A Novel Survey on Next Generation Networks- A study for IPv6 Deployment in India

Varsha Jain*, Dipti Chauhan**, Prof. Damodar Tiwari***, Jay Kumar Jain**** and Dr. Shishir K Shandilya*****
* M.Tech Student, Bansal Institute of Science & Technology
its.varsha16@gmail.com
-** Assistant Professor, MANIT, Bhopal
Email: dipti.chauhan09@gmail.com, jayjain.research@gmail.com
*** Assistant Professor, Bansal Institute of Science & Technology
damodarptiwari21@gmail.com
*****Bansal Institute of Science and Technology, Bhopal

Abstract: Internet Protocol IPv4 has met the demands of the years, but the number of addresses, while Large, finite solution to reduce this problem was the development of new IPv6 protocols using a 128-bit address instead of a 32-bit address. In addition to addressing limitations to address, IPv6 has several streamlined features. This research is centered around IPv6 deployment in the our country India and shows the IPv6 adoption rate by various public & private sector organizations. The objective of this survey paper is to highlight issues related to IPv6 deployment and to see the IPv6 transition mechanism from IPv4. In addition, IPv6 provides insights on global efforts around the world to contribute to the deployment. Also, identify potential solutions or suggestions that could improve the IPv6 deployment rate. In order to achieve the said objectives, we survey the number of papers on IPv6 deployment from different countries and continents. The deployment of IPv6 is essential to avoid reaching this situation, and it is the only practical solution to IPv4 exhaustion.

Keywords: Dual Stack, IPv4, IPv6, Network Address Translation (NAT), Tunneling.

Introduction

Internet usage is increasing over time and this growth is exponentially increasing day-by-day. It has undoubtedly become a huge part of our lives. Many people in today's generation are relying in the internet to do a lot of different tasks such as: social networking websites, search engines, video calls and many more to access these services; People use internet-connected devices such as computers, mobile phones, personal digital assistants (PDAs). All of these devices are communicating with each other through the network using the Internet Protocol (IP), where each device has been assigned a unique IP address. Internet Protocol Version 4 (IPv4) is the fourth amendment to the development of Internet Protocol (IP) and is one of the most widely used internet layer protocols [1]. It is a connectionless protocol that is used for packet-switched link layer networks. It operates on a best effort delivery and uses 32-bit addressing and can cover 4.3 billion addresses. However, IPv4 addresses have been depleted due to the increasing number of devices using the Internet and upcoming technologies, In addition to this there are several major weaknesses in IPv4, like Security, Network congestion, Packet Loss, Data priority etc due to which there will be difficulty in the development of the Internet [2]. Due to lack of IPv4 address the Internet Assigned Number Authority (IANA) pool of unallocated IPv4 Internet addresses got completely emptied on 3 Feb 2011 and the Regional Internet Registries (RIRs) unallocated IPv4
address pool exhaustion date is predicted a month or two on either side of 1 July 2011 [3]. The shortage of IPv4 address space is anticipated long back and different techniques have been introduced to extend the life of the existing IPV4 infrastructure, including Network Address Translation (NAT), Dynamic Host
Configuration Protocol (DHCP), and Classless Inter-Domain Routing (CIDR) [4]. IPv6 is the next generation internet protocol, will eventually replace IPv4. IPv6 offers a large address space than IPv4. It uses 128 bits to represent an IPv6 address and can address up to 2^{128} devices which is 294 times more than IPv4. With 128 bits of IPv6 address allow with some 340 trillion, trillion, trillion addresses [5]. IPv6 will also solve the problems associated with IPv4 by changing the strategy for allocating addresses, making improvements to ease the routing of packets thereby enabling better routing capabilities, and making it easier to configure a machine when it first joins the network.

Despite of several advantages that IPv6 offers over IPv4, the adoption rate of IPv6 by the end users is very slow. The reason behind slow adoption is that both the protocols are not compatible with each other, i.e. an IPv6 node cannot communicate directly with another IPv4 only node and vice versa. It means a host or a router which supports only IPv4 does not forward an IPv6 packet, similarly IPv6 only hosts cannot communicate with IPv4 hosts & routers [6]. IPv4 network will be into the play for a long time, but due to the address depletion problem it is impossible to sustain with IPv4. Therefore, IPv4 and IPv6 will

coexist for a long period, and the transition process will be gradual. During this time transition stages comes into the play. Different technique shave been proposed from the past to enable the smooth interoperation of the two protocols. The existing transition techniques for transitioning a network from IPv4 to IPv6 includes: Dual Stack, Tunneling, and Translation. Figure 1 depicts these techniques.

