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

Signalling requirements and protocols for SDN – Resource control protocols

Signalling requirements for dynamic bandwidth adjustment on demand on broadband network gateway implemented by software-defined networking technologies

Recommendation ITU-T Q.3715

ITU-T Q-SERIES RECOMMENDATIONS

SWITCHING AND SIGNALLING, AND ASSOCIATED MEASUREMENTS AND TESTS

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Signalling requirements for dynamic bandwidth adjustment on demand on broadband network gateway implemented by software-defined networking technologies

Summary

Recommendation ITU-T Q.3715 describes the architecture and signalling requirements for dynamic bandwidth adjustment on demand on broadband network gateway implemented by software-defined networking technologies. The objective is to enhance the intelligent control of broadband networks, provide open southbound interfaces to network devices, support extensible capability for open northbound interfaces to service platform, and then build flexible, intelligent, secure next-generation broadband network and service system.

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Signalling requirements for dynamic bandwidth adjustment on demand on broadband network gateway implemented by software-defined networking technologies

1 Scope

This Recommendation describes the architecture for dynamic bandwidth adjustment on demand on broadband network gateway (BNG) implemented by software-defined networking technologies. The signalling requirements between the software-defined dynamic bandwidth on demand (S-DBoD) controller and the BNG/vBNG are also specified.

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

[ITU-T Y.3302]   Recommendation ITU-T Y.3302 (2017), *Functional architecture 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 broadband network gateway (BNG) [ITU-T Q.3315]: The access point to the provider's IP network for wireline broadband services.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 virtual BNG: The virtual BNG is the broadband network gateway of which all features or some features are directly implemented as virtual network function(s) (VNF(s)) running on the network functions virtualization infrastructure (NFVI). It is used to either augment or replace the existing traditional BNG.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACL	Access Control List
API	Application Programming Interface
BGN	Broadband network gateway
COA	Change Of Authorization
COPS	Common Open Policy Service
DBoD	Dynamic Bandwidth on Demand
ID	Identification
S-DBoD	Software-defined Dynamic Bandwidth on Demand
SDN	Software-Defined Networking
NFVI	Network Functions Virtualization Infrastructure
QoS	Quality of Service
vBGN	virtual Broadband Network Gateway
VNF	Virtual Network Function

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 Architecture of the S-DBoD

6.1 General architecture

The architecture for implementation of the dynamic bandwidth adjustment on demand based on the SDN technologies (S-DBoD) may consist of a service platform, the S-DBoD controller, the operational support system, the billing system and the broadband network gateway/virtual broadband network gateway (BNG/vBNG), which is depicted in Figure 6-1.
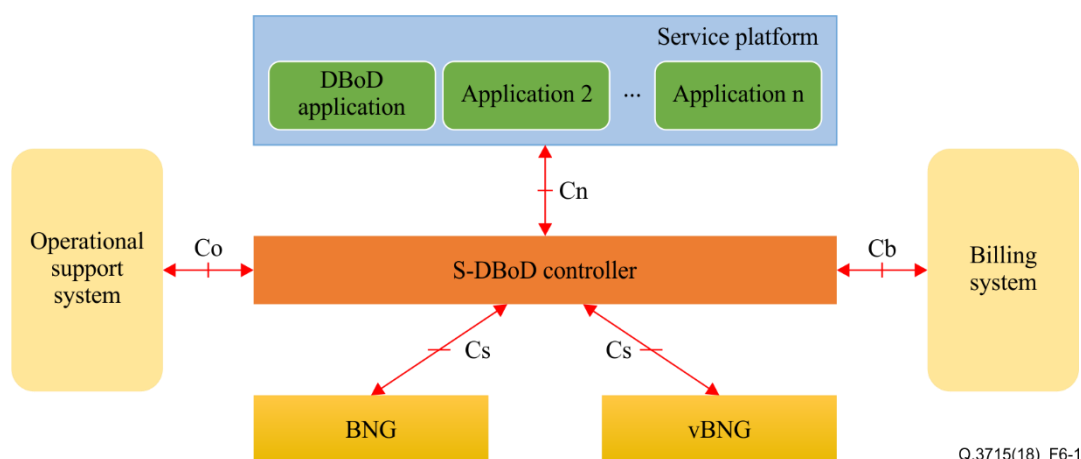
Figure 6-1 – Architecture of the S-DBoD

The BNG/vBNG is responsible for enforcing the quality of service (QoS) policies to forward the subscriber packets.

