International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.3154
(04/2020)

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

Resource pooling for scalable network slice service management and orchestration in the IMT-2020 network

Recommendation ITU-T Y.3154

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.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.3154

Resource pooling for scalable network slice service management and orchestration in the IMT-2020 network

Summary

Managing the lifecycle of network slices has recently attracted much attention as well as constructing end-to-end network slices. Especially, the agility and flexibility in resource allocation to network slices becomes more important for rapid service delivery to network slice service customers in the International Mobile Telecommunications-2020 (IMT-2020) network. Recommendation ITU-T Y.3154 describes scalable service management and orchestration framework using the middle layer named "resource pool", which intensively stores a variety of virtual resources information collected from the underlying infrastructure layer relevant to network slice instances (NSIs). NSIs can be created from the resources reserved according to a network slice service demand forecast. The proposed approach in Recommendation ITU-T Y.3154 is generic and thus applicable to a wide variety of organizational entities in network slicing, such as a network infrastructure provider, network slice provider, network slice service provider and network slice service customer.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3154	2020-04-29	13	11.1002/1000/14254

Keywords

Management and orchestration, network slice (instance), network softwarization, resource pool, service instance, scalability

* 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, 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 TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.3154

Resource pooling for scalable network slice service management and orchestration in the IMT-2020 network

1 Scope

This Recommendation provides an overview of resource pooling for scalable service management and orchestration of end-to-end network slicing. This Recommendation describes the following points on resource pooling:

– typical characteristics contributing to scalable management and orchestration;

– a hierarchical service model;

– key performance indicators;

– general workflows of network slice lifecycle management and orchestration (LCM&O).

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 X.1601] Recommendation ITU-T X.1601 (2015), *Security framework for cloud computing*.

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

[ITU-T Y.3101] Recommendation ITU-T Y.3101 (2018), *Requirements of the IMT-2020 network*.

[ITU-T Y.3102] Recommendation ITU-T Y.3102 (2018), *Frameworks of the IMT-2020 network*.

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

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

[ITU-T Y.3500] Recommendation ITU-T Y.3500 (2014) | ISO/IEC 17788:2014, *Information technology – Cloud computing – Overview and vocabulary*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 IMT-2020 [b-ITU-T Y.3100]: (Based on [b-ITU-R M.2083-0]) 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.

3.1.2 management [b-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.

3.1.3 network function [b-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.

3.1.4 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.

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

3.1.5 network slice blueprint [b-ITU-T Y.3100]: A complete description of the structure, configuration and work flows for 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.

3.1.6 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.

3.1.7 network softwarization [b-ITU-T Y.3100]: An overall approach for designing, implementing, deploying, managing and maintaining network equipment and/or network components by software programming.

NOTE – Network softwarization exploits the nature of software such as flexibility and rapidity all along the lifecycle of network equipment and/or components, for the sake of creating conditions enabling the re-design of network and services architectures, the optimization of costs and processes, self-management and bring added values in network infrastructures.

3.1.8 orchestration [b-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 infrastructures by optimization criteria.

3.1.9 service instance [b-ITU-T Y.3100]: An instance of a service that is realized within a network slice.

NOTE 1 – A service may be represented by one or more service instances.

NOTE 2 – A service instance may be provided by the network slice operator or a third party.

3.1.10 resource allocation [b-ISO/IEC 19099]: Process of assigning, separating, reserving, granting share of, or emulating resources for use by a consumer.

3.1.11 resource pool [b-ISO/IEC 19099]: Abstract entity exposed by the virtualization platform for the purpose of allocation of allocated resources to consumers.

3.1.12 virtual resource [b-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.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BSS	Business Support System
CAPEX	Capital Expenditure
CPU	Central Processing Unit
CSP	Communication Service Provider
eMBB	enhanced Mobile Broadband
FCAPS	Fault, Configuration, Accounting, Performance and Security
ICN	Information Centric Networking
ICN-SP	Information Centric Network Service Provider
IMT-2020	International Mobile Telecommunications-2020
IoT	Internet of Things
IoT-SP	Internet of Things Service Provider
LCM&O	Lifecycle Management and Orchestration
mMTC	massive Machine Type Communication
NFV	Network Function Virtualization
NSI	Network Slice Instance
MVNE	Mobile Virtual Network Enabler
MVNO	Mobile Virtual Network Operator
OAM	Operation Administration and Maintenance
OPEX	Operational Expenditure
OSS	Operation Support System
URLLC	Ultra-Reliable and Low Latency Communication

5 Conventions

None.

