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Shaw Communications IPv6 Deployment

Developing Company Momentum

A Technical Paper prepared for SCTE/ISBE by

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Introduction

Despite a decade of conferences, papers and seminars dedicated to the subject, IPv6 deployment remains mixed amongst MSOs in 2017.

Most technical staff now have the knowledge, desire, and good reasons for deploying IPv6. However, an organization's culture and processes may remain as obstacles. By both realigning one's IPv6 deployment to meet the immediate needs of their business, and understanding how things are most effectively done in their own organization, they can overcome these hurdles and make better progress.

This document is intended for technical audiences, who benefit most from this information.

Background

Devices on the Internet must be uniquely addressed and use common protocols in order to communicate with each other. Without this, users would not be able to reach some or all other users and sites.

IPv4 is the addressing protocol used on nearly every device on the Internet. Deployed in 1983 [1], it was never intended to be used on a network the size of today's Internet. Problems include:

- The central body for address management has already allocated all available IPv4 addresses [2].
- Large MSOs have already exhausted their internal-only address allocations, and many have resorted to using non-advertised space on the Internet, hoping that it will not be repurposed.
- Address allocation for infrastructure must be carefully allocated. A network that grows outside of its original purpose may need to be painfully readdressed.
- Merging internal networks from two companies is generally impossible without mass-readdressing.

IPv6 was introduced to address these problems, including nearly unlimited address space [3]. Devices can be addressed with both IPv4 and IPv6 address (Dual-stack) which allows compatibility with both IPv6-only and IPv4-only devices. Multiple private networks can be merged without readdressing [4].

While IPv6 is becoming increasing important with the growth of the Internet, the adoption of IPv6 for both internal and Internet use has been mixed, however. Reasons include:

- Adding IPv6 to one's Internet customers has limited business value in 2017. Websites and Internet services will continue to have IPv4 addresses for the foreseeable future, until the number of Internet users with IPv4-only connections becomes very low.
- Adding IPv6 to one's own website or Internet service also has had limited business value as IPv6-only Internet users are virtually nonexistent. Organizations may still choose to add IPv6 to their sites for altruistic reasons or as a form of positive advertising to other technical users, but only a minority of the top 1000 sites on the Internet have done so as of this paper.

- IPv6 does not solve the IPv4 exhaustion problem that MSOs face, although it may be part of its solution.
- Deploying IPv6 means additional costs, including:
    - Costs and time to replace hardware to support it
    - Costs and time to update firmware and software versions to support it
    - Upgrading resource assurance and resource inventory systems to support it
    - Training for operational and support staff

Organizations such as the Internet Society and Google have tried large-scale events and conferences to encourage adoption [5] [6]. These have been partially successful, however as of January 1 2017, Google reports that only 16.5% of its users are using Native IPv6 connections [7].

