A Survey on Next Generation Internet Protocol: IPv6

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***Abstract*—IPv4 is the most dominant addressing protocol used on the Internet and most private networks today. With the advent of wide variety of devices and upcoming technologies, the limited addresses of IPv4 are not able to cope with the current internet. IPv6 was mainly developed to resolve the addressing issues as well the security concerns which are lacked by IPv4. One of the major challenges in the internet is to deploy IPv6. In the transition to IPv6, both IPv6 and IPv4 will co-exist until IPv6 eventually replaces IPv4. In this paper an attempt is being made to enlighten the importance of IPv6 in current scenario and the key reasons to deploy the IPV6, and also discusses the standards and techniques which are required for smooth interoperation between the two protocols.**

***Index Terms*—auto configuration, dual stack, ISATAP, NAT, Teredo, translation, tunneling**

I. Introduction

IPv4 [1] is the most common protocol that governs the entire communication over the internet. In the current scenario as the exponential growth of internet has led to the shortage of IPv4 addresses. 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 [2]. So, before the RIRs and ISPs may start denying requests for IPv4 addresses, the successor Internet protocol IPv6, must be deployed actively worldwide.

IPv6 is the next-generation Internet protocol that will replace IPv4. IPv6 is acknowledged to provide more address space, better address design, and greater security. IPv4 offers 32 bit address space and IPv6 offers 128 bit address space [3]. This expansion allows for many more devices and users on the internet as well as extra flexibility in allocating addresses and efficiency for routing traffic. However the two protocols are incompatible i.e. an IPv6 node cannot communicate directly with another IPV4 only node and vice versa. Different mechanisms for transition have been developed so that both the protocols may coexist. Companies such as Microsoft [4] and Nokia [5] have issued white papers on accelerating the IPv6 progress.

The shortage of IPv4 address space is long been observed , and various 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). Network Address Translation (NAT) [6] allows multiple devices to use local private addresses within an enterprise while sharing one or more global IPV4 addresses for external communications. While NAT has to some extent delayed the exhaustion on IPV4 address space for the short term, but its usage complicates general application bi-directional communication. It also eliminates the primary need for network address translation (NAT), which gained widespread deployment as an effort to alleviate IPV4 address exhaustion [7]. Due to the above said constraints, migration to IPv6 protocol requires changing the existing network infrastructure completely. In this review paper a basic study on enlighten the importance of IPv6 in current scenario after that we have discussed the key reasons to deploy the IPV6 on the basis of comparing both IPV4 and IPV6.

The rest of the paper is structured as follows: In section 2 the header formats for both the protocols are discussed. In section 3 discusses about the addressing of IPv6, In section 4 various transition techniques while migrations from IPv4 to IPv6 are discussed. Section 5 discusses IPv6 features and benefits. Section 6 discusses the Industry readiness for adopting IPv6. Section 7 presents our concluding remark.

II. Header Format and Comparision for IPv4 & IPv6

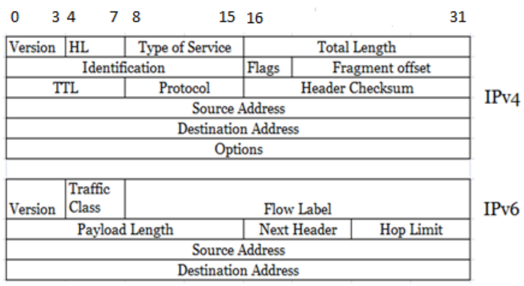

Figure 1. Header format

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With the depletion of IPv4 address space just a short time away, it is in the best interest for the network engineers to become familiar with IPv6 [8]. 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. The processing of IPv6 header is very convenient as compared to IPv4 as it involves fewer overheads. The following Fig. 1 shows the header formats for both the protocols and Table I shows the fields in the both protocols and their comparison:

