International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Q.3915

(09/2020)

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

Testing specifications – Testing specifications for next generation networks

Set of parameters for virtualized broadband network gateway monitoring

Recommendation ITU-T Q.3915

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Recommendation ITU-T Q.3915

Set of parameters for virtualized broadband network gateway monitoring

Summary

The virtualized broadband network gateway (vBNG) has been developed as an entry point for telecommunication providers to introduce network functions virtualization (NFV). Recommendation ITU-T Q.3915 focuses on monitoring of vBNG in NFV. This Recommendation provides the set of parameters that indicate the state and event of vBNG.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.3915	2020-09-29	11	11.1002/1000/14416

Keywords

Monitoring, parameter, virtual broadband network gateway.

* 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.

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Set of parameters for virtualized broadband network gateway monitoring

1 Scope

This Recommendation describes the monitoring architecture and requirements for the virtualized broadband network gateway (vBNG), and specifies a set of parameters which will be monitored during the lifecycle of a vBNG instance.

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 Q.3315] Recommendation ITU-T Q.3315 (2015), *Signalling requirements for flexible network service combination on broadband network gateway*.

[ITU-T Q.3715] Recommendation ITU-T Q.3715 (2018), *Signalling requirements for dynamic bandwidth adjustment on demand on broadband network gateway implemented by software-defined networking technologies*.

[ITU-T Q.3719] Recommendation ITU-T Q.3719 (2019), *Signalling requirements for the separation of control plane and user plane in a virtualized broadband network gateway (vBNG)*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 broadband network gateway (BNG) [ITU-T Y.3315]: The access point to the provider's IP network for wireline broadband services.

3.1.2 virtual broadband network gateway (vBNG) [ITU-T Q.3715]: The virtual BNG is the broadband network gateway of which all features or some features are directly implemented as VNF(s) running on the network functions virtualization infrastructure (NFVI). It is used to either augment or replace the existing traditional BNG.

3.1.3 vBNG control plane (vBNG-CP) [ITU-T Q.3719]: The virtualized broadband network gateway (vBNG) control plane is in charge of the control functions, including authentication, authorization and accounting (AAA) management function, IP address management function, user management function, access protocol processing function, and vBNG user plane management function, etc. The vBNG control plane is implemented using virtualization technologies and is deployed in the mode of centralization.

3.1.4 vBNG user plane (vBNG-UP) [ITU-T Q.3719]: The virtualized broadband network gateway (vBNG) user plane mainly provides user packets switching under the instruction of the vBNG control plane. The vBNG user plane can be implemented in different types of forwarding hardware, including NP-based dedicated equipment, ASIC-based dedicated equipment, or X86-based commercial equipment.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA	Authentication, Authorization and Accounting
ASIC	Application Specific Integrated Circuit
BNG	Broadband Network Gateway
CP	Control Plane
CPU	Central Processing Unit
DHCP	Dynamic Host Configuration Protocol
DPDK	Data Plane Development Kit
FPGA	Field Programmable Gate Array
IP	Internet Protocol
IPoE	Internet Protocol over Ethernet
MPLS	Multi-Protocol Label Switching
NFV	Network Functions Virtualization
NFVI	Network Functions Virtualization Infrastructure
NIC	Network Interface Controller
NP	Network Processor
OSS	Operational Support System
PPPoE	Point-to-Point Protocol over Ethernet
RAM	Random Access Memory
SR-IOV	Single Root I/O Virtualization
UP	User Plane
vBNG	virtualized Broadband Network Gateway
vBNG-CP	virtualized Broadband Network Gateway control plane
vBNG-UP	virtualized Broadband Network Gateway user plane

5 Conventions

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

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

6 Reference architecture of vBNG

There are two main functions in a traditional broadband network gateway (BNG), the user access management function, and the user data routing and forwarding function. In a virtualized broadband network gateway (vBNG), it has been found that separating these two functions can make a

difference. Actually, the user management function of a traditional BNG can be centrally deployed in the form of a concentrated virtualized network function (VNF) or modules or a device, which can be called a vBNG control plane (vBNG-CP). The reserved functions such as routing and forwarding function can be deployed in the form of a vBNG user plane (vBNG-UP).

The monitoring architecture for a control plane and user plane separated vBNG is shown in Figure 6-1.

