An Overview of the most Important Implementations of IPv4aaS Technologies

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Abstract **This paper discusses the need to use IPv4-as-a-service (IPv4aaS) technologies in an ISP/enterprise network where both IPv4 and IPv6 can co-exist together efficiently, considering also their performance, operations and properties. There are currently many IPv6 transition technologies, but in this paper the most prominent ones are being discussed, moreover, the deployment and implementations of the theses technologies are also addressed.**

Keyword **IPv4 as a service, IPv6 transition technologies 464XLAT, DS-Lite, LW4o6, MAP-E, MAP-T.**

I. Introduction

As expected years ago, the world is now running out of IPv4 addresses. In February 2011, IANA, the global body responsible for managing Internet addresses, distributed the last five “/8” sets of IPv4 Internet addresses to the five global Internet address registries [1]. IPv4 uses a 32-bit addressing scheme, which was thought to be enough supporting billion of devices, yet the more devices connected within the 4^{th} industrial revolution and the internet of things, IPv6 was the solution of the dilemma that many were predicting.

The deployment of the IPv6 protocol around the world is relatively slow, as the problem lies in the following:

1. Service providers do not want to activate IPv6, because there is no demand from subscribers, and subscribers do not request IPv6 because of the lack of content that works on it, and content providers do not want to activate IPv6, until it becomes a demand from users.

2. IPv6 hosting provides many features for users of the built-in protection of the protocol, a greater number of available Internet addresses in addition to navigation and many other features.

3. If one wants to deploy something new into the network, there is an impact on the stability of the network, routers have to be upgraded, sometimes firmware has to be changed and the code of IPv6 in the routers and switches is brand new, so an upgrade is needed more often, debugging this software is necessary and it costs extra effort. IPv6 and IPv4 are incompatible protocols meaning that if one have at least one application that does not support it, then both protocols have to be run.

IPv6 is the new generation of IP addressing for the Internet, which solves many of the limitations of IPv4 and the main one is that IPv4 is running out of addresses, IPv6 is more efficient and secure; that's why it's a necessity to deploy it.

IPv6 activation is the main solution to the problem of lack of IPv4 addresses. IPv6 is the next generation of network environment needs to be converted from IPv4 to IPv6, it may take a long time because of some factors, such as the inability of the IPv4 network device to be completely replaced.

There are a high number of IPv6 technologies have been developed to facilitate the co-operation of the two incompatible versions of IP (IPv4 and IPv6) for different scenarios [2]. One important scenario is, when IPv4 addresses ran out and only IPv6 is being distributed to the clients, but there are still many old servers, which have only IPv4 addresses. A suitable solution for this scenario is the combination of NAT64 [3] and DNS64 [4]. This technology works well with the majority of the generally used client-server network applications [5], however there are some applications such as skype which can't use IPv6. For this reason, many providers, who would like to forget about IPv4 in the access and core network, still have to provide IPv4 to the customers. It is called “IPv4 as a service” (IPv4aaS) and there are several new solutions were developed for this purpose. The advantages and disadvantages of the five most important IPv4aaS technologies are discussed in the following active Internet Draft [6].

The remainder of this paper is organized as follows. Section II introduces the five most important IPv4aaS technologies. Section III deals with their implementations. Section IV is about plans for future work.

II. The Five IPv4aaS Technologies

A. 464XLAT

IPv6 hosts cannot communicate directly with IPv4 hosts and for this reason, several transitions methods have been developed; 464XLAT [7] technology provides the IPv4 access by combining stateful (RFC 6146) and Stateless translation (RFC 6145).