The rest of the paper is structured as follows: Section 2 discusses the advantages of IPv6 over IPv4 protocol. Section 3 discusses about the header formats for both the protocols. In section 4 the IPv6 adoption rate by our country India is discussed. Section 5 discusses the issues & challenges of IPv6. Section 7 presents our concluding remark.

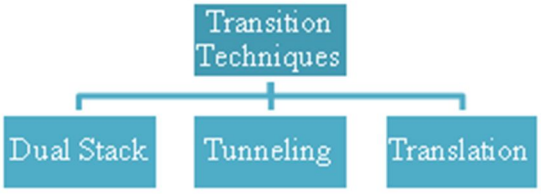

Figure-1 Transition Techniques

Benefits of IPv6 over IPv4

IPv6 offers several benefits as compared to IPv4 those are listed below-

1. Huge Address space: IPv6 provides a much larger address space than IPv4. 340 trillion, trillion, trillion addresses are allowed from the 128-bit IPv6 address. With such a large number of addresses, the requirement of the NAT effectively ends.
2. Better header format: IPv6 allows extension for new options by introducing a new header format. Now with this format processing of IPv6 packets is much simpler than IPv4. In IPv6 extension headers are not processed by every router except hop by hop option and the checksum field is also eliminated from the header, thus making processing simpler [7].
3. Support for more security: There was no concern when IPv4 was given security, although with IPv6, the IPCC was built in the protocol with an appropriate key infrastructure. IPSec provides privacy, authentication and data integrity, which is cooked in IPv6 [8].
4. Better routing: IPv6 reduces the size of the routing table and makes routing more efficient and hierarchical. IPv6 allows ISP to collect its customers' network prefixes in the same prefix, and IPv6 announces this prefix on the Internet. In addition, in the IPv6 network, one for the search of the maximum transmission unit of the path Using the protocol, the fragmentation is managed by the source device instead of the router.
6. Support for mobility: IPv6 provides better support for mobility by providing Route Optimization (RO) mode which sanctions the packets to be sent directly between the mobile node and the correspondent node, with the avail of home agent only in the initial phase. Utilizing RO the shortest path for communication can be utilized, thereby elimination the congestion at the home agent [9].
7. Efficient Packet Processing: Packet processing is simplified in IPv6 as compared with IPv4 as most of the header fields are either abstracted or shifted in extension headers, like checksum field is eliminated from IPv6 header, so there is no desideratum to recalculate it at every router hop. Checksum is eliminated since most link-layer technologies already contain checksum and error-control capabilities. Withal all the fragmentation fields are eliminated from the IPv6 header and shifted in the fragmentation header of IPv6.
8. Auto Configuration: The address is a built-in feature of the self-configuration IPv6. For 64 bit of a host local link prefix, expanded Unique Identifier (EUI) can convert to 64-bit format, by creating its own IP address by adding its MAC address. IPv6 offers three types of auto configurations - Stateful, Stateless and both [10].

Despite of numerous advantages that IPv6 offers over IPv4, the adoption rate of IPv6 by the end users is very slow. The main reason behind slow adoption of IPv6 is that both the protocols are incompatible with each other and the header overhead involved with IPv6 protocol. The main issue evolved with both the protocols is different header format, IPv6 uses different header than IPv4 and the size of IPv6 header is double the size of IPv4 [11]. The IPv4 header is of variable length of 20 bytes when no option is specified and can be up to 60 bytes with options specified, and IPv6 uses a fixed length header of 40 bytes. This header overhead could affect the performance of network especially over ad-hoc networks which have limited resources [12]. The following section discusses the header formats for both the protocols.

Header Formats IPv4 and IPv6

When studying IPv6, one of the main things that differs from IPv4 is the complexity of the IPv6 header compared with that of its predecessor's header. The IPv6 header was designed to be less complex and easier to process than the IPv4 header, and with efficiency as one of the main design elements. One of the main reasons for the incompatibility of the two protocols is that IPv6 is having different header than IPv6. The IPv6 header has been streamlined for efficiency. The new format

introduces the concept of an extension header, allowing greater flexibility to support optional features [13]. The processing of IPv6 header is very convenient as compared to IPv4 as it involves fewer overheads [14]. Figure-2 shows the header formats for both the protocols Version: This field is used to specify the version of protocol: 0100 in case of IPv4 and 0110 in case of IPv6.
Header Length: This field specifies the length of header in case of IPv6. It is not the part of IPv6 header since IPv6 header is of fixed length 40 bytes.