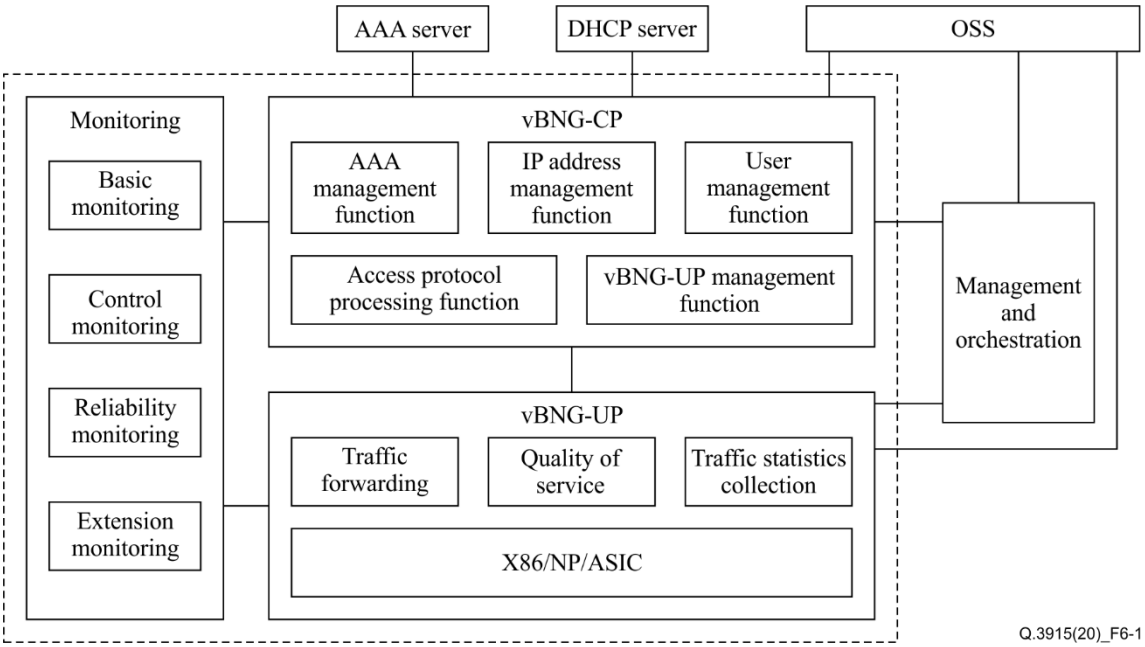

Figure 6-1 − Architecture of vBNG monitoring

The vBNG is separated into two components, the control plane (CP) and the user plane (UP), which are described as follows:

- vBNG-CP is the control plane of the vBNG.

The vBNG-CP could be implemented using virtualization technologies and deployed in a centralized mode. It consists of the main control functions, e.g., authentication, authorization and accounting (AAA) management function, IP address management function, user management function, access protocol processing function and vBNG-UP management function. The functional components of the vBNG-CP can be implemented in the form of VNFs and hosted in a network function virtualization infrastructure (NFVI).

- vBNG-UP is the user plane of the vBNG.

The vBNG-UP mainly provides user packets switching under the instruction of the vBNG-CP. The vBNG-UP can be implemented in different types of forwarding hardware, including network processor (NP)-based dedicated equipment, application specific integrated circuit (ASIC)-based dedicated equipment, or X86-based commercial equipment, etc. For the X86-based vBNG-UP, in order to improve its forwarding performance, acceleration technologies can be used, e.g., data plane development kit (DPDK), single root I/O virtualization (SR-IOV), ASIC or field programmable gate array (FPGA)-based smart network interface controller (NIC), etc.

The details of the vBNG functional components are described as follows:

- The vBNG control plane should support:

(1) IP address management function: management of the unified IP address pool.

(2) AAA management function: implementation of the AAA function for access users by cooperating with the AAA server.

(3) User management function: management of user information and forwarding policy.

(4) Access protocol processing function: handling protocol packets accessed by users via point-to-point protocol over Ethernet (PPPoE)/Internet protocol over Ethernet (IPoE) or PPPoE/IPoE.

(5) vBNG-UP management function: management of the interface status of the vBNG-UP, and the set up, deletion, maintenance of channels between the vBNG-CP and the vBNG-UP.

(6) the vBNG-CP should also support the unicast routing, multicast routing and multi-protocol label switching (MPLS) protocol, etc.

The vBNG user plane should support traffic forwarding, quality of service (QoS) and traffic statistics collection.

This Recommendation mainly describes the vBNG monitoring functional component, which is as follows:

- Basic monitoring functionality of the vBNG are mandatory, such as physical resource monitoring, virtual resource monitoring, network resource monitoring, etc. They can reflect the basic state of the vBNG.
- Control monitoring functionality of the vBNG will be used when the state of the vBNG changes.
- Reliability monitoring functionality of the vBNG can reflect the reliability of the system during the vBNG running.
- Extension monitoring functionality of the vBNG is to monitor the vBNG from other external factors.

7 Requirements for the vBNG monitoring functionality

Monitoring the vBNG is very important for the providers and consumers to ensure the reliability of the vBNG during it running. This functionality lays the foundation for the stability of the whole network. Monitoring for the vBNG is required to support basic monitoring functionality, control monitoring functionality, reliability monitoring functionality and other extension monitoring functionality.