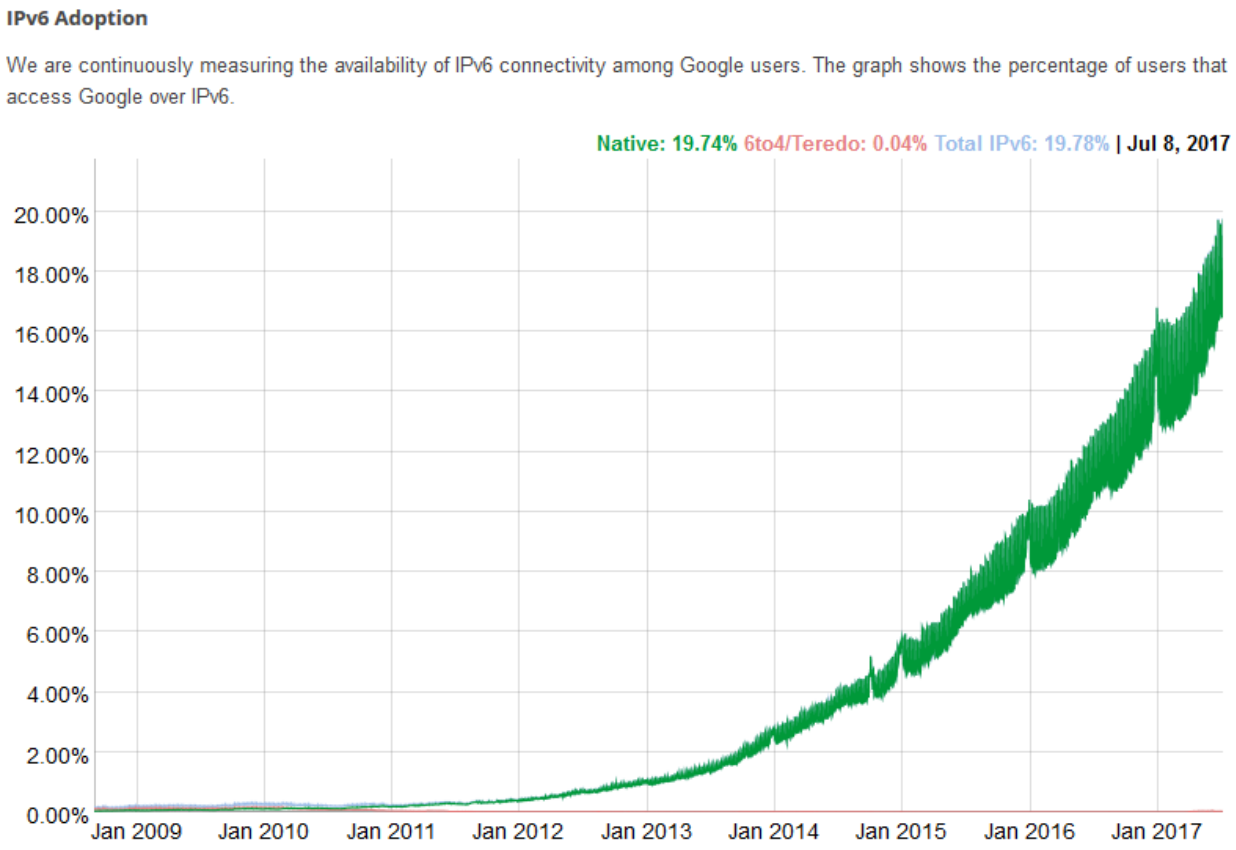

Figure 1 - Percentage of users that access Google over IPv6 [7]

Internet IP exhaustion aside, there are still many other useful reasons for an organization to start using IPv6 now.

Shaw Communications began its IPv6 deployments in 2009, starting with IPv6 on its backbone and enabling IPv6 transport on its caching and authoritative DNS systems in 2010.

In 2012, Shaw's next project was to deploy IPv6 to its customers. The project was widely supported by its network, broadband, activation and operational teams. However, during a change event in the production field trial, there was an outage with light impact. The project members were asked why they were doing the change event, and the reasons given were "We're running out of IPv4 IPs" and "We need to future-proof our network". It was determined that these reasons were not enough to justify the risk, and the project was postponed.

Shaw instead focused its IPv6 efforts internally, moving its CMs to IPv6 management addresses, and identifying ways that IPv6 would assist its future projects, such as with its BlueSky video product and partner-managed eRouters. Each of these projects had easily quantified benefits for using IPv6, and would also bring Shaw closer to deploying reliable dual-stack Internet service.

Potential IPv6 deployments

IPv6 Customer Internet may be the goal as laid out by the Internet Society and Google, but for most MSOs, this represents a lot of work for very little business value, at least in 2017. Very few residential customers base their choice of Internet over it. It also does not directly solve the problem of IPv4 exhaustion – that requires different work that may or may not use IPv6.

However, technical staff may find greater success in deploying IPv6 in other areas and in smaller projects which have more quantifiable value. Doing so not only makes their infrastructure easier to manage, but will close the gap on the work needed for larger projects like IPv6 Customer Internet, making that decision much easier to justify.

There are many ways that IPv6 can be used in an organization to give value to its customers, enable new architectures, or simplify management. In an organization where IPv6 usage has been slow, or work must be justified with benefits understandable by one's management, one could consider some of the following options:

1. Network support

Having knowledge and support for IPv6 on a MSO's network is a prerequisite for any deployment.

Shaw Communications was able to justify this work due to demand for IPv6 service from some of its non-cable business customers. If an MSO has a direct business need for IPv6 service, then this alone can be justified as a project. Otherwise, it may need to be done as a prerequisite for another project instead.

2. Addressing for MSO-managed CPE equipment

2.1. RFC 1918 Address Exhaustion

For larger MSOs, the number of CMs, CMTAs, digital receivers and other CPE equipment may exhaust the private address space offered in RFC 1918. Even before this happens, the MSO will need to carefully portion out space and perform frequent changes to reallocate it.

The MSO may commandeer public IPv4 address space that is not currently advertised on the Internet, and hope that it does not get used and that its users do not notice it [8]. A safer, simpler solution is to move many of these devices to IPv6. All DOCSIS 3.0+ and some DOCSIS 2.0 modems can be addressed with IPv6. Very old CMs and older embedded devices may not support it, but IPv4 and IPv6 devices can coexist.

