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Q. Fu, Ed.
China Mobile
S. Gundavelli
Cisco
H. Deng
China Mobile

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Motivations, usecases and Models of VCPE
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Abstract

This document introduces the concept of Virtual Customer Premises Equipment (VCPE). Such concept was first proposed in Broadband Forum (BBF) as Network Enhanced Residential Gateway (NERG). The VCPE is the Home Agent (HA) of the Mobile Nodes (MN) attached to the physical CPE (pCPE). In this document, we explain the motivation and advantages of VCPE. Three usecases of VCPE is further discussed in the enterprise network, the residential network, and the Internet of Things (IoT) Network. Two models of field deployment of VCPE are discussed afterwards. The models of VCPE decompose the Control Plane (CP) and the Data Plane (DP), which makes it easier for the deployment of the distributed mobility model.

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1. Introduction

This document introduces the concept of VCPE. The concept of VCPE is to shift most of the networking and service functionalities from the customer side to the network side. In this way, the customer side's equipment, that is the pCPE (Physical Customer Premises Equiptment), can be simplified. The VCPE refers to one or a set of equipments at the network side to execute the networking and service functionalities used to be executed at the CPE. In such architecture, the CPE can be a simple L2 switch, which is only responsible for forwarding packets to a certain next hop. The concept of VCPE was first introduced in BBF as NERG (WT-317), which mainly focuses on shifting some of the functionalities of a residential gateway to the operator's network, for enabling network based features. The aim is to facilitate the deployment, maintenance and evolution of both existing and new capabilities without adding complexity to the RG and/or the home network.

Figure 1 shows the architecture of the pCPE and the VCPE. In this architecture, the VCPE is the HA for the mobile nodes adhear to the pCPE at the network side.

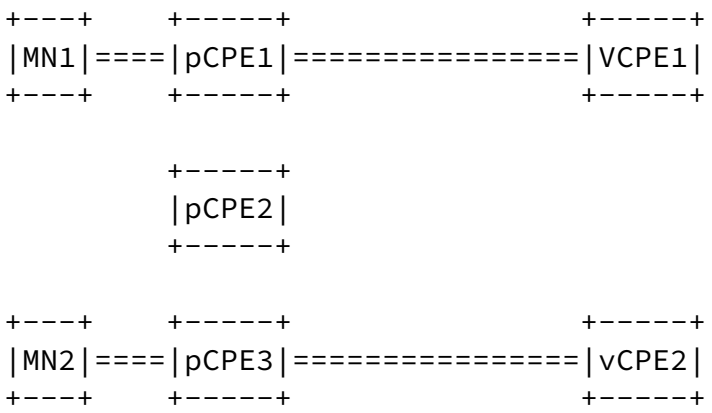

Figure 1: VCPE Architecture

In this document, we would like to further propose such concept in the following aspects:

(1) Motivation and advantages of VCPE.

(2) Usecases of VCPE. We propose three usecases, including the enterprise network, the residential network, and the IoT (Internet of things) network.

(3) Models of VCPE deployment. We propose two models for the field deployment of VCPE. Such models can be used for deployments in multiple scenarios, including both residential network and enterprise network.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Motivation and Advantage of VCPE

The motivation and advantage of introduting VCPE can be concluded as follows:

(1) It will reduce the cost of manufacturing and maintaining of the pCPE. By shifting most of the complicated functions from the customer's side to the operator's side, the cost of the pCPE can be reduced significantly. Such redunction can be remarkable in the enterprise network, since network functions, such as Firewall and NAT(Network Address Translator) at the customer side can be expensive. In the meantime, deployment of VCPE can also reducing the OPEX of operators. Orders of on-site repair can be reduced because of the simplicity of the customer equiptments.

(2) It will avoid complicating the pCPE devices when providing value-added L3-L7 services to the customers. Take the transport network as example. Traditionally, pCPEs at the enterprise customer side are simple L2 devices in the transport network. In order to meet the requirements for value-added L3-L7 services from the customers, the pCPEs should be redesigned to become L3 or even more complicated devices. Such devices will not only result in an increase of manufacture and maintenance cost, and will also request addtional efforts for frequent update to meet the constantly increased requirements of the customers. Nevertheless, by utilizing the VCPE achitecture, pCPE can remain to be a simple L2 device, which is only responsible for L2 forwarding. In this way, frequent update of these pCPEs is not necessary, which will greatly decrease both CAPEX and OPEX of the network operators.

(3) It will greatly speed up the service launching period. Since most of the complicated functions are located at the VCPE in the network side, operators have more power over services. Benefitting from the recent NFV (Network Function Virtualization) and cloud technologies, VCPE can be accomplished using SFC in the virtual network, where different services can act as different VNFs (Virtual Network Functions). Operators only need to add new VNFs on the VCPE side to launch new services to the customers. In this way, Operators can provide a variety of services through the network.

(4) It will provide user-define-network experience. By introducing SFC concept into the VCPE, users can define his own service order and sequence. Therefore, enterprise customers can enjoy the self-defined services over the public network.

