MARKETING REPORT

MR-276

Lessons Learned from IPv4 to IPv6 Migration and Guidance for Future Deployment

Issue: 01
Issue Date: October 2016

Issue History

Issue Number	Approval Date	Publication Date	Issue Editor	Changes
1	26 October 2016	27 October 2016	Cancan Huang, China Telecom Fan Liang, ZTE Corporation Angela Zhou, China Mobile	Original

Comments or questions about this Broadband Forum Marketing Report should be directed to help@broadband-forum.org.

Editors	Huang Cancan	China Telecom	huangcc@gsta.com
	Fan Liang	ZTE Corporation	fan.liang2@zte.com.cn
	Angela Zhou	China Mobile	zhoulinlang@chinamobile.com
Strategic Marketing Director	Mark Fishburn	Broadband Forum	mfishburn@broadband-forum.org

TABLE OF CONTENTS

List of Figures

1. Executive Summary

1.1 Purpose

IPv6 deployment has become an imperative. There are a number of technologies and approaches for the service providers (SPs) and Internet Content Providers (ICPs) to choose as a transition strategy. For example, the Broadband Forum's TR-242 (reference pointer) documented a number of IPv6 transitional mechanisms based on technologies developed by IETF, along with details on nodal requirements, deployment scenarios and management methodology, contributed by a number of Internet Service Providers. This paper documents use cases from some service providers that implement their respective IPv6 transition technologies and approaches, and deployment experiences. It reviews examples and lessons learned from service providers and ICPs as a timesaving guide for those considering or in the process of IPv4 to IPv6 transitions.

1.2 Relation to other Broadband Forum documents

TR-177 and TR-187 describe respectively IPoE and PPPoE Dual-Stack architectures that can be deployed by operators to provide IPv6 services in addition to existing IPv4 services, leveraging TR-101 based broadband network architecture.

TR-242 specifies the nodal requirements necessary to support selected transition IPv6 mechanisms enabling operators to handle the operational and deployment challenges related to IPv4 address exhaustion, IPv6 introduction and IPv4/IPv6 co-existence.

This document focuses on collecting and abstracting typical deployment scenarios from various service and content providers.

1.3 Intended Audience

This document is intended for those network professionals responsible for planning and executing the deployment of network services and applications that benefit from the migration to IPv6.

2. References

The following references are of relevance to this Marketing Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Marketing Report are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

A list of currently valid Broadband Forum Technical Reports is published at www.broadband-forum.org.

Document		Title	Source	Year
[1]	RFC 5969	IPv6 Rapid Deployment on IPv4 Infrastructures (6rd)	IETF	2010
[2]	RFC 6333	Dual-Stack Lite Broadband Deployments Following IPv4 Exhaustion	IETF	2011
[3]	TR-069	CPE WAN Management Protocol	Broadband Forum	2013
[4]	TR-242	IPv6 Transition Mechanisms for Broadband Networks	Broadband Forum	2015
[5]	TR-296	IPv6 Transition Mechanisms Test Plan	Broadband Forum	2015
[6]	RFC6888	Common Requirements for Carrier-Grade NATs (CGNs)	IETF	2013
[7]	TR-177	Migration to IPv6 in the context of TR-101	Broadband Forum	2010
[8]	TR-187	IPv6 for PPP Broadband Access - update	Broadband Forum	2013

3. Abbreviations

This Marketing Report uses the following abbreviations:

AFTR	Address Family Transition Router
BNG	Broadband Network Gateway
CGN	Carrier-Grade NAT
CE	Customer Edge
CPE	Customer Premises Equipment
DC	Data Center
DS-Lite	Dual Stack-Lite
DHCP	Dynamic Host Configuration Protocol
IPTV	Internet Protocol Television
6RD	IPv6 Rapid Deployment
MR	Marketing Report
NAT	Network Address Translation
P2P	Peer-to-Peer
PPP	Point-to-Point Protocol
PPPoE	PPP over Ethernet
RADIUS	Remote Authentication Dial In User Service
RG	Residential Gateway
STB	Set-Top-Box
TCO	Total Cost of Ownership
VOIP	Voice Over Internet Protocol
WA	Work Area

4. Principles & Constraints

Though many approaches could be chosen for the migration of IPv4 to IPv6, each with impact on the network and the subscribers.

