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

Signalling requirements and protocols for SDN – Resource control protocols

Procedures for virtualized broadband network gateway acceleration with programmable acceleration card

Recommendation ITU-T Q.3720

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Recommendation ITU-T Q.3720

Procedures for virtualized broadband network gateway acceleration with programmable acceleration card

Summary

Recommendation ITU-T Q.3720 specifies the framework, working modes and procedures for virtualized broadband network gateway (vBNG) acceleration with programmable acceleration card.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.3720	2020-09-29	11	11.1002/1000/14415

Keywords

Acceleration, programmable acceleration card, vBNG.

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* 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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Recommendation ITU-T Q.3720

Procedures for virtualized broadband network gateway acceleration with programmable acceleration card

1 Scope

This Recommendation specifies the framework, working modes and procedures for vBNG acceleration with programmable acceleration card.

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.3719] Recommendation ITU-T Q.3719 (2019), *Signalling requirements for the separation of control plane and user plane in vBNG (Broadband Network Gateway)*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

3.1.2 vBNG control plane [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 the virtualization technologies and deployed in the mode of centralization.

3.1.3 vBNG user plane [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

This Recommendation defines the following terms:

3.2.1 programmable acceleration card (PAC): A type of network interface card (NIC) with high performance, low power consumption and programmable acceleration capability, such as field programmable gate array (FPGA)-based smart NIC. It is used to optimize data packet processing while accelerating compute-intensive traffic shaping and quality of service (QoS).

3.2.2 in-line mode: For X86-based virtualized broadband network gateway (vBNG) acceleration with programmable acceleration card (PAC), in in-line mode, all packets have to go through the vBNG functions on both the PAC and the central processing unit (CPU) simultaneously processed in a pipeline.

3.2.3 fast-path mode: For X86-based virtualized broadband network gateway (vBNG) acceleration with programmable acceleration card (PAC), in fast-pass mode, all signalling packets are processed by software in the central processing unit (CPU), while data packets are only processed in the PAC and bypass the CPU.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA	Authentication, Authorization, Accounting
CP	Control Plane
DPDK	Data Plane Development Kit
DPI	Deep Packet Inspection
FPGA	Field Programmable Gate Array
HQoS	Hierarchical Quality of Service
IP	Internet Protocol
NFVI	Network Functions Virtualization Infrastructure
NIC	Network Interface Card
PAC	Programmable Acceleration Card
PCIESwitch	Peripheral Component Interconnect Express Switch
QOS	Quality of Service
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

None.

6 Framework for vBNG acceleration with programmable acceleration card

vBNG consists of several functions e.g., authentication, authorization, accounting (AAA) management function, IP address management function, user management function, access protocol processing function, firewall, deep packet inspection (DPI), hierarchical quality of service (HQoS)/ quality of service (QoS), packet forwarding, etc. Some control functions, e.g., AAA management function, IP address management function, user management function, access protocol processing function, etc. are supported by vBNG control plane (vBNG-CP), and some routing and traffic forwarding functions are supported by vBNG user plane (vBNG-UP) [ITU-T Q.3719]. For X86-based vBNG with programmable acceleration card (PAC), the functions of vBNG-CP can be implemented by software running in CPU, and the functions of vBNG-UP can be offloaded to PAC, which is a type of network interface card (NIC) with programmable acceleration capability, such as field programmable gate array (FPGA)-based smart NIC.

The framework for X86-based vBNG acceleration with PAC is shown in Figure 6-1.

