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

Testing specifications – Testing specifications for IMT-2020 and IoT

Framework for software-defined network controller testing

Recommendation ITU-T Q.4061

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Recommendation ITU-T Q.4061

Framework for software-defined network controller testing

Summary

The concept of the International Mobile Telecommunications-2020 (IMT-2020) system is represented by a wide spectrum of information communication technology applications, cloud services and network infrastructure, dynamically responding to the relevant requirements of each service, whether already widely used or new. One approach to building network infrastructure is that of the software-defined network (SDN). It is described in ONF TR-526 and ITU-R M.2083.

Recommendation ITU-T Q.4061 contains: a classification of SDN controller tests; parameters, structure, sequence and methodology of SDN controller testing.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.4061	2019-04-29	11	11.1002/1000/13887

Keywords

Layers, northbound interface, openflow, parameters testing, SDN, southbound interface.

* 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.

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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.

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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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Recommendation ITU-T Q.4061

Framework for software-defined network controller testing

1 Scope

This Recommendation describes the general approach to testing of software-defined network (SDN) controllers, specifies a number of key parameters, the totality of which determine the ability of a controller to handle a specific load and type of controlled network.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 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.

3.1.2 network virtualization [b-ITU-T Y.3011]: A technology that enables the creation of logically isolated network partitions over shared physical networks so that heterogeneous collections 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.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

App	Application
API	Application Programming Interface
CPU	Central Processing Unit
IMT-2020	International Mobile Telecommunication-2020
LAN	Local Area Network
PCB	Printed Circuit Board
RAM	Random Access Memory
SDN	Software-Defined Network

5 Conventions

None.

6 Classification of approaches to testing controller software-defined networking

An SDN is a flexible structure, which in turn can be implemented in different conditions and constructed according to the parameters required in each case. In accordance with this provision, SDN controller testing requires appropriate approaches, taking into account the peculiarities of the SDN implementation variant. Many factors in the implementation of the network infrastructure and the infrastructure of the application-level controller are considered. In some cases, testing is also required, subject to a different reservation controller. As a result of ongoing tests with subsequent collection of the results obtained, a comprehensive analysis is required, which involves the study of parameters related to testing performed on all interfaces that can possibly give an informed decision about the suitability for use of this controller in many different situations, either particular or general. However, following systems theory and in particular system properties, such as emergence, in the study of controller parameters separately from the subsequent integrated analysis does not give an accurate picture of the behaviour of the controller subject to the complex interplay of all possible effects considered separately. Study of this complex interplay is also required and needs consideration, thus the necessary resources need to be made available according to the relevant characteristics.

See Figure 1.

