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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 the separation of control plane and user plane in a virtualized broadband network gateway (vBNG)

Recommendation ITU-T Q.3719

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Recommendation ITU-T Q.3719

Signalling requirements for the separation of control plane and user plane in a virtualized broadband network gateway (vBNG)

Summary

Recommendation ITU-T Q.3719 specifies architecture, signalling requirements and information flows for the separation of control plane and user plane in a virtualized broadband network gateway (vBNG).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.3719	2019-12-14	11	11.1002/1000/14144

Keywords

Control plane, user plane, vBNG.

* 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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Table of Contents

Recommendation ITU-T Q.3719

Signalling requirements for the separation of control plane and user plane in a virtualized broadband network gateway (vBNG)

1 Scope

This Recommendation describes the architecture, signalling requirements and information flows for implementation of the separation of control plane and user plane in a virtualized broadband network gateway (vBNG).

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

[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.*

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 terms:

3.2.1 vBNG control plane (vBNG-CP): 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.

3.2.2 vBNG user plane (**vBNG-UP)**: 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.

3.2.3 virtualized BNG (vBNG): The virtualized BNG is the broadband network gateway of which all features or some features are directly implemented as virtualized network function(s) (VNF) running on the network function 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:

AAA Authentication, Authorization and Accounting

ACL Access Control List

ASIC Application Specific Integrated Circuit

BNG Broadband Network Gateway

CGN Carrier Grade Network address translation

CHAP Challenge Handshake Authentication Protocol

CP Control Plane

DHCP Dynamic Host Configuration Protocol

DPDK Data Plane Development Kit

FPGA Field Programmable Gate Array

GRE Generic Routing Encapsulation

ID Identifier

IPCP Internet Protocol Control Protocol

IPoE Internet Protocol over Ethernet

MAC Media Access Control

MPLS Multi-Protocol Label Switching

NAT Network Address Translation

NFVI Network Function Virtualization Infrastructure

NP Network Process

NIC Network Interface Controller

PADI PPPoE Active Discovery Initiation

PADO PPPoE Active Discovery Offer

PADR PPPoE Active Discovery Request

PADS PPPoE Active Discovery Session-confirmation

PPPoE Point-to-Point Protocol over Ethernet

QoS Quality of Service

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

VLAN Virtual Local Area Network

VNF Virtualized Network Function

VxLAN Virtual Extensible Local Area Network

5 Conventions

None.

6 Architecture for control plane and user plane separated 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. While 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 traditional a 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 architecture for a control plane and user plane separated vBNG is shown in Figure 6-1.

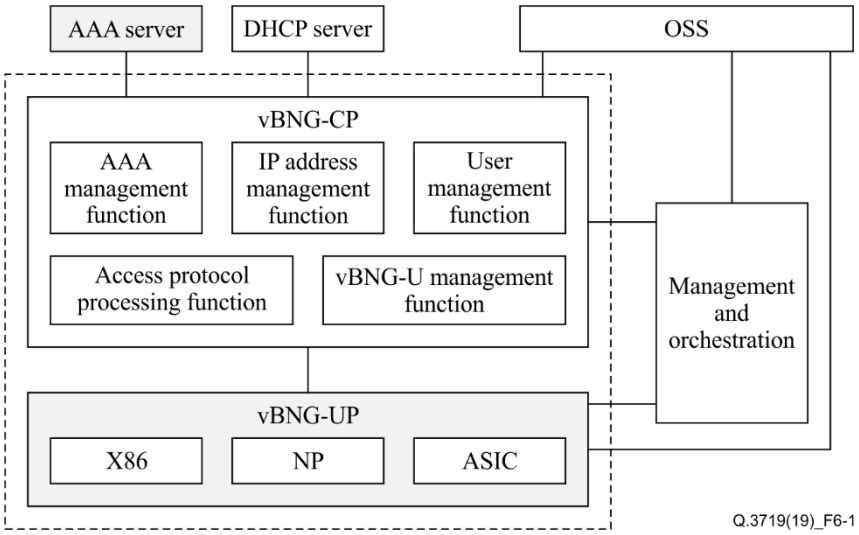

Figure 6-1 – Architecture for control plane and user plane separated vBNG

The vBNG is separated into two main components, the control plane (CP) and the user plane (UP):

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

The vBNG control plane could be implemented using virtualization technologies and deployed in the mode of centralization, which consists of main control functions, e.g., 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 control plane can be implemented in the form of VNFs and hosted in a network function virtualization infrastructure (NFVI).