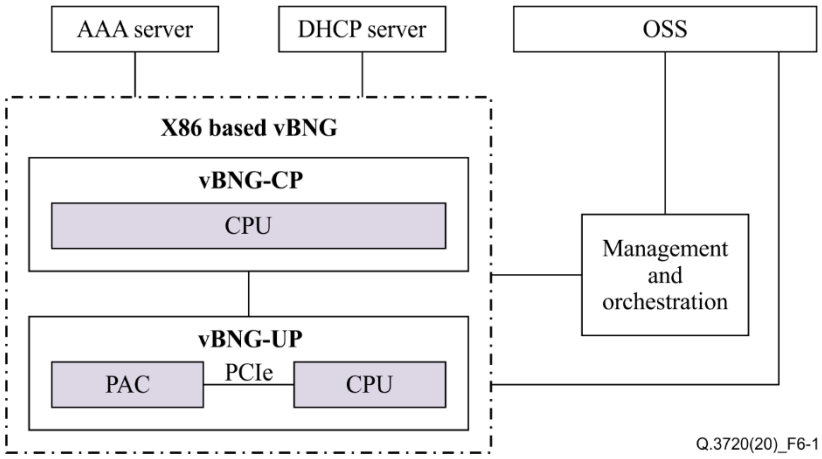

Figure 6-1 – Framework for X86-based vBNG acceleration with PAC

7 Working modes for vBNG acceleration with programmable acceleration card

There are two working modes for vBNG acceleration with programmable acceleration card, including in-line mode and fast-path mode. For in-line mode, all packets have to go through the vBNG functions on both the PAC and the CPU simultaneously processed in a pipeline. For fast-path mode, all signalling packets are passed by the PAC to the CPU for processing and further establishing of the forwarding table in the PAC. Then, after the forwarding table is established in the PAC for a user session, data packets for this user session will be only processed in the PAC and bypass the CPU. The major difference between the two working modes are illustrated in Figure 7-1.

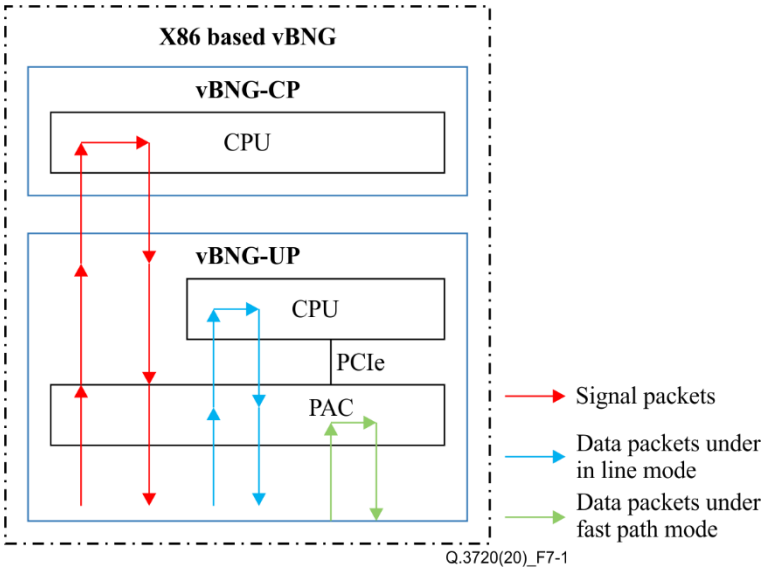

Figure 7-1 – Illustration of packet flow paths for two working modes

8 Procedures for vBNG acceleration with programmable acceleration card

8.1 Procedures for processing signalling packets

Figure 8-1 depicts the procedure for processing signalling packets.

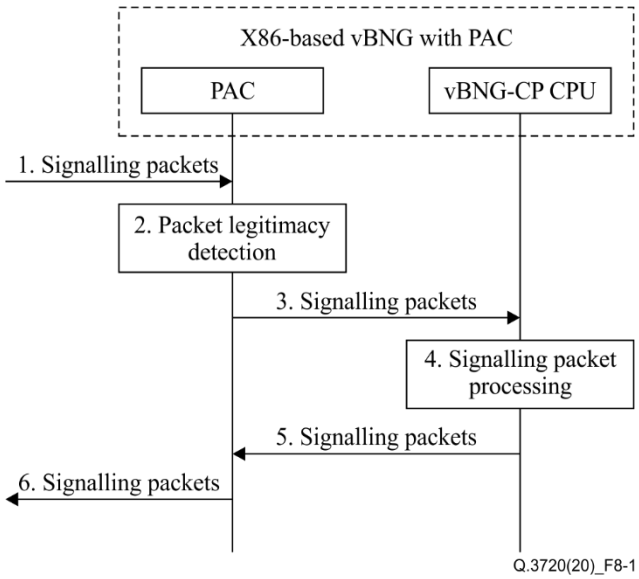

Figure 8-1 – Procedure for processing signalling packets

The main steps for processing signalling packets by X86-based vBNG with PAC include:

1) The signalling packets directly enter the PAC through the network port.
2) The PAC detects the legitimacy of the signalling packets through hardware detection.
3) The PAC delivers legal signalling packets to vBNG-CP CPU.
4) Once it receives the signalling packets, the CPU executes the most of the functions of vBNG for these signalling packets.
5) CPU sends the signalling packets to the PAC.
6) The PAC sends out the signalling packets through the network port.