The service providers may take the following factors into consideration when choosing the migration path:

1） Guarantee high subscriber experience: whether it will decrease the quality of user experience, e.g. higher operational complexity or lower service experience.
2） TCO investment control.
3） Mature technology which is appropriate to dedicated network.

These factors can be further subdivided into the following principles:

1） Considering developing the application capability of IPv6
2） Terminal custom-built plug-ins as few as possible
3） Long-term scalability (assume that pure NAT44 will have scalable issue in the long term, etc.)
4） Whether to swap current CPE/RG
5） Available for both centralized and contributed deployment
6） Easy for network operating during the migration
7） Minimize the change of the OAM (AAA, BOSS, NMS, etc.) system

5. Case Study

Based on the results of the MD-276 service provider survey and real time information collected from the official website of service providers, five typical scenarios are shown below:

5.1 Service Provider 1

5.1.1 Network Architecture (current, targeted)

Currently, the access network (from RG to BNG) mainly serves residential customers. It covers most of residential broadband services, such as high speed internet, VoIP, BoD & VoD, etc.

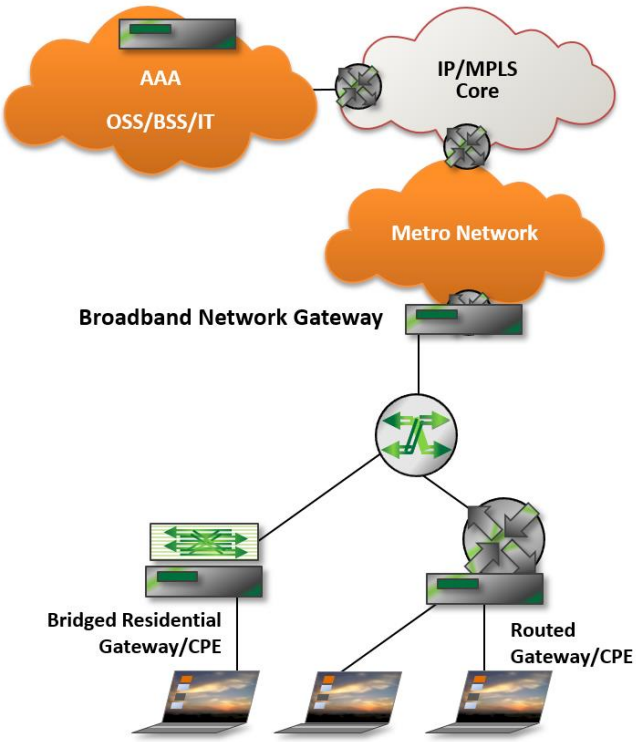

Figure 1 –Network Architecture of SP1

The L2 Access Node indicates IP-DSLAM and/or OLT. Currently there're lots of BNG (around one hundred per city avg.) with different sets of IPv6 capabilities. The assignment of IP address pools (currently public IPv4 address) are based on the subscriber number on each BNG. Most subscribers using PPPoE to get a public IPv4 address from the BNG for HSI service. SP1 provides a bridged RG/CPE to the subscriber. Currently SP1 does not manage the RG/CPE through ACS or other remote control systems (part of existing routed RGs are ready for TR-069). SP1 also allows the subscribers to deploy routed RG/CPE by themselves (usually a small router with PPPoE WAN and Wi-Fi LAN function under the bridged RG/CPE). Now the bridged RG/CPE number is much larger than the routed RG/CPE.

5.1.2 Deployment experience (problem, solution)

Problem statement:
Practically, there are millions of NAT sessions per 10G uplink of CGN device, and tens of thousands of sessions updates per second. According to current TR-242(02) requirements, the log information for each session should include “Destination IPv4 address”, “Destination UDP or TCP port or ICMP identifier” and some other information. It means that there will be a huge number of log information per second per 10G uplink port. It will be a strict requirement of storage and processing capacity for CGN device and indirectly results in a limitation to the forwarding capacity of CGN. The per-session logging requirement potentially creates a significant scaling problem. A method which would greatly reduce the real-time reporting amount of NAT session log information becomes very important (Refer to R98/R99 of TR-242).

