International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.3301

(09/2016)

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

Future networks

Functional requirements of software-defined networking

Recommendation ITU-T Y.3301

International Telecommunication Union

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND 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.3301

Functional requirements of software-defined networking

Summary

Recommendation ITU-T Y.3301 describes the functional requirements of software-defined networking (SDN) including the general requirements and functional requirements of the SDN application layer, SDN control layer, SDN resource layer and any multilayer management functions. This Recommendation is based on Recommendation ITU-T Y.3300 (Framework of software-defined networking), which describes the fundamentals of SDN including the definitions, objectives, high-level capabilities, requirements and high-level architecture of SDN.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3301	2016-09-29	13	11.1002/1000/13016

Keywords

Abstraction, multilayer management, orchestration, programmability, SDN.

* 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 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.3301

Functional requirements of software-defined networking

1 Scope

This Recommendation describes the functional requirements of software-defined networking (SDN), which are defined in [ITU-T Y.3300], by providing:

– general requirements,

– functional requirements of the SDN application layer,

– functional requirements of the SDN control layer,

– functional requirements of the SDN resource layer, and

– functional requirements of the multilayer management functions.

NOTE – In [ITU-T Y.3300] the term "application layer" refers to "SDN application layer" and "resource layer" refers to "SDN resource layer".. As the names "application layer" and "resource layer" are too general this Recommendation uses more specific names of layers such as "SDN application layer" and "SDN resource layer".

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.3300] Recommendation ITU-T Y.3300 (2014), *Framework of software-defined networking*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 software-defined networking [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.

3.1.2 network virtualization [ITU-T Y.3011]: A technology that enables the creation of logically isolated network partitions over shared physical networks so that heterogeneous collection of multiple virtual networks can simultaneously coexist over the shared networks. This includes the aggregation of multiple resources in a provider and appearing as a single resource.

3.1.3 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.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BSS Business Support Systems

FCAPS Fault, Configuration, Accounting, Performance and Security

IP Internet Protocol

MAC Media Access Control

OSS Operations Support Systems

SDN Software-Defined Networking

5 Conventions

This Recommendation uses the following conventions:

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

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

6 Overview

[ITU-T Y.3300], the framework of SDN, defines SDN as a set of techniques that enables network resources to be directly programmed, orchestrated, controlled and managed, which facilitates the design, delivery and operation of network services in a dynamic and scalable manner. The high-level architecture of SDN in the framework consists of the application layer, SDN control layer, resource layer and multilayer management functions. The application layer executes SDN applications and enables network resources to act as instructed from SDN applications in a programmatic manner via the SDN control layer. The SDN control layer provides a means to control the behaviours of network resources via resource-control interfaces. The resource layer performs the transporting and the processing of data packets based on the decisions of the SDN control layer. The multilayer management functions provide functionalities for managing other layers including FCAPS.

This Recommendation defines the following functional requirements of SDN:

– general requirements;
– SDN application layer;
– SDN control layer;
– SDN resource layer; and
– multilayer management functions.

7 Functional requirements

7.1 General requirements

The general requirements are as follows:

– It is required to provide interoperability with external OSS/BSS.

– It is required to provide an orchestration functionality of the SDN application layer and SDN control layer, and multilayer management to handle the lifecycle management of software-based SDN functions.
– It is required to provide scalability for supporting a large number of users and vast geographical areas.
– It is required to provide a management support functionality in each layer to enable the delegation of multilayer management functions.
– It is recommended to maximize the energy-efficient usage of physical resources of all layers.

7.2 SDN application layer

The SDN application layer executes SDN applications and enables network resources to behave in a service-aware, programmatic manner.

The functional requirements for the SDN application layer are as follows:

– It is required to create and apply the application-specific programs to the SDN resource layer by interacting with the SDN control layer.
– It is required to support multiple applications at the same time.
– It is required to notify network events from the SDN control layer to the corresponding SDN application.

NOTE – Network events are information of network resources that are necessary for SDN applications to run in an appropriate manner, e.g., start/end of an activity, failure, performance degradation to be handled by SDN applications.

