



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.3150

(09/2020)

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

Future networks

High-level technical characteristics of network softwarization for IMT-2020

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High-level technical characteristics of network softwarization for IMT-2020

Summary

With the global recognition of the usefulness of network slicing technology, which is the most typical substantiation of the network softwarization approach, this Recommendation describes how network softwarization and network slicing contribute to IMT-2020 systems. It explores network slicing from two viewpoints: vertical and horizontal aspects. The Recommendation further describes network slicing for mobile fronthaul/backhaul, introduction to advanced data-plane programmability, and capability exposure. These technical characteristic descriptions are expected to lead to their detailed study.

This revision contains i) the change of a basic model, which contains SDN, NFV, cloud computing and other technical environments, and ii) security consideration for network slicing. In addition, informative information on hierarchical orchestration is included.

Keywords

IMT-2020, network slicing, network softwarization.

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High-level technical characteristics of network softwarization for IMT-2020

1 Scope

This Recommendation describes high-level characteristics of network softwarization for non-radio part of IMT-2020. It explores network slicing from two viewpoints: vertical and horizontal aspects. After overviewing in each aspect, the Recommendation further describes network slicing for mobile fronthaul/backhaul, introduction to advanced data-plane programmability, and capability exposure, whose technical characteristic descriptions are expected to lead to their detailed study.

The detailed technical features (e.g., signalling specifications) are out of the scope of this Recommendation.

This revision mainly includes descriptions on i) an updated reference model showing relations with SDN/NFV and cloud computing, and ii) security consideration for network slicing. In addition, supplemental information regarding orchestration is added.

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.1038] Recommendation ITU-T X.1038 (2016), *Security requirements and reference architecture for software-defined networking*.
- [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.3100] Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network*.
- [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), *Framework for the IMT-2020 network*.
- [ITU-T Y.3105] Recommendation ITU-T Y.3105 (2018), *Requirements of capability exposure in the IMT-2020 network*.
- [ITU-T Y.3108] Recommendation ITU-T Y.3108 (2019), *Capability exposure function in IMT-2020 networks*.
- [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.3151] Recommendation ITU-T Y.3151 (2019), *High-level technical characteristics of network softwarization for IMT-2020 - Part: SDN*.

- [ITU-T Y.3152] Recommendation ITU-T Y.3152 (2019), *Advanced data plane programmability for IMT-2020*.
- [ITU-T Y.3153] Recommendation ITU-T Y.3153 (2020), *Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network*.
- [ITU-T Y.3154] Recommendation ITU-T Y.3154 (2020), *Resource pooling for scalable network slice service management and orchestration in the IMT-2020 network*.
- [ITU-T Y.3300] Recommendation ITU-T Y.3300 (2014), *Framework of software-defined networking*.
- [ITU-T Y.3502] Recommendation ITU-T Y.3502 (2014), *Information technology – Cloud computing – Reference architecture*
- [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 backhaul [ITU-T Y.3100]: A network path between base station systems and a core network.

3.1.2 control plane [b-ITU-T Y.2011]: The set of functions that controls the operation of entities in the stratum or layer under consideration, plus the functions required to support this control.

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

3.1.4 fronthaul [ITU-T Y.3100]: A network path between centralized radio controllers and remote radio units of a base station function.

3.1.5 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. A network path between base station systems and a core network.

3.1.6 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.

3.1.7 network functions virtualization [b-GS-NFV003]: principle of separating network functions from the hardware they run on by using virtual hardware abstraction.

3.1.8 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 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).

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3.1.9 network slice blueprint [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 – Network slice template can be used synonymously with network slice blueprint.

3.1.10 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.

3.1.11 network softwarization [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 natures of software such as flexibility and rapidity all along the lifecycle of network equipment/components, for the sake of creating conditions enabling the re-design of network and services architectures, optimizing costs and processes, enabling self-management and bringing added values in network infrastructures.

3.1.12 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.

3.1.13 physical resource [ITU-T Y.3100]: A physical asset for computation, storage and/or networking.

NOTE – Components, systems and equipment can be regarded as physical resources.

3.1.14 virtualized network function [b-ITU-T Y.3321]: A network function whose functional software is decoupled from hardware, and runs on virtual machine(s).

