International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.3157

(02/2021)

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

Future networks

IMT-2020 network slice configuration

Recommendation ITU-T Y.3157

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	**Y.3000–Y.3499**
CLOUD COMPUTING	Y.3500–Y.3599
BIG DATA	Y.3600–Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	Y.3800–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.3157

IMT-2020 network slice configuration

Summary

Recommendation ITU-T Y.3157 specifies a network slice configuration in order to dynamically create and manage network slice instances (NSIs) in the International Mobile Telecommunications-2020 (IMT-2020) network. Detailed topics are methods for: creation of an NSI; provision of quality of service (QoS) to the network slice; and association of user equipment (UE) application services with the NSI.

Network slicing is regarded as a key technology in the successful deployment of the IMT-2020 network. The concept of network slicing and use cases in the IMT-2020 network are introduced in Recommendation ITU-T Y.3112.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3157	2021-02-13	13	11.1002/1000/14597

Keywords

Network slice, network slice instance, network slice template, network slice type indicator.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents/software copyrights, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-T databases available via the ITU-T website at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.3157

IMT-2020 network slice configuration

1 Scope

This Recommendation specifies a dynamic network slice configuration in order to dynamically create and manage network slice instances (NSIs) in the International Mobile Telecommunications-2020 (IMT-2020) network. The network slice configuration changes information about functional constituents (e.g., capacity of virtual network function (NF), capacity of virtual link and topology) in a dedicated NSI. The network slice configuration is updated when the network slice is modified according to the instructions of NSI life cycle management.

This Recommendation covers the following aspects:

– an overview of a network slice template, including its attributes and network slice key performance indicators (KPIs);

– relations between NSI modification and the configuration file;

– update procedures for dynamic network slices.

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.1541] Recommendation ITU-T Y.1541 (2011), *Network performance objectives for IP-based services*.

[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.3153] Recommendation ITU-T Y.3153 (2019), *Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network.*

[ITU-T Y.3156] Recommendation ITU-T Y.3156 (2020), *Framework of network slicing with AI-assisted analysis in IMT-2020 networks*.

[ITU-R M.2083] Recommendation ITU-R M.2083 (2015), *IMT vision – Framework and overall objectives of the future development of IMT for 2020 and beyond*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 network slice [b-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 functionalities, performance and resource allocation.

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

3.1.2 network slice blueprint [b-ITU-T Y.3100]: A complete description of the structure, configuration and workflows 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.

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

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

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

5G fifth Generation

5QI 5G QoS Identifier

AMF Access Mobility Function

CN Core Network

CUG Closed User Group

DL/UL Down Link/Up Link

eMBB enhanced Mobile Broadband

GRPS General Packet Radio Service

GTP GRPS Tunnelling Protocol

IMT International Mobile Telecommunications

IP Internet Protocol

KPI Key Performance Indicator

mMTC massive Machine Type Communication

NACF Network Attachment Control Function

NF Network Function

NFI Network Function Instance

NSI Network Slice Instance

NST Network Slice Template

NSTI Network Slice Type Indicator

OAM	Operation, Administration and Maintenance
PCF	Packet Control Function
PDU	Protocol Data Unit
QFI	QoS Flow Identifier
QoS	Quality of Service
RAN	Radio Access Network
SMF	Session Management Function
SST	Slice Service Type
TN	Transport Network
UE	User Equipment
UPF	User Plane Function
URLLC	Ultra-Reliable Low-Latency Communication
V2X	Vehicle to everything

5 Conventions

In this Recommendation:

The phrase "is required to" indicates a requirement that must be strictly followed and from which no deviation is permitted, if conformity to this Recommendation is to be claimed.

The phrase "is recommended to" indicates a requirement that is recommended, but which is not absolutely required. Thus, this requirement need not be present to claim conformity.

6 Introduction

Network slicing is regarded as a key technology in the deployment of the IMT-2020 network. In this regard, relevant Recommendations relating to the network slicing framework and management are [ITU-T Y.3111], [ITU-T Y.3112] and [ITU-T Y.3153]. [ITU-T Y.3111] provides an overview of IMT-2020 network management and orchestration. [ITU-T Y.3112] describes the concept of network slicing and use cases when a single piece of user equipment (UE) simultaneously attaches to multiple network slices in the IMT-2020 network. [ITU-T Y.3153] further describes network slice orchestration and management for the provision of network services to a third party in the IMT-2020 network. They briefly introduce the network slice template and the related attributes. This Recommendation further describes the network slice template and the network slice configuration.