The S-DBoD controller located between the service platform and the BNG/vBNG exchanges policy information used for the dynamical adjustment bandwidth on demand with the BNG/vBNG through the southbound interface, and also provides responses to application control signals from the service platform.

The service platform provides application programming interfaces (APIs) for the applications deployed on it and delivers application controls to the S-DBoD controller. Applications can be easily deployed on the service platform with the APIs provided by the service platform. Applications control the BNG/vBNG through the service platform and the S-DBoD controller. The BNG/vBNG acts based on the policies/action/commands from the applications.

The billing system receives service usage information, groups this information for specific accounts, produces invoices, creates reports for management, and records payments made to customer accounts. It is also responsible for receiving policy usage billing information from the S-DBoD controller to synchronize the billing information.

The operational support system is responsible for synchronizing the subscriber basic information (e.g., subscriber account, access time, access mode, basic bandwidth (uplink and downlink), account type, etc.) with the S-DBoD controller.

NOTE – The signalling requirements between the S-DBoD controller and the service platform is outside the scope of this Recommendation.

6.2   Enhanced function modules of the S-DBoD controller

Some enhanced function modules for implementation of the DBoD service are required to be added in the S-DBoD controller based on the function architecture of the SDN controller specified in [ITU-T Y.3302], including subscriber management, equipment management, system management, policy parameter management, and policy generation.

6.2.1   Subscriber management

The subscriber management is responsible for the subscriber information management and operation. It supports creating, modifying and authorizing a subscriber through the interface automatically or manually. It can be used to query a subscriber and related information, record a subscriber online status and policy usage status. The subscriber management may consist of subscriber information management, subscriber policy management and subscriber billing management described as follows:

1)   Subscriber information management

Support maintenance of the subscriber information, including:

a)   Adding a subscriber

b)   Deleting a subscriber

c)   Modifying a subscriber's information

Support query of subscriber information, including the following query conditions:

a)   Subscriber's account

b)   Subscriber's IP address

c)   IP address of the device (such as BNG) that a subscriber accessed.

Support refreshment and synchronization of a subscriber's online/offline status.

2)   Subscriber policy management

Subscriber policy management is required to support:

−   The recording of the subscriber policy usage status, including unused, in use and completed policies.

– Querying the usage status of a subscriber's policy, including:

a) Current usage status of a subscriber's policy

Usage status is required to query the subscriber policy identification (ID), policy name and the date of subscription.

b) Usage history of a subscriber policy

Usage history is required to query the subscriber's policy ID, policy name, the date of subscription and the termination of the subscription according to the subscriber and the period when the subscriber policy has been used.

3) Subscriber billing management

The subscriber billing management is responsible to start billing when the policy is enabled, and generating the billing record when the policy is terminated. It is required to support automatic generation, storage and export of the original billing file according to the following conditions:

a) The period of original billing records

b) The subscriber's account of original billing records

c) Periodic automatic generation of original billing records, such as automatically generating daily bills.

Also, it is required to support transferring an original bill, including:

a) Periodic, automatic upload

b) Manual upload

6.2.2 Equipment management

The equipment management is responsible for managing and recording the access mode, the protocol capability, IP address and other information from policy execution device. It supports policy judgment when receiving the subscriber information reported from policy execution device, and then generates the policy to facilitate the S-DBoD controller to convert the policy control request into the corresponding equipment's instruction.

1) Equipment information management

Support maintenance of device information, including:

a) Adding equipment

b) Removing equipment

c) Modifying equipment information

d) Batch import of equipment information

e) Batch export of equipment information

Support querying equipment information, including the following query conditions:

a) Equipment's name

b) IP address

c) Online/offline status

2) Equipment operation management

Support the S-DBoD controller to control and manage the BNG/vBNG through the open southbound interface using the following control protocols, including but not limited to:

a) Radius

b) COA

c) COPS

d) Diameter

e) Netconf

6.2.3 System management

The system management refers to the functional modules of the system itself, which guarantee the safe and reliable operation of the entire system. It includes system user management, alarm management, log management, system monitoring, report statistics management, etc.

1) System user management

Support login information maintenance for a system user, including:

a) Adding a system user

b) Removing a system user

c) Modifying a system user's information

d) Modifying a system user's access rights

e) Modifying a system user's access control list (ACL) policy

Support online user management, including:

a) Real-time check of online users' login information, including the name of the login user, login time, user action, etc.

b) Monitoring of user's actions, and the possibility of forceful termination of the session by the administrator.