SP1’s Solution:
It is recommended that SP1 use CGN+IPv6. In this solution, the block of ports are dynamically allocated when the first NAT session of each internal IP address established, after that a fixed number of the following external ports will be pre-allocated for the following session of the same internal IP address. So that the CGN device just needs to send log information when the first NAT session established and the last session terminated of each internal IP, it means logging for each block of ports instead of each port. For example, if the dynamically allocated external IP address and external port for the first session of a specific internal IP is IP_A and Port_N, and the fixed external port bulk size is 500, then the ports from Port_N to Port_N+499 of IP_A will be pre-allocated for IP_A(Refer to R99/TR-242).

5.2 Service Provider 2

5.2.1 Network Architecture

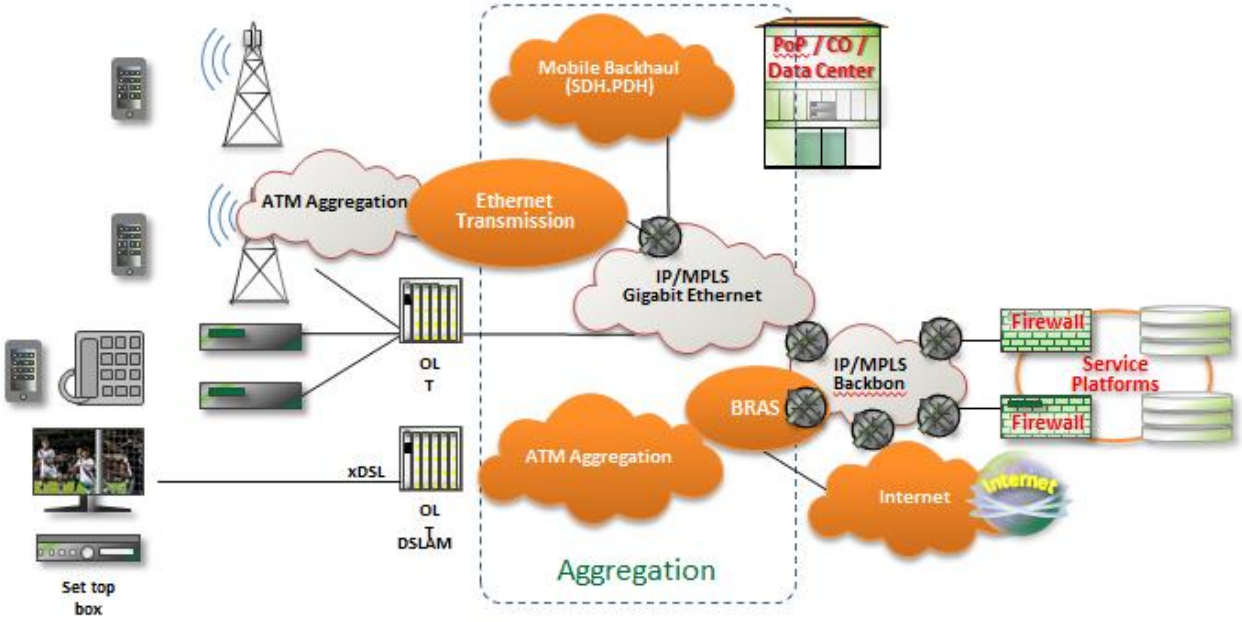

Figure 2 –Network Architecture of SP2

The SP2's access network is mainly based on L3, extending from the residential gateway to the service platforms. All the RGs could be controlled by SP2's centralized management system.

5.2.2 Main Considerations and deployment experience

According to the large amount of IPv4 addresses they got in early years of Internet growth, the IPv4 public address depletion is not a very imperative issue to SP2, even though there have been a very huge number of residential customers with very high growth rate. According to the survey, the migration of SP2's residential Internet and VPN services are planned in 3 to 5 years. So, the relative transition strategy will be certainly different. Of course, the TCO investment controlling, customer experience guaranteeing and influence to management system are still very sensitive parameters.