4. Use case of VCPE

The concept of VCPE can be used in multiple scenarios. In this section, we will propose two use cases of VCPE, one in residential network, and the other in the enterprise network.

(1) Use Case of VCPE in the Enterprise network.

Traditional enterprise network uses the tranport network access. Multiple network functions, including Firewall (FW) and NAT, are deployed at the enterprise customer's side. Such deployment not only increases the cost of the equiptment at the customer side, but also makes it difficult for both the enterprise customers and the service providers operating and maintaining the functions.

By introducing VCPE into the transport network, functions such as FW and NAT can be shifted to the aggregate network or core network, acting as VCPE at the service provider's side. Moreover, value-added

services can be provided. For example, by deploying a virtual Deep Packet Inspection (vDPI), service providers can provide fine grained data control to the enterprise customers.

(2) Use case of VCPE in the residential network.

In the residential network, traditionally, pCPE locates at the customer premises terminates the home network and connect the LAN devices to the Internet or to some service platforms through the broadband access network. With the expansion of the broadband access and the development of the OTT (Over The Top) industry, the quantity and requirements of addtional functions of pCPE increases rapidly. By shifting most of the complicated functions to VCPE, the cost of the largely deployed CPE can be saved. In the meantime, deployment of new features by service providers can be accelerated.

Taking PPPoE access as example. By shifting PPPoE client to VCPE, pCPE can be a simple L2 device. In this case, VCPE takes the responsibility to initiate PPPoE request to BRAS once receiving traffic flow from the customers. When receiving the certification from BRAS, VCPE will act as DHCP server by assigning IP address to the traffic generating port. Such approach can also be used for IPv6

upgrade,in which case VCPE can act as IPv6 DHCP relay.

(3) Use case of VCPE in the IoT (Internet of Things) network.

VCPE can also be used in the IoT network. So far, multiple wireless communication standards, including Wi-Fi, Zigbee, Blue Tooth, and etc., exist for the connection of the IoT devices to the GW. The IoT GW is responsible for decomposing the L2 packets from the devices, composing them into L3 packets and transferring to the Internet Server. Due to these various wireless communication standards, multiple IoT GWs have to be deployed at users' home to support different IoT devices. By shifting the packet transforming function to VCPE, IoT GW can be a simple and unified L2 forwarding GW, while VCPE will support different standard stacks and is responsible for transforming packets following different communication standards to IP packets.

5. Models of VCPE Deployment

There are multiple models when deploying VCPE in use cases as are discussed in the previous section. In this document, we conclude the deployment of VCPE into two models. In the first model, a logical instance of VCPE is deployed in the cloud for each pCPE instance. All traffic from pCPE goes through the vCPE. In the second model, the VCPE is based on service chains attached to BNG. The classifier on BNG puts the pCPE traffic through the correct set of service

functions. Both of these two models can easily introduce CP/DP decompositon at the VCPE side, and the DMM protocol can be used.

Figure 1 and Figure 2 show the two models of VCPE deployment. For the first model, logical instance of VCPE is deployed. Such logical instance can be a seperate instance deployed before or after the BNG, as is shown in Figure 1(a) and Figure 1(b). It can also be deployed by upgrading the traditional BNG to include the functions of VCPE, as is shown in Figure 1(c).

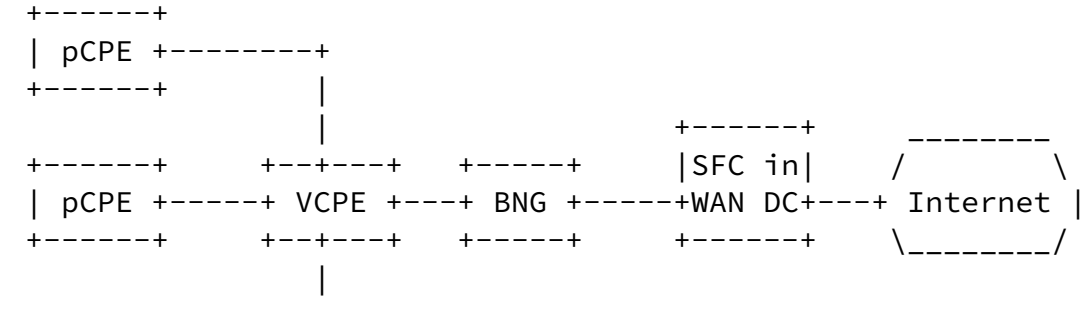
pCPE
pCPE
VCPE
BNG
SFC in
WAN DC
Internet