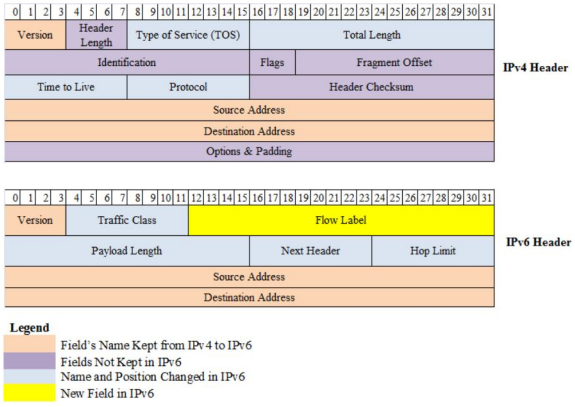

Figure 2: IPv4 & IPv6 Header Comparison

Type of Service: This field specifies the quality of service desired for the datagram, i.e. it tells the datagram's priority and request a route for low-delay, high throughput, or highly-reliable service. It serves the same purpose as IPv6 Traffic Class field.
Total Length: This field specifies the total length of the datagram including the header. This field was replaced by IPv6 Payload Length field, which only indicates the size of the payload.
Identification, Fragmentation Flags, Fragment Offset: These fields are related to fragmentation and reassembly of an IPv4 datagram. All these fields are removed from IPv6 header and moved to fragment extension header.
Time to Live (TTL): This field specifies the life of a datagram in the network, and is decremented with every hop in the network. Datagram was discarded when the value of TTL becomes zero. This field was replaced by Hop Limit field in IPv6 Header.
Protocol: This field specifies the upper layer protocol that uses the services of the IPv4 layer. This field was replaced by Next Header field in IPv6 header.
Header Checksum: This field specifies the error at the header level, i.e. checksum in the IPv4 packet covers only the header, not the data. This field is removed from IPv6 header since, bit-level error detection for the entire IPv6 packet is performed by the link layer.
Source Address: This specifies the source address of 32 bits in case of IPv4, and the field is same except that IPv6 addresses are 128 bits in length. Destination Address: This specifies the destination address of 32 bits in case of IPv4, and the field is same except that IPv6 addresses are 128 bits in length.
Options: This field specifies the options, for the IPv4 datagram. They can be used for network testing and debugging. This field is removed IPv6 and is replaced by IPv6 extension headers.
Flow Label (IPv6): This is a new field in IPv6 header which is not a part of IPv4 header. A flow label can be used to speed up the processing of a packet by a router. This field specifies the special handling of packets for the same flow.

IPv6 Deployment status in India

IPv6 forum was formed in July 1999 as a step towards the deployment of IPv6 across the globe. The mission of this forum is to educate Internet users on the advantages of the IPv6 protocol, and to promote and implement the worldwide deployment of this protocol [15]. The current status of deployment of IPv6 in different parts of the world is very encouraging and gives an idea of what the future holds for the Internet in the coming years. In Jan 2016, Google measured IPv6 adoption at reaching the 10% deployment mark [16]. Services like Google and facebook are currently available via IPv6, and several large ISPs, telecommunications and web service providers are actively migrating.IPv6 deployment is increasing around the world, with over 9 million domain names and 23% of all networks advertising IPv6 connectivity. As per the latest report Reliance Jio boosts India past 20% IPv6 capability [17]. Almost 90% of our LTE 4G subscribers are using IPv6 – accounting for almost 70% of the country's IPv6 traffic – which in itself has equated to a rapid rise in India's total IPv6 capabilities, increasing from 1% to 16% in 2016. These graphs show the evolution of default protocol, v6 address types, and average bandwidth in

India over time. They are generated using the data collected by the ipv6-test.com connection test page, and are updated on a monthly basis. As per the recent statistics the overall IPv6 support by June 2017 is 28.9% and that of IPv4 is 96% [18]. Figure 3 shows Overall IPv6 and v4 protocol support in India.