7.1 Requirements of basic monitoring functionality

Basic monitoring functionality can be used to monitor the basic information of the vBNG, which includes the basic physical resources, the basic virtual resources and network resources.

The requirements for the basic monitoring functionality are as follows:

- The basic monitoring functionality is required to reflect the utilization of basic physical computing and storage resources, such as processors, memory and disks. Monitoring the state of these resources can ensure system reliability and availability.
- The basic monitoring functionality is required to reflect the state of basic virtual resources and the physical resources, while the applications are running.
- The basic monitoring functionality is recommended to detect network bandwidth to enable the vBNG running smoothly.
- The basic monitoring functionality is recommended to detect network traffic to enable the efficiency and stability of heavy traffic forwarding by the vBNG-UP.
- The basic monitoring functionality is recommended to detect the I/O performance to improve network performance.

7.2 Requirements of control monitoring functionality

Virtual BNG control monitoring functionality depends on the management of physical and virtual resources which allow it to create, edit, start and stop.

The requirements of control monitoring functionality are as follows:

− The control monitoring functionality is recommended to provide the state information which is obtained by monitoring and statistics collection of resource operation, when the vBNG adjusts its resources dynamically based on demand.

7.3 Requirements of the reliability monitoring functionality

The reliability monitoring functionality enables operation and interaction stability for both the vBNG-CP and vBNG-UP, ensuring the availability and reliability of the vBNG network.

The requirements for the reliability monitoring functionality are as follows:

− The reliability monitoring functionality is required to measure whether the performance parameters of equipment will fluctuate when monitoring for a period of time.

− The reliability monitoring functionality is recommended to monitor the connection signalling between CP and UPs.

− The reliability monitoring functionality is recommended to monitor the event of vBNG backup and recovery.

7.4 Requirements of the extension monitoring functionality

The extension monitoring functionality can reflect the external factor which can also impact to evaluate the vBNG.

The requirements for the extension monitoring functionality are as follows:

− The extension monitoring functionality is recommended to monitor the factors of the equipment or the room that can impact the performance of vBNG.

8 Parameters for vBNG monitoring

Monitoring vBNG is a key tool that helps telecommunication providers to evaluate the quality of the network. According to the requirements for the vBNG monitoring functionality, the parameters of vBNG monitoring could be divided into four parts: basic parameters, control parameters, reliability parameters and extension parameters.

8.1 Basic parameters

The basic parameters for the vBNG monitoring include the physical resource parameters, the virtual resource parameters and network resource parameters.

The basic parameters are shown in Table 8-1.

Table 8-1 – Basic parameters to monitor the vBNG

Metric name	Description	Unit
vCPUs	Number of virtual CPUs allocated to the vBNG	CPU
vCPU utilization	Average vCPU utilization	%
vCPU using percent	Percent of vCPU is in using status	%
vCPU idle percent	Percent of vCPU is in idle status	%
vMemory	Volume of virtual random access memory (RAM) allocated to the vBNG	MB

Table 8-1 – Basic parameters to monitor the vBNG

Metric name	Description	Unit
vMemory utilization	Average virtual RAM utilization	%
vMemory used size	Used virtual memory size	MB
vDisk size	Size of virtual disk allocated to the vBNG	GB
vDisk used size	Size of disk used	GB
vDisk read byte rate	Average rate of reads virtual disk	kB/s
vDisk write byte rate	Average rate of writes virtual disk	kB/s
CPUs	Number of CPU used	CPU
CPU utilization	Average CPU utilization	%
CPU idle percent	Percent of CPU in idle status	%
CPU using percent	Percent of CPU in using status	%
memory	Volume of RAM	MB
memory utilization	Average of RAM utilization	%
memory used size	Size of RAM used	MB
disk size	Total disk size	GB
disk used size	Size of disk used	GB
disk read byte rate	Average rate of reads disk	kB/s
disk write byte rate	Average rate of writes disk	kB/s
incoming bytes	Number of bytes received by network interface	KB
incoming byte rate	Rate of byte received by network interface per second	KB/s
outgoing bytes	Number of bytes sent by network interface	KB
outgoing byte rate	Rate of byte sent by network interface per second	KB/s
bandwidth of incoming	Total capacity of the connection of the incoming	Mb
bandwidth of outgoing	Total capacity of the connection of the outgoing	Mb
average latency	Average of delay of data transition	ms
Minimum latency	Minimum time interval between submitting a packet and arrival at its destination	ms
Maximum latency	Maximum time interval between submitting a packet and arrival at its destination	ms
jitter	Difference in end-to-end one-way delay	ms
packet loss	Percentage of packets lost	%

8.2 Control parameters

The control parameters for vBNG monitoring include the time signal while the physical and virtual resources are changed.