2) Alarm management

The system alarms include various abnormal events related to service provisioning, operation management, operation and maintenance, as well as detection and diagnosis of faults occurring during operation. It is required to support alarm display, alarm confirmation, alarm recovery and alarm clear function.

3) Log management

The system log management is required to record various anomalies related to service provisioning, operation management, operation and maintenance, and the system access records for auditing. It is required to support, to query and backup the system log.

4) System monitoring

The system monitoring is responsible for monitoring the system hardware resource usage (e.g., CPU, memory, hard disk, etc.), including process status, storage space, among others. It is required to automatically generate an alarm when an exception occurs, for example, CPU usage reaches a threshold.

5) Report statistics management

It is required to generate the statistics report for the policy usage according to subscribers, access devices, time slots, etc.

6.2.4 Policy management

The policy management refers to the management of the system's policy execution mode, decomposition process, conflict decision and policy selection, including policy information management and policy template parameter management. The implementation policy can be flexibly modified according to the actual situation.

1) Policy information management

The policy information consists of policy ID, policy name, uplink bandwidth value, downlink bandwidth value, etc. Policy management is required to support maintenance of policy information, including:

a) Adding a policy

b) Deleting a policy

c) Modifying policy information

d) Batch import policy information

It is also required to support queries of the policy, such as the history of use, who has used the policy and when it was used.

2) Policy template parameter management

It is required to support policy template information management for the BNG/vBNG. The policy template information consist of a BNG's ID, the vendor of BNG, template name, uplink bandwidth value, downlink bandwidth value, etc. The operation for the policy template parameter management should support increase, deletion and modification.

6.2.5 Policy generation

The policy generation refers to the process of analysing the subscriber parameters and the current usage status of the policy according to the interface parameter request, and finally determining the operation steps and methods to the devices.

1) Policy pre-processing

Support the identification of a subscriber, including:

a) Determining the account of a subscriber according to the subscriber's IP address.

b) Determining the base bandwidth of a subscriber according to the subscriber's account.

Support checking the validity of the policy parameters, including:

a) Determining the validity of interface parameters.

b) Determining whether the current operation is a repeated operation according to the subscriber's current policy status (a subscriber can only call one at a time).

c) Determining whether to meet the policy request according to the availability of the bandwidth resources of the network which the subscriber accessed.

2) Policy decomposition processing

Support the identification of a device, including to:

a) Locating the subscriber's online device based on the subscriber accounts and his online status;

b) Determining the protocol type and the operation method supported by the device according to the device management table;

c) Determining whether a policy decomposition is needed according to a policy request.

Support to generate a policy, including:

a) Determining the parameters of the policy template according to the device capability;

b) Identifying the policy implementation devices and generate the instruction parameter template.

3) Policy issuance

It is required to support controlling the order of policies when multiple policies are issued and returning the results of the execution of the policies.

6.3 Reference point

This clause describes the reference points shown in Figure 6-1.

1) Reference point Co

The reference point Co is located between the S-DBoD controller and the operational support system. The S-DBoD controller and the operational support system exchange signalling messages for synchronization of the subscriber's basic information (e.g., subscriber account, access time, access mode, basic bandwidth (uplink and downlink), account type, etc.). The protocol used at the Co reference point can be FTP, web service, etc.

2)   Reference point Cn

The reference point Cn is located between the S-DBoD controller and the service platform. The S-DBoD controller and the service platform exchange signalling messages for querying policies which can be executed in the S-DBoD controller, executing the policies in the S-DBoD controller, and terminating the policies when some exceptions occurred in the S-DBoD controller. In addition, the S-DBoD controller needs to pass the subscriber online/offline information to the service platform. The protocol used at the Cn reference point can be Restful, web service, etc.

3)   Reference point Cs

The reference point Cs is located between the S-DBoD controller and the BNG/vBNG. The S-DBoD controller communicates with the BNG/vBNG to exchange the subscriber online/offline information and to install the bandwidth adjustment policy. The protocol used at the Cs reference point can be Openflow, Netconf, COA, COPS, Diameter, etc.

4)   Reference point Cb

The reference point Cb is located between the S-DBoD controller and the billing system. The S-DBoD controller and the billing system exchange signalling messages for synchronizing the billing information, passing policy bill information to the billing system to check the billing accuracy. The protocol used at the Cb reference point can be FTP, etc.