The architecture of network slice management and orchestration is depicted schematically in Figure 6-1, which is based on Figure 1 of [ITU-T Y.3153]. Network slicing management and orchestration architecture basically consists of three functional entities: the network slice customer; slice management and orchestration; and resource management. The network slice customer is an end-user or a group of end users (e.g., tenant, vertical industry and third party). A network slice template represents the characteristics of a network slice that is managed by slice management and orchestration. The network slice template can be generated by slice management and orchestration by designing NFs and their topology in a specific network slice based on different scenarios and requirements. As shown in Figure 6-1, the network slice template consists of sub network slice templates relevant to a specific network domain, such as a radio access network (RAN), a core network (CN) and a transport network (TN) in the IMT-2020 network. The sub network slice templates are filled with information on each domain. According to the sub network slice templates, resource management conducts the life cycle of the NFs required and the resources they need.

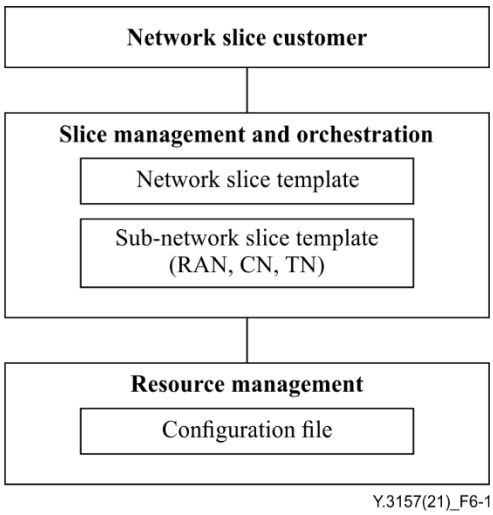

Figure 6-1 – Abstracted architecture of network slice management and orchestration

7 Network slice template

This clause mainly focuses on key attributes of a network slice template, particularly in terms of the type and KPIs of a network slice.

A network slice template is generated and managed by slice management and orchestration according to service requirements from a network slice customer. The service requirements are translated into the network slice template. The network slice customers are operators, third parties or may be an individual user or a group of users.

The network slice template moreover includes detailed characteristics of the network slice to reflect customer service requirements. The network slice identifier is used to distinguish a specific template when multiple network slice templates exist. Furthermore, additional information related to network slice capacity of are described hereafter.

NOTE – The generic network slice template (GST) [b-GSMA NG.116] and the service profile [b-ETSI TS 128 530] are specified by GSMA and 3GPP SA5, respectively.

7.1 Network slice type indicator

In the IMT-2020 network, network slices can be explicitly linked to all kinds of services and user groups.

The network slice type indicator (NSTI) is key information for the identification of a network slice and is associated with an application service of a piece of UE with the network slice [ITU-T Y.3112]. One key attribute of an NSTI is a slice service type (SST). Examples of SSTs are ebb, ultra-reliable low-latency communication (URLLC), massive machine type communication (mMTC), and vehicle to everything (V2X). They represent categorizations of eight parameters, which are key capabilities of the IMT-2020 and also called KPIs. The eight KPIs are: peak data rate; user experienced data rate; latency; mobility; connection density; energy efficiency; spectrum efficiency; and area traffic capacity [ITU-R M.2083]. The SSTs indicate a broad range of values with respect to the eight KPIs. To uniquely indicate the values, the attributes of the network slice template include the KPIs, e.g., up-link throughput and latency, down-link throughput and latency, mobility and connection density [ITU-T Y.3112].

However, the usage of SSTs is limited to at most four (i.e., enhanced mobile broadband (eMBB), URLLCs, mMTCs and V2X) as standard values.

When an NSTI is further extended to include additional SSTs such as eMBB + URLLC, additional service requirements may be optional (e.g., throughput or latency). If a closed user group (CUG) of

an NSTI is used to indicate a specific KPI, the CUG may represent additional performance requirements.

[REQ-1] The IMT-2020 network is recommended to cover a wide variety of SST values to support diverse service requirements (e.g., expansion of SST values, usage of a mixture of SST values).

