International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Q.3963

(04/2020)

SERIES Q: SWITCHING AND SIGNALLING, AND ASSOCIATED MEASUREMENTS AND TESTS

Testing specifications – Testing specifications for next generation networks

Compatibility testing of software-defined networking (SDN)-based equipment using the OpenFlow protocol

Recommendation ITU-T Q.3963

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Recommendation ITU-T Q.3963

Compatibility testing of software-defined networking (SDN)-based equipment using the OpenFlow protocol

Summary

One of the challenges in the area of software-defined networking (SDN) is to ensure the compatibility of solutions from various producers at all layers of the network function virtualization (NFV) and SDN network. There are many SDN solutions, both open-source and proprietary; each is unique in terms of the software implementation by the object, which, even if it delivers the functionality required by the standard, is still at risk in certain cases of the network failing or holding up traffic owing to a loss of the OpenFlow connection between the SDN switch and controller of the programmable network, exposing the operator (network owner) to the risk of financial and other losses (e.g., of customers).

To prevent such situations, when installing equipment on a telecommunication network, the operator tests the equipment in question for compatibility with other devices already operating on the network. In the case of SDN, tests are required to check the compatibility of OpenFlow protocol modules of each version installed on the device being tested.

Recommendation ITU-T Q.3963 has been developed with a view to harmonizing existing practices in the area of compatibility testing of devices using the OpenFlow operation system (OS).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.3963	2020-04-29	11	11.1002/1000/14245

Keywords

Integration testing, openFlow, software-defined networking.

* 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

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

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NOTE

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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/.

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Compatibility testing of software-defined networking (SDN)-based equipment using the OpenFlow protocol

1 Scope

This Recommendation describes compatibility testing of devices using the OpenFlow protocol. It also specifies the means and methods for testing using a model network under laboratory conditions.

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-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*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 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.

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

3.1.3 future network (FN) [b-ITU-T Y.3001]: A network able to provide services, capabilities, and facilities difficult to provide using existing network technologies. A future network is either:

a) a new component network or an enhanced version of an existing one, or

b) a heterogeneous collection of new component networks or of new and existing component networks that is operated as a single network.

3.1.4 IMT-2020 [b-ITU-T Y.3100]: Systems, system components, and related aspects that support to 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.

3.1.5 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.

3.1.6 software-defined networking [b-ITU-T Y.3300]: A set of technologies 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.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

FN Future Network

ICT Information Communication Technology

NFV Network Function Virtualization

OS Operation System

SDN Software-Defined Networking

5 Conventions

None.

6 Overview

Future networks (FNs), according to clause 3.1.3, are able to provide different kinds of services that are difficult to supply using existing network technologies. Responsibility for ensuring the required network performance falls on the infrastructure of IMT-2020 telecommunication networks, which according to [ITU-R M.2083-0], should be based on software-defined networking (SDN) and network function virtualization (NFV), which in turn help to ensure high-level network scaling and flexibility in management, allowing delivery of new services. Thus, a large-scale implementation of such network technologies is expected.

In this regard, this Recommendation specifies testing for compatibility of devices that support the protocols in order to maintain a multi-vendor approach to building information communication technology (ICT) infrastructure. As part of this Recommendation, the testing structure, types of testing, test scenarios, functions of the main elements and notes are given.

7 General structure of OpenFlow device testing

Considering the framework of SDN defined in clause 3.1.6, Figure 1 shows the general structure of OpenFlow device testing. There are main functional elements of this structure: controller SDN, operation system (OS), test modules (A and B), control server and OpenFlow switch.

The program-defined network controller is a complex object of the general architecture of SDN, which is responsible for both the functioning of the network as a whole, and for the operation of individual services and applications. One of the requirements for the designed and developed software-configured network is its fault tolerance, which depends on the correctness and stability of work between the OpenFlow controller and the OpenFlow device (switch) in various cases of operation.