Moving all devices to IPv6 is not necessary; only enough that IPv4 address allocation is no longer a problem.

Shaw Communications chose to move all of its non-EOL CMs to IPv6 management addresses. This frees up address space under 10.0.0.0/8, allow rehomes to be done more easily, and to allow modern CMs to be accessed by vendors for future projects.

If a MSO is suffering from this particular problem, IPv6 should be strongly considered as both a solution and also an ideal means to introduce its staff to the technology.

2.2. Network access requirements

Conversely, a MSO may have a need to provide network access to some devices; to a vendor, partner or other entity, which otherwise does not require Internet access.

Doing this with IPv4 may be impractical due to security and/or use of scarce public addresses. IPv6 may be a better solution to these problems, in either a single-stack or dual-stack configuration.

Shaw Communications deployed its BlueSky product single-stack on IPv6. Amongst other benefits, this allows regional IP address definitions to remain static.

3. Infrastructure management

DNS, DHCP, activation and provisioning systems will need to be addressed with IPv6 to have these services.

However, one may also choose to use IPv6 on some or all management networks. This greatly simplifies network management, eliminates the problems with subnetting, and allows any number of virtual servers to be quickly created or destroyed on a given network. While addressing servers is straightforward, changes are needed to the network, resource inventory and resource assurance systems.

Shaw Communications deployed this support in stages, starting with the minimums to support IPv6 servers, and expanding as additional IPv6 systems were required.

4. Caching DNS transport

Addressing an MSO's DNS caches with IPv6 can allow it to reach other IPv6 authoritative servers, and/or allow IPv6 clients to reach it.

IPv6 support in both DNS products and servers is extremely mature [9]. The incremental work needed to implement this change is very small, if the MSO is able to build and support IPv6 servers. By itself, it will increase the reliability and speed of the cache by increasing the number of sources it can get data from. Shaw Communications justified its change based on this benefit. The real value of this change is its ability to serve DNS to IPv6 clients, which is a prerequisite to other deployments.

5. Authoritative DNS record and transport

Like DNS caching, the incremental work to add IPv6 support to authoritative DNS systems is small [9].

This change would be necessary if authoritative DNS systems are needed in IPv6-only networks with IPv6-only caches, or IPv6-only devices that do not use a cache. This is not common but such a need may exist.

A MSO may instead do this for positive perception by the Internet community and its customers. Internet IPv6 authoritative servers are visible to the Internet, and adding IPv6 hosting to one's domains is far easier than adding it to one's Internet customers.

Shaw implemented this in 2010, to both increase the visibility of its servers, and to gather data about how Internet DNS caches use IPv6.

6. Customer Internet through eRouter

In 2017, modern mobile and computer operating systems have very mature support for dual-stack IPv4 and IPv6 configurations. Most services on the Internet with IPv6 enabled are not expected to pose problems.

The reliability of dual-stack IPv4/IPv6 eRouters does vary enormously, however. Each model will need to be tested, and one should expect to stage their deployment by device type. One's testing should include how the device blocks incoming IPv6 traffic to its internal network, what size of prefix(es) the

device requests, how the user can selectively allow traffic in, and how the device gracefully readdresses its internal network when there is a change to its prefix delegation.

One will also need to do detailed testing of how performance will change when a device is made dual-stack, as dual-stack customer devices will generally prefer IPv6 when it is available. APNIC has released data comparing IPv4 to IPv6 performance with loading website images, showing that IPv6 is generally faster [10] [11]. But, a more detailed report showed that YouTube performance was poorer over IPv6. The report cited several reasons, including the time needed for the O/S to determine the appropriate protocol [12]. Shaw's investigations in 2017 on its network revealed that performance does vary from site to site, but on average, IPv6 is slower. Shaw views this as an obstacle to overcome, and not an inherent flaw with IPv6. One should do similar testing on their own network and ensure that all on-site CDN caches are dual-stacked prior to putting customers on IPv6.

