In response to the NTIA's Request for Comment I offer the following comments. I am responding as an individual, without having conferred with any organization with which I am affiliated.

I thank the NTIA for this opportunity to comment, and for its history of leadership in the Internet. I have been working directly on IPv6 transition for seven years, and indirectly for fifteen.

In response to questions about costs and benefits of the transition, I have done analysis on the alternatives to IPv6, which are essentially limited to either buying IPv4 addresses or address sharing of some form. I refer to my previous work on the Total Cost of Ownership of Carrier-Grade NAT[1] and my IPv4 Supply Analysis[2]. In addition, I worked with Jesse Sowell to compare public policy approaches to the IPv4-IPv6 transition.[3]

The IPv6 transition has three legs, each of which must be solid before IPv6 can stand without the support of IPv4: content, access, and devices.

Content is moving slowly. Only 16 of the top 50 U.S. web sites are capable of IPv6[4], essentially unchanged for nearly two years[5], and 15% of the top 25000 worldwide[6]. Recent announcements from Amazon Web Services (AWS)[7] and Microsoft Azure[8] are almost as encouraging Akamai's announcement that IPv6 is on by default for new customers[9], and that CloudFlare has enabled it for their existing customers[10]. A lot more companies need to follow CloudFlare's lead and enable IPv6 for existing web sites.

---

[1] http://conference.apnic.net/data/36/cost-of-cgn_1377486548.pdf and other links at http://wleecoyote.com/appearances.htm and http://wleecoyote.com/documents.htm
[2] http://www.wleecoyote.com/documents/IPv4-supply-analysis.pdf
[3] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=240589
[4] https://www.vyncke.org/ipv6status/detailed.php?country=us
[5] https://www.vyncke.org/ipv6status/project.php?metric=w&country=us
[6] http://www.employees.org/~dwing/aaaa-stats/
[7] https://aws.amazon.com/blogs/aws/now-available-ipv6-support-for-amazon-s3/
[8] https://azure.microsoft.com/en-us/updates/ipv6-for-azure-vms/
[9] https://blogs.akamai.com/2016/06/four-years-since-world-ipv6-launch-entering-the-mainstream.html
[10] https://blog.cloudflare.com/four-years-later-and-cloudflare-is-still-doing-ipv6-automatically/

Access networks in the U.S. are doing fairly well, with huge deployments among major mobile carriers, and major deployments from three of the four largest residential Internet providers.[11] The U.S. compares well to the rest of the world in "eyeballs" using IPv6, with 28% of users reaching Google over IPv6[12] and 33% capable of using IPv6.[13] While more work is needed among enterprise networks, there is reason for optimism among remaining large and medium ISPs.

The biggest reason more users don't have IPv6 in the home is a lack of support from retail consumer electronics. ISPs have been providing IPv6-capable modems and gateways for several years (in fact, the DOCSIS 3.0 specification required IPv6 support ten years ago). There may still be a number of older, IPv6-incapable modems needing to be replaced by ISPs. However, consumers are allowed to buy their own modems and gateways, and there is no incentive for those retail manufacturers to include IPv6 support: unlike ISPs, most consumers don't know anything about IP, and therefore IPv6 does not drive sales.

Beyond capability counts, another metric of success is how much traffic is using IPv6. With Netflix and YouTube both being major sources of traffic, and both supporting IPv6, one would expect very high levels of IPv6 traffic. But it turns out that the most common video streaming devices[14] do not stream over IPv6: Roku, Amazon Fire, video game consoles, and smart TVs have no IPv6 support. Again, the major gap is in IPv6 support among retail electronics.

The slow transition should be a particular concern for the Department of Commerce. As individual companies run out of IPv4 addresses, they will either have to buy more or deploy address-sharing translators. In either case, costs will increase, which may lead to higher prices for consumers. The address market is already tightening, with large blocks of IPv4 addresses being in short supply.

With addresses scarce, address sharing through Network Address Translators (whether NAT44 or NAT64 types of carrier-grade NAT) bring a host of concerns.

---

[11] http://www.worldipv6launch.org/measurements/

[12] https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption&tab=per-country-ipv6-adoption

[13] http://stats.labs.apnic.net/ipv6

[14] http://www.techinsider.io/the-brands-americans-use-most-to-stream-2015-11

First, some applications, such as peer-to-peer, work poorly or not at all.[15] This could be a regulatory concern, where companies may appear to be blocking P2P, in violation of Net Neutrality principles, but actually have no recourse for managing their networks. Second, address sharing means fate sharing: if an IPv4 address is blocked by a web site, either because one user did something malicious, or because the web site thought that one user was maliciously generating the traffic of multiple users, then all users sharing that address will be affected. Similarly, if a translator runs out of ports assigned to a user, some applications may fail or degrade.[16] Third, the architecture of address translators may not provide the same performance as native IP traffic, with either higher latency or lower throughput experienced by consumers.

In addition to direct effects on consumers, the additional costs of IPv4 addresses or translators inhibits competition. New market entrants must pay more for IPv4 than incumbents. This is true in either Internet access or providing application hosting or content, and whether they buy addresses or translators.

The NTIA does have an opportunity for leadership. Countries with IPv6 regulations have generally delayed their deployments by at least a couple of years, but countries where the government has convened meetings of industry leaders to discuss the transition have accelerated their deployment. Multiple agencies are involved, so the NTIA should work with the FCC and Justice to convene a series of meetings to discuss methods to advance the adoption of IPv6.

The NTIA should take the lead in convening representatives from major Internet companies and stakeholders, including other government agencies and civil society. The goal of such a meeting or meetings is to work together to minimize the distress to consumers during the transition. Based on experiences in other countries, and examples such as World IPv6 Day, it seems likely that collaboration can advance the public's interest, with representatives from each segment (content, access, electronics) providing incentives to the others to accelerate support.

Again, I appreciate the NTIA's past leadership, and I hope it will continue to work with industry to advance the public interest.

---

[15] https://tools.ietf.org/html/rfc7021
[16] https://tools.ietf.org/html/rfc6269

Sincerely,

Lee Howard