The control parameters are shown in Table 8-2.

Table 8-2 – Control parameters to monitor the vBNG

Metric name	Description	Unit
vBNG start	Time of vBNG start	Seconds

Table 8-2 – Control parameters to monitor the vBNG

Metric name	Description	Unit
vBNG stop	Time of vBNG stop	Seconds
CPU of vBNG start	Time of CPU start	Seconds
CPU of vBNG stop	Time of CPU stop	Seconds
CPU of vBNG scale up	Time of CPU scale up	Seconds
CPU of vBNG scale down	Time of CPU scale down	Seconds
memory of vBNG scale up	Time of memory scale up	Seconds
memory of vBNG scale down	Time of memory scale down	Seconds
disk of vBNG scale up	Time of disk scale up	Seconds
disk of vBNG scale down	Time of disk scale down	Seconds

8.3 Reliability parameters

The reliability parameters for the vBNG monitoring can reflect the availability and reliability of the vBNG network. These parameters include two parts: directly monitored parameters and calculated parameters.

The directly monitored reliability parameters are shown in Table 8-3.

Table 8-3 – The directly monitored reliability parameters to monitor the vBNG

Metric name	Description	Unit
Signalling of connection	Time of a periodic signalling sent between CP and UP**s**	Seconds
vBNG backup	Time of the vBNG backup	Seconds
Recovery time	Time from the failure to successful restart within an existing backup	Seconds

The reliability parameters can play a role in performance assessment. Some of them are calculated by a number of parameters. In order to monitor the reliability of the vBNG, it is necessary to consider comprehensively that the vBNG should be monitored at different times and on different platforms (e.g., NFVI). To measure the reliability of the vBNG, the following parameters are used:

X: service input, a certain amount of service input is based on the service requirement;

G: observed indicators, the indicators are measured by the test instrument to evaluating if the status of the vBNG is normal;

Y: performance indicators, are the resource requirements of the vBNG for NFVI;

Hence, when there exists service input and $G \leq G_H$,the performance indicator obtained in this point is $Y = \{Y_1, Y_2, \dots, Y_N\}$. $Y_N(n = 1, \dots, N)$ means the vBNG will occupy multiple resources and the utilization of each resource, e.g., the vBNG, will occupy several vCPUs. Y_N stands for the utilization of each vCPU.

In addition, the other two dimensions should be considered, those are time dimension (*t*) and platform dimension (*j*). Time dimension means the indicators should be measured at different times. Platform dimension means the indicators should be measured in different NFVIs. So $Y_n^{(t,j)}$ is the *n*-th resource utilization monitored at time *t* on platform *j*.

The calculated reliability parameters are described as follows:

stability coefficient(α): This coefficient is used to measure whether the performance parameter of equipment will fluctuate after monitoring a period of time.

$$\alpha = \sqrt[2]{\frac{\sum_{n=1}^{N}\left(\frac{\sum_{t=1}^{T}\sum_{j=1}^{J}Y_n^{(t,j)}}{T*J} - \frac{\sum_{n=1}^{N}\sum_{t=1}^{T}\sum_{j=1}^{J}Y_n^{(t,j)}}{T*N*J}\right)^2}{N}}$$

equilibrium parameter(β): To measure whether the occupancy rate of each resource is balanced when the same type of resource exists.

$$\beta = \sqrt[2]{\frac{\sum_{t=1}^{T}\left(\frac{\sum_{n=1}^{N}\sum_{j=1}^{J}Y_n^{(t,j)}}{N*J} - \frac{\sum_{n=1}^{N}\sum_{t=1}^{T}\sum_{j=1}^{J}Y_n^{(t,j)}}{N*T*J}\right)^2}{T}}$$

irrelevant parameter(γ): To measure whether vBNG is running consistently on different NFVI.

$$\gamma = \sqrt[2]{\frac{\sum_{j=1}^{J}\left(\frac{\sum_{n=1}^{N}\sum_{t=1}^{T}Y_n^{(t,j)}}{N*T} - \frac{\sum_{n=1}^{N}\sum_{t=1}^{T}\sum_{j=1}^{J}Y_n^{(t,j)}}{N*T*J}\right)^2}{J}}$$

8.4 Extension parameters

The extension parameters for the vBNG monitoring include the external factor parameters which can impact the vBNG network.

The extension parameters are shown in Table 8-4.

Table 8-4 – Extension parameters to monitor the vBNG

Metric name	Description	Unit
temperature	Temperature of room	℃
voltage	Voltage of electricity	V
humidity	Humidity of room	%

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Printed in Switzerland
Geneva, 2020