- vBNG-UP, which 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 NP-based dedicated equipment, 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., DPDK, SR-IOV, ASIC or FPGA-based smart NIC, etc.

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

The vBNG control plane should support:

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

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

(3) User management function: managing 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: managing the interface status of the vBNG-UP, and the setup, 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.

7 Signalling requirements for the separation of control plane and user plane

7.1 Interfaces between the vBNG-CP and the vBNG-UP

Several interfaces are defined to support the communication between the vBNG-CP and the vBNG-UP. Figure 7-1 illustrates the interfaces of the separation of control plane and user plane in vBNG.

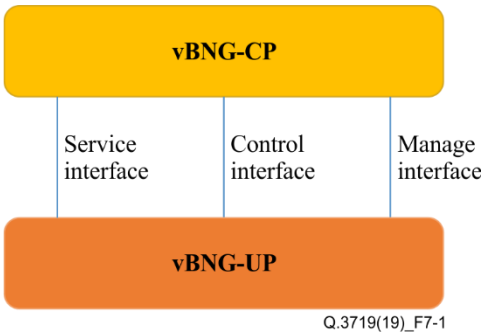

Figure 7-1 – Interfaces of control plane and user plane separated vBNG

Service interface: The vBNG-CP and the vBNG-UP use this interface to establish tunnels with each other and transmit access protocol (PPPoE and IPoE) packets over the tunnels. This interface may run network virtualization technology protocols such as generic routing encapsulation (GRE) or virtual extensible local area network (VxLAN), etc.

Control interface: The vBNG-CP uses this interface to deliver routing information and forwarding policies, and the vBNG-UP uses this interface to report user plane events to the vBNG-CP.

Management interface: The vBNG-CP uses this interface to deliver configuration parameters to the vBNG-UP. This interface may run Netconf protocol.

7.2 General requirements

This clause specifies some of the general requirements that the protocol used for the separation of control plane and user plane should support.

7.2.1 CU separation protocol and flow table

The control plane and user plane separation (CU separation) protocol must allow the vBNG-CP to send forwarding tables to each user plane device. The CU separation protocol should be lightweight to achieve high performance. The CU separation protocol should support batch processing capabilities to provide centralized session management, user management capabilities and high scalability, as well as cost-effective redundancy. The CU separation protocol should be able to deliver commands to the vBNG-UP devices in an ordered group of packets. Each set of commands should be sent to the vBNG-UP with as few messages as possible. In addition, the protocol must support the ability to specify whether the command group must have "all or nothing" semantics. The CU separation protocol should be able to support enough vBNG-UP devices and ports. For example, the size of protocol field corresponding to the vBNG-UP or port numbers shall be large enough to support the minimum required numbers. This requirement does not affect system performance when the number of vBNG-UPs or ports in the system increases.

7.2.2 Message priority

In CU separation vBNG, the protocol between the vBNG-CP and the vBNG-UPs should provide a means of indicating the priority of the protocol message.

7.2.3 Keep alive

In CU separation vBNG, the heartbeat is generated to indicate normal operation and to synchronize the vBNG-CP and vBNG-UPs, which is sent between the vBNG-CP and vBNG-UPs at a regular interval in the order of seconds. If the vBNG-CP or the vBNG-UP does not receive a heartbeat for a time, usually a few heartbeats intervals, it is assumed to have a fault.

The CU separation protocol should support heartbeat monitor mechanism, and this mechanism should have ability to distinguish whether the interruption is an actual failure. For example, in some scenarios (i.e., the vBNG-CP and the vBNG-UP upgrade, etc.), the connection between the vBNG-UP and the vBNG-CP need to be interrupted. In this case, the interruption should not be notified.

7.2.4 Version compatibility

The CU separated vBNG may include devices from different vendors when deployed in a carrier network. Since devices from different vendors may implement different versions of the protocol, the CU separation protocol should provide some mechanism to perform version compatibility. The version compatibility is the process by which the control plane of the CU separated vBNG is used to evaluate the protocol versions supported by the control plane and user plane devices. Then the CU separated vBNG selects the appropriate protocol version to communicate. This process is "negotiating" because it needs to identify the latest protocol version supported by both the control plane and the user plane device.

