing E2E network slice template which can fulfill the service requirement.

When there is no appropriate E2E network slice template, the slice management and orchestration function searches sub network slice templates which can partly meet the received service requirement. Then it generates the whole new E2E network slice template by using the sub network slice templates, and stores the new E2E network slice template in the repository.

Step 3-2: The template may also contain attribute information of a network slice such as a network slice identifier, deployment information and management information.

The slice management and orchestration generates the deployment configuration information and maintenance management configuration information.

NOTE – Details of deployment information and management information are out of the scope of this Recommendation. The deployment configuration information may include the following:

– If the E2E network slice instance can be shared by different customers;

– If the sub network slice instance can be shared by different E2E network slice instances;

– If the network function entity can be shared by different E2E network slice instances.

Steps 4 and 5: Resource management instantiates the network slice instance based on the network slice template in step 3 according to requests from the slice manage and orchestration. After resource allocation and instantiation are finished, the slice management and orchestration also sends a network configuration request to the resource management in each domain to configure sub network slice instances.

Step 6: Then the E2E network slice instance is instantiated to serve a specific customer.

9.2 Network slice modification/termination

This clause introduces general procedures of network slice modification/termination. Figure 4 shows the procedure of network slice modification/termination.

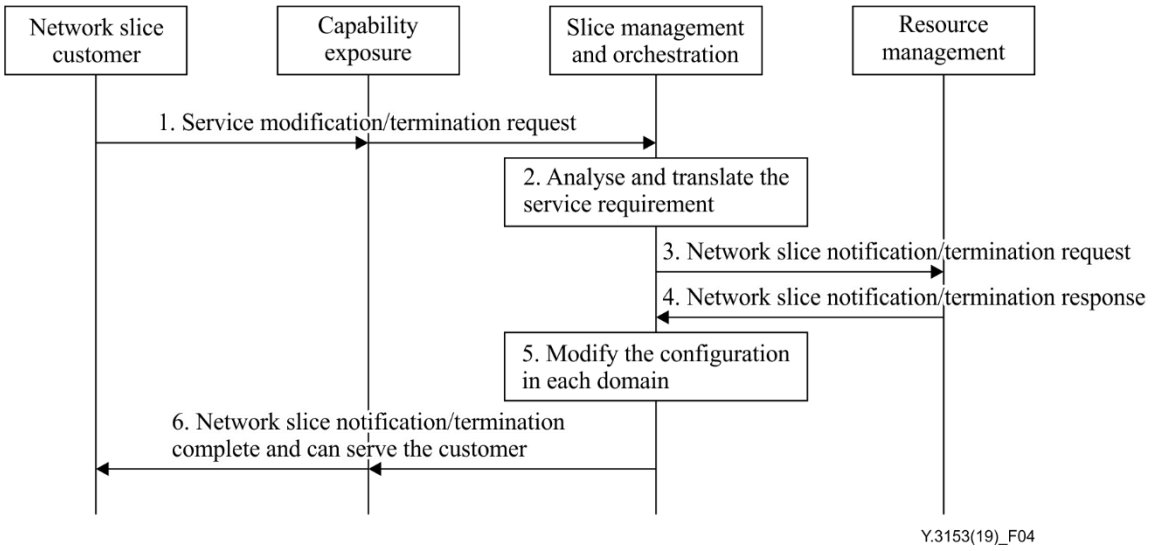

Figure 4 – Procedure of network slice modification/termination

Step 1: A customer's network modification/termination requirement is input into a network slice capability exposure function. The capability exposure transfers the customer's requirement to the slice management and orchestration function.

Step 2: When receiving the modification/termination requirement, the slice management and orchestration translates the requirement to modification/termination information. The slice management and orchestration analyses the information and determines what kind of network functions/configurations to satisfy the modification/termination requirement. Moreover, the slice management and orchestration may evaluate if the modification/termination request will influence the existing network slices, and try to avoid influence on the other network slices.

Step 3: The slice management and orchestration function requests to resource management to modify/terminate network slice resources over cross-domain.

Step 4: After modifying the resources, the slice management and orchestration receives resource modification/termination acknowledgement.

Step 5: The slice management and orchestration modifies the configuration of related sub network slice instances in each domain.

Step 6: Then the E2E network slice instance is modified/terminated according to the customer's network modification/termination requirement.

NOTE – The term "termination" in this clause does not contain the process regarding release of network instances.

10 Security consideration

This Recommendation defines requirements, architecture, functionalities of network slicing orchestration and management. Thus, it is assumed that security considerations in general are based on the security of IMT 2020 network management and orchestration [ITU-T Y.3111].

Appendix I

Scenarios for mobile network slicing orchestration and management

(This appendix does not form an integral part of this Recommendation.)

There are three scenarios where slice management and orchestration should be considered. The following describes orchestration and management of three main types of network slices, namely network slices for enhanced mobile broadband (eMBB), massive machine type communication (mMTC) and ultra-reliable low latency communication (uRLLC) [b-ITU-R M.1645].

I.1 Mobile network slicing orchestration and management for eMBB slicing

The eMBB slicing requires high capacity of bandwidth and high capabilities of multimedia streaming processing, including handling of three dimensional video, virtual reality, hologram and other related services. These characteristics require slice management and orchestration to provide high throughput and powerful forwarding capability. Hence, the slice management and orchestration is requested to assign efficient virtual I/O ability and processing ability of data plane. At the same time, virtual storage and computing resources can be deployed on the edge data centre (DC) so as to cache and pre-process the multimedia contents locally. This reduces the resource consumption of core DC and IP transport network.

I.2 Mobile network slicing orchestration and management for mMTC slicing

The mMTC slicing involves a small amount of network data interaction and a low frequency of signalling interaction for a vast number of terminals. The large number of connections consume massive radio and signalling resources, while their individual traffic is relatively small. Despite some dedicated low-power wide-area network (LPWAN) technologies, network slicing may offer an automated and efficient manner for providing tailored services. For the massive connections nature of mMTC, mMTC slice over RAN domain is required to be equipped with sufficient wireless access resources. The slice management and orchestration can provide management templates for different groups of terminals to simplify the configuration and management. The edge DC can deploy computing resources with data aggregation function to reduce the large signalling resource consumption.

I.3 Mobile network slicing orchestration and management for uRLLC slicing

The uRLLC slicing requires fast creation, modification, migration of virtual network functions and reliable transmission from end to end. These features depend partly on performance of the edge DC and RAN assigned with sufficient virtual resources. The slice management and orchestration generates network slices with guaranteed QoS according to predefined uRLLC service profiles. These specific network slices are expected to offer agile and on-demand scaling ability to handle abrupt data transmission and processing.

Bibliography

[b-ITU-T Y.2011] Recommendation ITU-T Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.

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