6 Introduction of resource pooling for scalable management and orchestration

6.1 Overview

Network softwarization is an overall approach to designing, implementing, deploying, managing and maintaining network equipment and network components by software. It exploits the characteristics, such as flexibility and rapidity, of software throughout the lifecycle of network equipment or components.

This Recommendation focuses on resource pooling for scalable management and orchestration for providing both service providers and their service customers with network slice services in the International Mobile Telecommunications-2020 (IMT-2020) network [ITU-T Y.3102]. Resource pooling realizes the dynamics and flexibility of resource usage for network slice services depending on various situations (e.g., in natural disasters, between peak and non-peak hours, between different locations) due to the following characteristics.

A middle layer named "resource pool" mediates between a lower service provider layer and an upper service customer layer. This layered model has a structure that is recursive and hierarchical in nature. There are three key characteristics of resource pooling: resource abstraction; multiple service provider or domain support: and flexible resource assignment.

Resource pooling can be managed by a network slice LCM&O, which is a functional entity that provides and manages network slice instances based on requests from organizational entities or applications in the upper layer [ITU-T Y.3150].

The first merit of resource pooling is to reduce direct interaction processes between functionalities in the lower and upper layers. In other words, the characteristic of the model is that service providers can support multiple customers while at the same time using abstraction to mask the complexity of the process from customers [ITU-T Y.3500].

Resources in the lower layer that the resource pool can manage are categorized into diverse types depending on the nature of the functions of each appliance or application. For instance, the number of CPU cores, memory size and storage space are typical computing resources. Bandwidth, latency, and address space are network resources. Furthermore, other types of physical resources, such as routers, gateways, firewalls and even the radio frequencies of Internet of things (IoT) devices, can be represented as virtual resources. All the virtual resources mentioned can be represented as digitalized virtual assets.

The second merit is to mediate the provision of virtual resource distribution over multiple providers or multiple domains, or to provide aggregated tenancy for the same virtual resource because of the flexibility of the location of the resource pool (see clause 8 for details).

The third merit is a capability for swift and elastic increase or decrease in the assignment of resources on demand. It is expected that a network slice is created proactively by a network slice provider based on the specific network slice service demand forecast (see clause 6.3).

6.2 End-to-end service instance

An end-to-end service instance includes a complete set of service(s) that is realized within an end-to-end network slice, which may contain several network slices. Network slice stitching, which means a concatenation of multiple network slices, has therefore to be considered for realizing an end-to-end service instance. From the networking viewpoint, network slice stitching performs the interconnection of domain-specific network slices, each of which is operated within a dedicated maintenance domain.

NOTE – Clause 8.1 of [ITU-T Y.3150] introduces cases on the concatenation of partial network slices to provide an end-to-end network service. In Figure 6-1 a), three network slice instances (NSIs) in different domains are stitched to serve a single service instance.

Resource pooling has a feature that treats information in a service provider's virtual resources relevant to an NSI in the lower layer. The information can be aggregated in order to serve one or more service customers in the upper layer by using the form of a service instance(s). Figure 6-1 shows the typical relations between the lower NSI(s) and the upper service instance(s). A service instance can correspond to more than one NSI (e.g., a roaming service by multiple operators), or a single NSI shared among multiple service instances.

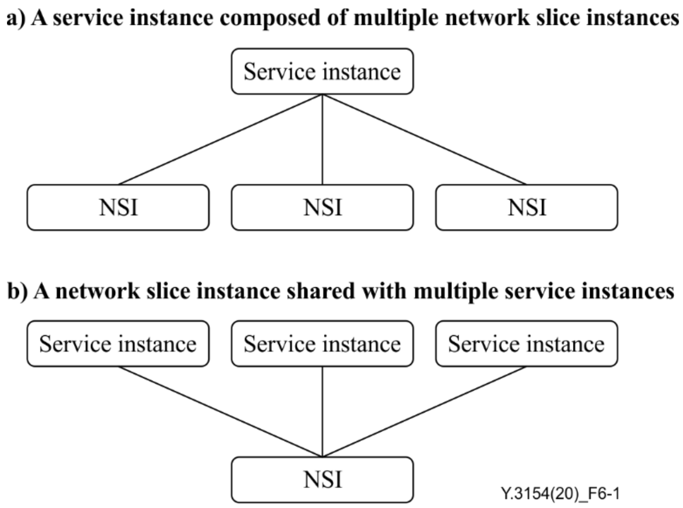

Figure 6-1 – Models between NSIs and service instances

6.3 Provisioning by demand forecast

When service demands increase dramatically or new services are about to be provided, a new service-line(s) would be reinforced. In the former case, the current network slice provided in IMT-2020 communication facilities may need to be scaled-up (i.e., increase in the same types of facilities). For the latter, a new network slice may need to be scaled out (i.e., addition of new types of facilities or replacement by the same type of facilities).