7.2.5 Capability exchange

The CU separation vBNG should provide some mechanism to exchange the functionality of the vBNG-UP, for example, display device configuration files, service functions and other assigned functions in CU separated vBNG.

7.2.6 vBNG-UP event notification

The vBNG-UP should be able to report the events occurring on the vBNG-UP asynchronously to the vBNG-CP, such as faults and changes in available resources and functions.

7.2.7 High availability

vBNG-CP and vBNG-UP are key components, and some redundancy should be used for reliability. The vBNG-CP should support single instance reliability and multi-instance remote disaster recovery reliability. vBNG-DP should support 1 + 1/1:1 hot spare requirements and N:1 hot spare requirements. The channel between vBNG-CP and vBNG-DP should also support higher reliability.

The CU separated vBNG network requires an alternate vBNG-CP for disaster recovery. And some mechanisms should be provided to implement the backup vBNG-CP: a) In some cases, there may be two vBNG-CPs that declare the primary vBNG-CP, which should be supported or associated to determine which vBNG-CP is the primary device. b) It shall support switching between the primary vBNG-CP and the standby vBNG-CP when the primary vBNG-CP is disconnected.

7.2.8 Security

The vBNG-CP can send some information tables to the vBNG-UP, which may be critical to network functions (e.g., user information, IPv4/IPv6 information), and can reflect business information (e.g., QoS, service level agreements, etc.). Therefore, it should be supported to ensure the integrity of all CU separation protocol messages and to prevent man-in-the-middle attacks.

7.3 Signalling requirement of service interface

Service interface is used to transmitting PPPoE/IPoE dialup packets between user plane and control plane. For user access authentication, the vBNG-CP need to know which port of the vBNG-UP the user is connected to for the authentication at access location because a specific user is only permitted to access on specific port/location. The necessary information includes node ID, slot ID, sub-card ID, port ID and so on. The access port information should be carried in transmit tunnel encapsulated by vBNG-UP.

7.4 Signalling requirement of control interface

The vBNG-CP uses this interface to deliver service entries, and the vBNG-UP uses this interface to report service events to the vBNG-CP. When users access to the broadband network, the control plane solicits these users' information (such as user's ID, user's MAC, user's access methods, for example via PPPoE/IPoE), associates them with available bandwidth which are reported by user planes, and based on the service requirement to generate a set of tables, which may include user's information, vBNG-UP's IP address pool, and QoS, etc. Then the control plane can transmit these tables to the user planes. User planes receive these tables, analyse them, match the corresponding rules, and then perform the corresponding actions.

The following items should be included in the tables delivered from the vBNG-CP to the vBNG-UP,

a) Interface information accessed by the user,

b) Virtual local area network (VLAN) information accessed by the user,

c) user's MAC address,

d) user's IP address,

e) QoS information authorized to the user,

f) some attributes of the user customized by the vendor, such as access control list (ACL), policy routing, and so on.

7.5 Signalling requirement of management interface

The management interface between the vBNG-CP and the vBNG-UP is mainly used for service configuration and information query. The service configurations delivered from the vBNG-CP to the vBNG-UP mainly include:

1) vBNG service interface configuration
   (1) BNG sub-interface and VLAN configuration;
   (2) BNG interface enable configuration;
2) vBNG business policy template configuration
   (1) QoS template configuration;
   (2) ACL template configuration;
3) vBNG service control channel configuration
   (1) Control channel configuration;
   (2) Service channel configuration.

8 Information flows

8.1 PPPoE process flow

Figure 8-1 shows the PPPoE process flow. In the scenario where the vBNG control plane and the user plane are separated, the processes of a PPPoE home user accessing the Internet are according to the following flows:

(1) User dialup packets via PPPoE from a UP that will be send to the CP from the UP's service interface.

(2) CP processes the dialup packet. Confirming with the AAA, CP makes the decision to permit or deny the dial by means of authentication.

(3) After that, the CP tells the UP to do the corresponding forwarding actions with related policies.

(4) If the user is authenticated and permitted, the UP forwards the traffic into the Internet with related policies such as limited bandwidth, etc. Otherwise, the user is denied to access the Internet.

