Towards IPv6 Migration and Challenges

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ABSTRACT

The Internet, since its genesis in 1970’s, has already become a global broadcasting potential for information dissemination and a channel for information collaboration and an interface between disparate users and their systems, separated by large geographical locations. The rate of growth of interconnected devices has been on exponential scale from the last decade. As of now, more than 5 billion devices are accessing the Internet. The Internet Protocol Version 4 (IPv4) which is a three decade old standard internetworking protocol using 32-bit address, fails to cater such a large number of hosts. In February 2011, the Internet Assigned Numbers Authority (IANA), the nodal agency for IP address allocation exhausted the central pool of IPv4 addresses completely. This rapid depletion of IP addresses was inevitable as a large number of devices are getting connected to internet. Also, inefficient utilization and remiss planning of IP address space acted as catalyst in the process of depletion. NAT, CIDR and Subnetting only serve as short interim solutions provided by IPv4. Moreover, IPv4 fails to scale up and bridge the security enhancements required by the modern Internet today. The only feasible option lies in unabridged transition to IPv6. Internet Protocol Version 6 (IPv6) provides an address space of \(2^{128}\) i.e. trillions of addresses, making the IP address space potentially inexhaustible. Thus, adopting IPv6 makes a paragon choice of replacement for IPv4. This article reviews the next generation internet protocol IPv6 and explicates the discussion over the need for migrating to IPv6. The article also presents technical as well as non-technical challenges related to migration and presents overall statistics regarding IPv6 adoption around the world.

KEYWORDS
CIDR, IANA, IPv4, IPv6, NAT, RIR

1. INTRODUCTION

Internet Protocol Version 4 (IPv4) since its genesis has been pervasive even in today’s operational networks. The IPv4 protocol enabled the hosts to send packets to other hosts having a unique address. However, it was never designed to scale millions and billions of hosts online. The contributing factor in address depletion has been exponential increase in internet ready devices and origin of broadband wireless networks (Chen & Liao, 2017). The three decade old protocol with a limited address space cannot scale up to the ever demanding needs of present day internet. This limited address space got exhausted and raised an alarming issue over the growth of internetworks.

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In late 80’s, IETF came up with the idea of using temporary internet patches like CIDR (classless inter-domain routing) and NAT (network address translation) for internet continuity. But in 1992, CIDR (classless inter-domain routing) design was put into operation and the number of internet nodes surpassed over 100,000 (Rekhter & Li, 1993; Fuller et al., 1993). Thus, these short term antidotes failed given the ever expanding nature of internet. Also, being an obsolete protocol, the distinct attributes like mobility, security and QoS (Quality of Service) were supplemented by retrofitting such characteristics in IPv4. For example, Internet Protocol Security (IPsec) provides security for IPv4 packets at the network level using encryption mechanism. As IPsec is not an inherent component in IPv4, its implementation has compatibility issues with NAT (Kent & Seo, 2005). Although IPv4 ToS (type of service) and identification attributes provide support for real time data, but its implementation has a limited domain (only 8 bits). Also the term ToS has been polished over a number of times. IPv4 has also issues in payload identification when encryption is used on a TCP or UDP port address.

IETF in 1992 came to the conclusion that IPv4 was on the verge of exhaustion. The Internet Engineering Task Force (IETF) soon started the process of searching a more flexible solution by creating a temporary adhoc IP Next Generation (IPng) group to address the problems and issues of next internet protocol version. Consequently, a white paper solicitation was released for the Next Generation Internet Protocol which was followed by the release of several RFC’s related to IPv6 (Bradner & Mankin, 1993). Thus, after an exhaustive research and owing to the problems of address depletion, a new version of IP known as IPv6 was proposed and designed (Rekhter & Li, 1993).

In the initial stage, a migration from IPv4 to IPv6 was visualized which will help IPv6 hosts to maintain connectivity and reachability with IPv4 hosts (Gilligan & Nordmark, 2000). When an entire transition occurs, IPv4 will automatically be wiped out. However, given the current statistics, the migration to IPv6 is still underway. In fact, it is still in its initial stages as only average 7% of world population is using IPv6 as per Google 2015 statistics. It’s well understood that transition to IPv6 will be slow and gradual process overtime. The main rationale behind this being the massive deployment of NAT devices in enterprise and home networks which have acted as delaying catalyst in migration process. In fact, some people envisioned that the migration might even not occur. However as on Feb 3, 2011, the last block of IPv4 address space was allocated by the IANA (Internet Assigned Numbers Authority), thus declaring end of IPv4 addresses (Chen & Liao, 2017). Thus, adopting IPv6 makes an unblemished choice of replacement for IPv4.

2. INTERNET PROTOCOL VERSION 6 (IPV6)

Internet Protocol version 6 (IPv6) or IP next generation is the successor of IPv4. The protocol is viewed as a decisive step forward by IETF after foreseeing the depletion of IPv4 address space. IPv6 supports an 128 bit address format and supplements an address space of $2^{128}$ (approximately $3.4 \times 10^{38}$) addresses, i.e. more than sufficient to cover theoretically every internet ready device on earth with a global unique address (Dunn, 2002). The huge address space also provides flexibility for every node in the world to remain connected to the internet. The protocol also abolishes the requirement for NAT and enhances connectivity, reliability and flexibility of the network. The major objectives of IPv6 were to dispense huge address space, enhance security element in the protocol and support for real time traffic. IPv6 treats IPsec as an intrinsic element unlike that in IPv4 where it was retrofitted and optional. A new field Flow Label has been introduced to support Payload identification (used in QoS) in IPv6 packet. The idea of fragmentation has been dropped. The extension headers part takes care of the checksum and option in IPv6. Also, IPv6 introduces “stateless” auto configuration which is one of the design goals and thus eliminates the cumbersome manual configuration of IP or DHCP. Lastly the size of packet header has been increased from 20 byte in IPv4 to 40 byte in IPv6 (Chen & Liao, 2017).