The service demand forecast estimates the volume of network resources sufficient for resource pooling and they can be reserved for future service. The response time for offering a network slice service is shortened because the only configuration of pre-assigned virtual resources is a required process.

7 Key performance indicator of end-to-end service instance

This clause addresses a scalability key performance indicator (KPI) of an end-to-end service instance. The end-to-end service instance may contain several network slices operated in each dedicated maintenance domain. Three KPIs to evaluate the performance of management and orchestration processes for the complex end-to-end network slice stitching are described in 1) to 3) as follows.

1) **Total number of instances**

   This KPI indicates a total number of instance objects, which the scalable management and orchestration should handle. This KPI corresponds to "number of slices", "heterogeneity" and "hierarchy level" in Table 7-1. High degrees of heterogeneity or hierarchy level may cause additional operational expenditure (OPEX) on scalable management and orchestration.

2) **Total operation frequency**

   This KPI indicates a total number of operations (e.g., creation, reservation, activation, de-activation and termination) of the managed instance objects. This KPI corresponds to "frequency of status change" and "lifecycle time" in Table 7-1. Less status change leads to lower OPEX.

3) **Performance of assigned resources**

This KPI indicates a performance of assigned computing resource (e.g., memory size, number of CPU cores) and networking resource (e.g., bandwidth, wireless capacity).

This KPI corresponds to the efficiency management of the number of instances, frequency of status change and hierarchy level in Table 7-1. For example, it is important for computing resource to have sufficient memory and CPU performance to execute all expected functions and operations. Also it is important for networking resources to evaluate network performance in wireless systems (e.g., special multiplexing and beams, assigned frequency in radio and frequency efficiency relevant to propagation channel conditions). Increases in both number of instances and frequency of status change are, however, critical from the capital expenditure (CAPEX) viewpoint.

In terms of the scalability to manage an end-to-end NSI and a network slice service instance, examples of KPI parameters are shown in Table 7-1.

In general, these parameters are stored in the resource pool and administered by the management and orchestration functionality, such as network slice LCM&O.

Table 7-1 – Examples of KPI parameters

No.	KPI	Description
1	Number of instances	The number of a NSIs for a specific service (e.g., enhanced mobile broadband (eMBB), ultra-reliable and low latency communication (URLLC) and massive machine type communication (mMTC)), and the number of service instances associated with them
2	Network performance	Evaluation of network performance in wireless systems, depending on the location of devices
3	Frequency of status change	Total number of status changes (creation, activation, de-activation, etc.) of all NSI and service instances in a fixed period
4	Lifecycle time	The runtime duration (e.g., a day, month or year) of an NSI, and runtime durations of a service instance associated with the corresponding NSIs. See Note 1
5	Heterogeneity	The number of network domains to make an end-to-end service instance. See Note 2
6	Hierarchy level	The number of vertically nested NSIs. See Notes 3 and 4

NOTE 1 – The runtime duration depends on the use case.
NOTE 2 – In Figure 6-1 a), a service instance is provided over three network domains
NOTE 3 – The number of instances in each layer should be counted. The total for a whole layer is related to the management cost.
NOTE 4 – The number of layers is closely related to the number of service providers involved in a network service (See clause 8).

8 Resource pool modelling

8.1 Fundamental structure of resource pool

The usage of a resource pool is intended to enhance scalability and agility of network slice services as a partial role in the network management and orchestration framework [ITU-T Y.3111].

The resource pool is an information database of logical instances to represent virtual resources corresponding to the NSIs. A fundamental model of resource pooling is illustrated in Figure 8-1. Key entities relevant to resource pooling are as follows.

– Resource provider: an organizational entity or an application in the lower layer that registers information of its own network resources including NSIs in the resource pool.

– Service requestor: an organizational entity or an application in the upper layer that requests a network service, which is an integration of NSIs registered in the resource pool.

– Management functions: a set of management functions for resource pooling. For example, an operation support system and business support system (OSS/BSS) or a network slice LCM&O (see clause 6) can be used, depending on the role of the owner or administrator of the resource pool.