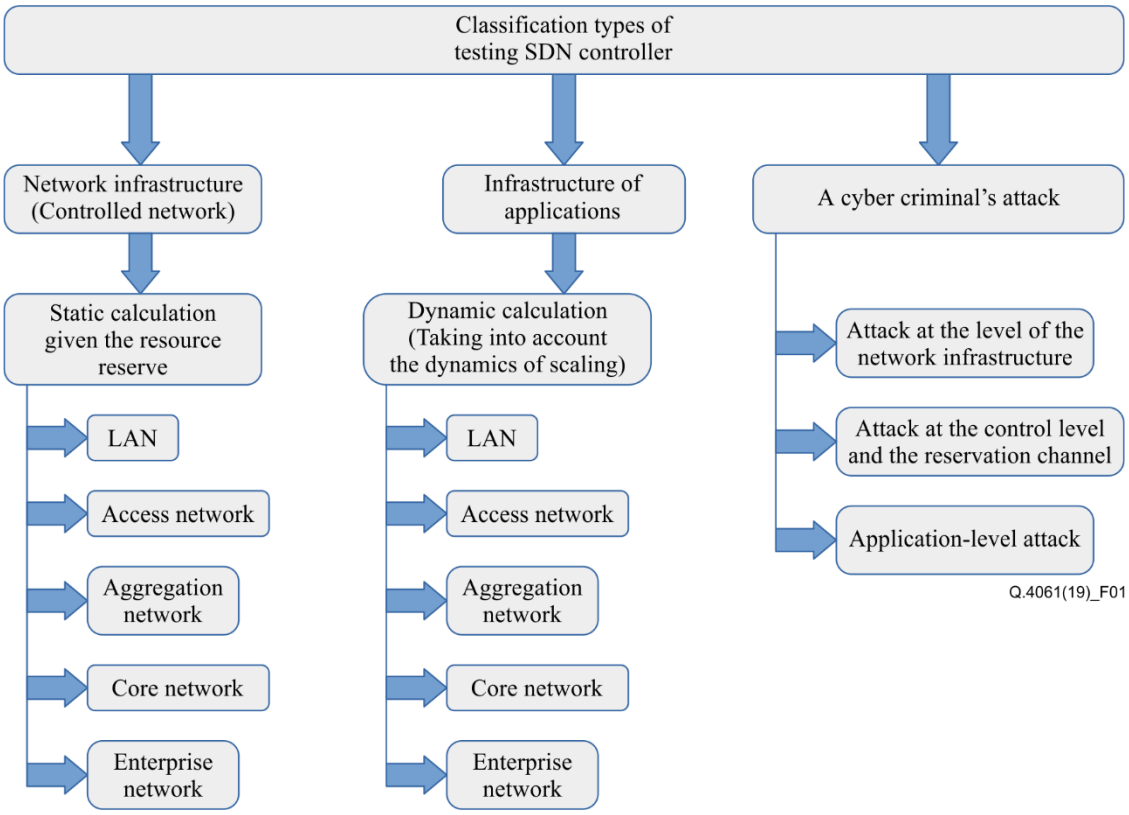

Figure 1 – Classification types of testing software-defined network controller

7 The number of parameters determined during testing of the software-defined network controller

During controller testing, determination of the characteristics of several parameters is required for the complex analysis of controller operability in the program-defined network, carried out at a subsequent step, under specific conditions. Each type of testing requires several specific parameters, a complex analysis of which gives a more realistic answer about the suitability of the controller under study.

Table 1 lists a number of possible parameters, the type of test, the relevant characteristics and recommendations for considering a parameter as a necessary element for conducting a subsequent analysis of the set of characteristics, and deciding whether the controller is suitable under specific conditions.

Table 1 – List of parameters for testing

No	Name of test	Type of test	Estimated characteristics	Conditions for using the controller
1	Measuring the bandwidth of the controller, depending on the number of connected managed switches, with a constant number of hosts behind each switch	Load testing	1. Bandwidth controller [flow/s]	1. In all cases
2	Measurement of the bandwidth of the controller depending on the number of hosts connected to a constant number of switches controlled by the controller	Load testing	1. Bandwidth controller [flow/s]	1. In all cases
3	Measuring the processing time of one request (delay) depending on the number of connected switches, with a constant number of hosts	Load testing	1. The processing time per request [ms]	1. Aggregation-level networks; 2. Core-level networks; 3. Corporate networks
4	Measuring the processing time of a single query (delay) depending on the number of terminal nodes, at a constant number of switches	Load testing	1. The processing time per request [ms]	1. Local networks; 2. Corporate networks
5	Study of the scalability of the controller (controller performance, in the maximum load on the controller)	Load testing	1. Productivity of the processor of the controller [kbyte/s] for cores 2. The availability of the file service (SDN controller) [%]	1. In all cases
6	Testing the reliability of the controller (the controller's performance, in the maximum load on the controller)	Load testing	1. Productivity of the processor of the controller [%] for cores 2. Removable memory random access memory (RAM) [GB] 3. Temperature [°C]	1. In all cases