7.2 Network slice key performance indicator on protocol data unit session

The network slice template includes KPIs as well as an NSTI. The network slice accommodates protocol data unit (PDU) sessions and packet flows to network slice customers. Therefore, the KPI of the network slice is assigned to guarantee the quality of service (QoS) of PDU sessions and packet flows.

NOTE 1 – In [b-ITU-T Y.3106], the peak data rate of IMT-2020 for eMBB is expected to support up to 20 Gbit/s. For wide-area coverage cases, a user-experienced data rate of 100 Mbit/s is expected to be enabled. IMT-2020 is expected to support a connection density of up to $10^6/km^2$, e.g., in mMTC scenarios. IMT-2020 would be able to provide 1 ms over-the-air latency for URLLCs.

Network QoS classes and a packet flow are described in [ITU-T Y.1541]. A packet flow can be more specifically described as traffic associated with a given connection or connectionless stream having the same source host address, destination host address, protocol and port number. A single network QoS class will be allocated to the packet flow.

NOTE 2 – The network QoS classes are specified in both Tables 1 and 3 of [ITU-T Y.1541] presenting bounds on network performance between user network interfaces. Different packet flows can have the same network QoS class if their QoS requirements are within a certain pre-configured level.

NOTE 3 – Each network QoS class creates a specific combination of bounds on Internet protocol (IP) packet performance values indicating transfer delay, delay variation, loss ratio and error ratio.

NOTE 4 –Thenetwork QoS classes of 3GPP differs from those of ITU-T. In [b-3GPP TS 23.501], a QoS flow identifier (QFI) is used to identify a QoS flow having QoS differentiation. A fifth generation (5G) QoS identifier (5QI) may be used for a QFI as a default. The 5QIs include various QoS classes including packet loss rate, packet delay budget and maximum data burst volume.

The packet flow is generated at the request of network slice customers, and a session management function (SMF) in the IMT-2020 network initiates a PDU session based on pre-defined QoS profiles.

When the SMF modifies the session, it can update QoS profiles simultaneously. The QoS class of packet flow should be set within the range of the KPI that the network slice is supposed to support.

[REQ-2] The IMT-2020 network is required to allocate a QoS class of a packet flow within the range of the KPI that the network slice supports.

7.3 Other key performance indicators

Additional KPI information related to the capacity of a network slice are considered in this clause.

The maximum number of pieces of UE quantifies the maximum number that can access the network slice simultaneously. This information may be associated with the performance of the network attachment control function (NACF), which handles a registration request message to a network slice. The maximum number of PDU sessions describes the maximum number of concurrent sessions supported by the network slice. This information may be associated with the performance of the SMF, which handles a PDU session establishment message to the network slice. Other KPI information may be added to the network slice template.

8 Network slice configuration

Slice management and orchestration generates a configuration file that is used to configure sub network slices and transfers it to resource management before or during network slice initialization. An NSI is instantiated by resource management according to the network slice template generated by

slice management and orchestration. Resource management assigns the necessary resources to the NSI. The configuration file includes provisioning information to instantiate the NSI. For example, network resource information may be a part of the configuration file. The network resource information includes all resources assigned to the NSI.

NSI modification in the run-time phase could map to several workflows, e.g., changes in NSI capacity, changes in NSI topology and NSI reconfiguration.

NSI modification can be triggered by receiving new network slice-related requirements from network slice customers or as the result of NSI supervision. The former case is mentioned in [ITU-T Y.3153] from the third part aspect. The latter case is described in clause 9 from the network slice monitoring aspect.

NSI modification may change the capacity or topology of the NSI.

NSI termination may terminate the constituents of an NSI that is not used by other NSI(s). After the termination phase, that NSI no longer exists.

9 Procedures of network slice update

High-level configuration processes of an NSI are illustrated in Figure 9-1. The preparation of a network slice template is the first phase before instantiating a new NSI; subsequently, the NSI is created, configured and activated accordingly as described in [ITU-T Y.3156].

The network slice template is filled with the allocated values of the resource, if the NSI is successfully created. During the run-time phase, the NSI is monitored and controlled to meet QoS and performance requirements until the end of the life cycle of the NSI.