NOTE – Clause 6.1 of [ITU-T Y.3103] introduces various business roles from a network slicing perspective. The structure with lower resource provider and upper service requestor is generally applicable to a network infrastructure provider, network slice provider, network service provider and network slice service customer.

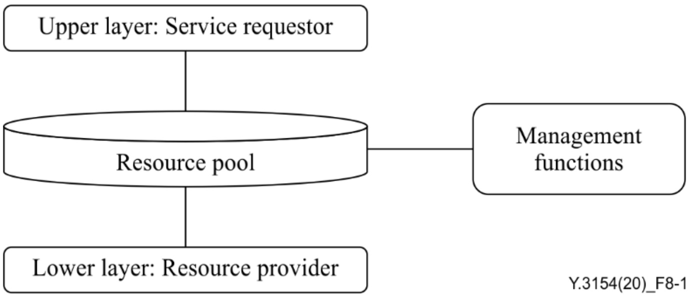

Figure 8-1 – A fundamental model of resource pooling

8.2 A typical model for providing network service

A typical model for providing a service instance is shown in Figure 8-2. In this case, the resource pool is owned and managed by a network slice LCM&O provider. Multiple network resource providers register their virtual resources with a resource pool. A network slice service provider creates a service instance consisting of NSIs that are assembled from the virtual resources registered in the resource pool.

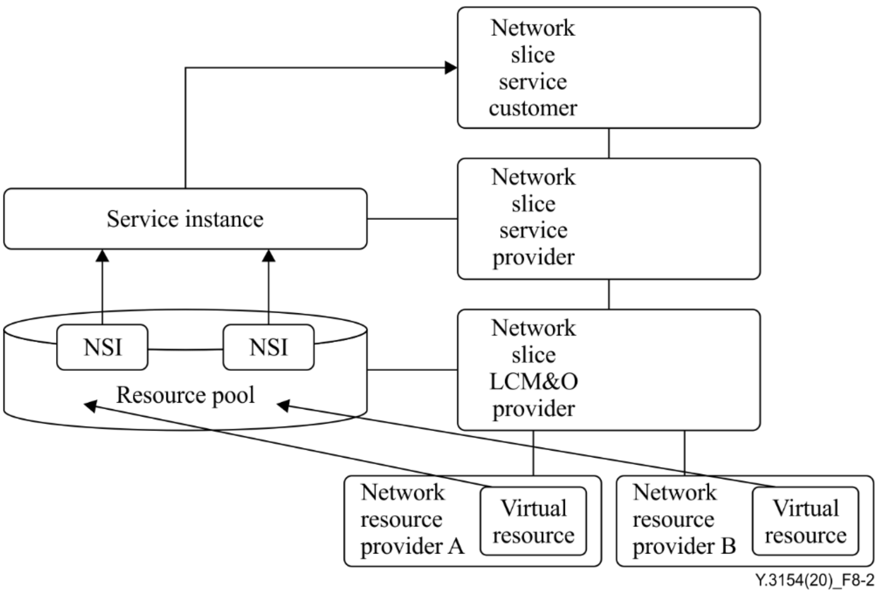

Figure 8-2 – A typical model for providing a network service

The organizational entities in Figure 8-2 are as follows.

– Network resource provider: provides the virtual resource to assemble a network slice in the resource pool and assists the network slice LCM&O to gather information about individual components of the network slice.

– Network slice LCM&O provider: offers network slice LCM&O functionality as a service.

– Network slice service provider: requests the creation of an NSI based on service requests from an entity in the upper layer, and serves NSIs as a service.

– Network slice service customer: a user of the network slice service.

NOTE – [ITU-T Y.3150] introduces the detailed relation among resources, a network slice LCM&O and a network slice customer.

8.3 Resource pool hierarchical service model

Figure 8-3 shows an example of a hierarchical service model mediated by the hierarchical use of the resource pool.