TABLE I. HEADER COMPARISON

IPv4 Header Field	IPv6 Header Field
Version	Same field but with different version numbers.
Header Length	This field is not kept in IPv6 since IPv6 header is of Fixed length 40 bytes. Each extension header is either a fixed size or indicates its own size.
Type of Service	Serves the same purpose as IPv6 Traffic Class field, specifies how traffic is handled in congestion.
Total Length	Replaced by the IPv6 Payload Length field, which only indicates the size of the payload.
Identification Fragmentation Flags Fragment Offset	Removed in IPv6. Fragmentation information is not included in the IPv6 header. It is contained in a Fragment extension header.
Time to Live	Replaced by the IPv6 Hop Limit field.
Protocol	Replaced by the IPv6 Next Header field.
Header Checksum	Removed in IPv6. In IPv6, bit-level error detection for the entire IPv6 packet is performed by the link layer.
Source Address	The field is the same except that IPv6 addresses are 128 bits in length.
Destination Address	The field is the same except that IPv6 addresses are 128 bits in length.
Options	Removed in IPv6. IPv4 options are replaced by IPv6 extension headers.

III. ADDRESSING

IPv6 addresses are assigned to interfaces not to nodes. IPv6 offers three types of addresses: unicast, anycast and multicast [9]. There is no broadcasting in IPv6, this function is being replaced by multicast address.

Unicast: Unicast Address is an identifier for a single interface and is delivered to the interface identified by that interface. Load sharing over multiple physical interfaces can be obtained by assigning unicast address or a set of unicast addresses to multiple physical interfaces, if the implementation treats the multiple interfaces as single interface.

Anycast: Anycast address is an identifier for a set of interfaces, However packet sent to this address is delivered to only one of the interfaces identified by that address, possibly the nearest one.

Multicast: Multicast address is an identifier for a set of interfaces. Packet sent to a multicast address is delivered to all interfaces identified by that address.

IV. TRANSITION TECHNIQUES

IPv6 offers several benefits over the legacy IPv4 technology, however for the successful deployment of IPv6 requires both the protocols to co-exist. IPv6 is not backward compatible with IPv4 [10] and IPv4 hosts and routers will not be able to deal directly with IPv6 traffic and vice-versa. The hardware and software used to route packets across networks and that performs security analysis will not work with IPv6 protocol unless they are upgraded to versions that support IPv6 protocol. It will take years to migrate completely from IPv4 network to IPv6 network. Till then both the protocols need to be interoperated together. For both the protocols to co-exist, different transition and inter-operation mechanisms have been developed. During the transition period, IPv6 nodes are going to need to communicate with IPv4 nodes and isolated "Islands of IPv6 installations" are going to need to use the wider IPv4 network to connect to each other [11].

The existing transition techniques [12] transitioning a network from IPv4 to IPv6 includes: Dual Stack, Tunneling, and Translation. The following subsection discusses these mechanisms in detail:

Dual Stack

In dual-stack architecture, all the components of the network system should support both the protocols. Applications must choose either IPv4 or IPv6, by selecting the correct address based on the type of IP traffic and particular requirements of the communication. Currently dual-stack is the most preferred deployment strategy for the network with a mixture of IPv4 and IPv6 applications that require both the protocols. But it includes many problems like all the routers must be upgraded to IPv6 and it also requires the dual management of IPv4 and IPv6 routing tables.

Tunneling

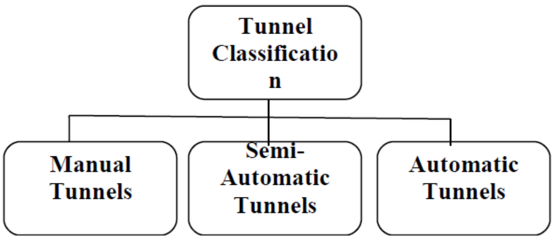

Figure 2. Classification of tunneling mechanism

Tunneling is a mechanism by which the existing IPv4 backbone can be used to carry IPv6 traffic and vice versa. The tunneling protocol carries the tunneled protocol. Tunneling can be either IPv6-over-IPv4 or IPv4 –over-IPv6 networks. In this transition period while the IPv6 infrastructure is being deployed, the existing IPv4 backbone over the network can be used to carry IPv6 packets. IPv6 or IPv4 hosts and routers can tunnel IPv6 datagrams over regions of IPv4 routing topology by encapsulating them within IPv4 packets.