8.2 Procedures for processing data packets in in-line mode

Figure 8-2 depicts the procedure for data packet processing in in-line mode.

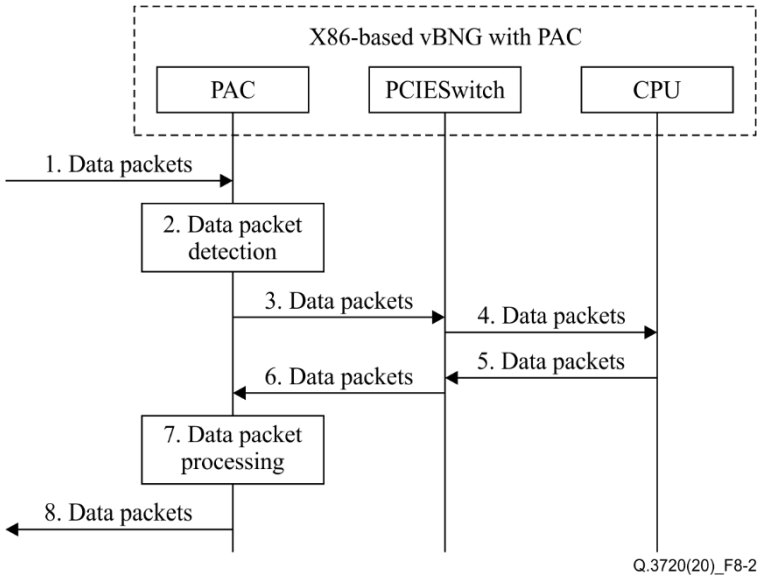

Figure 8-2 – Procedure for processing data packets in in-line mode

The main steps for processing data packets by X86-based vBNG with PAC in in-line mode include:

1) The data packets directly enter into the PAC through the network port.
2) The PAC executes legitimacy detection for data packet.
3) The PAC delivers legal data packets to PCIESwitch.
4) The PCIESwitch sends the data packets to the CPU through PCIe.
5) CPU forwards the data packets to the PCIESwitch.
6) The PCIESwitch sends the data packets to the PAC.
7) The PAC completes some processing functions for the data packets.
8) The PAC sends out the data packets through the network port.

8.3 Procedures for processing data packets in fast-path mode

Figure 8-3 depicts the procedure for processing data packets in fast-path mode.

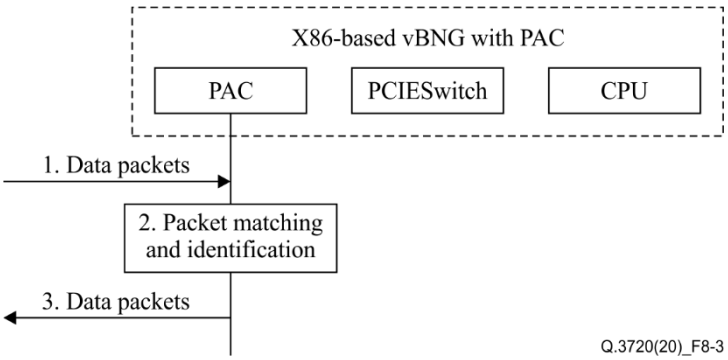

Figure 8-3 – Procedure for processing data packets in fast-path mode

The main steps for processing data packets by X86-based vBNG with PAC in fast-path mode include:

1) The data packets directly enter the PAC through the network port.
2) PAC matches these data packets by querying flow table and user table, and identifies the packets that need to be forwarded.
3) After matching and identifying, the PAC forwards the data packets through the network port.

Appendix I

Deployment models of vBNG with PAC

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

The deployment models of X86-based vBNG with PAC include centralized and distributed models. The centralized and distributed deployment models of vBNG with PAC are illustrated in Figure I.1 and Figure I.2 respectively.