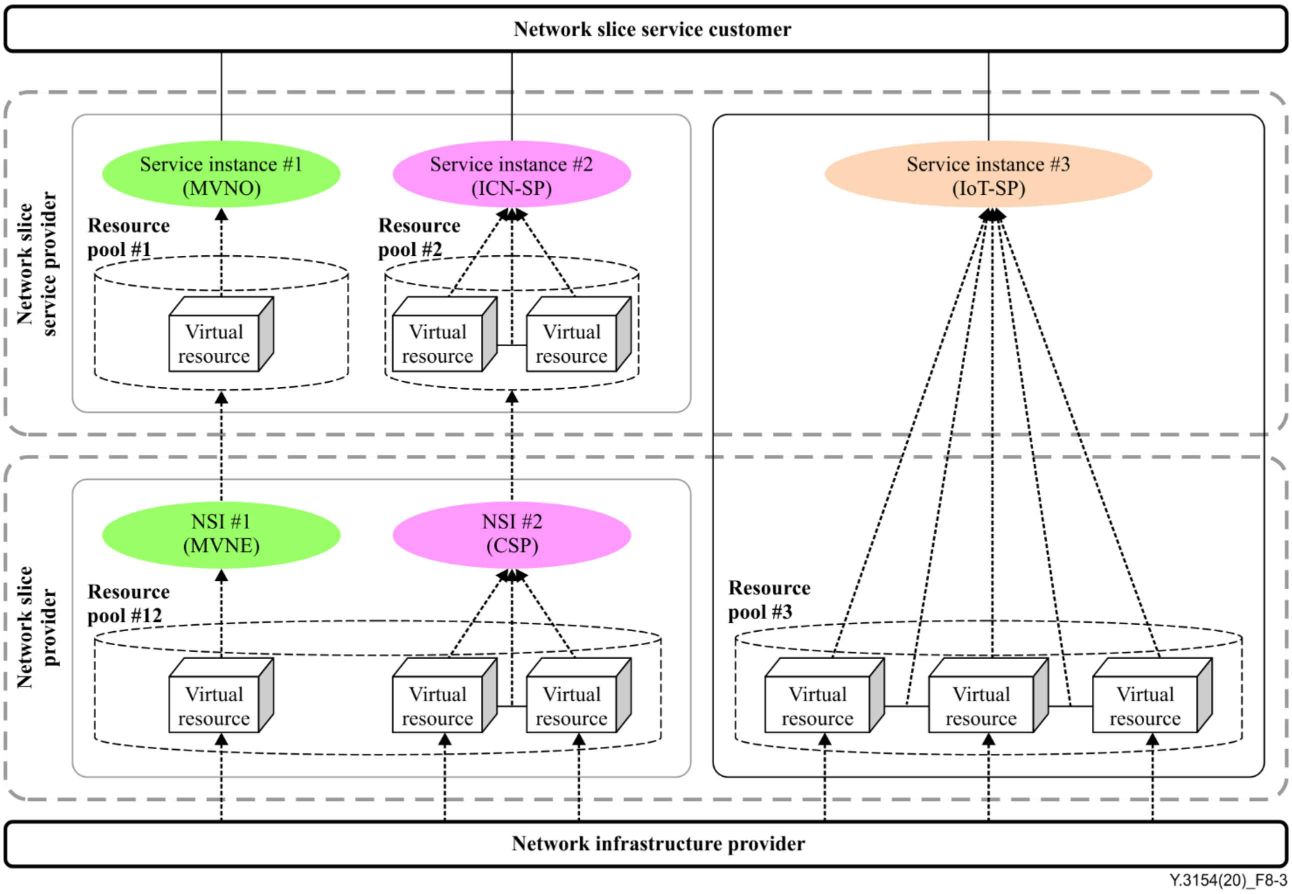

Figure 8-3 – An example of a hierarchical network service model

Figure 8-3 shows network slice service providers offering service instances to network slice service customers. Diverse types of network slice service providers are assumed as follows.

– Mobile virtual network operator (MVNO): offers a mobile service to its customers.

– Mobile virtual network enabler (MVNE): provides an MVNO with network services, and does not have a direct relationship with the MVNO's customers.

– Information centric networking service provider (ICN-SP): provides an information centric networking (ICN) service to its customer.

– Communication service provider (CSP): provides communication services (e.g., private peer-to-peer network and Internet) to its customers.

– Internet of things service provider (IoT-SP): provides an IoT service to its customer.

MVNO and ICN-SP are service instances composed of NSIs provided two network slice service providers, MVNE and CSP, respectively, in Figure 8-3. On the other hand, an IoT service consisting of a network slice is directly created by an IoT-SP itself by using virtual resources of a network infrastructure provider.

As shown in this example, the relationship between service customers and service providers can be hierarchical based on their own business model. Each provider in this hierarchical model may have resource pools to mediate between upper layer requirements and lower layer virtual resources. The resource pool in each layer stores different sets of virtual resource information according to management purpose or its owner's role. For instance, resource pool No. 12 is used for the lifecycle management of NSI Nos 1 and 2, and resource pool No. 1 is used for the lifecycle management of service instance No. 1, which is relevant to NSI No. 1. Therefore, resource pool No. 1 stores a partial replication of information stored in resource pool No. 12.