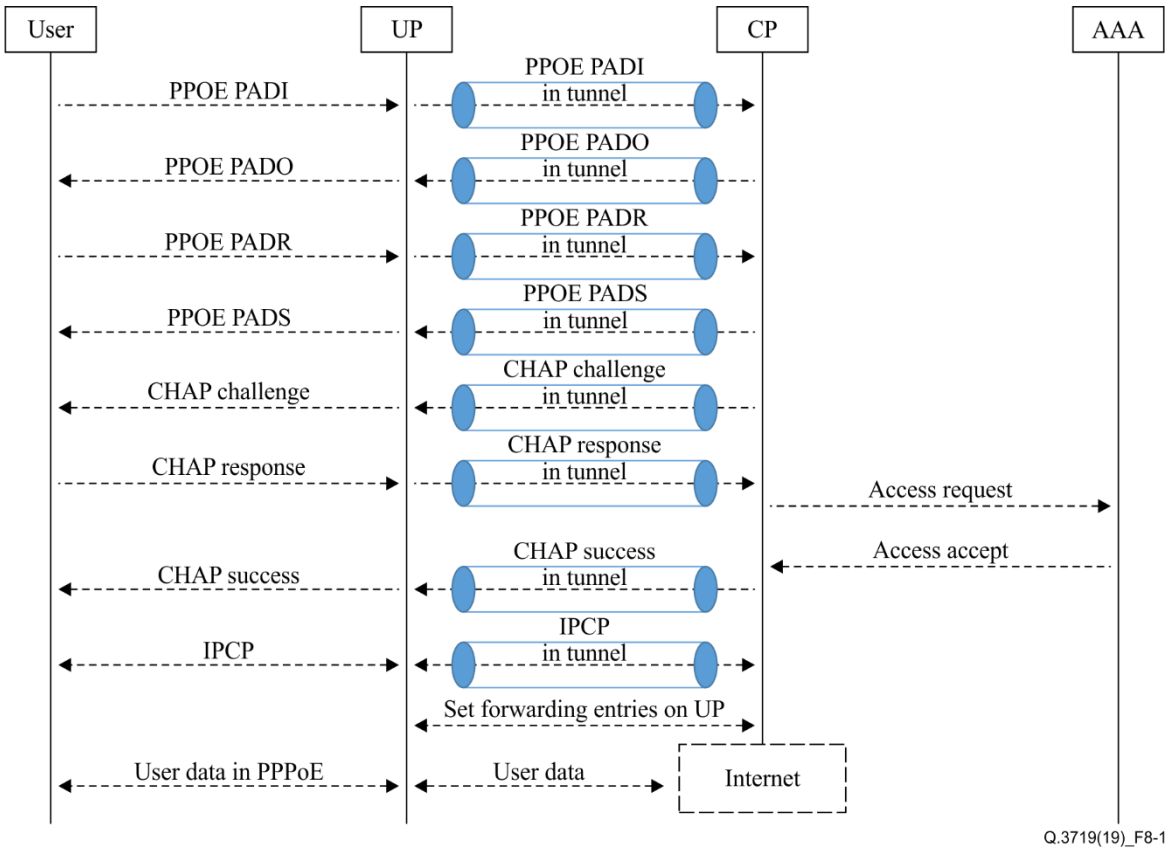

Figure 8-1 – PPPoE process flow

8.2 IPoE process flow

Figure 8-2 shows the IPoE process flow. In the scenario where the vBNG control plane and the user plane are separated, the processes of an IPoE home user accessing the Internet are according to the following flows:

(1) User dialup packets via IPoE from UP that will be sent to the CP from a UP's service interface.

(2) The CP processes the dialup packet. Confirming with the AAA, the CP makes the decision to permit or deny the dial by means of authentication.

(3) After that, the CP tells the UP to do the corresponding forwarding actions with related policies.

(4) If the user is authenticated and permitted, the UP forwards the traffic into the Internet with related policies.