The following is the impact of SP2 finds when choosing the 6rd solution:

1) They will still face to IPv4 public address depletion problem but not that urgent like SP1, so the CGN(NAT44) devices are not very necessary when there is not obvious address problem.
2) 6rd requires RG/CPE swapping/upgrading for all the residential customer and asks for a remote control system of RG/CPE.SP2s have such remote control system, so RG/CPE swapping will not become a serious problem for SP2.
3) IPv6 service will be influenced when the problem of IPv4 tunnel happens.
4) Hard to differentiate the IPv4 and IPv6 flow since all of them are under IPv4 header. It will be difficult for the SPs to implement differentiate charging policy for IPv4 and IPv6, and probably influence the IPv6 service developing.
5) It will postpone the IPv6 deployment in the network side since the main network is still based on IPv4.

The following are the main influence if SP2 finds when choosing DS-Lite solution:

1) DS-lite has the same influences as 6rd mentioned before except the fifth;
2) It will accelerate the IPv6 deployment in the network side.

The following are the main influence if SP2 chooses Dual-Stack with IPv4 Release Control solution:

It requires RG/CPE swapping/upgrading for all residential customers (to support the IPv4 session/traffic monitoring and the IPv4 address releasing and (re)assignment function inside a PPP session). SP2s have such remote control system, so RG/CPE swapping will not become a serious problem for SP2. Deployment experience (problem, solution).

5.3 Service Provider 3

5.3.1 Network Architecture

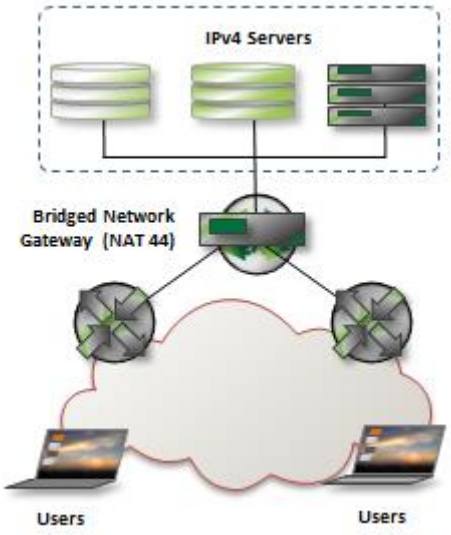

Figure 3 –Network Architecture of SP3

5.3.2 Deployment experience

IPv4 to IPv6 migration techniques within the context of IPv6 -only network currently included in TR-242 focuses mainly on the stateful mechanisms(DS-Lite), in which the network should maintain user-session states relying on the activation of a NAT function in the providers' network [RFC6888]. States maintenance for per-session may have several limitations as listed below.

1） NAT logging: The logging information on per-session will consume significant parts of physical resources, such as memory and processors resource. In addition, Operators have to make complicated data inspection to dig up desired information from inner tunnel header.
2） Centralized Traffic Bottleneck: DS-Lite takes "Hubs and Spokes model" where there are major CPEs connecting a relatively small number of AFTR. When a user behind CPE requires communications with others behind another CPE, data packets have to go through AFTR to reach proper users. AFTR easily becomes a traffic bottleneck as the number of subscriber increases. Moreover, it could also cause latency during traffic delivery.
3） Scalability: In some DS-Lite deployment, multiple AFTRs may be deployed to serve the same group of subscribers for preventing from single point of failure but also for load balancing. And in this case, subscribers' connection states must be maintained in a synchronized manner among these AFTRs. This practice is usually complicated and costly.
4） Complexity and Cost: The presence of the CGN may makes the provider's routing and service design and implementation more complex and operational cost more expensive.

Therefore, a lightweight transition is a very attractive approach in order to expedite the benefits of lower cost, scalable, automated deployment and operations. Accordingly, the Service Provider

community has found that the stateless IPv4 over IPv6 approaches may be required in some scenarios.