Using this technique an IPv4 user can communicate with IPv6 network using the existing IPv4 network. Fig. 2 shows the classification of tunneling:

In manual tunneling mechanism the end points of the tunnels need to be specified manually where as in automatic tunneling mechanism the IPv4 address information is embedded in an IPv6 address. Semi-Automatic tunnels use tunnel brokers to create tunnel from source to destination.

Translation

Translator is a device capable of translating traffic from IPv4 to IPv6 or vice and versa. This mechanism intends to eliminate the need for dual-stack network operation by translating traffic from IPv4-only devices to operate within an IPv6 infrastructure. It performs Header and Address Translation between the two protocols. The advantage of this technique is IPv4 users can use this translation technology with no or little change in the existing infrastructure to connect with IPv6 network and vice versa. Some of the feature of IPv6 are lost when translation techniques and it does not solve the problem of IPv4 address space depletion.

V. IPV6 Features and Benefits

IPv6 offers a large address space than IPv4. With 128 bits of IPv6 address allow with some 340 trillion, trillion, trillion addresses. With such a large number of addresses, the need for NAT is effectively eliminated. When IPv4 was designed security is not the concern, however with IPv6, IPSEC is built into the protocol with a suitable key infrastructure. 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 [13].

Auto configuration is the main feature of IPv6. IPv6 offers three types of autoconfiguration- Stateful Autoconfiguration, Stateless Autoconfiguration and both [14]. Clients using IPv4 addresses use the Dynamic Host Configuration Protocol (DHCP) [15] server every time they log onto a network. This process is called stateful auto-configuration. IPv6 supports a revised DHCPv6[16] protocol to support similar stateful auto-configuration, but also supports stateless auto-configuration of nodes that do not require a server to obtain addresses, but uses router advertisements to create an address. This creates a "plug-and-play" environment and can simplify management and administration. IPv6 also allows automatic address configuration and, empowering administrators to renumber network addresses without accessing all clients.

IPv6 also offers efficient and hierarchical addressing and routing infrastructure, Built -in security, Mobility, Multicast support, Better support for QoS and New protocol for neighbouring node interaction.

VI. Industry Standards for Adoption of IPV6

IPv6 has become the future of internet, and across the globe industry is being slow to adopt this new protocol. Being reason is that when the things are running smooth with IPv4 then why IPv6. Many parts of the industry are now supporting IPv6, while others are lagging behind. Microsoft can help businesses ready for this by providing solutions that help for soft transition to the next generation Internet Protocol [17]. The following is a brief analysis of the readiness of key industry sector. All the networking equipments and the new devices like mobile handsets, tablets etc are provided with IPv6 support i.e. it allows dual stack architecture. The backbone network is largely based on IPv4; all routing tables are based on IPv4 entries. The global network of IPv6 interconnectivity is now growing rapidly

Applications must written in such a way that it support IPv4/IPv6 dual stack capabilities in the underlying operating system [18]. Most of the applications, including web browsers, already support dual-stack function. Others are subject to the planned timing of upgrades by the application developer. Ideally, applications should be agnostic to the use of IPv4 or IPv6. An application that supports dual-stack will usually give preference to IPv6 if it is available, otherwise it will fall back to using IPv4.

VII. Conclusion

IPv6 provides great advantages over IPv4 i.e. large address space, support for real time audio and video streaming as well as quality of service (QoS), greater security, extension headers etc. Despite of these advantages the challenging issue is that it will still take time for completely migrate from IPv4 to IPv6, the reason for this is that the devices are not compatible i.e. the devices at layer 2 can work with no or a bit modification, but the devices at layer 3 are needed to be upgraded. But the industries and companies don't want to upgrade their devices because of their cost and various technical issues. Another reason is that the backbone routers are using IPv4 addresses and they need to change their routing tables. Since the rapid growth of Internet in last few decades the need of IPv6 is must because IPv6 solves internet scaling challenges, provides flexible transition mechanisms for the current internet, and meets the needs of such new markets as mobile, personal computing devices, network entertainment and device control. Security and Scalability are the major concerns with today's Internet, Thus we must implement IPv6 as early as possible.

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