NOTE – For reference, the 3rd Generation Partnership Project (3GPP) specification [b-TS 28.530] introduces the relation among organizational entities in network slice services.

9 Workflows of resource pooling

9.1 Workflow of lifecycle management of service instance

The LCM&O of a service instance consists of two phases: i) service preparation phase; and ii) service instance runtime management phase.

In the first service preparation phase, necessary virtual resources for a requested service are reserved and a service template is created beforehand.

In the second service instance runtime management phase, the service instance (e.g., creation or termination, activation or deactivation) is managed during its run time.

Table 9-1 shows general processes relevant to the service instance.

Table 9-1 – Processes of service instance management

No.	Process name	Description
1-0	Service registration	A service requirement (e.g., geographical coverage or lifecycle time) is provided by a service requestor. See Note 1
1-1	Service template creation	A service template is created in advance based on a service demand analysis or a service catalogue. See Note 2
1-2	Service creation	A service instance is created after service template selection and parameter configuration. A reserved network slice in the resource pool is assigned to a specific service instance
1-3	Slice validation check	The availability of reserved NSIs is tested. See Note 3
1-4	Service activation	A service instance is activated, and corresponding NSIs are also activated
1-5	In-service OAM	Service instance operation, administration and maintenance (OAM), including fault, configuration, accounting, performance and security (FCAPS) functionalities, are executed
1-6	Service de-activation	A network slice service instance is de-activated. See Note 4.

Table 9-1 – Processes of service instance management

No.	Process name	Description
1-7	Service termination	A network slice service instance is destroyed. See Note 5
NOTE 1 – The service requestor may analyse the past and current demand and forecast the future demand by itself. In other cases, the service demand forecast can be conducted by a management functionality based on past service requirements. NOTE 2 – A service template typically denotes service specifications including a set of functions or a connectivity performance for a specific industry, e.g., end-to-end connectivity over multiple domains, network capabilities and functions or the specification of an NSI. NOTE 3 – If a test fails due to insufficient network slice capability, the NSI is terminated, and service registration may be restarted. NOTE 4 – Corresponding slice instances may be de-activated. NOTE 5 – Corresponding NSIs may be terminated.		

Figure 9-1 illustrates the general workflow of service instance management.

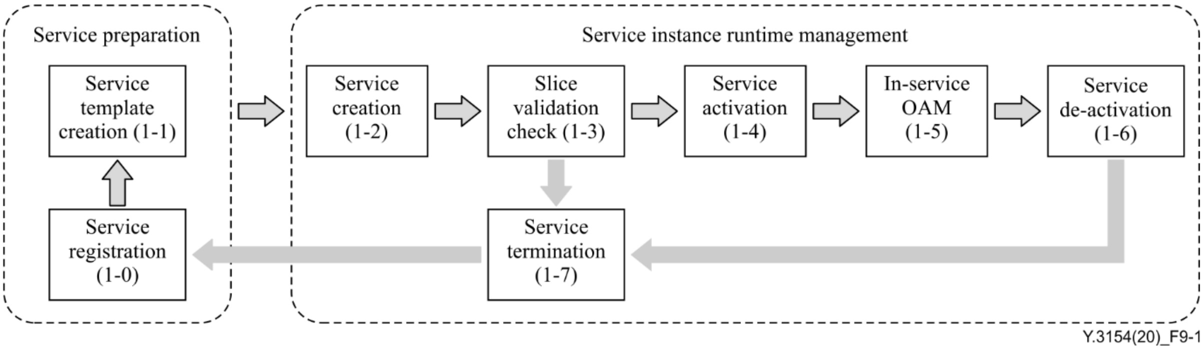

Figure 9-1 – A workflow of service instance management

A network slice service management starts with the initial process No. 1-0 (service registration). It is assumed that each lifecycle of a service instance will be triggered by the service requestor.

NOTE – Appendix I provides an example of the detailed workflow of an IMT-2020 system based on resource pooling.

9.2 Workflow of lifecycle management of an NSI

The lifecycle management of an NSI conducts its two-phase processes: i) network slice preparation phase; and ii) network slice runtime management phase.

In the first network slice preparation phase, resource orchestration functionalities for multiple slice customers are executed.