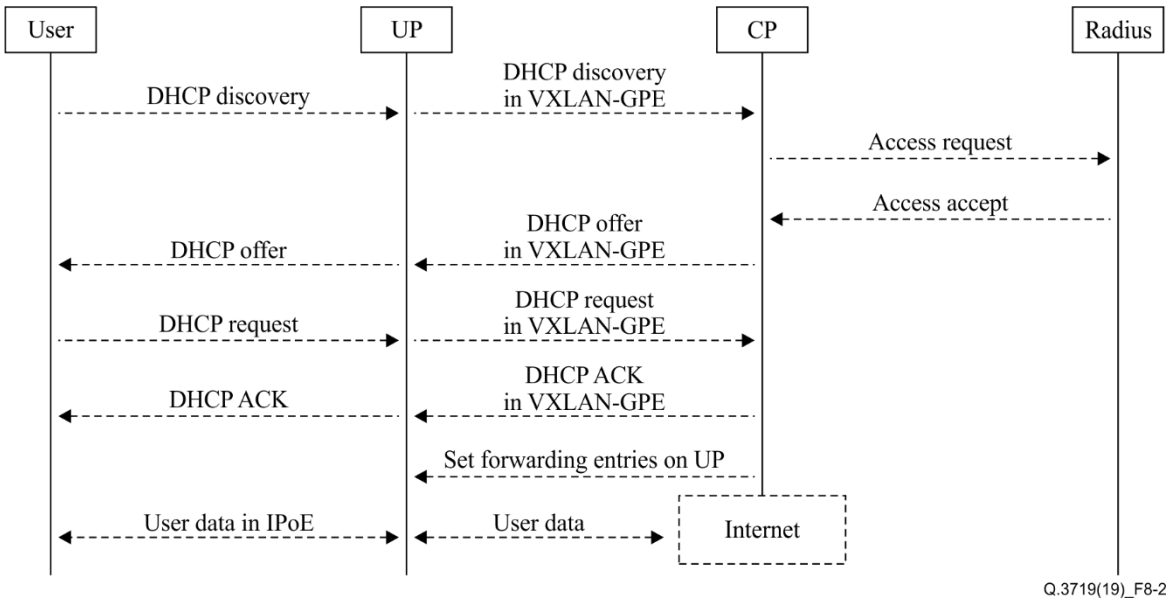

Figure 8-2 – IPoE process flow

8.3 User plane resource reporting

After the completion of the control plane and a user plane established in a session, the user plane reports the information of the boards and access side interfaces on this user plane to the control plane as shown in following Figure 8-3.

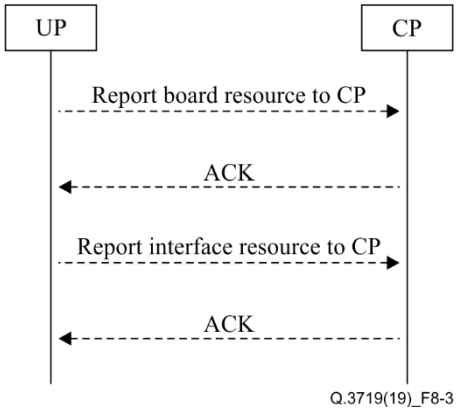

Figure 8-3 – Forwarding plane resource reporting

8.4 CGN process flow

Figure 8-4 shows CGN process flow. In the scenario where the vBNG control plane and the user plane are separated, the processes of a user with carrier grade network address translation (CGN) mode accessing the Internet are according to the following flows:

(1) The first step is that the CP allocates one or more CGN address blocks to the UP

(2) Next step is a user access process of the CGN mode;

(3) The UP will report the network address translation (NAT) information to the CP when a CGN session is created.