7   Signalling requirements for dynamic bandwidth adjustment on demand

7.1   Overview of the information flow for dynamic bandwidth adjustment on demand

The broadband subscriber initiates the on-line request, and then the billing for this subscriber commences, based on the basic subscription, once the subscriber is successfully authenticated. The BNG/vBNG notifies the S-DBoD controller that the subscriber is on-line, and the S-DBoD controller updates the subscriber's status to "on-line". The S-DBoD controller can issue and terminate the bandwidth adjustment policy according to the request from the subscriber.

The information flow for dynamic bandwidth adjustment on demand on BNG is described as follows:
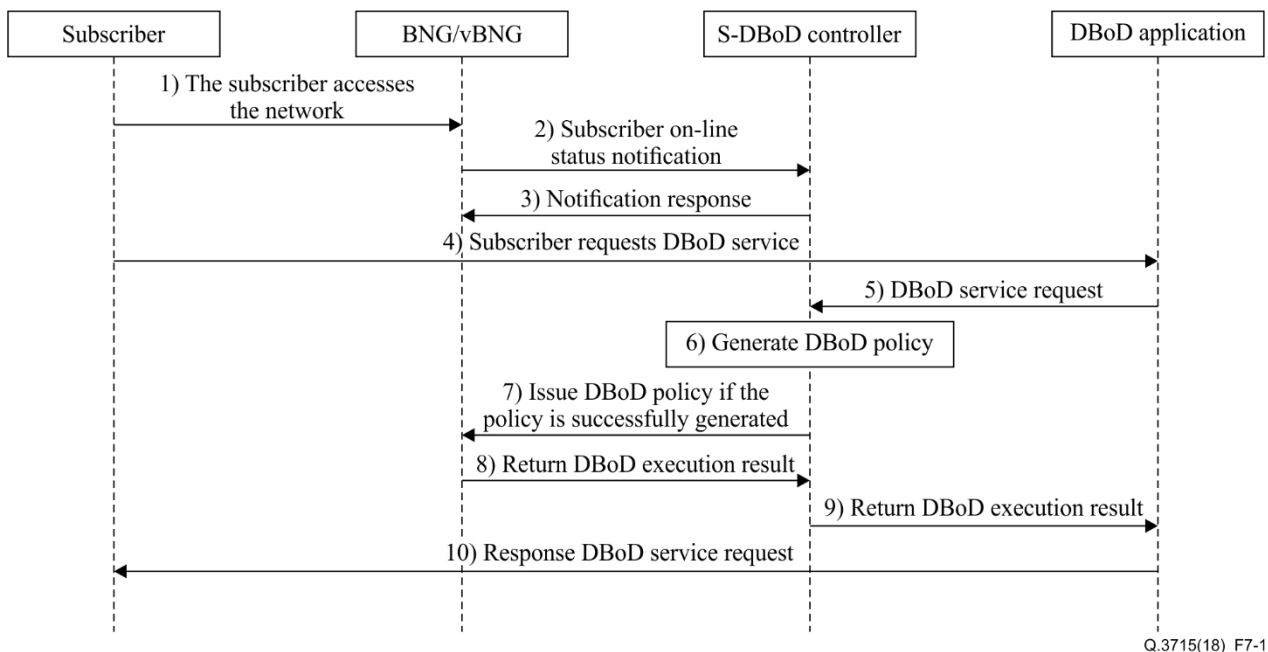
Figure 7-1 – Information flow for dynamic bandwidth adjustment on demand

1) The subscriber successfully accesses the network;

2) The BNG/vBNG sends the subscriber information and informs of the on-line status to the S-DBoD controller;

3) The S-DBoD controller records the subscriber information and his online status and returns the response notification to the BNG/vBNG;

4) The subscriber requests the DBoD service to the DBoD application if he/she wants to increase/decrease the access rate;

5) The DBoD application delivers the DBoD service request to the S-DBoD controller;

6) The S-DBoD controller generates the DBoD policies according to the availability of bandwidth resources;

7) The S-DBoD controller issues the DBoD policy to the BNG/vBNG if the DBoD policy is successfully generated, otherwise it replies with a failure notification to the DBoD application;

8) The BNG/vBNG replies with a success notification to the S-DBoD controller if the DBoD policy is successfully executed, otherwise it replies with a failure notification;

9) The S-DBoD controller replies with a success notification to the DBoD application if the DBoD policy is successfully executed, otherwise it replies with a failure notification;

10) The DBoD application informs of the result of the DBoD service request to the subscriber.