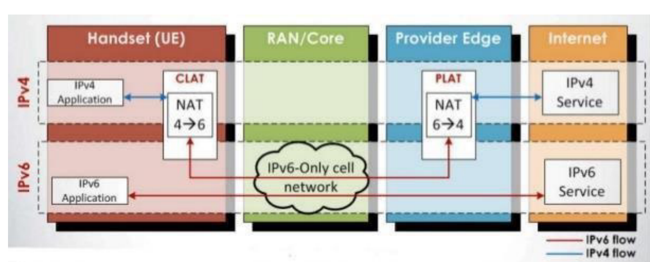

Figure 1: 464XLAT mechanism [8]

According to [9], 464XLAT is essentially an extension to NAT64, if there is an IPv6-only connection; sometimes it's not possible to access IPv4 only content. 464XLAT solves this problem. With 464XLAT, a client application uses a stateless IP/ICMP translation algorithm, which is a translator) [7], the IPv4 address comes from a specially reserved prefix. On the provider side, PLAT [7] translates statefully IPv6 to IPv4 using stateful NAT64, (see figure 1). This solution is similar to NAT64, but the main difference is that the CLAT service needs to be installed on the mobile equipment. For example: Skype is an IPv4 only application so it does not work with IPv6, the CLAT is used to translate skype clients IPv4 packets into IPv6 packets, the packets are then sent over an IPv6 only network to a NAT64 translator which translates them back into IPv4 and sends the packets to an IPv4 only server (Skype server). 464XLAT helps a lot of mobile providers with the IPv6 implementations, because customers with 464XLAT can have an IPv6 only connection and still access all IPv4 only applications and content.

B. Dual Stack Lite or DS-Lite:

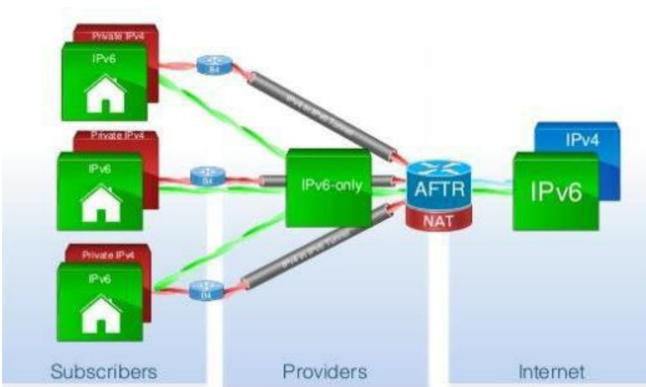

Figure 2: DS-Lite mechanism [9]

According to [9], DS-Lite enables service providers to deploy IPv4 services over an IPv6 infrastructure. It's a transition mechanism based on native IPv6 tunneling and Network Address Translation. DS-Lite (see Figure 2) allows an ISP to give access to IPv4 only services for customers that have only native IPv6. As it becomes impossible to provide customers with public IPv4 addresses to connect to the Internet, ISP has to make sure that all customers can access the Internet whether they are IPv4 only IPv6 only or dual-stack. When a customer has only public IPv6 addresses, DS-Lite is the way to let this customer reach IPv4 only services by giving this customer native public IPv6 addresses and private NAT-ted IPv4 addresses. The customer needs a native IPv6 connection with DS-Lite capable CPE supporting IPv6 tunneling and IPv4 as well as a private IPv4 address to be able to connect to the IPv4 Internet. The ISP sends the customer one private IPv4 through a tunnel over the IPv6 connection between the customer network and the providers network. Because the customer is given private IPv4 address that is non-routable on the Internet, the ISP must do network address translation on behalf of the customer. The problem is that the ISP keeps several customers behind one public IPv4 address. In DS-Lite, the translator box records the public IPv6 address the private IPv4 address and TCP/UDP port number of the customer to keep track of who uses which connection. This mechanism is very useful for DSL or cable provider as the client has public IPv6 address and can still use all the home devices as they do today. In most cases, DS-Lite deployment requires zero involvements from the customer, while the fully automated configuration is possible on the service provider side.