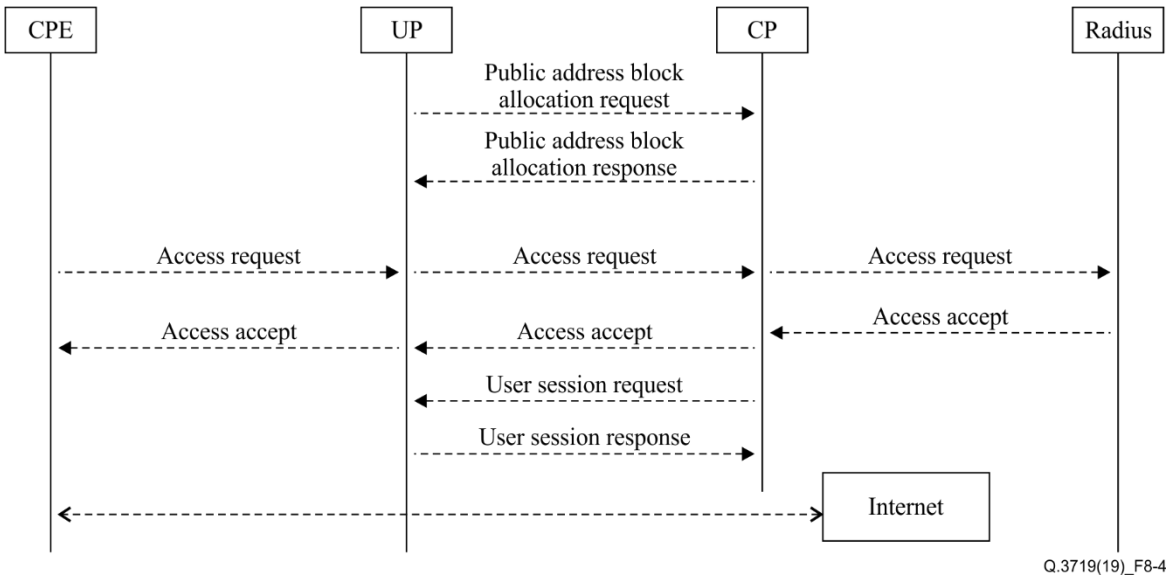

Figure 8-4 – CGN process flow

Appendix I

The deployment scenario of vBNG

(This appendix does not form an integral part of this Recommendation.)

The vBNG with the control plane and user plane separated is composed of a control plane and multiple user planes. The control plane can be composed of VNFs and deployed centrally. As a component for user control and management, the control plane takes responsibility for managing user plane resources such as the user information and forwarding policy. The user plane is composed of a number of forwarding devices at the boundary of the broadband network, and can form a resource pool. The control plane interacts with different management systems to implement user access, authentication, and accounting. After the user is authenticated and permitted, the control plane tells the user plane to do the corresponding forwarding actions with related policies, and the user plane forwards the traffic into the Internet with related policies.

The deployment scenario of vBNG is shown in Figure I.1:

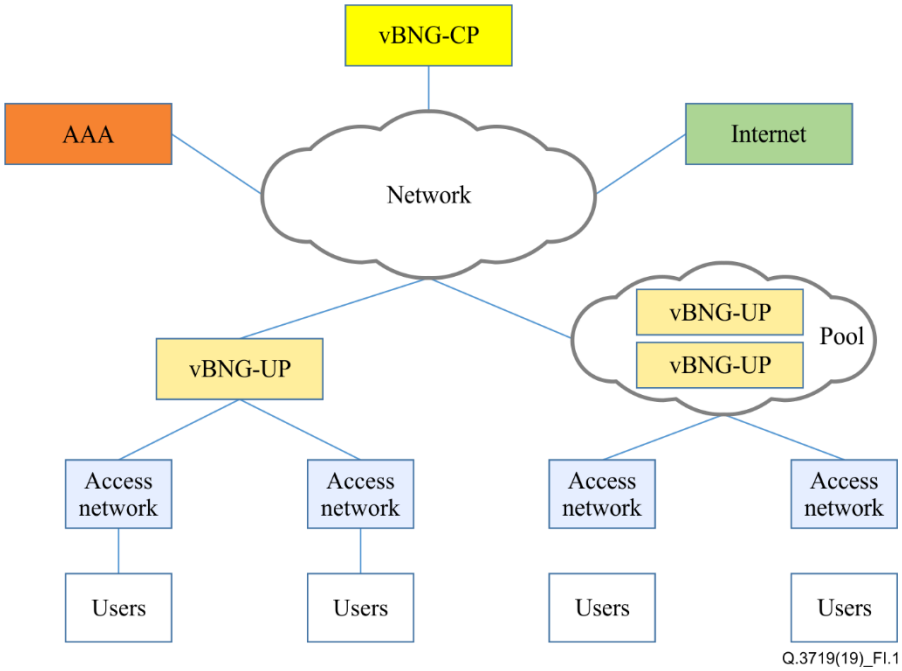

Figure I.1 – Deployment scenario of vBNG

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