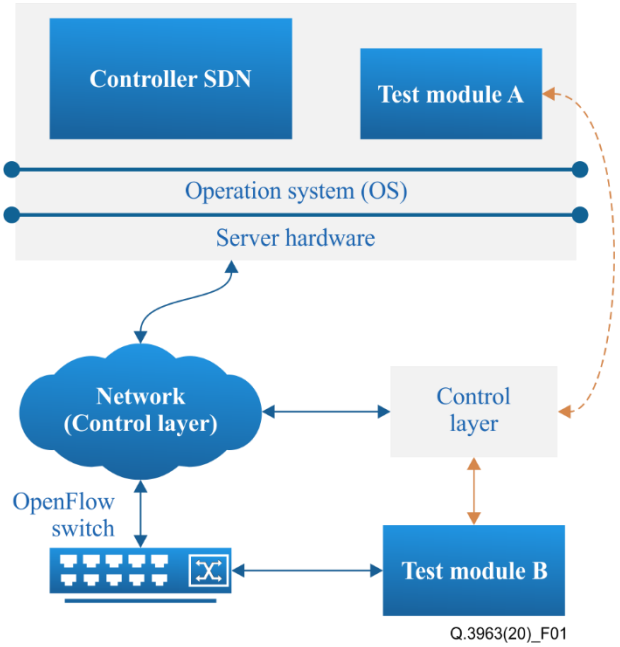

Figure 1 – The general structure of OpenFlow device testing

There are two types of test scenarios for compatibility testing of SDN-based equipment using the OpenFlow protocol:

- system start;
- system in operation.

7.1 Test scenario for system start

This type of test scenario combines various approaches to testing the operation of the OpenFlow protocol modules on each of the devices under study during their entry into operation. According to the specifications of the OpenFlow protocol, when devices are connected, the devices send an OpenFlow-hello message, while sending the maximum version of the supported OpenFlow protocol. Agreement is then sought on the version of the protocol to be used. Ultimately, both devices (controller and switch) must agree on the version of the protocol being used; usually, the minimum version is selected, supported by one of the devices. During the scenario, test module A intercepts OpenFlow traffic and sends it to the control server for subsequent analysis.

7.2 Test scenario for the system in operation

This type of testing includes a number of integration tests to verify the correct operation of the OpenFlow protocol modules in various modes: operational state (there is no high traffic activity at the data plane level) and high load (the high load generated traffic on the data plane level). As part of this test, the correctness of sending OpenFlow messages of various types approved in the OpenFlow specification [b-ONF] is checked. According to [b-ONF], the OpenFlow switch protocol supports three message types, each with multiple sub-types.

7.2.1 Controller-to-switch

Controller-to-switch messages are initiated by the controller and used to directly manage or inspect the state of the switch. These are the messages specified in OpenFlow:

- Features;
- Configuration;
- Modify-State;

- Read-State;
- Packet-Out;
- Barrier;
- Role-request;
- Asynchronous-Configuration.

7.2.2 Asynchronous

Asynchronous messages are initiated by the switch and used to update the controller about network events and changes to the switch state. These are the messages specified in OpenFlow:

- Packet-In;
- Packet-Out;
- Flow-Mod;
- Flow-Removed;
- Port-Status.

7.2.3 Symmetric

Symmetric messages are initiated by either the switch or the controller and sent without solicitation. These are the messages specified in OpenFlow:

- Hello;
- Echo;
- Experimenter.

As part of the integration testing of OpenFlow devices, performance of comprehensive testing, which includes checking the correctness of the processing of messages indicated in the foregoing, is required. This includes consideration of the different load level at the data plane level of the SDN network.

As part of this test, special attention needs to be paid to verifying the operation of Packet-In message generation logic by the SDN switch. According to the specifications of [b-ONF], this type of message is used to encapsulate messages at the data plane level to the management level (SDN controller). Thus, with the incorrect implementation of the OpenFlow protocol (in terms of implementing the logic of generating and processing Packet-In messages) by one of the devices, there is a risk of disrupting the SDN controller and violating security rules.

8 Functions of elements

The architecture of the system for testing (Figure 1) includes the elements specified in clauses 8.1 to 8.3.

8.1 Control server

This server provides monitoring and control of tests. This server implements a test module management system (A and B), the functions of generating test scenarios, and stores basic test scenarios. In addition, the server implements functions for analysing the information obtained from test modules (A and B).

8.2 Test module A

This module is a software solution for an OS in which an SDN controller is deployed. The main goal of this module is to intercept the OpenFlow traffic that comes to the controller port or is generated by the SDN controller for switches.

8.3 Test module B

This module is a software or software-hardware solution, which works on the SDN data plane, and is connected with the OpenFlow switch. Also, module B is connected with the control server for management purposes. The main goal of this module is to generate traffic to the OpenFlow switch. Also, on test module B, another OpenFlow switch (software component) can be realized, if necessary, for interconnection testing between switches.

Bibliography

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Printed in Switzerland
Geneva, 2020