C. Lightweight 4over6

Lightweight 4over6 [9], while remaining the stateful nature of DS-Lite, it relies on two network functions: the B4 is called Lightweight Basic Bridging Broadband "lwB4" that represents client's gateway and the AFTR called Lightweight Address Family Transition Router "LwAFTR", and represents provider's side, the main task of the first one is to do the NAT-ting and the encapsulation, where the LwAFTR is doing the de-capsulation as well as the software lookup.

The way Lightweight 4over6 (see figure 3) shares the addresses among clients is different, where it gives a portion to port space to each client, the CPE is going to do a NAT and encapsulates the packets into IPv6, the packets get through the border router. Here it comes the task of LwAFTR. The LwAFTR is doing a lookup in the binding table which is a static table, once there is a match, LwAFTR de-capsulates the packets and forwards it to the Internet.

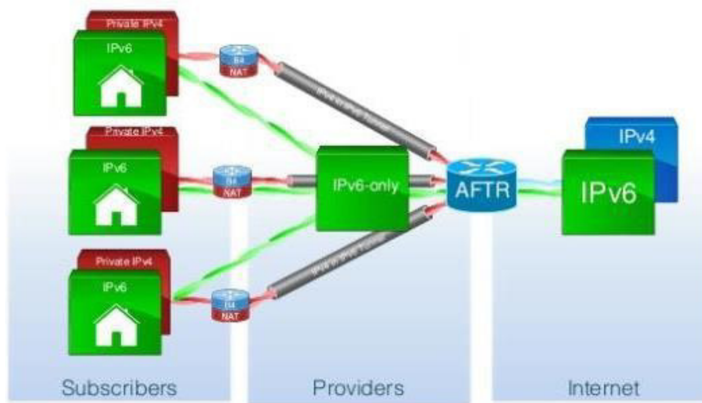

Figure 3: Lightweight 4over6 mechanism [9]

Lightweight 4over6 is a technology that flips the complexity of the dynamic address translation (between the LAN interface and the given public address) back to the client, where every CPE does the address translation and port-based NAT-ting, the difference in lightweight AFTR is that customer shares the public IP address and each client gets the same IP address over limited port range to use, which makes this function stateless, where they all share the same binding table.

Lightweight 4over6 is a scalable solution where all routers are configured equally to load balance the traffic, for single flow packets can be distributed, and once the routing updates don't get through an instance fails then it's quickly picked up as another negligible hop and the traffic gets distributed to the other one.

D. MAP

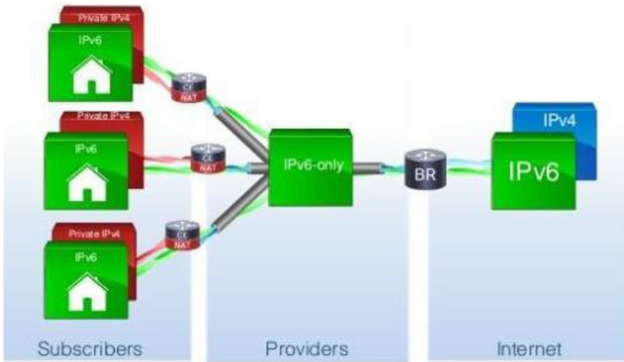

Figure 4: MAP mechanism [9]

MAP stands for mapping address and port, it's another transition mechanism; it basically maps the addresses and ports of IPv4 into the IPv6 addresses in order to serve IPv4 traffic, where IPv4aaS on top of IPv6 is being delivered using this stateless technology. MAP (see figure 4) is targeted access customer of broadband service providers, where it allows them to deploy an IPv6 infrastructure for the dominant type of traffic such as Google, Facebook, Yahoo and all serving IPv6 content.