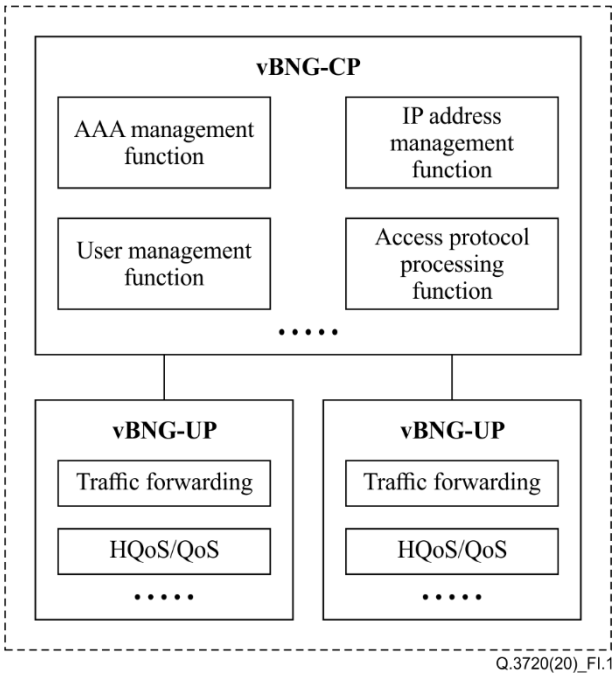

Figure I.1 –Centralized deployment of vBNG with PAC

In centralized deployment, the vBNG-CP and vBNG-UPs are co-located. The vBNG-CP can be deployed by X86-based servers, and execute control functions such as AAA management function, IP address management function, user management function, access protocol processing function, etc. The vBNG-UPs can be deployed by X86-based servers with PAC, and large traffic service can be offloaded to PAC to ensure forwarding capability and QoS capability. For delay-insensitive services, the vBNG-CP and vBNG-UPs are usually co-located in a central data centre.

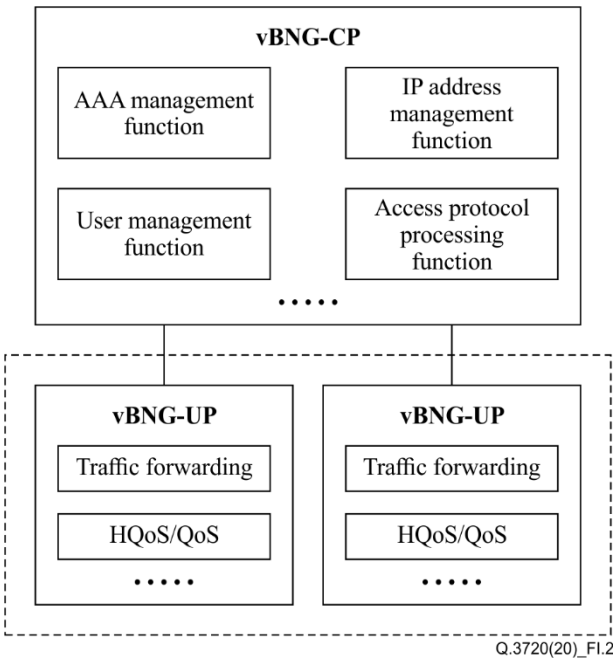

Figure I.2 –Distributed deployment of vBNG with PAC

In distributed deployment, the vBNG-CP and vBNG-UP are not co-located. The vBNG-CP interacts with the geographically separated vBNG-UPs and processes the control signals aggregated from multiple vBNG-UPs. Each geographically separated vBNG-UP in the network could interact independently with the vBNG-CP, receives the management policies and executes the corresponding packet forwarding. For delay-sensitive services, the vBNG-CP usually is located in a central data centre and vBNG-UPs are usually located in edge data centres.

Appendix II

Evaluation of working modes for vBNG acceleration

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

Using PAC to accelerate vBNG is one of the important means to solve the bottleneck of network functions virtualization infrastructure (NFVI) forwarding performance when QoS control is enabled, since PAC has the advantages of programmability and reusability. Working modes for vBNG with PAC have different influence on forwarding performance.

Fast-path mode has a shorter forwarding path of data packets than in-line mode, it can avoid PCIe bandwidth limitation, and greatly reduces CPU resource consumption. The evaluation of in-line mode and fast-path mode is given in Table II.1.

Table II.1 – The evaluation of in-line mode and fast-path mode

Evaluation item	In-line mode	Fast-path mode
Acceleration method	Throughput depends on CPU and data plane development kit (DPDK) performance (essentially software acceleration)	Throughput does not depend on CPU performance (essentially hardware acceleration)
Requirement for PCIe bandwidth	High (throughput is limited by PCIe bandwidth)	Low (throughput is not limited by PCIe bandwidth)
Packet loss rate	Difficult to achieve nearly 0	Nearly 0
Hardware cost	Need higher performance CPU	Reduce CPU consumption

Bibliography

[b-ITU-T Q.3715] Recommendation ITU-T Q.3715 (2017), *Signalling requirements for dynamic bandwidth adjustment on demand on broadband network gateway implemented by software defined networking technologies.*

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