Table 1 – List of parameters for testing

No	Name of test	Type of test	Estimated characteristics	Conditions for using the controller
7	Testing the performance of the controller, depending on the time and frequency of changes in the network topology, with a constant parameter of the number of measurements.	Load testing	1. Productivity of the processor of the controller [%] for cores 2. Removable memory RAM [GB,%]	1. Core-level networks
8	Testing the influence of loadable module of a protocol on the performance of the controller, with increasing load on this module	Load testing	1. Productivity of the processor of the controller [%] for cores 2. Removable memory RAM [GB,%] 3. Processing time of one request [ms] for this module	1. In all cases
9	Testing the influence of loadable module of a protocol on the performance of the controller, with increasing load on the controller	Load testing	1. Productivity of the processor of the controller [%] for cores 2. Removable memory RAM [GB,%] 3. The processing time of one request [ms]	1. In all cases
10	Testing the performance of the controller, depending on the increased load on the controller application programming interface (API) (each of its modules)	Load testing	1. Productivity of the processor of the controller [%] for cores 2. Removable memory RAM [GB,%] 3. The processing time of one request [ms] with a constant number of hosts and switches	1. In all cases

Table 1 – List of parameters for testing

No	Name of test	Type of test	Estimated characteristics	Conditions for using the controller
11	Performance testing of the controller depending on the number of connected applications and their maximum load	Load testing	1. Productivity of the processor of the controller [%] for cores 2. Removable memory RAM [GB,%] 3. The processing time of one request [ms] with a constant number of hosts and switches	1. In all cases
12	Testing the response of the controller to the switching speed, with using it as a backup (at the time of a sharp increase in the number of requests)	Load testing	1. The availability of file service (controller printed circuit board (PCB)) [%] 2. The performance of the central processing unit (CPU) of the controller [%] in the kernels 3. The processing time per request [ms] switching to reserve. 4. The duration of the transition process [ms]	1. In all cases

8 Structure of software-defined network controller testing

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 the operation of individual services and applications. One requirement for the projected or developed SDN is its fault tolerance, which in turn depends on the stability and correctness of the controller of the program-defined network in various possible non-ordinary cases of operation. This requires building the SDN controller testing approach on the basis of systematic analysis of the necessary range of parameters, which in turn gives with some certainty the suitability of this controller in a specific case under review. The overall structure of the test is shown in Figure 2. This structure is based on the general SDN architecture and shows the main interfaces through which the controller can be disabled.