5.4 Service Provider 4

5.4.1 Network Architecture

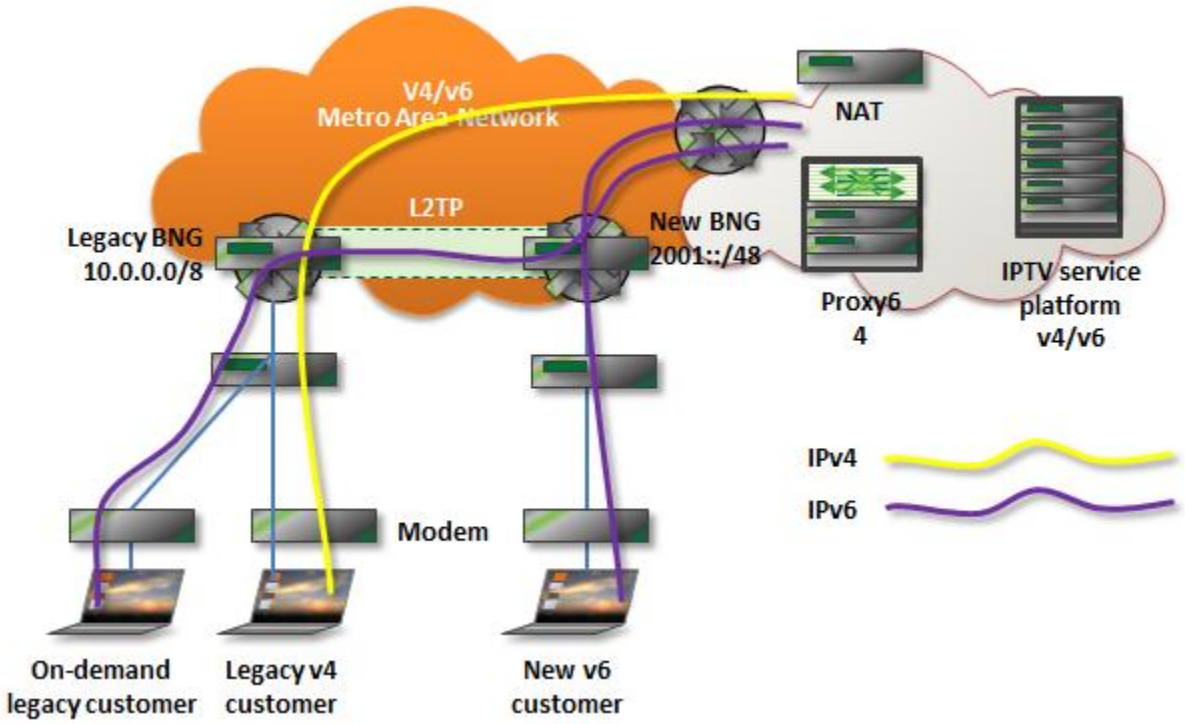

Figure 4 –Network Architecture of SP4

5.4.2 Deployment experience

In real network, there are two migration solutions according to two types of customers:

1） For Legacy customers:

The legacy customers are usually access the internet through legacy BNG device. Some of the legacy BNG support IPv6 by software upgrading and other cannot support Ipv6. For customer who access to the first type of BNG, after STB upgrade to dual-stack, they can visit the dual-stack resources as they wish. For customer who access to the second type of BNG, the SP can use the L2TP tunnel to pass through the customer's requirement to the first type of BNG.

2） For new developed customers:

The new IPv6 customers can visit the video source through the protocol translation device which is deployed ahead of it.

5.5 Service Provider 5

In Current DC network, a large number of the network layer devices don't have IPv6 capability, e.g. the CDN system, the load balancing devices, the firewalls, some switches and routers, etc. At

the meantime, most of the standard servers and their operation systems support IPv6, as well as some software platforms. On the other hand, most of the individually developed software couldn't move to IPv6 since it wasn't taken into consideration during the developing procedure. There would be difficulties of solving these problems when the network and software migrate to IPv6. The strategy is providing dual-stack capability for new services and upgrading the legacy services the dual-stack mode gradually.