Figure 5: MAP-T mechanism [9]

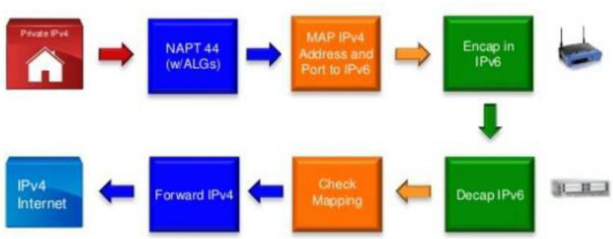

Figure 6: MAP-E mechanism [9]

The main benefit of this technology is that it's stateless, where no additional hardware is required even with the growth of the traffic. MAP-T [10] (see figure 5) is one of two transform modes of the parent technology MAP, which aims to transport IPv4 over an IPv6 domain, while MAP-E [11] (see figure 6) uses encapsulation, similarly to DS-Lite, where an IPv4 Packet is prepended with an IPv6 header and transported across the network, MAP-T uses IPv4 and IPv6 stateless translation, so the header translation as opposed to encapsulation. With MAP-T, the IPv4 addresses are embedded within the corresponding IPv6 address.

III. IMPLEMENTATIONS

The following are some implementation cases for the most IPv4-as-a-service (IPv4aaS) developed technologies:

1. CLATD :

CLATD [12]- a CLAT / SIIT-DC Edge Relay implementation for Linux is free software available to implement the CLAT components of the 464XLAT stateful NAT64 network where it allows IPv6 content only to have IPv4 content across the network by translating from to IPv6.

2. Android CLAT

Android CLAT [13] is an open -source application already Installed for any Android OS 4.3 jellybean or above. This solution relies on the routing table in order to separate traffic, this implementation does not support IPv6 content only; it was mainly designed to offer CLAT services through Wi-Fi connection.

3. Cisco CGv6:

Cisco CGv6 [14] supports stateless MAP technology to deliver both IPv4 and IPv6 services more efficiently on a high scale at a lower cost and less latency. Machine to Machine services is an advantage of this technology, while IPv4 is still supported, unlike DS-lite, which is a stateful tunneling of IPv4 over IPv6 where both information must be maintained, CGv6 gets rid of that by reducing the cost of additional carrier grade network address translation appliances for handling IPv4, with this technology gateway maps IPv4 into IPv6 using a v6 header before sending it over the v6 network, while at the boundary router the IPv4 traffic is stripped and forwarded to the v4 internet, that makes MAP easy to deploy, this technology is built into hardware and software, making it ideal and better solution for a better internet experiences, traffic is delivered more efficiently , IPv4 addresses are easily traceable without state sessions at the boundary router which lowers the cost and enhances geo-location and geo-proximity identification, optimizing network content delivery.

4. Map:

Map [15] is an open source repository supports both MAP-T and MAP-E and can be configured with or without NAPT44 function. This software is also compatible with AFTR of DS-Lite and NAT64 (stateful and stateless), this CPE implementation runs on Linux and Openwrt.

5. SNABB

SNABB [16] is fully compatible open source software with Lightweight 4o6 that has a large binding table with high performance, it consists mainly three elements: APP (Filter, LwAFTR), Programs and links to connect applications together. The 3rd version of SNABB supports YANF IETF. The 4-th version of SNABB supports RSS (Receive Side Scaling) ,multiprocess and YANG Alarm Module.

6. AFTR

AFTR [17] two sources for these implementations were needed: a licensed software tunneling IPv6 through a tunnel broker and an open source one from ISC, in this implementation CGN (DS-Lite AFTR) must be available..

IV. Plans for Future Research

By carefully studying the most five prominent IPv4aas technologies, collecting the available software implementations; my next step is a comprehensive comparative analysis according to some aspects such as security, performance efficiency, which will be done through experiments. I will be trying out those technologies for a better understanding by measuring the performances of their most important implementations according to RFC 8219 [18].

Conclusion

I came across the necessity of deploying IPv6 technologies, have given an overview of the five IPv4aas technologies, their mechanism advantages and disadvantages and their most important implementation cases.

Acknowledgment

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