Performance measurement may be made in the NF of each NSI or by operation, administration and maintenance (OAM) functions to monitor the KPI.

During the run-time phase, the configuration of the NSI is modified if an NSI KPI is not able to support pre-defined service requirements, as shown in Figure 9-1.

Network function instances (NFIs) (e.g., NACF, SMF or user plane function (UPF)) may measure and collect the relevant performance values (e.g., the number of pieces of UE in the NACF). If the measured values reach a certain limit, an appropriate NF may directly request an update of the NSI configuration to slice management and orchestration or via OAM.

Slice management and orchestration can scale in additional NFs to the NSI, and the capacity of the NSI can be updated. The topology of the NSI can be modified for load balancing among the NFs by adding extra ones to the existing topology.

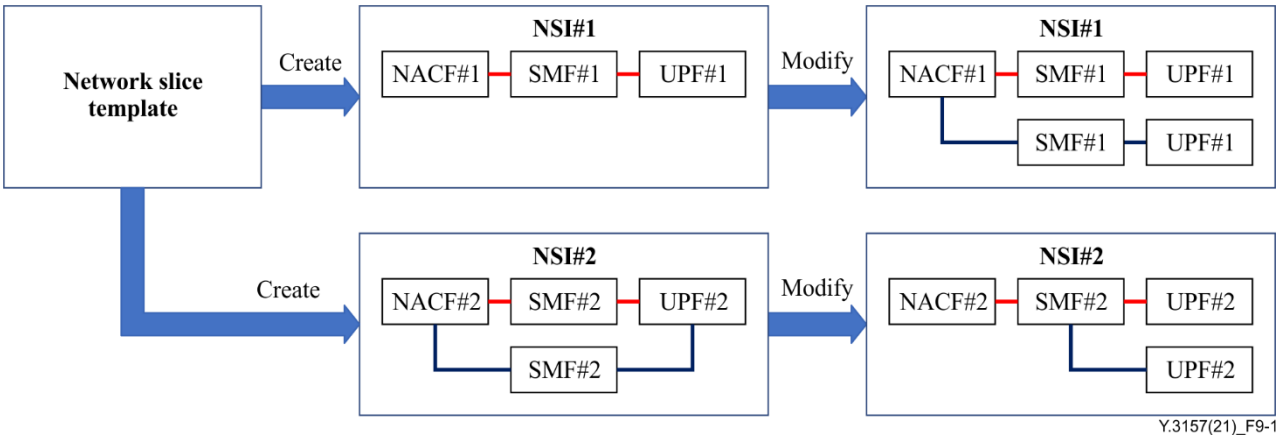

Figure 9-1 – High-level configuration processes of a network slice instance

The general procedures of network slice configuration are shown in Figure 9-2.

NOTE 1 – The NF belonging to a certain NSI can monitor and collect the relevant performance measurements as specified in [b-3GPP TS 28.552].

For example, the NACF (also known as the access mobility function (AMF)) may perform the performance measurement in terms of the number of registered subscribers. The performance measurement for the number of PDU sessions and the number of general packet radio service (GRPS) tunnelling protocol (GTP) data packets are monitored by the SMF and UPF, respectively.