Figure 1(a) VCPE instance deployed before BNG

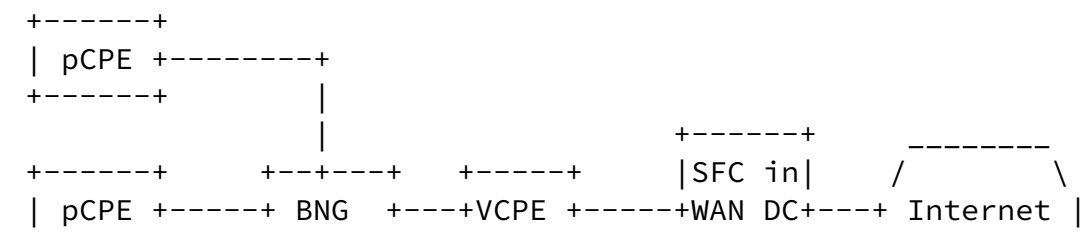

Figure 1(b) VCPE instance deployed after BNG

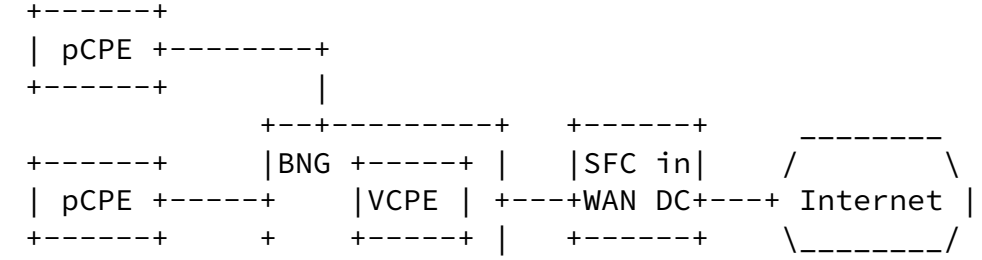

Figure 1(c) VCPE instance deployed through upgrading BNG

Figure 2: VCPE deployment model NO.1: Logical Instance of VCPE

For the second models, no logical instance exists as VCPE. VCPE is realized as a sequence of service function chaining (SFC) in the WAN DC. In this model, BNG is acting as the classifier of SFC. Such classfication should be based on user profile, in which case, users can define his own VCPE service.

SDN (Software Define Network) controllers can also be introduced in

the second model. In which case, all of the pCPEs and the BNG data plane (BNG-dp) can be controlled by the SDN-controller (also acting as the BNG control plane(BNG-cp)), as is shown in Figure 3. When the customer selects a set of services, the SDN-controller will inform the pCPE and the BNG-dp to direct the traffic flow to a certain SFC. the Service Classification Function (SCF) is located in the BNG, responsible for classifing traffic from different customer/network/ service. The SCF is controlled by the SDN-controller. When a packet arrives, the SCF will ask the controller which Service Founction Path (SFP) this flow should follow, and put corresponding SFC encapsulation into the packet. The packet then goes into the service founction region, and will be directed to different Service Founctions (SF) based on the encapsulation.

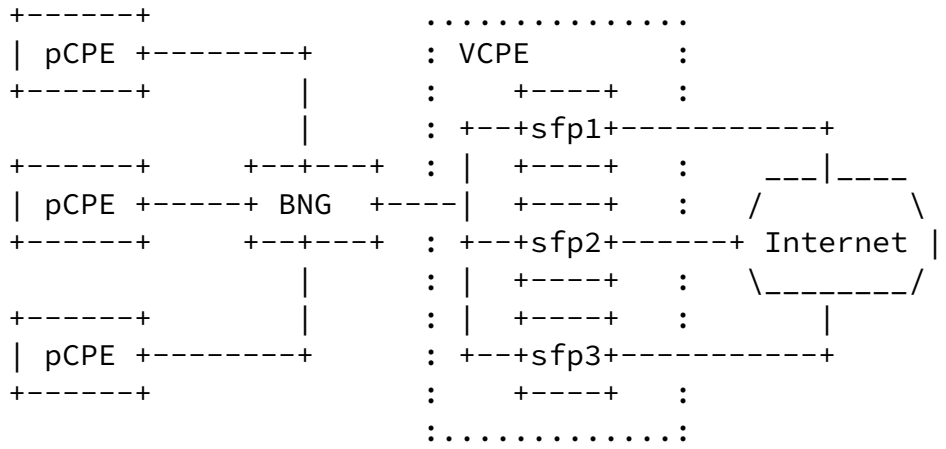

Figure 3: VCPE deployment model NO.2: SFC realization of VCPE

6. Conclusion

In this document, the concept of VCPE is illustrated in detail. The basic concept of VCPE is to shift the complicated functions from the pCPE at the customer side to the VCPE at the service provider side. The motivation of such shifting can be concluded as reducing the Capex and Opex of the pCPE, and providing quick launched customer defined services in the meantime. Three use cases are proposed for VCPE, including scenarios in the enterprise network, the residential network and the IoT network. Two models are then discussed for the field deployment of VCPE.

7. Informative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

Authors' Addresses

Qiao Fu (editor)
China Mobile
Xuanwumenxi Ave. No.32
Beijing
China

Email: fuqiao1@outlook.com

Sri Gundavelli
Cisco

Email: sgundave@cisco.com

Hui Deng
China Mobile
Xuanwumenxi Ave. No.32
Beijing
China

Email: denghui@chinamobile.com