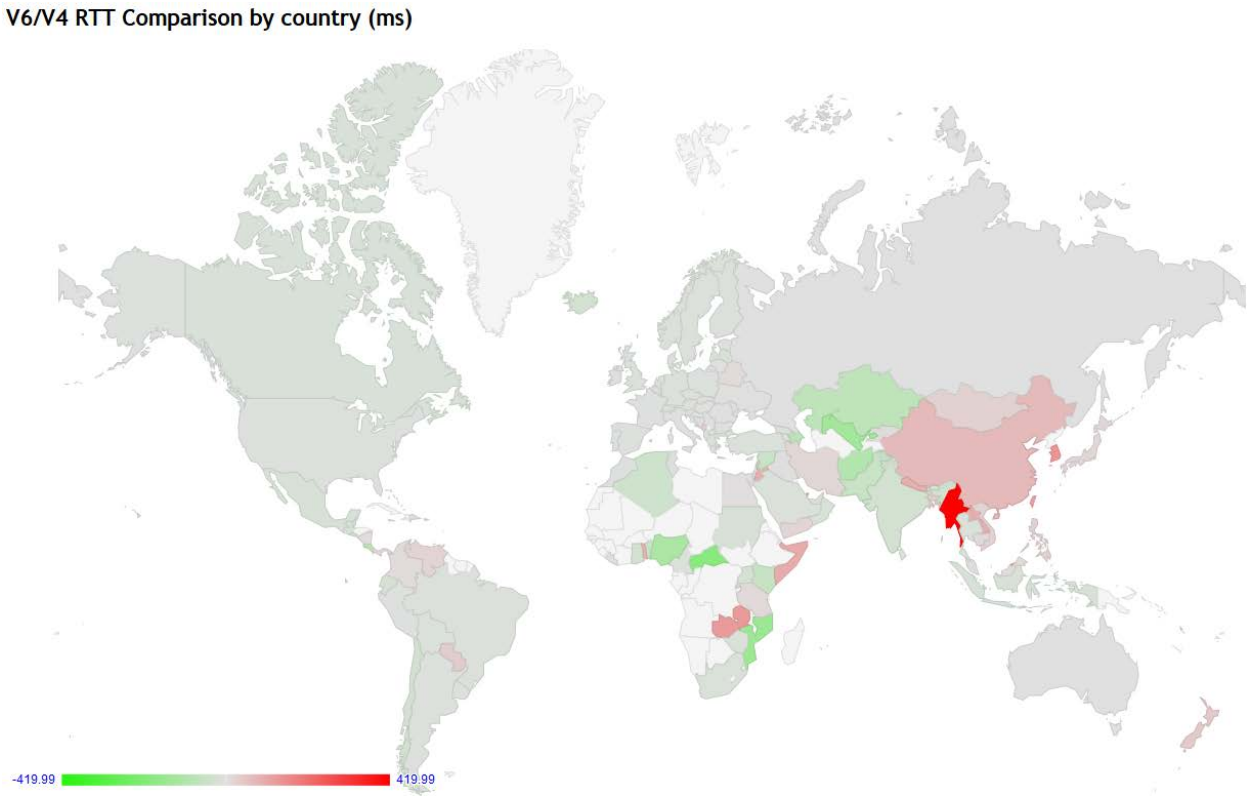

Figure 2 – V6/V4 RTT Comparison by country (ms) [11]

Significant training of frontline staff with IPv6 is also required.

Shaw's provisioning and activation systems can support dual-stack CPE devices as of this report, but deployment has been limited to due concerns with customer experience, eRouter support, and lack of need.

7. Customer Internet without eRouter

A MSO may want to delay supporting 3rd-party devices until it is comfortable with its deployment of dual-stack enabled eRouters.

At the time of this paper, many third-party eRouters do support dual-stack, but not all do it reliably or securely. One's frontline staff must be experienced enough with IPv6 to accurately determine if a problem lies with the customer's device or elsewhere.

Shaw has not extensively tested consumer eRouters.

8. Enterprise network

Addressing one's corporate LANs allow staff members to more easily access and test IPv6 devices.

Moreover, it gives all of the company's staff detailed exposure to the technology.

Shaw has not pursued IPv6 on its Enterprise network.

9. Others

This list is far from exhaustive. IPv6 is not a service- it is a tool. It can be used to make something new easier to build or something existing easier to manage.

Conclusion

An engineer wishing to introduce IPv6 into its network should remember the following:

1) **In order to get engagement and momentum in the company, one must understand the motivations and culture(s) in the company**. How important is executive buy-in vs. support of its operational teams? Or do things get done by having many managers come to a consensus? How soon do benefits need to be realized? How much autonomy do staff have?

2) **Separate components of IPv6 customer Internet into smaller projects**. They are easier to do, and some have their own benefits, and will bring one closer to their final goals.

3) **Justify each of the deployments with quantifiable benefits**. Explaining why IPv6 is needed on a residential Internet network may be difficult or impossible, but adding it to one's infrastructure may be easier.

Abbreviations

DNS	Domain Name System
DHCP	Dynamic Host Configuration Protocol
CM	Cable Modem
eRouter	Embedded Router
DOCSIS	Data Over Cable Service Interface Specification
MSO	Multiple System Operator,
ISBE	International Society of Broadband Experts
SCTE	Society of Cable Telecommunications Engineers

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