Problem Statements of Virtualizing Home Services

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Abstract

Network Virtualization is proven a success to more effectively manage services in data center. This draft states the motivations and problem statements of decoupling services from Customer Premises Equipment (CPE) and virtualizing them in the Network Service Provider (NSP).

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1. Home CPE

In the early days of Internet era, most users used dial-up directly connecting to Internet from desktop Personal Computer (PC). Network Service Provider (NSP) offered a single public IPv4 address to the dial-up (i.e., PPP) connection to the PC. This model was revised when Internet and PC became more popular. Multiple PCs would share a single NSP connection. NSP wanted to preserve the model to offer only a single public IPv4 address per connection, NAT [RFC2663] enabled Customer Premises Equipment (CPE) was introduced in home network. When days advance, NSP are offering more and more IP services (e.g., video, voice, home automation), NSPs must provide seamless support and excellent services to their users. Today CPEs are doing more than just NAT-ing. They may include but not limited to the following services:

- IPv4 NAT Services
- DHCPv4 Server Service
- Personal Firewall Services
- Parental Control Service
- Voice over IP (VoIP) Service
- Home Monitor Service
- Video Streaming Service
2. CPE Deployment Model

Although the current CPE deployment model is a by-product of limited public IPv4 addresses, it is very successful and serves very well to users. More importantly, NSP network has limited service capacity in the network and the capacity isn’t growing as fast as the user demand. NSP can offload and distribute their services to the CPE so that NSP can focus on growing bandwidth capacity. With all the CPE’s successes, there are also some drawbacks:

- No Uniform set of Services: There is no uniform set of services a CPE vendor can build an one-for-all-NSP CPE. Each NSP may offer slightly different set of services and hence each NSP may develop its CPE specifications for CPE vendors to build.

- Service Variation: Even for a well defined service, each NSP may still have different requirements. For example: NSP-A may use SIP for its VoIP and NSP-B may use WebRTC.

- CPE Manageability: When an NSP plan to offer a new service that is not compatible to the current CPE. The NSP must update or upgrade the CPE. Depending on the NSP subscription base, it could mean to update or upgrade thousands to millions of CPEs.

Among all three, CPE manageability is particularly critical to NSP.

Since the IPv4 addresses are depleted, IPv6 emigration has finally started. One major advantage of IPv6 is network transparency. In IPv4, NSP and Content Service Provider (CSP) can’t identify a device simply by examining just an IPv4 address because a public IPv4 may represent multiple devices behind NAT. In IPv6, every device will have one or more Global Unicast IPv6 addresses (GUA). This enables NSP and CSP to offer device specific services. This inspires innovation in services. For NSP, they may refine and evolve the current "heavy" CPE deployment model to speed up offering new services.

3. Network Virtualization

Software Defined Network (SDN) is originally designed to simplify and rationalize data center deployment. One main goal is to virtualize services from hardware. Service designers can focus on service development without coupling to the underneath hardware architecture. SDN provides a set of Application Programming Interface (API) for service designers to interact with the hardware. There are two critical criteria to make this concept possible: Fast network in data center and Exponential growth of computation power in general purposed hardware. SDN/Virtualization has been proven successful.
Recently SDN has attracted researchers and network equipment vendors to apply the same concept to core and edge network design and development.

The success of SDN in data center also inspires serious considerations by the NSP to apply the same concept to home services. The basic idea is to move the current home services run in the CPE to the NSP network. The CPE will focus on data plane function such as Wifi and packet forwarding.

4. High-level Architecture

Similar to classic SDN architecture, virtualizing home services include a Controller (Virtual CPE Controller) that hosts and virtualizes home services and a Packet Processor (Virtual CPE Packet Forwarder) that process packet forwarding. There exists an open API between the Virtual CPE Controller (VC) and the Virtual CPE Packet Forwarder (VDF) to exchange control plane information. Figure 1 shows the high-level architecture of virtualizing home services.
Virtualizing Home Services High-Level Architecture Diagram

Figure 1

Virtual Service contains the service definitions and service logic. For example: Virtual Service 1 (vs1) could be a parental control service and manage web filter rules configured by subscriber. Virtual Service 2 (vs2) could be personal firewall that protects a home from botnet and intrusion. NSP can scale Virtual Service horizontally to meet user demand. NSP can also dynamically create Virtual Service per subscriber only when the subscriber wants that service. For example: NSP initiates vs1 for User X and vs2 for User Y. In this model, NSP no longer updates CPE for service addition or modification.

Virtual CPE Controller (VC) stores the user’s service subscription. Each user may have different set of home services. For example: User A may have video service. User B may have VoIP service. VC contains the user’s service subscription and interact with the Virtual Service module to provide proper services to users. It contains a north-bound API (Ia) to interact with NSP provisioning system.
Virtual CPE Packet Forwarder (VPF) is usually a networking device that is optimized for processing packet. It has a north-bound API (Ib) to communicate to the VC.

CPE is a simple access device that connects to the subscriber’s devices at home to the NSP network.

Service Provisioning API is used between NSP provisioning system and VC to communicate user’s home service data such as service activation and service specific parameters.

Service Activation API is used between VC and VPF to communicate data plane policy such as QoS parameters and Access Control List (ACL) rules.

Data Path Specification is the protocol agreed between CPE and VPF. It could be Ethernet or any encapsulation technology such as PMIP or MPLS.

5. Problem Statement

Virtualizing home services enables NSP to offer service in a more rapid pace. It also enables NSP to offer new possible services such as:

1. Connect a user mobile device to his home network at outdoor access point.
2. Provide more flexibility IPv4 and IPv6 address management.
3. Provide more granular QoS management.

Section 4 describes the high-level architecture. One possible deployment is to put the Virtual CPE Controller in a centralized location and put the Virtual CPE Switch closer to users. This deployment requires to standardize the following:

- Service Definition: Define the service semantics and user interaction. This allows the vendor community to standardize the service definition and build the Virtual Service model to support it.

- Home Service Provisioning API (Ia): Define and specify the API to provision the service to the Virtual CPE Controller for user and service parameters.

- Home Service Activation API (Ib): Define and specify the API to activate service policy in the data plane.
Standardizing the Service Definition, Ia and Ib will simplify service integration and equipment interoperability. This will help vendors to speed up development and NSP to speed up new service offering.

6. Security Considerations

7. Conclusion

8. Acknowledgements

9. IANA Considerations

This memo includes no request to IANA.

10. References

10.1. Normative References


10.2. Informative References


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