7.2 Subscriber on-line notification message and response message

The subscriber online notification message is defined as DBoD-SN message.

The DBoD-SN message, indicated by the message type in the message header field, is sent by the BNG/vBNG to the S-DBoD controller to convey the subscriber information and on-line status.

Message format:

    <DBoD-SN-Message>::= < Message Header >

            {Controller-ID}

{Subscriber-Account}

{Subscriber-IP-Address}

{Subscriber-Session-ID}

{Subscriber-Link-Description}

{BNG-ID}

{BNG-IP-Address}

Meanings and explanations:

1) Controller ID uniquely specifies the S-DBoD controller.

2) Subscriber-Account uniquely specifies the subscriber.

3) Subscriber-IP-Address uniquely specifies the IP address used by the subscriber.

4) Subscriber-Session-ID uniquely specifies the subscriber's session.

5) Subscriber-Link-Description specifies the subscriber access link information, including access link type (e.g., PON, DSL), port number of the access device, etc.

6) BNG-ID uniquely specifies the BNG/vBNG device.

7) BNG-IP-Address specifies the IP address used by the BNG/vBNG device.

The response message to the DBoD-SN is defined as the subscriber online notification response (DBoD-SNR) message. The DBoD-SNR message, indicated by the message type in the message header field, is sent by the S-DBoD controller to the BNG/vBNG in response to the DBoD-SN message.

Message format:

<DBoD-SNR-Message>::=<Message Header>

{Controller-ID}

{BNG-Id}

{Notification-Id}

{Notification-Result}

Meanings and explanations:

1) Controller ID uniquely specifies the S-DBoD controller

2) BNG-ID uniquely specifies the BNG device

3) Notification-Id uniquely specifies the type of each notification sent by the S-DBoD controller

4) Notification-Result is used to indicate the notification result for the DBoD-SN message, which is specified by the other parameters in this message.

7.3 Subscriber's dynamic bandwidth adjustment request message and response message

The subscriber's dynamic bandwidth adjustment message is defined as DBoD-SBA message.

The DBoD-SBA message, indicated by the message type in the message header field, is sent by the S-DBoD controller to the BNG/vBNG in order to increase/decrease the subscriber's access rate.

Message format:

<DBoD-SBA-Message>::=< Message Header >

{Controller-ID}

{Subscriber-Account}

{Subscriber-IP-Address}

{Subscriber-Session-ID}

{BNG-ID}

{BNG-IP-Address}

{Policy-Configuration-ID}

Meanings and explanations:

1)   Controller ID uniquely specifies the S-DBoD controller

2)   Subscriber-Account uniquely specifies the subscriber

3)   Subscriber-IP-Address uniquely specifies the IP address used by the subscriber

4)   Subscriber-Session-ID uniquely specifies the subscriber's session

5)   BNG-ID uniquely specifies the BNG/vBNG device

6)   BNG-IP-Address specifies the IP address used by the BNG/vBNG device

7)   Policy-Configuration-ID indicates the detailed bandwidth control action for target subscriber executed by the BNG/vBNG.

The response to the DBoD-SBA message is define as the subscriber's dynamic bandwidth adjustment response (DBoD-SBAR) message.

The DBoD-SBAR message, indicated by the message type in the message header field, is sent by the BNG/vBNG to the S-DBoD controller in response to the DBoD-SBA message.

Message format:

<DBoD-SBAR-Message> :: =< Message Header >

{Controller-ID}

{BNG-ID}

{Subscriber-Account}

{Subscriber-IP-Address}

{Subscriber-Session-ID}

{Policy-Configuration-ID}

{Configuration-Result}

Meanings and explanations:

1)   Controller ID uniquely specifies the S-DBoD controller

2)   BNG-ID uniquely specifies the BNG/vBNG device

3)   Subscriber-Account uniquely specifies the subscriber

4)   Subscriber-IP-Address uniquely specifies the IP address used by the subscriber

5)   Subscriber-Session-ID uniquely specifies the subscriber's session

6)   Policy-Configuration-ID should be aligned with the same field in the DBoD-SBA message

7)   Configuration-Result indicates the configuration result for the DBoD-SBA message.

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