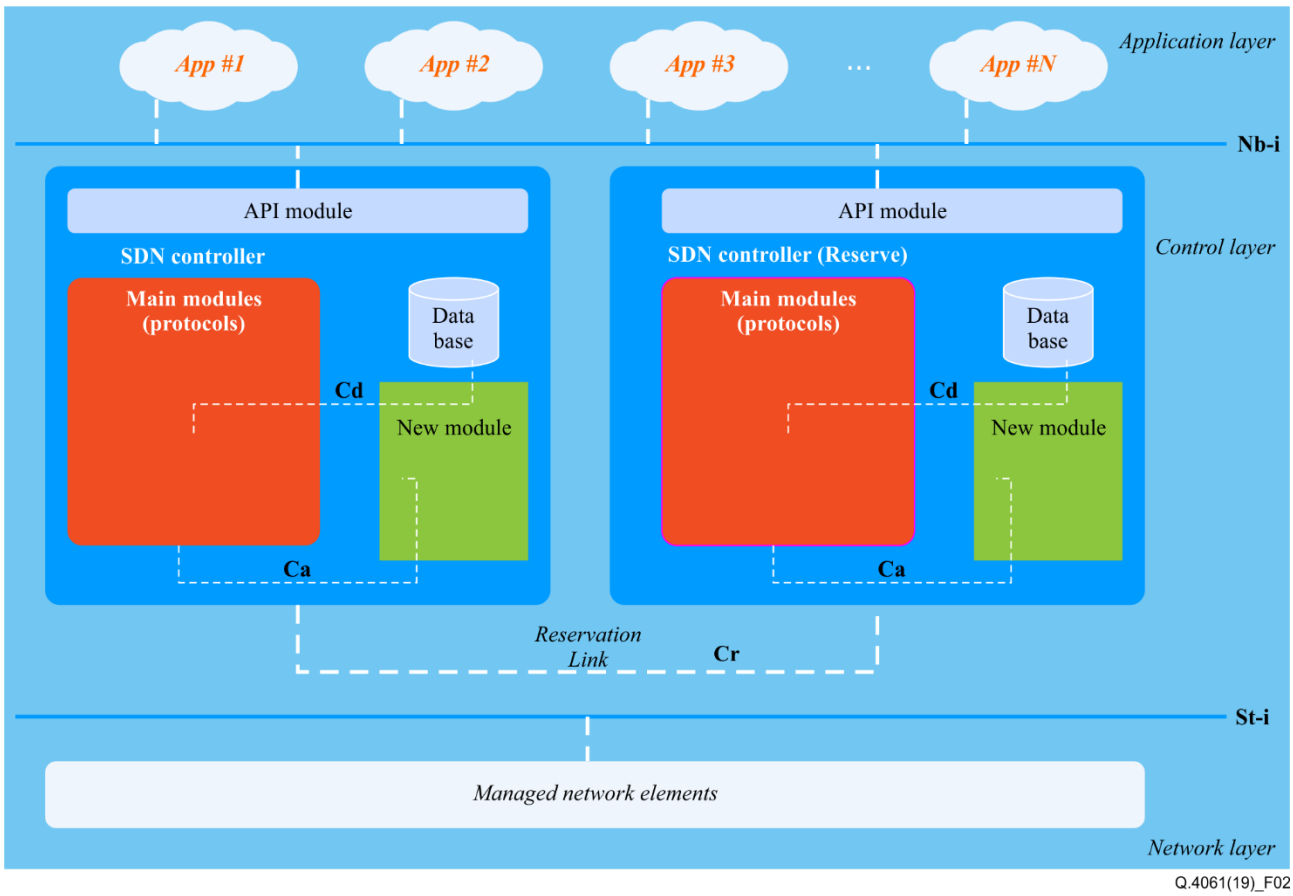

Figure 2 – Structure of testing of controller software-defined network
App: application

Figure 2 shows the general architecture of the test controller, the main communication modules and related reference points reflecting the total number of interfaces through which the controller can be overloaded and subsequently destroyed.

Figure 2 identifies a number of reference points:

– St-i: southbound interface;
– Cr: controller reservation link;
– Ca: controller access bus;
– Cd: controller access bus to database;
– Nb-i: northbound interface.

White dotted lines labelled "Ca" and "Cd" denote the software bus of the programming language framework based on which is the developed controller. For example, white dotted lines labelled "Ca" denote the software bus for interconnections between modules: main modules (protocols); database; new module.

9 Methodology for testing the software-defined network controller

The sequence of tests is an algorithm consisting of four stages. Tests should be carried out in the order given in this paragraph. Tests that are present at the next stage do not begin until all the processes of the previous stage are completed.

Step 1. Development of test procedures for the controller.

– The necessary parameters for testing the controller are determined. Strict quality assessments of each parameter (boundary conditions) are determined taking into account the network infrastructure that the SDN controller controls.

Step 2. An initial test of the controller.

Step 3. Identifying program and test method errors and their adjustment.

Step 4. Conducting the main tests and analysis of results.

– Tests of specific hardware and software characteristics of the SDN controller must be carried out.
– The tests should show that certain characteristics of the SDN controller meet the specified evaluation criteria and test metrics.

10 The list of works carried out after completion of the tests

Upon completion of the tests, the results are recorded in the test book, which is in the laboratory. A test report is also prepared, which contains the relevant general and special data.

General data

1. A description of the material side of the test object – name, colour, use, manufacturer, etc.
2. Date of testing and the roles of the personnel participating in the trials.
3. The conditions for finding a test object prior to the tests.
4. Test conditions – relative humidity of indoor air, ambient temperature, atmospheric pressure, etc.
5. Measuring instruments with an indication of their precision class and a description of the laboratory stand for testing.

Special data are determined by the purpose and method of testing, the features of the object under test.

The document on the tests carried out is signed by the head and personnel who conducted the tests.

Bibliography

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