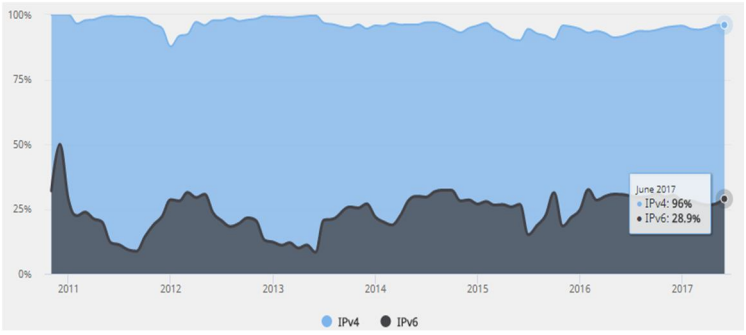

Figure 3: IPv4 & IPv6 support in India

This graph shows the evolution of IPv6 support vs IPv4 for our entire connection test. The numbers are percentages, so we can expect almost 100% of hosts supporting IPv4 with a slow growth for IPv6. IPv6 Test counts for Top 25 internet service providers for IPv6 in India (Jun 2017) [18] is shown in table 1.

Table 1: Top 25 internet service providers for IPv6 in India (Jun 2017)

S.No	Internet Service Provider (ISP)	IPv6 tests count
1	Reliance Jio Infocomm Ltd	1,495
2	Bharti	119
3	Google-corp-apac	106
4	Tata Teleservices Limited Isp Division	53
5	Bharti Airtel	45
6	STPI-Kolkata	41
7	Idea Cellular Limited	41
8	Hurricane Electric	40
9	Sifynet	33
10	Reliance-communications	27
11	Rjil Internet	25
12	Reliancejio	24
13	Bsnlnet	23
14	Set R4G TRAIL	22
15	BSNL Internet	21
16	Netmagic	18
17	Ttsl Cdma	16
18	Msft	15
19	Nicnet	14
20	RIL Infotel	14
21	Tatacomm	13
22	anuragbhatia.com in India	11
23	Gatik Business Solutions	10
24	2400:ea80::/32	10
25	2402:f200::/32	9

The following figure 4 shows the percentage of users who accessed IPv6 over Google in India.

Major Challenges of IPv6

IPv6 is the next generation Internet Protocol which give the internet new dimensions beyond our imagination but still it faced few challenges discussed below

1. Lack of knowledge in the field of IPv6 is one of the major challenges in the transition to IPv6.
2. Transition costs: The transition cost towards IPv6 is very costly as the devices need to be upgraded. However Network Address Translation (NAT) delayed the IPv4 exhaustion but still faced many problems.

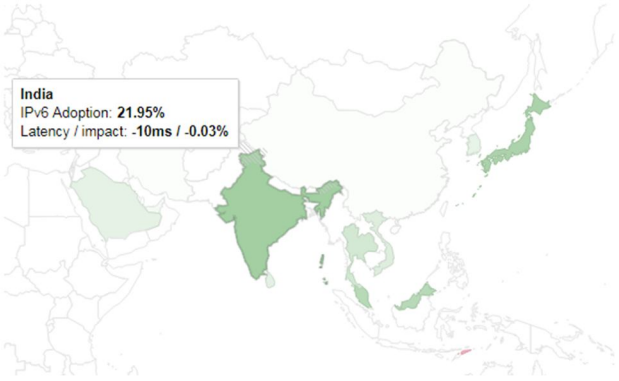

Figure 4: IPv6 over Google in India

3. Compatibility issues: The main reason for slow acceptance and usage of IPv6 is that both the protocols incompatible with each other and the change is hard and expensive. IPv6 is not backward compatible with IPv4 and IPv4 hosts and routers will not be able to deal directly with IPv6 traffic and vice-versa.

Conclusion

In this paper we have addressed the deployment issues related to IPv6 in India. It is clear that the smart choice for a long term solution to IPv4 exhaustion is IPv6. This is not a choice this is compulsion to move towards IPv6. IPv6 provides a very large address space and has many features. This protocol was designed to completely replace IPv4, but it will take several years before we fully migrate. This change is indispensable, therefore, to maintain interconnectivity between the two protocols and to maintain these protocols without any problems, to find strategies and mechanisms for transmitting on IPv6 in a modified level. It is clear that the percentage of IPv6 adoption in India is very low as compared to IPv4. Implementation and deployment of IPv6 is really a challenge, risk and costly work, but with a good plan it can be very easy and effective and choose the optimal selection of implementation tools and methods.

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