In the second NSI runtime management phase, the lifecycle of the NSI is managed during its runtime.

Table 9-2 illustrates the general processes for NSI management.

Table 9-2 – Processes of NSI management

No.	Process name	Description
2-0	Pool registration	Management functionalities of a resource provider registers virtual resources with a resource pool
2-1	Resource reservation	Virtual resources to assemble a NSI is reserved according to a service template. The reserved virtual resources are registered with the resource pool. See Note 1
2-2	Slice creation	An NSI is built from registered virtual resources
2-3	Slice registration	An NSI is registered with the resource pool
2-4	Slice activation	An NSI is activated
2-5	In-slice OAM	An NSI operation and management including FCAPS is executed
2-6	Slice de-activation	An NSI is de-activated. See Note 2
2-7	Slice termination	An NSI is terminated.
NOTE 1 – Resource pooling can use a service demand forecast to evaluate the volume of reserved resources. NOTE 2 – Re-activation or re-use of instances may occur in case of service instance scale up or out.		

Figure 9-2 illustrates the general workflow of NSI management.

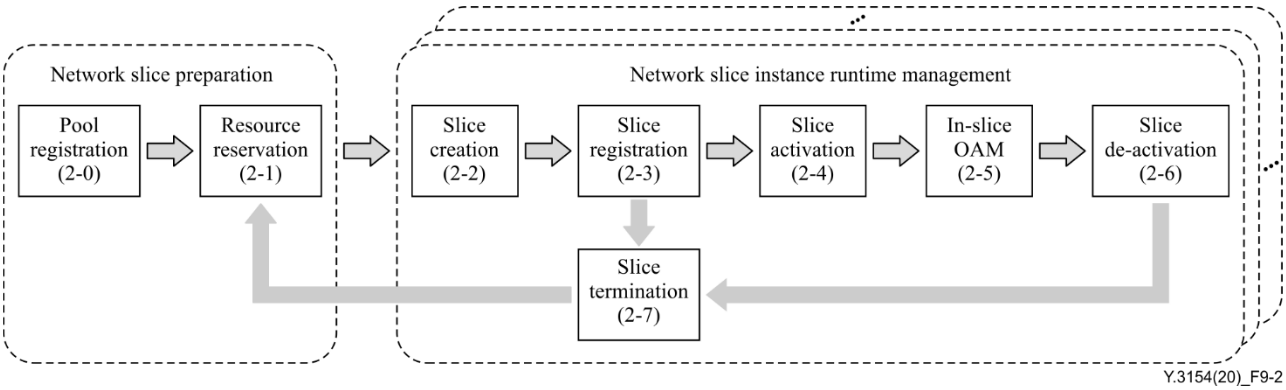

Figure 9-2 – A workflow of NSI management

Network slice preparation to assemble NSIs may be on-demand or proactively executed in process No. 2-1 (resource reservation) for realizing fast network slice provisioning.

NOTE 1 – The proactive reservation can be based on the forecast.

NOTE 2 – Appendix I provides an example of the workflow of an IMT-2020 system based on resource pooling.

10 Security consideration

General security requirements for IP-based networks in [ITU-T Y.2701] and for IMT-2020 systems in [ITU-T Y.3101] are fundamentals for network softwarization. Network softwarization consist of SDN, network function virtualization (NFV) and cloud computing techniques; therefore, security threats in each technical field should be taken care of.

Security and privacy issues related to cloud computing services and some of the issues identified may occur in network softwarization environments using network virtualization techniques. The issues described in [ITU-T X.1601], which introduces a general security framework for cloud computing, should be considered during planning and designing networks for mitigating the issues.

Appendix I

An example of an IMT-2020 system workflow

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

Figure I.1 illustrates an example of the workflow of an IMT-2020 system based on resource pooling.

The abstracted workflow of the service requestor is described in clause 9.1 and that of the resource pool in clause 9.2.

The resource provider converts physical resources to virtual resources.

The management function is responsible for a service demand forecast by analysing service requests according to the service request in this example. Availability of virtual resources and slice is evaluated and notified to the service requestor.

