Alexander Hickey

Professor McIntosh

University of Louisville

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Implementing IPv6 in Existing Network Designs

IPv6, or Internet Protocol version 6, is the successor of the network protocol Internet Protocol version 4, or IPv4. IPv4 was and still is a revolutionary network protocol and has been widely used for years and years. However, at some point, IPv4 will become unsuitable to adequately accommodate additional nodes or requirements of emerging applications. The number of unallocated IPv4 addresses is becoming slim, and IPv4 is becoming exhausted. There are too many existing applications using too many IPv4 addresses, and, eventually, the system will break down, and is currently in dire need of an upgrade (Fiuczynski). IPv4 is a great internetworking protocol, and has a multitude of strengths, allowing tremendous strides in the Internet and the computer technology industry as a whole, and even still directing most of the internet traffic to date (Lewis).

IPv4, or Internet Protocol version four, is the primary protocol still in use throughout the Internet. IPv4 is the networking protocol that connects users and devices to each other. Regardless of the current operating system a user has on his or her device, IPv4 provides the structural capabilities to connect with any other device on the globe. The fourth version of the Internet Protocol was introduced in 1983, the first of which to be introduced in production. IPv4 has been expanded and improved upon for decades, but with today’s global environment, IPv4 is starting to become exhausted (Lewis).

Internet Protocol v4 is sometimes referred to as TCP/IP, or Transmission Control Protocol/Internet Protocol, because even though previous versions of IP used only Internet Protocol structures, IPv4 actually uses a hybrid of TCP and IP. Most of the communications across the Internet that device users will come across use TCP. TCP allows for reliable transmission of data, and thus, lost packets can be detected and retrieved. Lost packets, once detected, can be resent to make sure that data loss has not occurred during transmission. IPv6 operates similarly to IPv4, except it is much more reliable, and is capable of an exponentially higher number of addresses. This is apparent in the fact that IPv6 operates on a 128-bit structure, in contrast to the 32-bit structure of IPv4 (Lewis).

The main issue with IPv4 today is that there is a finite amount internet addresses that have been made available to the public since 1983, because IPv4 utilizes a 32-bit address structure. Given this structure, the amount of publicly available IP addresses under version four is calculated to be slightly over 4 billion. This number has carried us for decades, but is slowly dwindling, and proper transition and implementation of a new Internet Protocol, IPv6, is running out of time. Some measures have been implemented to mitigate IPv4's exhaustion, and slow its obsolescence, like the NAT (Network Address Translation) protocol, which allows the sharing of IP addresses on a singular connected network. Even still, eventually, IPv4 will become completely exhausted, and IPv6 will need to take the helm as the primary source of Internet Protocol communications (Lewis).

The translation and implementation of IPv6 has been slow-going for the past couple decades. Many Internet service providers are reluctant to completely transition into version 6 addresses and are less likely to completely adopt the new version's structures. Therefore, IPv4 will remain the dominant Internet Protocol for the foreseeable future. This is why proper transition and implementation of IPv6 in existing network designs will be absolutely crucial in the coming years (Lewis).

A giant advantage that IPv6 has over IPv4 is the sheer number of Internet Protocol addresses that are available; IPv6 is an absolute address avalanche, easily allocating individual IP addresses to every possible computer, tablet, or smartphone on the globe, and enough for every conceivable device to come into fruition for the distant future. Every device hosted on every individual network, included personal computers, tablets, smartphones, and even printers, would be assigned a unique Internet Protocol address with IPv6, eliminating the need for Network Address Translation. The move to IPv6, however, has been more difficult than was originally anticipated. Lack of compliance from nearly every Internet service provider in the western world has made the very necessary transition to IPv6 a drag (Knights).

Even through all the translation and transition techniques for implementing IPv6 addresses into existing network structures, it may be entirely possible that, after all these years, we are woefully unprepared for an exclusive transition to IPv6. Even the world's largest vendor of networking equipment, Cisco, which has included streamlined support for IPv6 in its routers for years now, has expressed difficulties with IDS/IPS and firewall services. Safety and security for public end users may be a problem, and we may need to tread lightly in the coming years to successfully implement IPv6 in existing network designs, in order to protect Internet constituents from the woes of malevolent actors, and corrupt Internet service providers (Knights).

In order for the implementation of a new internetworking protocol, IPv6, network address and protocol translation would need to occur, because IPv6 addresses are altogether incompatible with IPv4 addresses, and implementing software that adheres to IPv6 would require existing software to make changes in every device on a certain network. Eventually, IPv6 would become one hundred percent established, and is still used to this day. However, the disenfranchisement of IPv4 and the implementation of IPv6 in existing network designs would need to run in a parallel implementation scheme, and therefore, there would need to be many trials and tribulations to make a smooth switch. This is where Internet Protocol translation comes into place (Fiuczynski).