– It is required to orchestrate multiple SDN applications within the SDN application layer.
– It is required to categorize SDN applications and combine multiple applications into an integrated SDN application.

7.3 SDN control layer

The SDN control layer includes application support, orchestration, and abstraction functions.

Orchestration provides the coordination of requests from the SDN application layer and automated control of network resources, such as the management of physical and virtual network topologies, network resources and traffic.

Abstraction provides abstracted views of the property and behaviour of underlying network resources, in order to support the management and orchestration of physical and virtual network resources.

The functional requirements for the SDN control layer are as follows:

– It is required to provide orchestration, abstraction and programmability of the network resources.

NOTE – Programmability provides the ability to control or configure the network resources by introducing a high level of automation. Behaviour of network resources can be programmed by SDN applications for network control and management functionality.

– It is required to discover underlying network topology to see how network resources (e.g., SDN-enabled switches) connect to each other.
– It is required to collect and maintain network information about the capability of network resources and network-wide information, including the status of forwarding tables, routing policies and network topologies.
– It is required to back up network information in case of failures.

– It is required to build and update forwarding paths constituted by network resources, such as switches, routers and data processing entities.
– It is required to provide an abstracted view of different network solutions (e.g., Packet Transport Network, Optical Transport Network) to SDN applications.
– It is required to expose network configurations (e.g., routing policies) to the SDN application layer.
– It is required to maintain a set of lists of data processing entities (e.g., firewall, transcoding) categorized by their capabilities.
– It is recommended to create and maintain mapping information between SDN applications and network resources.

7.4 SDN resource layer

The SDN resource layer provides control support, data transport and processing functions.

The functional requirements for the SDN resource layer are as follows:

– It is required to perform data transport and data processing according to requests from the SDN control layer.
– It is required to support the allocation and release of necessary network resources.
– It is required to provide information and capabilities of virtual and physical elements of network resources including ports, links and addresses (MAC/IP/transport) to the SDN control layer.
– It is required to provide up-to-date information to the SDN control layer when the status of network resources changes.
– It is recommended to make data transport and processing functions extensible.
– It is recommended to enable resource virtualization of physical resources.
– It is recommended to enable the reconfiguration of virtual resources.

NOTE 1 – Examples of the reconfiguration of virtual resources include merging multiple virtual resources into a single one and splitting a virtual resource into multiple ones.

– It is recommended to maintain the mapping information between virtualized resources and physical resources.
– It is recommended that the SDN control layer utilizes the abstraction of physical and virtual resources by the SDN resource layer.

NOTE 2 – Resource virtualization can be realized by either or both the SDN resource layer and SDN control layers.

7.5 Multilayer management functions

Multilayer management functions provide cross-layer management functionality for software upgrades, fault isolation, performance optimization and the initial configuration of the network resources, SDN controllers and SDN applications.

The functional requirements for multilayer management functions are as follows:

– It is required to monitor and update status information of the SDN application layer, SDN control layer and SDN resource layer.
– It is required to access and collect network information including resource identifier, resource address, port information and network connectivity.
– It is required to monitor status including availability, failure and overload of network resources.

– It is required to (re/)configure SDN layers e.g., due to policy changes for management, maintenance and software updates, and physical resource changes.
– It is required to detect faults and manage reactions (i.e., protection, restoration and isolation) to the fault across multiple layers.
– It is required to support the exchange of information with external management entities.
– It is required to provide functionality for metering, charging and accounting information exchanges.
– It is recommended to provide topology and connectivity information such as IP address, network domain, port, interface and location and functional information, such as service description, type, vender and software version of data processing entities.

8 Environmental considerations

SDN can contribute to reducing energy consumption through the optimization of network resource usage. SDN, with its feature of logically-centralized control of network resources, can simplify the functionalities, as well as network operations, leading to a longer lifetime of equipment and reduced energy consumption.

9 Security considerations

For SDN security, securing the controller, verifying the communication channel between the controller and network resources, shaping secure data traffic, and logging all the network changes are considered.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
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	Terminals and subjective and objective assessment methods
Series Q	Switching and signalling
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 and next-generation networks, Internet of Things and smart cities**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2016