3.1.15 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:

API	Application Programming Interface
BH	Backhaul
CMUD	Create, Monitor, Update and Delete
CPU	Central Processing Unit
DNS	Domain Name System
eMBB	enhanced Mobile Broadband
EMS	Elementary Management System
FCAPS	Fault, Configuration, Accounting, Performance and Security
FH	Fronthaul

GPRS	General Packet Radio Service
GTP	GPRS Tunnelling Protocol
IMT-2020	International Mobile Telecommunications for 2020
Inf&NF-M	Infrastructure and NF Management
IoT	Internet of Things
LCM&O	Lifecycle Management and Orchestration
mMTC	massive Machine Type Communication
NAT	Network Address Translation
NEM	Network Element Management
NF	Network Function
NFV	Network Functions Virtualization
NFVI	NFV infrastructure
NFV-MANO	NFV-Management/Orchestration
OLT	Optical Line Terminal
OSS	Operations Support System
PDU	Protocol Data Unit
RAN	Radio Access Network
SDN	Software Defined Networking
URLLC	Ultra-Reliable and Low Latency Communication
VNF	Virtual Network Function
VNFM	Virtual Network Function Manager
VIM	Virtualized Infrastructure Manager

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 Recommendation is to be claimed.

6 Introduction to network softwarization for IMT-2020

Network softwarization is an overall approach for designing, implementing, deploying, managing and maintaining network equipment and network components by software. It exploits the natures of software such as flexibility and rapidity all along the lifecycle of network equipment/components, for the sake of creating conditions enabling the re-design of network and services architectures, optimizing costs and processes, enabling self-management and bringing added values in network infrastructures.

Figure 6-1 shows how network softwarization contributes to IMT-2020 network, whose requirements are specified in [ITU-T Y.3101]. With network softwarization, underlying heterogeneous physical infrastructure is abstracted as network, computing and storage resources. With management and orchestration, these resources and functions form multiple isolated networks as network slices. Individual network slices can have specific characteristics that reflect various different requirements derived from application and services.

[ITU-T Y.3102] shows the concept of network slice in IMT-2020 networks. In addition, [ITU-T Y.3112] introduces use-cases, functional and performance aspects and high-level requirements of network slicing.

Key components to realize network softwarization are software defined networking (SDN), network functions virtualization (NFV) and cloud computing, which are described in the next sub-clause.