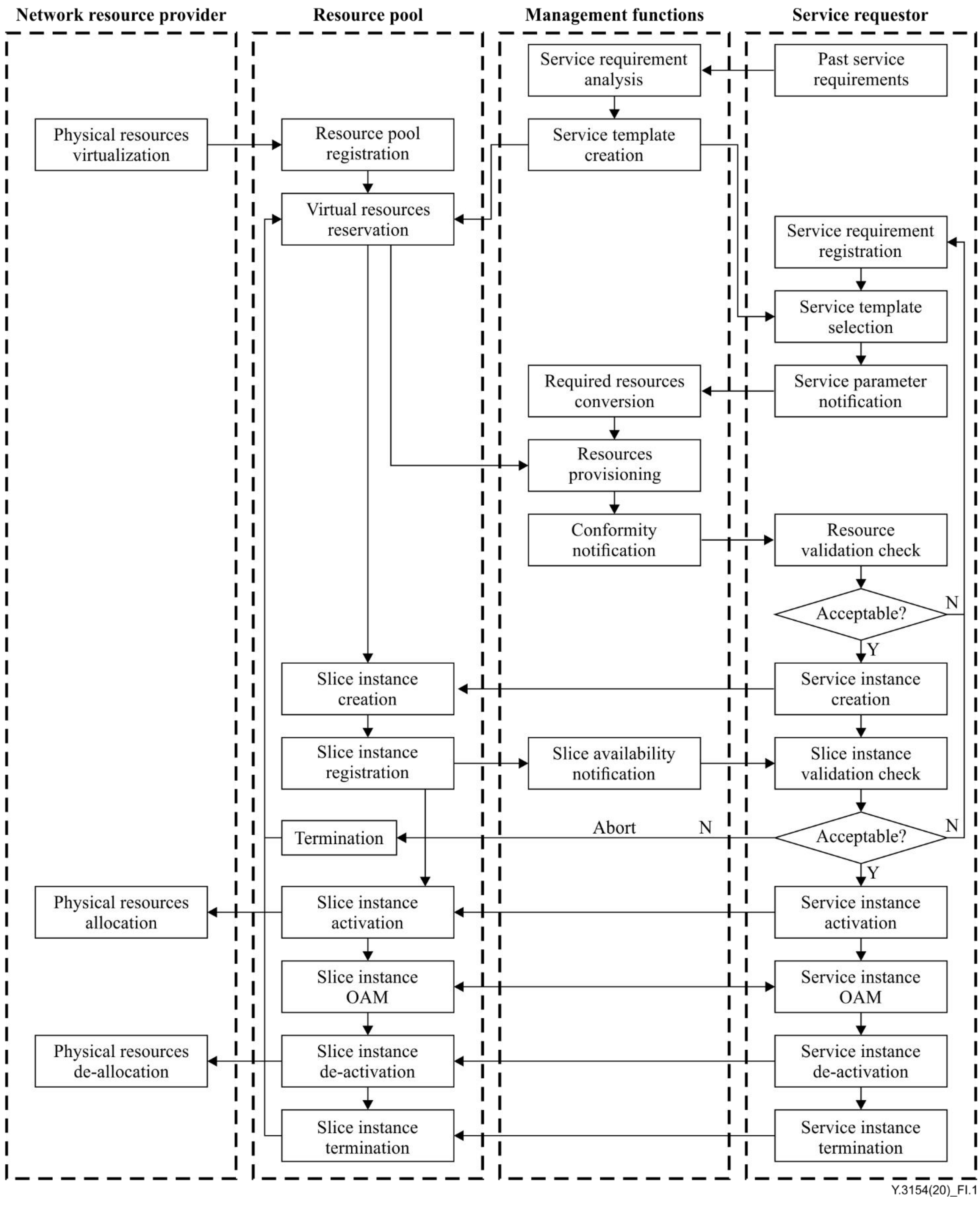

Figure I.1 – An example workflow of an IMT-2020 system based on resource pooling

Bibliography

[b-ITU-T Y.3011]	Recommendation ITU-T Y.3011 (2012), *Framework of network virtualization for future networks*.
[b-ITU-T Y.3100]	Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network*.
[b-ITU-T Y.3103]	Recommendation ITU-T Y.3103 (2018), *Business role-based models in IMT-2020.*
[b-ITU-R M.1645]	Recommendation ITU-R M.1645 (2003), *Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000.*
[b-ITU-R M.2083-0]	Recommendation ITU-R M.2083-0 (2015), *IMT vision – Framework and overall objectives of the future development of IMT for 2020 and beyond*.
[b-ISO/IEC 19099]	ISO/IEC 19099:2014, *Information technology – Virtualization management specification*.
[b-TS 28.530]	3GPP TS 28.530 (2020), *Management and orchestration of 5G networks: Concepts, use case and requirements (Release-16)*.

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, 2020