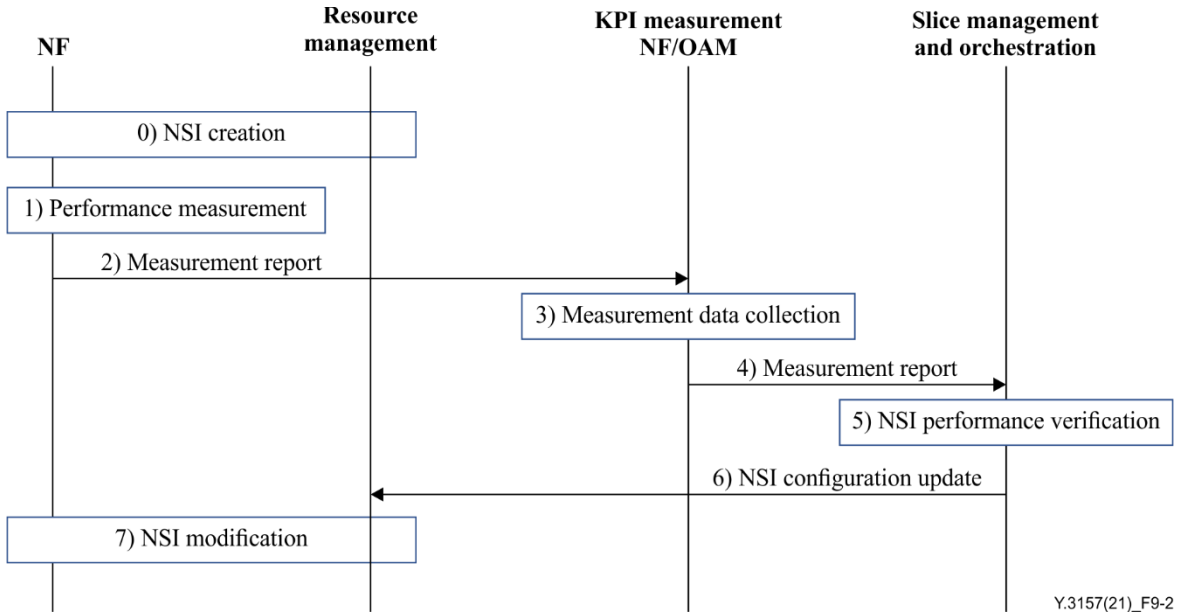

Figure 9-2 – Procedure of network slice configuration

Step 0: Slice management and orchestration create an NSI based on a network slice template (NST). The NSI consists of several NFIs such as NACF, SMF, UPF and packet control function (PCF). NSI capacity depends on NFI capacity. The NSI capacity can be changed by scaling NFIs in or out.

Step 1: The NFIs within the NSI start performance measurement when the NSI is activated to monitor and ensure NSI performance. The measurement result is delivered periodically or when a pre-defined threshold is reached.

NOTE 2 – The NACF instance measures the number of terminals connecting to the NSI. The SMF instance measures the number of sessions connecting to the NSI. The UPF instance measures the down link/up link (DL/UL) packet volume through the NSI. The UPF instance measures the DL/UL packet delay through the NSI.

Step 2: Each NF delivers its own measurement data to a KPI measurement NF. The NF can deliver the measurement data directly to slice management and orchestration if the KPI measurement NF cannot support the measurement report.

Step 3: The KPI measurement NF or OAM collects the measurement data.

Step 4: The KPI measurement NF delivers the measurement report for slice management and orchestration to initiate an NSI configuration update if needed.

Step 5: Slice management and orchestration verifies the requested performance level of the NSI. If the requested performance level is higher than pre-defined thresholds, the NSI configuration is updated to increase the NSI capacity by scaling in relevant NFIs. If the requested performance level is lower than the thresholds, the NSI configuration is updated to decrease NSI capacity by scaling out the relevant NFIs.

Step 6: Slice management and orchestration instructs the scaling in or out of NFs to increase or decrease the number of NFs.

Step 7: NSI capacity is appropriately modified to ensure NSI performance. The NFIs activate and continue relevant performance measurement.

10 Security considerations

This Recommendation specifies a network slice template and procedures of network slice configuration. The descriptions of network slices are related to network management and orchestration. Therefore, security considerations concerning IMT 2020 network management and orchestration [ITU-T Y.3111] can be applied.

Bibliography

[b-ITU-T Y.3100] Recommendation ITU-T Y.3100 (2018), *Terms and definitions for IMT-2020 network*.

[b-ITU-T Y.3106] Recommendation ITU-T Y.3106 (2019), *Quality of service functional requirements for the IMT-2020 network*.

[b-ETSI TS 128 530] Technical Specification ETSI TS 128 530 V16.2.0 (2020), *5G; Management and orchestration; Concepts, use cases and requirements (3GPP TS 28.530 version 16.2.0 Release 16)*.

[b-3GPP TS 23.501] 3GPP TS 23.501 (2019), *3rd Generation Partnership Project – Technical Specification Group Services and System Aspects – System architecture for the 5G System (5GS); Stage 2*.[b-3GPP TS 28.552] 3GPP TS 28.552 (2020), *3rd Generation Partnership Project – Technical Specification Group Services and System Aspects – Management and orchestration; 5G performance measurements*.

[b-GSMA NG.116] GSM Association Official Document NG.116 (2020), *Generic network slice template*, Version 4.0.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2021