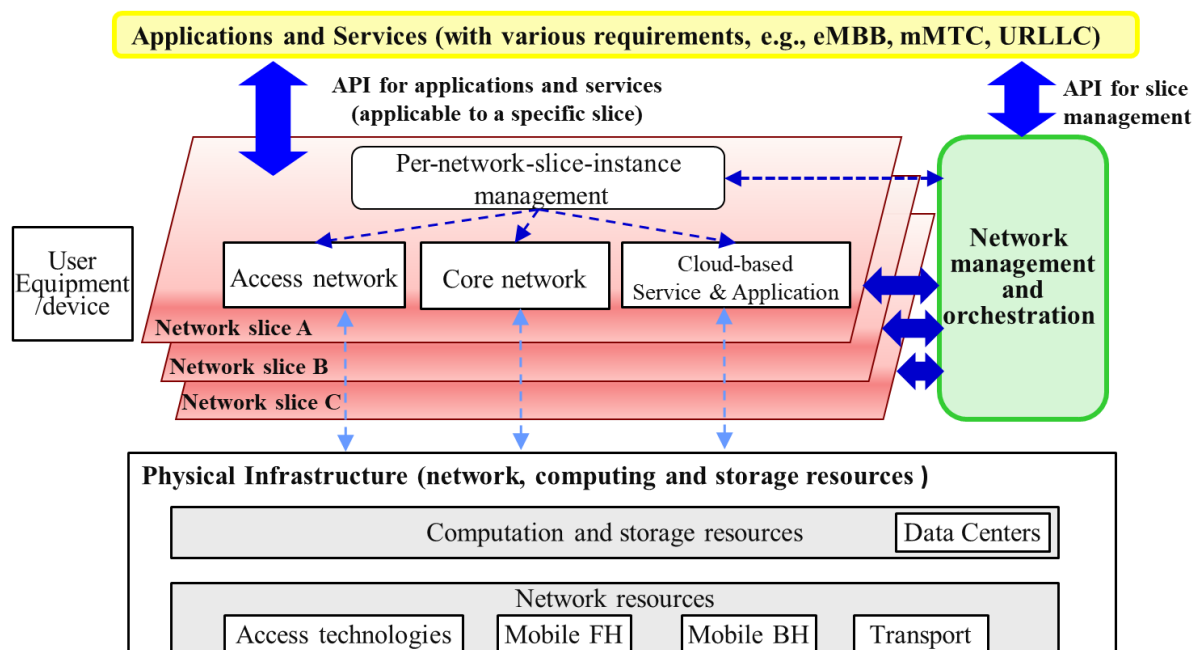


Figure 6-1 – Network softwarization for IMT-2020

6.1 Underlying technologies for softwarization

Together with SDN, NFV and cloud computing technologies, network softwarization is established for rapid service creation especially new services.

6.1.1 SDN

SDN is an umbrella term encompassing several kinds of network technology aimed at making the network as agile and flexible as the virtualised server and storage infrastructure of the modern data centre. The goal of SDN is to allow network engineers and administrators to respond quickly to changing business requirements. In a software-defined network, a network administrator can shape traffic from a centralized control console without having to touch individual switches, and can deliver services to wherever they are needed in the network, regardless of what specific devices a server or other device is connected to. The key technologies are functional separation, network virtualization and automation through programmability.

ITU-T Recommendations in Y.3300 series cover this technology area.

6.1.2 NFV

NFV offers a new way to design, deploy and manage networking services. NFV decouples the network functions from proprietary hardware appliances such as network address translation (NAT), firewalling, intrusion detection, domain name system (DNS), and caching. All network functions can run in software.

It is designed to consolidate and deliver the networking components needed to support a fully virtualised infrastructure – including virtual servers, storage, and even other networks. It is applicable to any data plane processing or control plane function in both wired and wireless network infrastructure.

NOTE – ETSI GS NFV series mainly cover this technology area.

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6.1.3 Cloud computing

Cloud computing technologies in telecommunication infrastructure bring both new opportunities of service offering and challenges in management perspective. One important challenge for telecommunication operators is efficient management of cloud computing taking into account the legacy management system framework and assuring the customer's satisfaction including the end-to-end quality of service.

Cloud computing is different from traditional telecommunication networks since it does not expose individual elements to the telecommunication management system. Moreover, cloud computing does not distinguish between management operations carried out on behalf of customer and network operator.

ITU-T Recommendations in Y.3500 series cover this technology area.

6.2 Potential use cases supported by network softwarization

In the IMT-2020 era, a variety of changes in information and telecommunication environment and social requirements impacting on network infrastructure should be taken into account. Typical examples of these are as follows.

- Video traffic already dominates the mobile communication traffic and still has been increasing. This requires the network architecture having an efficient video-on-demand delivery mechanism in terms of network/server congestion reduction and shorter response time.
- In many countries, disaster resilience, which is the ability on both service continuity and recovery against disruption, is a key concern. Since network systems are a part of life line infrastructure, they are expected to be robust. Increased network flexibility such as dynamic network resource allocation helps respond to this request.
- IoT and big data processing are booming. Future networks including the IMT-2020 network should provide with functions that fit to efficient IoT communication and big data processing systems.
- One of the expectations for IMT-2020 is the realization of ultra-low latency. Total design including data processing and service provisioning is necessary to fulfil this expectation.
- Applicability of SDN and NFV are expanding as possible key technologies for future networks including the IMT-2020 network. Data plane programmability, which enables change of the action of data forwarding devices by programming, and the usage of open source software are involved in this perspective.

These wide varieties of objectives can be achieved via network softwarization. With the adoption of SDN and NFV, software programmability of network nodes will in turn makes it feasible to run information processing and service software on network nodes as a new concept called “in-network computing”.

7 Vertical aspects

This clause describes technical characteristics of network softwarization (including network slicing) in terms of different levels of abstraction, of which a range is from physical infrastructure, virtual resources, and virtualized network functions and to network slices, in managed network domain(s) and their interactions.

In this Recommendation, these are referred to as vertical aspects.

7.1 Basic model for providing network slices

7.1.1 Overview

From the vertical viewpoint, the IMT-2020 network providing network slices can be modelled by the three key functional entities as shown in Figure 7-1.