In real network, most websites have lots of links which connect to other websites. We couldn't upgrade all the websites to IPv6-only mode at the same time, and we also couldn't upgrade part of them to that mode. The idea is we need to distribute the content both in IPv4 and IPv6 simultaneously.

For the important value-added services, it is planned to provide the converting service which could transforming the IPv4 resource to IPv6 mode, then provide both modes to the subscribers. The SP plans to provide dual-stack CDN service to the dual-stack DC resource.

6. Conclusion

The paper shares the use cases and deploying experience of the tier-1 SPs/ICPs. Through these cases we can draw the conclusion that the migration strategy choice is not only related to the network architecture but also related to the current and future planned services provided by the SP/ICP. The detailed technical requirements of some transition technologies have been listed in the published BBF technical reports, e.g. TR-242/296/177/187.

Notice

The Broadband Forum is a non-profit corporation organized to create guidelines for broadband network system development and deployment. This Marketing Report has been approved by members of the Forum. This Marketing Report is subject to change. This Marketing Report is copyrighted by the Broadband Forum, and all rights are reserved. Portions of this Marketing Report may be copyrighted by Broadband Forum members.

Intellectual Property

Recipients of this Marketing Report are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of this Marketing Report, or use of any software code normatively referenced in this Marketing Report, and to provide supporting documentation.

Terms of Use

1. License

Broadband Forum hereby grants you the right, without charge, on a perpetual, non-exclusive and worldwide basis, to utilize the Marketing Report for the purpose of developing, making, having made, using, marketing, importing, offering to sell or license, and selling or licensing, and to otherwise distribute, products complying with the Marketing Report, in all cases subject to the conditions set forth in this notice and any relevant patent and other intellectual property rights of third parties (which may include members of Broadband Forum). This license grant does not include the right to sublicense, modify or create derivative works based upon the Marketing Report except to the extent this Marketing Report includes text implementable in computer code, in which case your right under this License to create and modify derivative works is limited to modifying and creating derivative works of such code. For the avoidance of doubt, except as qualified by the preceding sentence, products implementing this Marketing Report are not deemed to be derivative works of the Marketing Report.

2. NO WARRANTIES

THIS MARKETING REPORT IS BEING OFFERED WITHOUT ANY WARRANTY WHATSOEVER, AND IN PARTICULAR, ANY WARRANTY OF NONINFRINGEMENT IS EXPRESSLY DISCLAIMED. ANY USE OF THIS MARKETING REPORT SHALL BE MADE ENTIRELY AT THE IMPLEMENTER'S OWN RISK, AND NEITHER THE BROADBAND FORUM, NOR ANY OF ITS MEMBERS OR SUBMITTERS, SHALL HAVE ANY LIABILITY WHATSOEVER TO ANY IMPLEMENTER OR THIRD PARTY FOR ANY DAMAGES OF ANY NATURE WHATSOEVER, DIRECTLY OR INDIRECTLY, ARISING FROM THE USE OF THIS MARKETING REPORT.

3. THIRD PARTY RIGHTS

Without limiting the generality of Section 2 above, BROADBAND FORUM ASSUMES NO RESPONSIBILITY TO COMPILE, CONFIRM, UPDATE OR MAKE PUBLIC ANY THIRD PARTY ASSERTIONS OF PATENT OR OTHER INTELLECTUAL PROPERTY RIGHTS THAT MIGHT NOW OR IN THE FUTURE BE INFRINGED BY AN IMPLEMENTATION OF THE MARKETING REPORT IN ITS CURRENT, OR IN ANY FUTURE FORM. IF ANY

SUCH RIGHTS ARE DESCRIBED ON THE MARKETING REPORT, BROADBAND FORUM TAKES NO POSITION AS TO THE VALIDITY OR INVALIDITY OF SUCH ASSERTIONS, OR THAT ALL SUCH ASSERTIONS THAT HAVE OR MAY BE MADE ARE SO LISTED.

The text of this notice must be included in all copies of this Marketing Report.

End of Broadband Forum Marketing Report MR-276