There are two versions of IP translation between versions 4 and 6. The first version uses special version 6 addresses to easily translate incoming packets transparently across all functioning applications. The second version of IP translation explicitly maps the communications between IPv4 and IPv6 addresses, and therefore allows IPv6 routers to translate incoming packets without the need for constant maintenance on the part of the strained IPv6 routers. In both versions, already-embedded IP addresses existing within most applications in an existing network design, like FTP, would need to be updated in order for complete transparency to occur, especially in version two, because of the less strenuous state, but constant mapping of the routers (Fiuczynski).

Both forms of IPv4 and IPv6 translation enable communication between individual nodes in an IPv4 site with notes in an IPv6 site, and vice versa. The difference between the two is that version one includes mapping a global IPv4 address pool that places direct reference to IPv6 addresses, while version two has the ability to leverage private IPv4 addresses in direct reference to IPv6 addresses. The goal of these translations would be to work for real world applications, like business logic applications, using a set of programs that primarily exercise the use of TCP, ICMP, and UDP protocols. Again, the purpose of the translations was not to create a subspace where IPv4 and IPv6 addresses could securely exist coincidingly, but rather, to create a temporary subspace where IPv4 and IPv6 addresses could effectively communicate until IPv6 addresses could be fully rolled out and implemented in existing network designs, and successfully replace IPv4 addresses in full. Translation and parallel implementation occurs simultaneously to achieve the least amount of data compromise and the most least amount of service disruption as possible, all while making the inevitably necessary switch to exclusive IPv6 use. (Fiuczynski).

The simple implementation of the transition phase of IPv4 to IPv6 starts with the individual nodes. To get a better sense of how the nodes function in this parallel functionality, it is conventional to refer to node notation. In standard node notation, nodes are denoted as IPxNODEy, where x is the version number, either four or six, and y is the number for which version the node is from. For example, a node with an IPv6 address directly referring to an IPv4 node would be denoted as IP6NODE4. From here, it is easy to see the process of mapping and address binding, with Key-to-Value node notation, like the following: IP6NODE4-toIP4NODE4, which denotes an IPv6 address statically mapped to an IPv4 node address (Fiuczynski). This is the fundamental process behind translation between the IPv4 and IPv6 protocols and is crucial to the ultimate overtaking of IPv6 amid IPv4 exhaustion. The translation of TCP/IP enlisted in the services of ISP's has done a sufficient job of extending IPv4's shelf life, but does not negate the overarching issue.

Short term solutions like translation are necessary because there is simply not enough time to fully migrate the entire Internet to IPv6 addresses, where end users exclusively communicate through IPv6. According to the American Registry for Internet Numbers, approximately 2.73% of all IPv4 addresses are still publicly available (Cannon). Furthermore, As of June 2012, the total number of discoverable website hostnames was almost 700 million (Dooley). Transitions and translations require a significant investment in time and money, and there is insufficient time to completely transition into IPv6 with IPv4 exhaustion looming. Over time, IPv6 could (and should) become a much more useful, more flexible mechanism for which end users communicate with each other on a day-to-day basis. The remodeled header structure of IPv6 and its advanced capabilities would also simplify configuration, leading to smoother operation of certain networks and services, and ultimately greater cost savings. Also, auto-configuration features in IPv6 could allow computers and smartphones easier access to the Internet (Cannon).

The costs of transitioning fully to IPv6 are surmounting and could be problematic. Costs would be something to consider in regard to the renumbering of networks, the running of two separate networks simultaneously (as we have now, with IPv4 and IPv6), the upgrading of relevant software applications and necessary hardware, the training of staff members, and the implementation testing. In a report constructed by the National Institute of Standards and Technology in 2005, it was found that 25 years would need to pass for total transition into IPv6 addresses could occur, and at a cost of roughly $25 billion. Catastrophically, it is presumed that we will run out of IPv4 addresses long before then (Cannon).

Luckily, the National Institute of Standards and Technology also found in this report that the benefits to the modern economy with fully migrating to IPv6 addresses could be upwards of $10 billion per year, in contrast to the indicated costs of slowly investing and implementing it, which would be about $1 billion per year. Not to mention, the NIST found that the $25 billion spent over the course of 25 years would attribute to less than %1 of total existing network design and infrastructure spending. In addition, the Federal Communications Commission found no barriers to transitioning to IPv6, and therefore, there would be no reason to governmentally force such a transition on private Internet service providers; they have an advantage in choosing to do so themselves. (Cannon). Using a simple cost-benefit analysis, it becomes intuitively obvious that the benefits far outweigh the costs, and Internet service providers should consider ramping up transition efforts.

Overall, with the looming threat of IPv4 becoming totally exhausted, it is in the best interest of everyone, including end users and Internet service providers to make more efforts to implement IPv6 in existing network designs, and to fully make the switch within the next decade. The amount of available IPv4 addresses is slim, and growing slimmer, and time is running out for a full transition. We can only benefit from fully operating on IPv6 Internet Protocol addresses.

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